WILL TOMORROW'S RESTRUCTURED MARKETS PROVIDE OPPORTUNITIES TO BETTER DETERMINE THE VALUE OF DEMAND-SIDE RESOURCES?

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SUMMARY

The creation of new regional electricity markets, along with advances in system monitoring and information technology, are enabling approaches that will permit electricity markets to better understand and quantify the value of demand-side resources. This paper provides a non-mathematical introduction to advanced valuation methods and reviews their data requirements. Trends in information technology and some the information becoming available from ISOs and other sources regarding system operations and costs are then reviewed. As advanced valuation methods become more practical, this may lead to an abandonment of today's benefit-cost ratios.

BACKGROUND

Demand-side resources, such as traditional energy conservation program and demand response programs, are normally viewed as a means of offsetting power plant and transmission capacity and generation requirements. Certain demand-side resources may also have value in providing ancillary services or may impact system operations. However, this value tends to be neglected by contemporary approaches to determining the value and cost-effectiveness of demand-side resources.

Under one theoretical approach,[1] the value of a supply-side or demand-side resource in an electricity market may be estimated based on its impact on marginal power plant operating costs, system losses, transmission constraints, generating capacity constraints, and network operating constraints. The value of a resource may vary over time, and may differ depending on its location in a network. A resource's value is affected by its impacts on the cost of providing reactive power, as well as real power.

Advanced theories of resource valuation have seldom been used to determine the value of demand-side resources, due to their complexity and data requirements. Instead, the California Standard Practice benefit-cost ratios are often applied.[2] The California Standard Practice approach compares the benefits and cost of a resource from various perspectives. This approach has many advantages. It is useful in a variety of applications, has intuitive appeal, and requires a minimal amount of data. However, the

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[1] See, for example, Fred Schweppe, Michael Caramanis, Richard Tabors, and Roger Bohn, *Spot Pricing of Electricity*, Kluwer, Boston, 1988; and Martin Baughman, Shams Siddiqi, and Jay Zarnikau "Integrating Transmission into IRP," *IEEE Trans. on Power Systems*, 1995.

[2] California Energy Commission & California Public Utilities Commission. *Standard practice manual: Economic analysis of demand-side management programs.* Sacramento, CA, December 1987.

recognized benefits tend to be limited to value of the generation and capacity requirements and the power plant emissions displaced by the program. If a demand-side resource impacts power factors, power plant dispatch decisions, environmental constraints on system operations, or affects other operating decisions, an analyst will find it difficult to reflect the economic consequences of these impacts in a simple benefit-cost framework.

EVALUATING RESOURCES: A REVIEW OF THE THEORY

A variety of alternatives to the California Standard Practice approach have been proposed over the years. Most of these alternatives attempt to refine how the value of displaced energy generation or generating and transmission capacity might be valued.[3] Other approaches to resource valuation focus on the risk management value of a resource, and thus view dispatchable demand-side technologies in a manner similar to call options.

Some proposed approaches have focused on the impacts of demand-side resources on short-run marginal costs in a utility system or in market for electricity. The planning framework developed through those papers recognizes that a resource's location within the network will affect its value, as well the impacts of the resource upon system operations, power quality, outages and outage costs, welfare or consumer surplus, compliance with environmental constraints, and reactive power flows. These approaches assign a value to resources based on their impacts upon short-run marginal costs. Under one elaborate formulation:[4]

Value of a Resource =

Impact on Marginal Generation Costs

+ Impact on Cost of Supplying Spinning Reserves

+ Impact on Outage Costs (possibly, based on cost of unserved energy)

+ Impact on Costs of Controlling Frequency

+ Impact on Tie Line Flows

+ Impact on Cost of Maintaining Dynamic Constraints on Phase Angles

+ Impact on Costs of Generation Controllers

+ Impact on Generating Capacity Constraints

+ Impact on Transmission Capacity Constraints

+ Impact on Cost of Maintaining Voltage within range

+ Impact on Cost of Meeting Emissions Constraints

+ Impact on Cost of Meeting Harmonic Distortion Constraints

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[3] See, for example, B. F. Hobbs. "The 'most value' test: Economic evaluation of electricity demand-side management considering customer value". *The Energy Journal*, 1991, 12(2), 67-91; and S. Braithwait and D. Caves. "The complete and unabridged measure of DSM net benefits: What we've been missing," in Proceedings: 6th national demand-side management conference. (Report No. EPRI TR-102021). Miami, FL: Electric Power Research Institute, 1993, p.p. 238-241.

[4] M. Baughman, S. Siddiqi, and J. Zarnikau. "Advanced Pricing in Electrical Systems, Part I: Theory and Part II: Implementation". *IEEE Transactions on Power Systems*, 12 (1): 489-502, February 1997.

The concept here is that there are costs associated with the many goals that a system operator must achieve. These goals involve not only meeting demand, but also include delivering electricity at the desired voltage and frequency, preventing system overloads, protecting equipment, and meeting environmental constraints. If a resource can reduce the cost to system operators and planners of meeting any of these objectives, then the cost reduction should be reflected in the valuation of the resource. Alternatively, if a resource increases the costs to the system of meeting any goals, then that increased cost should be reflected as a reduction in the value of the resource. This calculation would take the same perspective as a *utility cost test* or *societal test*, but include a number of costs and benefits that are typically ignored in a simple benefit-cost framework.

The impact of any resource on the systems costs may vary over time and may vary depending upon the resource's location in the network, as well. This implies that an accurate valuation of a resource requires estimates or forecasts of these effects over the life of the resource (which is no trivial matter!).

EXAMPLE TECHNOLOGIES

For most demand-side resources, estimates of avoided energy generation costs, avoided generating capacity costs, and avoided transmission capacity costs will tend to capture the majority of the resource's value. The added value attributable to their contribution to ancillary services (i.e., those services necessary to ensure the efficient operation of a system and provide needed operating reserves) and other operational costs will be small. Nonetheless, there may be some exceptions. Some resources whose cost-effectiveness might seem marginal under today's standard benefit-cost tests, might appear much more valuable if their contribution to reducing ancillary services and other operational costs are taken into account.

Interruptible or curtailable load programs provide one of the more obvious examples of a demand-side resource contributing ancillary services. In many instantaneous interruptible programs, service to the customer is automatically curtailed through underfrequency relay equipment whenever system frequency at the customer's point of service dips below 59.7 Hz or some other predetermined setting. Such programs not only reduce the amount of demand that the utility must plan to meet with generating capacity, but also assist in maintaining system frequency and can reduce a system's spinning reserve requirements.

Standby generator programs can provide operating reserves, and reactive power supply and voltage control services. Under such programs, large commercial or small industrial customers are asked to turn on their on-site standby or emergency generating equipment at the request of the utility or a third-party program manager. Most of these requests are made when a period of high demand on the utility system is anticipated. Customers are normally given a few hours notice before such actions are desired, and receive compensation in return for their compliance. These requests are limited in number and duration. Through these programs, the number of generating units on the grid increases during periods of high demand, and the demand that the utility plans to meet through its generation resources can be reduced. The standby generators can provide some of the ancillary services normally contributed by other generating equipment on the system.

Other forms of load control programs may also contribute ancillary services. A large number of electric utilities in the U.S. have implemented programs to control customer-owned air conditioners, electric water heaters, electric space heating systems, pool pumps, and irrigation pumps. Control over the customer's equipment can be exercised by the utility through a communications system, or via timers, temperature sensors, or other local means. Such programs can displace the need for operating reserves.

Similarly, real-time pricing programs may displace the need for operating reserves. Through real-time pricing programs, "price signals" are used as a means of rationing the demand on the system during times of potential capacity shortages, while possibly increasing electrical energy consumption during off-peak periods. Through these price signals, a better balance between demand and resources can be achieved.

A variety of storage technologies occasionally introduced through DSM programs, such as thermal energy storage devices, flywheels, and batteries, might also provide some of the ancillary services normally contributed by generating capacity. However, their impacts tend to be fairly localized.

Strategically-located demand-side resources can displace the need for reliability-must-run generating units and relieve local transmission congestion.

Some demand-side technologies can raise the costs of providing ancillary services. Variable speed motor drive equipment, installed through some industrial equipment retrofit programs, can adversely affect power quality, at least at the customer's site. Similar problems were encountered with some of the earlier generations of compact fluorescent light bulbs.

THE EVOLUTION OF ENERGY MARKETS

The restructuring of electricity markets and advances in information technology provide opportunities to implement more sophisticated valuation methods.

New nodal congestion management schemes can provide some of the locational marginal cost estimates required by advanced valuation methods. For example, locational marginal cost data are publicly-available for the PJM market on an hourly basis for geographical zones and nearly 3,000 nodes within that market. These estimates take into account generation costs and transmission constraints, and may at least indirectly take into account environmental constraints and other operating costs through generator bidding behavior. The marginal cost of meeting an increment of demand at a node (the locational marginal cost) can provide an indication of the value of demand reduction at that node and at that time.[5]

While it might seem far-fetched to determine the value of a demand-side resource based on its impacts on locational short-run marginal costs over the life of the demand-side resource, this is the same standard that must eventually be used in power plant investment decisions.

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[5] These values may not be exactly the same, since marginal cost reflects the cost of meeting an increment of *additional* demand, while the value of a demand-side resource should be equated with an increment of *reduced* demand.

CONCLUSIONS AND DISCUSSION

Some of the approaches to demand-side resource evaluation that were considered impractical when first suggested in the 1980s may now be approaching feasibility due to advances in market design, publicly-available data on locational marginal prices, and other advances.

Demand-side resources can play an important role in power system operations, above and beyond simply providing an offset to energy generation requirements and generation and transmission capacity requirements. The value of their potential contribution should not be overlooked in the economic analyses of such programs. Taking into account a program's contribution to ancillary services and system operations might make an otherwise marginal program appear significantly more attractive.

Demand-side resources still face challenges in being recognized as a source of ancillary services by players in the emerging competitive power markets. The impacts of demand-side resources tend to be more difficult to monitor and quantify than the effects of generating units and other providers of ancillary services. Demand-side resources often have small impacts which may be dispersed throughout a network. Thus demand-side resources may face the same challenges in being recognized as a legitimate source of ancillary services as they faced three decades ago in being recognized as a legitimate resource alternative to power plant capacity and generation.

ESCOs could become a natural provider and aggregator of demand-side ancillary services, providing such services for their own sake or as a byproduct of projects pursued for their energy conservation or load management benefits.

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