An Assessment of Analytical Capabilities, Services, and Tools for Demand Response

Prepared for the National Forum on the National Action Plan on Demand Response: Estimation Tools and Methods Working Group

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February, 2013

National Forum of the National Action Plan on Demand Response

An Assessment of Analytical Capabilities, Services, and Tools for Demand Response was developed to fulfill part of the *Implementation Proposal for The National Action Plan on Demand Response*, a report to Congress jointly issued by the U.S. Department of Energy (DOE) and the Federal Energy Regulatory Commission (FERC) in June 2011. Part of that implementation proposal called for a "National Forum" on demand response to be conducted by DOE and FERC.

Given the rapid development of the demand response industry, DOE and FERC decided that a "virtual" project, convening state officials, industry representatives, members of a National Action Plan Coalition, and experts from research organizations to work together over a short, defined period to share ideas, examine barriers, and explore solutions for demand response to deliver its benefits, would be more effective than an in-person conference. Working groups were formed in the following four areas, with DOE funding to support their efforts, focusing on key demand response technical, programmatic, and policy issues:

1. Framework for evaluating the cost-effectiveness of demand response;
2. Measurement and verification for demand response resources;
3. Program design and implementation of demand response programs; and,
4. Assessment of analytical tools and methods for demand response.

Each working group has published a final report that summarizes its view of what remains to be done in their subject area. This document is one of those four reports.

The Implementation Proposal, and the National Forum with its four working groups reports, is part of a larger effort called the National Action Plan for Demand Response. The National Action Plan was issued by FERC in 2010 pursuant to section 529 of the Energy Independence and Security Act of 2007. The National Action Plan is an action plan for implementation, with roles for the private and public sectors, at the state, regional and local levels, and is designed to meet three objectives:

1. Identify requirements for technical assistance to States to allow them to maximize the amount of demand response resources that can be developed and deployed;
2. Design and identify requirements for implementation of a national communications program that includes broad-based customer education and support; and
3. Develop or identify analytical tools, information, model regulatory provisions, model contracts, and other support materials for use by customers, states, utilities, and demand response providers.

The content of this report does not imply an endorsement by the individuals or organizations that are participating in NAPDR Working Groups, or reflect the views, policies, or otherwise of the U.S. Federal government.

An Assessment of Analytical Capabilities, Services, and Tools for Demand Response was prepared by Andrew Satchwell, Charles Goldman (Lawrence Berkeley National Laboratory), Hossein Haeri, and Mark Lesiw (Cadmus) for the Lawrence Berkeley National Laboratory, who is managing this work under a contract to the U.S. Department of Energy Office of Electricity Delivery and Energy Reliability, under Contract No. DE-AC02-05CH11231.

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Regarding the National Action Plan on Demand Response, visit:

http://www.ferc.gov/legal/staff-reports/06-17-10-demand-response.pdf

Regarding the Implementation Proposal for the National Action Plan for Demand Response, visit:

http://www.ferc.gov/industries/electric/indus-act/demand-response/dr-potential.asp

OR

http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/ImplementationProposalforNAPDRFinal.pdf

Regarding the National Forum for the National Action Plan for Demand Response project, visit:

http://energy.gov/oe/national-forum-demand-response-what-remains-be-done-achieve-its-potential

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Acknowledgements

An Assessment of Analytical Capabilities, Services, and Tools for Demand Response is a product of the National Action Plan on Demand Response Estimation Tools and Methods Working Group.

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Executive Summary

This document reports on the findings and conclusions of the Demand Response (DR) Tools and Methods Working Group, which included state officials, industry representatives, members of the National Action Plan Coalition, and experts from research organizations.

The Working Group focused on two key questions related to existing and future analytical capabilities, services, and tools for DR:[1]

- What gaps, if any, occur in DR capabilities, services and tools?
- What types of tools would be desirable to develop for supporting frameworks for DR planning, program design, cost-effectiveness screening, and measurement and verification of impacts?

The study's "gap analysis" began by identifying the analytic needs and requirements of stakeholders in the retail and wholesale DR markets. We identified four distinct groups of stakeholders: end users; curtailment service providers (CSPs);[2] load-serving entities (LSEs); and system operators. The study also developed an inventory of analytic capabilities, services, and tools (public and proprietary) currently available to stakeholders, based on interviews with industry experts and literature reviews. These capabilities, services, and tools exist across three broad classes of functions, common to nearly all stakeholder groups: planning, operations, and verification.

The resulting study identified gaps between stakeholder's needs (both immediate and anticipated, from evolution of the DR market) and analytical capabilities, services, and tools available for addressing those needs.

The gap analysis indicated that existing analytic capabilities and services are sufficient to effectively address many DR stakeholders' needs in most areas. Moreover, industry trade

[1] We define "demand response" in the same way the Federal Energy Regulatory Commission (FERC) and the U.S. Department of Energy (DOE) have consistently used the term: "Changes in electric use by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized." See DOE, *Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them: A Report to the United States Congress Pursuant to Section 1252 of the Energy Policy Act of 2005*, February 2006.

[2] We use "curtailment service provider" to refer to entities providing DR services to customers, including FERC's definition, established in FERC Order 719, of Aggregator of Retail Customers, which refers to an entity aggregating DR bids.

associations and a number of national forums and conferences provided opportunities for DR stakeholders to disseminate new ideas and exchange information.

However, DR programs operating today largely have been designed to meet specific local resource requirements, and to satisfy particular local planning and policy objectives. DR programs also tend to greatly vary in design, depending on local conditions (such as weather and the customer mix). Reporting requirements also tend to vary across jurisdictions. Clearly, these conditions hamper transfer of knowledge and expertise, making it more difficult to compare DR program effects and accomplishments across jurisdictions.

A concerted effort to develop more standardized analytic methods, techniques, and tools will greatly aid in addressing these issues and furthering DR policy. Based on our gap analysis, we identified several areas where further development of analytical tools may be appropriate:

- End-user Settlement Tools
- LSE Site Opportunity Assessment Tools
- LSE Program Implementation Tools
- LSE Impact Assessment Tools

The study concludes with a design roadmap, which describes a general set of design features and decision criteria for developing the needed tools and options.

1. Introduction

The Federal Energy Regulatory Commission (FERC) and the U.S. Department of Energy (DOE) define demand response (DR) as "changes in electric use by demand-side resources from their normal consumption patterns in response to changes in the price of electricity, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized".[3]

For several decades, DR has served as a critical resource portfolio component for many utilities. To manage their peak loads, utilities designed and deployed a variety of programs, utilizing: time-based or seasonal rates; interruptible/curtailable rates; and direct load control (DLC) programs targeting certain appliances and end uses (e.g., residential and small commercial air-conditioning, residential water heating and agricultural pumping). As the primary player in the retail DR market, utilities exercised primary control over planning, design, and delivery of DR products.

The DR market has undergone a dramatic transformation over the past two decades. Much of the impetus for this transformation originated from three sources:

1. The restructuring of the retail electric utility market in the late 1990s and early 2000s, leading to establishment of independent transmission system operators (ISOs) and regional transmission organizations (RTOs).
2. FERC policy initiatives and decisions on design, governance, and market rules for organized wholesale electricity markets, leading to development of day-ahead and real-time energy markets, forward capacity markets in some regions, and a requirement to integrate DR resources into each.
3. Expansions of state-level renewable portfolio standards, resulting in a greater need for resources to balance variable generation technologies (e.g., wind and solar).

In March 2011, through Order 745, the FERC established market-based compensation for DR resources in organized wholesale energy markets, which will likely further accelerate DR resource development. The rules outlined in FERC Order 745 require grid operators in organized wholesale markets to pay DR resources the market price for energy, known as the locational marginal price, when: those resources provide the capability to balance

[3] FERC. *2012 Assessment of Demand Response and Advanced Metering, Staff Report*. December 2012; DOE. *Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them: A Report to the United States Congress Pursuant to Section 1252 of the Energy Policy Act of 2005*. February 2006.

supply and demand as an alternative to a generation resource; and dispatch of those resources proves cost-effective as defined by a net-benefits test.

Together, these forces have stimulated greater retail and wholesale market participation by customers, utilities, and curtailment service providers (CSPs). This can be seen in the dramatic increase in DR resources in retail and wholesale electricity markets. The FERC estimated 2011 DR resources to be nearly 72,000 MW, or about 9.2 percent of peak demand (2012 FERC survey, covering calendar year 2011), an amount approximately 22 percent greater than in 2009.[4]

The following significantly affect DR's role in these retail and wholesale markets: the structure and design of electricity markets; retail rates; technical opportunities; and customer acceptance. Interactions and coordination of retail and wholesale markets has led policymakers, program designers, and end-use customers to require enhanced capabilities, services, and tools.

This study reports findings and conclusions from the DR Tools and Methods Working Group, which included state officials, industry representatives, members of the National Action Plan Coalition, and experts from research organizations.[5]

The Working Group focused on two key questions related to existing and future analytical capabilities, services, and tools for DR:

- What gaps, if any, occur in DR capabilities, services, and tools?
- What types of tools would best be developed to support frameworks for DR planning, program design, cost-effectiveness screening, and measurement and verification of impacts?

This study goes beyond a limited discussion of tools, as it has been based on a high-level review of DR capabilities, services, and tools, and is intended to serve entities new to DR. The report does not assess the accuracy or functionality of existing capabilities, services, and tools, and it does not make specific recommendations for capabilities, services, and tools appropriate in specific circumstances.

[4] FERC. *Assessment of Demand Response and Advanced Metering. Staff Report,* December 2012.

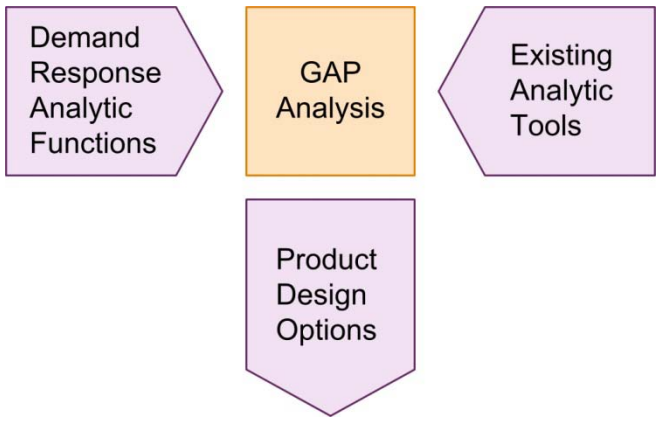
[5] The DR Tools and Methods Work Group served in an advisory capacity, providing critical input in assessing DR analytic needs and available capabilities and tools. The Working Group, in addition to interviews with other industry stakeholders and experts, essentially provided a Delphi approach, whereby the authors solicited input of subjective views, and sought consensus, where possible.

1.1. APPROACH

This study used a "gap analysis" approach, which involved four, sequential, interrelated steps (shown in Figure 1):

1. Identifying the analytic needs and requirements of stakeholders in the retail and wholesale DR markets.
2. Through interviews and literature reviews, developing an inventory of analytic capabilities, services, and products/tools (public and proprietary) currently available to stakeholders.
3. Identifying gaps between stakeholders' needs (both immediate and anticipated from the DR market's evolution), and the capabilities, services, and tools available to address those needs.
4. Describing a general set of design features for the needed tools and options, and methods for distributing such tools.

FIGURE 1. SCHEMATIC OF STUDY APPROACH



The remainder of this report is organized as follows:

- Section 2 discusses the inventory of existing analytic tools.
- Section 3 describes DR analytic functions.
- Section 4 summarizes the gap analysis.
- Section 5 concludes the study with a discussion.

Appendix A lists DR tools identified by Working Group members, other industry experts, and in literature reviews.

2. Existing Analytic Tools: Inventory of Capabilities, Services, and Products

The gap analysis began by focusing on identifying available DR analytic tools. As the research progressed, however, it became apparent the "tool" concept proved overly restrictive, and did not fully describe the many ways to meet stakeholders' identified needs. The literature review and interviews with experts revealed most stakeholders did not strictly need tools, but rather a broader set of analytic capabilities or "solutions."

Research on developing existing tool inventories resulted in a similar conclusion that many "tools" identified by interviewed experts represented capabilities needed by various stakeholders and/or services provided by various types of organizations.

This information led to a decision to broaden the needs assessment's scope to encompass "capabilities" and "services."

For this study's purposes, and in the context of DR, the following concepts have been defined:

- Capability: The knowledge and analytic skills required by stakeholders to effectively perform the necessary DR-related activity or function. As defined here, capability not only refers to the knowledge of analytic techniques, but also the necessary expertise for applying them effectively. These capabilities may wholly or partly be internal to an organization, or be available from external sources as services.
- Service: Analytical services available from capable external sources, such as: national laboratories; industry research organizations (e.g., the Electric Power Research Institute [EPRI], Edison Electric Institute [EEI]); academic institutions; or consultants to provide specialized skills to perform the necessary DR functions requested by stakeholders. Services can be differentiated from capabilities as they are presumed external to the stakeholder organization.
- Tool: Designed to perform specific analytic tasks, tools may be standardized products, or specialized products to meet a stakeholder's particular analytic needs. This study defines a tool as a commercially available product, enabling execution of DR business processes and/or analyses by capable users. The primary features of such tools include their being: standardized, transferable, and accessible, as either desktop or Web-based applications. In some instances, tools

may not be necessary for particular tasks due to existing services already fulfilling those needs.

These definitions serve as the basis for the gap analysis, and provide structure for this study's recommendations.

The study compiled information about available capabilities, services, and tools from various public sources, including (but not limited to): federal energy agencies; state regulatory commissions; national laboratories; RTOs/ISOs; utilities; DR service providers; and consulting firms. Interviews with Working Group members and various national DR experts provided addition information on specific services and tools.

Appendix A lists public and proprietary tools, identified through interviews and literature reviews. Note that some tools used by stakeholders in the list may be supplemented by services provided by vendors and/or consultants. Though not exhaustive, the list illustrates the types and range of tools provided by various entities, and in use by stakeholders.

3. Demand Response Analytic Functions

In investigating DR's analytical needs, one must recognize the diversity in roles stakeholders play, and the unique capabilities needed to support these roles. The study identified four distinct groups of stakeholders:

- End users (facilities): The ultimate consumers of electricity. In the context of DR, end users may be differentiated by size (e.g., residential, commercial, and industrial customer classes) and sophistication (e.g., ability to control end-use loads). This classification will, in turn, determine end-users' needs.
- CSPs (Curtailment Services Providers): Third-party DR implementers, delivering DR services and/or programs on behalf of a utility (either in wholesale or retail markets), or operating as aggregators of DR resources to provide a variety of bulk power system services in organized wholesale markets (e.g., capacity, energy, and/or ancillary services).[6]
- Load-serving entities (LSEs): An entity serving the demand and energy requirements of its end-use customers. These may include: vertically integrated investor-owned utilities; rural electric cooperatives; public utilities; retail electric suppliers; or electric distribution companies (EDCs) offering DR programs to their customers.
- System operators (RTOs and ISOs): Organizations responsible for grid interconnections and operations, facilitating wholesale market transactions, and offering DR programs.

The various DR stakeholders' activities may be defined in terms of three broad classes of functions, common to nearly all four stakeholder groups, as discussed below.

3.1. PLANNING

Planning functions encompass a variety of activities taking place within a stakeholder organization, and vary depending on the stakeholder's role. These analytical functions include: estimating DR resource potential; forecasting savings across customer segments;

[6] The term "curtailment service provider" includes FERC's definition of Aggregator of Retail Customers (ARCs) established in FERC Order 719, which refers to an entity aggregating DR bids in wholesale electricity markets.

projecting program participation and assessing customer preferences; and cost-effectiveness analysis. In this study, these functions divide into four categories:

System planning: These activities involve integrating DR and other capacity-oriented resources into a utility or market's resource portfolio (for example, integrated resource planning [IRP] in vertically integrated utilities).

Market assessment: These activities provide a means for projecting consumers' responses to DR programs and product offerings, thus determining the DR resource potential. Normally, such activities would precede the planning function.

Facility opportunity assessment: These activities seek to determine the feasibility, amount, potential adverse impacts, and benefits of load curtailment at particular facilities. These activities may be conducted by facility operators and owners or by program administrators and/or CSPs on their behalf.

Cost-effectiveness screening: These activities involve documentation and estimation of economic costs and benefits for DR programs from various perspectives (e.g., societal, administrator, participant, and non-participant), according to established guidelines prescribed by state regulatory agencies.

3.2. OPERATIONS

Operations are ongoing activities, involved in the marketing and delivery of DR programs and services. Examples of these analytical functions include: DR management systems (DRMS) supporting DR program objectives, and integrating DR into pricing and market price signals. For this study, these activities fall into three categories:

Program implementation: Activities designed to facilitate day-to-day DR implementation, and primarily involve tracking various program operations. These activities may include incorporating price elasticities and DR resource characteristics in system operator load forecasts to more accurately forecast day-ahead and real-time.

Load balancing/grid optimization: Specialized activities that primarily apply to grid system operators (e.g., RTOs, ISOs, or balancing authorities). These involve continuously balancing generation and demand to manage and optimize the grid system. Load balancing also includes integration of variable generation resources (e.g., wind and solar generation) into the system.

Transaction management (price response): Activities that help to maintain the communication infrastructure for price or curtailment event notification, particularly in the context of demand-bidding or demand buy-back programs or certain dynamic pricing tariffs. This may include communication of a price signal to the end user, or

communication of a signal from the utility or CSP to a device controlling an end-user load.

3.3. VERIFICATION

This function involves measurement and verification of DR load impacts, and their valuation at the facility or program level, as performed by various stakeholders. Examples include: determining impacts on participants and nonparticipants; and transferring results for use in other utility systems (e.g., resource planning and customer billing), or for use more broadly by other stakeholders. This study divides these activities into two categories:

Settlement: Determination of levels (e.g., quantity of load and/or demand reduction) and processing of payments for DR. This study defines settlement in terms of transactions between end-use customers and CSPs or LSE/EDCs.[7] These activities also include establishing customer baselines, and procedures for verification and reporting load impacts.

Impact assessment: Activities focusing on the measurement and verification of actual load impacts of particular DR programs on the system, taking place at the program or individual customer or facility levels.

The three main, common functional areas and their subsets of particular analytical activities define the gap analysis framework.

[7] Settlement also occurs between ISOs/RTOs and DR market participants to settle wholesale market financial transactions that arise from events where DR resources are called by the system operator.

4. Gap Analysis

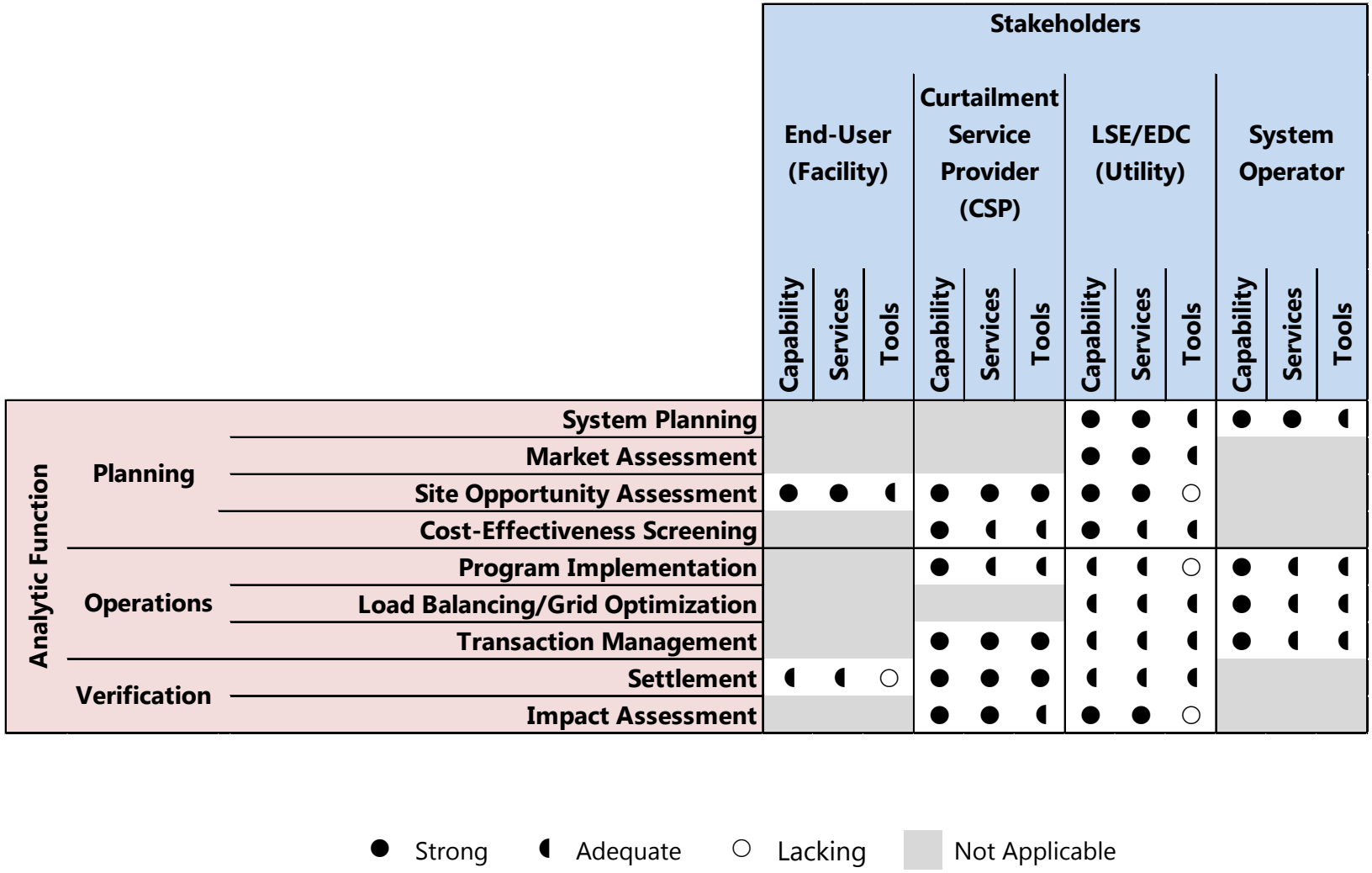
The gap analysis began by constructing a matrix, showing intersections of DR stakeholders and various activities involving analytic functions to support DR. Each matrix cell depicts where analytic functions and DR stakeholders interact, and includes a list of capabilities, services, and tools.

Informed by results of the needs assessment and inventory research, and by input from the Working Group, the study team rated capabilities, services, and tools applicable to each cell, with respect to their availability, strength, and quality. Ratings drew upon a qualitative scale, divided into four categories: "strong," "adequate," "lacking," and "not applicable," defined as follows:

- Strong: The stakeholder has access to the necessary tools and capabilities internally, or to services through outsourcing.
- Adequate: Though available resources prove adequate, room exists for refinements and/or standardizations.
- Lacking: From the stakeholder's perspective, insufficient internal resources and/or external resources. This designation signals existence of a potential gap. There are some instances in which a tool may not be necessary for performing analytical tasks due to existing services already fulfilling those needs. For example, while a shortage of standardized commercially available tools for program impact assessment exists, many third-party consultants and contractors offer such services.
- Not applicable: The capability, service, or product does not apply to the particular stakeholder, as the stakeholder does not perform that function or activity.

Figure 2 shows the resulting DR activities matrix, by stakeholder and analytic function. A discussion of gap analysis results and findings follows.

FIGURE 2. DR CAPABILITIES, SERVICES, AND PRODUCTS BY STAKEHOLDER AND ACTIVITY



4.1. CAPABILITIES

Broader regulatory reforms of electricity markets, new rules governing DR transactions, and improved technologies have rapidly transformed the DR market. The gap analysis suggested a fairly comprehensive set of organizational and analytic capabilities exist to serve the DR market effectively. System, market, and customer end-use site planning capabilities stand as the strongest areas. A number of demand-side management consulting firms also have strong analytic expertise and practical experience in planning, program design, and verification expertise to effectively fulfill DR needs.

Study research did not indicate areas where capabilities might be lacking. There appears, however, room for strengthening capabilities supporting DR operations within utilities and some end-users, particularly large customers.[8] Aside from customized, *ad hoc* procedures and systems in use by several utilities, this research did not identify a standard set of services, specifically designed to address DR operations.

4.2. SERVICES

Availability and strength of services available from third-party vendors follow nearly the same pattern as capabilities. Research results indicate a sufficient level of theoretical and analytic expertise available to address the needs of all stakeholders.

4.3. TOOLS

"Tools" can be defined narrowly as standardized commercially-available products available to stakeholders proficient in DR analysis for performing necessary analytic tasks. In many cases, services offered by consultants or other private-sector firms obviate the need for such products, as the service providers typically build and use their own tools to support the services they offer. However, based on our review of existing services and tools, the study team finds tools are either inadequate or could be improved in the following areas:

Site opportunity assessments: Site opportunity assessments characterizing DR options typically have been performed by utilities or their contractors as part of DR programs, or by CSPs for end users. In some cases, larger and more technically

[8] Large customers with on-site facility managers typically manage their own DR resources, including monitoring usage and potential bill impacts, actively bidding DR resources into wholesale markets, and responding to CSP and/or LSE resource dispatch signals during system events.

sophisticated end users (e.g., industrial customers) may perform their own assessments, or engage contractors to do so on their behalf. The study team identified a need for tools to be available to allow smaller and/or less sophisticated end users (e.g., small commercial customers) to conduct their own analyses to assess technical options for participating in load curtailment and in evaluating its financial implications.

Utilities can utilize widely available Web-based, interactive applications tools for performing similar calculations for identifying and evaluating energy-efficiency opportunities—often referred to "energy analyzers." A need exists for tools performing similar analyses for DR, particularly in identifying and evaluating curtailment contracts and opportunities to take service under time-varying prices.

Market assessment: Based on the gap analysis, the study team concluded market assessment tools and products, overall, prove adequate. However, room exists for improvements if the DR industry can become more consistent in reporting DR data from dynamic pricing pilots and DR programs. Such improvements could enhance transparency and consistency to facilitate sharing of DR results. The National Action Plan on DR specifically identified sharing information and experiences in DR program planning and implementation as a key area for further development, and provided a sample Web-based "clearinghouse" of DR materials.

Program implementation: Based on the gap analysis, the study team identified a need for additional tools to support utilities' day-to-day operations and tracking of DR activities. Though a number of vendors have developed and deployed database systems for tracking energy-efficiency activities and transactions, these systems typically do not lend themselves to tracking DR. It appears many utility program administrators use *ad hoc* tools and software to track and report DR activities.

Transaction management: For more than a decade, Web-based tools for managing event-based, price-response DR communications and transactions between utilities and end users have been available. CSPs typically use their own proprietary processes and tools for this purpose. With CSPs' widespread involvement in the DR market, the study team concluded available tools in this area are adequate to address stakeholders' needs.

Settlement: Program administrators and/or CSPs typically perform event-by-event determinations of load reductions by end users and payments owed. Based on the gap analysis, the study team concluded available tools and processes used by utilities and CSPs adequately address settlement needs, though there appears to be a lack of standardized tools or products for use by end users.

Impact assessment: Impact assessments, as defined in this study, relate to the determination of programmatic impacts. Independent, third-party contractors typically perform DR programs' impact evaluations, using analytic tools built on commercially

available software platforms. Given the complexity of methods used for determining program-level impacts, and the current, non-uniform evaluation methodologies employed, developing standard tools for this purpose does not seem feasible at this time.[9] However, as DR evaluation methodologies become more standardized, revisiting this issue may prove useful for determining whether additional tools in this area could aid in impact evaluations.

Cost-effectiveness screening: Program administrators typically adhere to standard methods for analyzing DR program's cost-effectiveness based on state and regional cost-effectiveness frameworks. For example, the California Public Utilities Commission (CPUC) published its *DR Cost-Effectiveness Protocols* in 2010. As tools accompanying the protocols demonstrate, cost-effectiveness calculations can be performed easily using spreadsheet tools. These tools, however, must offer the flexibility to accommodate local regulatory rules governing use of particular inputs and assumptions. Additionally, cost-effectiveness tools should consider cost-effectiveness of various DR options and strategies from multiple perspectives (e.g., program administrator, society, end user, participants, and non-participants).

[9] While the statistical and econometric methods employed to perform rigorous *ex post* evaluations are rather well known and documented, evaluation calculations for settlement purposes often rely on different baseline methods and are not standardized.

5. Discussion

This study focused on two key questions related to existing and future analytical capabilities, service, and products for DR:

- What gaps, if any, occur in DR capability, services, and products?
- What types of tool development would prove desirable to support frameworks for DR planning, cost-effectiveness screening, measurement and verification of impacts, and program design?

The gap analysis indicated a strong base of knowledge and information about DR currently existing in the United States. In most cases, existing analytic capabilities and services prove sufficiently effective to meet the needs of DR stakeholders in most areas. A number of national forums also exist, such as industry associations and conferences, providing opportunities for DR stakeholders to disseminate new ideas and exchange information.

However, DR programs operating today largely have been designed to meet specific, local resource requirements, and to satisfy particular local planning and policy objectives. DR programs also tend to vary in design a great deal, depending on local conditions, such as weather and customer mixes. Reporting requirements also tend to vary across jurisdictions. Clearly, these conditions hamper transfer of knowledge and expertise, and make comparing DR program effects and accomplishments across jurisdictions more difficult.

A need exists to develop standard practices and methods, where appropriate, for various DR functions, including a set of standardized tools to enable application of such practices and methods, and to facilitate transfer of DR knowledge.[10]

Based on the gap analysis, the study team identified the following areas for further development of analytical tools and products:[11]

[10] Implementation activities for the National Action Plan on DR include several other Working Groups, focused on suggesting standardized approaches for: screening DR programs for cost-effectiveness; and developing standard methods for DR impact assessments (i.e., measurement and verification). Findings and conclusions from those studies offer a framework for developing tools this study identified as unavailable.

- **End-User Settlement Tools**: It is important to differentiate between price-based DR (e.g., CPP, RTP, and demand bidding) and incentive-based DR (e.g., DLC, interruptible tariffs) when discussing tools for end-user settlement. End users primarily wish to reduce and manage potential "bill shocks" that could occur from high-price periods while on dynamic pricing tariffs. End-user settlement tools could be appropriately developed to assess the potential for significant changes in bills from pricing-based DR programs. For incentive-based DR programs, DR program administrators and/or CSPs typically provide information about end-user bills and account settlements. Tools could be developed for end users to verify the accuracy of these settlements.
- **LSE/EDC Site Opportunity Assessment Tools**: The study team collected several site opportunity assessment tools available to LSEs/EDCs for large customer DR programs. A gap exists, however, in tools to assess DR program opportunities for smaller customers.
- **LSE/EDC Program Implementation Tools**: These tools could support DR program administrators managing their program portfolios. Possible tools might include: program-tracking databases linking participants, utility accounts, and billing systems, and/or linking to customer services and account systems.

  DRMSs have emerged as a conceptual system that potentially could integrate DR data with other utility systems. Notwithstanding this potential for tool development, a significant amount of integration would be necessary for these tools to interact with various existing utility data systems in these business areas, presenting significant costs and other resource constraints. Thus, consultants typically offer such program implementation tools as services, given utility-specific needs and system integration challenges.
- **LSE/EDC Impact Assessment Tools**: Consultants and contractors typically offer these tools as services. Potential tool development in this area could include greater standardization of approaches for evaluation methods (e.g., customer baselines). This presents a challenge, however, for state utility regulators, given the lack of standardization among utilities within each state (and among states) on appropriate impact assessment methodologies. To best enable creation of DR tools, consistent methods should be established and adopted so effective knowledge transfers can take place, and tools can be developed to utilize the vast

[11] The current study identified areas where existing stakeholders agree tools and methods are insufficient to even address relevant questions. However, the study did not objectively assess the accuracy of current methods, compared to what might be achieved with further research. An additional study avenue, therefore, would be evaluation of the accuracy and usefulness of current capabilities this study identified as strong or adequate. Even within these areas, many existing methods could still be significantly refined. For example, DR program operations (such as deciding when to call DR events) often are determined using "rule-of-thumb" methods that probably could be improved. Similarly, determination of program cost-effectiveness is a sufficiently complex substantial improvement, probably possible in the future.

amount of DR results available across as many utility and third-party DR programs as possible.

Developing tools proves challenging because of diverse analytic needs and functions of various stakeholders. This study includes several considerations for development of tools and/or products to meet these diverse analytic needs and challenges.

Developing analytic software tools, often a complex and time-consuming process, involves a sequence of essential steps, such as the following:

1. Defining users' requirements: Identifying needs and requirements of users. These requirements may also include defining how users interface with the tool, and how results are reported.

2. Specification: Defining underlying tool analytics, and methods and calculations for performing the analysis.

3. Software architecture: The overall view of tool design, components, and interactions. Decisions regarding software architecture may also include choosing a software platform. A key consideration in designing and developing such tools is: how will they be made available to and be accessed by users. This has important ramifications regarding the software tool's use of a two-tiered structure (client/server, as in Web applications) or a one-tiered structure (client, as in desk-top applications). The choice between a Web-based tool and desktop software tends to be the most consequential decision in tool development, with important ramifications in terms of overall functionality, usability, and cost. Table 1 summarizes principal considerations involved in decisions regarding software architecture.

4. Implementation and testing: Actual coding of software and testing results in an ongoing, iterative way.

5. Documentation, training, and support: Documenting the software's internal design for future maintenance, user manuals, and enhancement and ongoing technical support.

6. Maintenance and enhancement: The ongoing process of maintaining and enhancing software to cope with newly discovered problems, or addressing new requirements or improvements resulting from user feedback.

Ultimately, the decision to develop the needed tools, and their features and specifications, must be based on DR policy priorities, stakeholder interests and involvement, and trade-offs among various considerations, as discussed previously.

TABLE 1. OPTIONS FOR AND CONSIDERATION IN TOOLS DEVELOPMENT

Consideration	Web-Based	Desktop
Infrastructure	Two-Tier (Client/Server)	Mostly single-tier (Client)
Deployment (from client perspective)	Simple	Complex, manual
Updating	Simple	Complex, manual
Cross- platform flexibility	Yes, in most cases	Expensive to achieve
Performance	Variable, relies on Internet connectivity	Consistently good
Remote Usage	Yes	Only in special, two-tiered solutions
Cost:		
Infrastructure	Variable	Low
Development	Same	Same
Deployment	Low	High
Administration	Low	High

Appendix A

The following list of sample DR tools has been identified by the Working Group members, other industry experts, and through literature reviews.[12]

Tool Name	Primary Function(s)	Vendor/Developer
Aclara DRMS	Program Implementation/Load Control Automation	Aclara/Calico Energy Services
Connected Energy Demand Management	Planning/Program Design/Impact Assessment	BPL Global
Beacon	Opportunity Assessment/ Planning/ Implementation	ICF International
Benefits Calculator Model	Cost-Effectiveness Screening	Lawrence Berkley National Laboratory
iGrid	Cost-Effectiveness Screening	The Brattle Group
Cost-Effectiveness Screening Tool	Cost-Effectiveness Screening	E3 Consulting
Cost-Benefit Guidebook for Smart Grid	Planning/ Cost-Effectiveness Screening	EPRI / DOE
Cost-Effectiveness Screening Tool	Cost-Effectiveness Screening	NW Coordinating Council
Demand Response Tool	System Planning/ Grid Optimization	Midwest ISO

[12] This does not represent an exhaustive list of all available tools. In some cases the listed tool may provide a larger set of functionalities and in some items on may represent capabilities and solutions, rather than a tool, as the terms has been defined in this report.

DRIVE Model	Planning	FERC
DemandSMART	Implementation/ Impact Assessment/ Settlement	EnerNOC
Demand Response Market Model	Market Assessment/ Planning	Navigant Consulting
DRBizNet	System Planning/ Load Balancing/ Operation	UISOL/Alstom
DR Pro	Market Assessment	The Cadmus Group, Inc.
DR Pricer	Planning/ Program Design	Integral Analytics
IntelliMEASURE	Program Implementation/ Impact Assessment	Comverge
Integrated Planning Model	Market Assessment/ Planning	ICF International
DSMore	Cost-Effectiveness Screening	Integral Analytics
Demand Response Quick Assessment Tool (DRQAT)	Site Opportunity Assessment/ Planning	Lawrence Berkley National Laboratory
IntelliSOURCE	Program Implementation/ Operation	Comverge
LoadMAP	Planning/ Implementation/ Impact Assessment	EnerNOC
PRISM (Pricing Impact Simulation Model)	Planning/Program Design	Edison Electric Institute
SMARTmeter / OptNET	Implementation/ Impact Assessment	Energy Curtailment Specialists

Portfolio Pro	Cost-Effectiveness Analysis	The Cadmus Group, Inc.
National Demand Response Potential Model	Planning/ Market Assessment	ICF International
Sector Energy End-Use Model	Market Assessment/ Planning	ICF International
SEEload	System Planning/ Implementation/ Operation	Lockheed Martin
VirtuaWatt	Site Opportunity Assessment/ Transaction Management/ Impact Assessment	Constellation New Energy
Ventyx DRMS	System Planning/ Implementation/ Operation	Ventyx/ABB
webDistribute	System Planning/ Implementation/ Operation	OATI