AVOIDED COST: AN ESSENTIAL CONCEPT FOR INTEGRATED RESOURCE PLANNING

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The principle of cost avoidance, and the metric of avoided costs, are central features of least-cost or integrated resource planning (IRP). The benefits of avoiding unnecessary costs seem obvious, sensible, and straightforward; it might be easy to presume that cost avoidance always has played a universally accepted role in utility planning. In the realm of utility planning, however, the concept still is relatively new and no clear consensus about its relevance and use has emerged.

Comparing resource options in the context of IRP requires a methodology for measuring costs (or savings). When conservation or demand-management strategies enter the mix of options, as least-cost planning dictates, the concept of avoided cost gains substantial relevance. Demand-management strategies range from efficiency-oriented pricing, to customer education programs, to rebates and retrofits. Avoided-cost analysis has played a central role in establishing demand management as a legitimate resource option for water utilities. Avoided-cost analyses have played a role in promoting conservation options in several communities. Two compelling applications of avoided-cost analysis (prepared for the City of Austin and the Metropolitan Water District of Southern California) appear in this issue of *Water Resources Update* (see the articles by Gregg and Rodrigo, respectively).

The applicability of the avoided-cost principle extends well beyond designing and justifying demand management. Avoided costs can be used to evaluate the benefits of resource alternatives on the supply side, including leak-detection and repair programs, water purchases from alternative suppliers, and source-of-supply or treatment options for complying with drinking water standards. Avoided costs also can be used to evaluate complex management issues, such as the potential benefits of regionalization through interconnection, partnerships, and mergers with other utilities (Beecher, 1996). Such evaluations are well within the spirit of comprehensive and integrated resource planning. This article explores the concept and application of avoided cost.

THE CONCEPT OF AVOIDED COST

In the context of IRP for water utilities, avoided costs are the incremental savings associated with *not* having to produce additional units of water or water service while meeting demand requirements (Beecher, 1995). This definition adopts a marginal or incremental theory of costing (see Beecher and Mann, 1990). Efficiency gains are realized as long as the marginal benefit of a resource option exceeds the marginal cost. In theory (perhaps only in theory), marginal cost is derived for the tiniest of units, such as a drop of water. In practice, marginal or incremental cost is used to refer to the unit cost of production for a known resource technology (such as a reservoir) that results in a specified amount of capacity (measured in millions of gallons, not drops).

An applied avoided-cost analysis compares the incremental savings associated with *not* producing an additional unit of output through a specific method to the incremental cost of supplying the equivalent unit through an alternative method. For example, conservation is justified when the unit cost of freeing-up existing supply capacity through demand management is lower than the unit cost of adding new supply capacity.

Many utilities can avoid costs by avoiding additions to supply capacity through conservation or load management strategies, including efficiency-oriented pricing. Utilities experiencing rapid demand growth and utilities with a history of underpricing water services may have the most to gain through demand management. Smaller increments of demand-side resources, compared with large-scale supply-side resources, can help some utilities respond to change with more flexibility and lower risk. As discussed later in this article, utilities also can avoid costs by various means, including but not limited to conservation. IRP provides a vehicle for assessing the potential for various cost avoidance strategies.

Theoretically, avoided costs can be segmented into three types of savings:

- Direct costs (capital and operating costs),
- Indirect costs (corollaries and externalities), and
- Opportunity costs.

Most avoided-cost studies emphasizes direct costs associated with resource alternatives, which are easiest to measure, analyze, and compare. Direct costs accrue to the utility and include the cost of canceled or deferred capital investments (including financing costs), as well as operating costs. Only costs directly associated with the specified avoided capacity are included. Significant operating costs for water utilities include energy costs (for pumping), chemical costs (for water treatment), and labor costs.

Avoided-cost analysis can be expanded to include indirect savings associated with corollary functions and externalities. Indirect costs or savings accrue to water customers, related industries, society, and the environment. Corollary savings in the water industry include capital and operating savings associated with reductions in wastewater collection and treatment. Water conservation, for example, can free-up both wastewater treatment and water supply capacity. Because the water supply and wastewater treatment are energy-intensive, direct energy savings in the water sector may have a corollary effect on energy utilities. Another type of corollary saving accruing to water customers is a reduction in energy costs (apart from the utility's direct energy savings noted above). Customers conserving hot water can see reductions in both water and energy usage.

Indirect avoided costs can be measured in environmental terms as well. Nature's costs and benefits are perhaps hardest to quantify. Incorporating environmental externalities (or spillover effects) into utility planning is difficult; incorporating externalities into utility pricing is controversial. Yet the long-term cost of resource depletion cannot be ignored. Water is a natural resource that is abundant in some respects, but also finite. Water extraction has environmental consequences; the magnitude and permanence of these consequences varies over time and space. Growing scarcity will drive environmental costs upward.

Major source development projects are environmentally disruptive, perhaps more so today than in the past. The true toll on the environment often is not reflected in the direct cost of the project. Spillover effects or externalities can be costly byproducts of major projects. These costs are real even though they are not accounted for on project books. Over time, public policy has recognized some of these costs and devised ways to assign them to the cost-causers. In some areas, where water resources are particularly scarce, some of these costs may be reflected directly in the cost of securing water permits or water. Avoided-cost measurement provides analysts with an opportunity to assess both the direct and indirect (environmental) costs of supply development.

Finally, another cost concept related to cost avoidance is opportunity cost. When utilities invest in any project, the required resources cannot be used elsewhere. Resource expenditures, in other words, also constitute opportunity costs because investing in one option closes opportunities to invest in other options. With pressure to make improvements and satisfy demand, today's utilities face difficult investment choices. Costs avoided are savings achieved. Opportunity savings may accrue to customers, the utility, or society. Regardless, these savings constitute resources that can be invested in other pursuits, related or unrelated to water resource management and use.

Analysts bear considerable responsibility in informing decisionmakers about the nature of costs included in their studies. It may be advisable to report a range of results, beginning with direct costs and expanded to reflect other types of costs. The analyses may point to different solutions, and make decisionmaking more challenging, but the reasons for the differences should be clear.

ORIGINS OF THE CONCEPT

The avoided-cost concept became a public policy tool in the context of energy efficiency. Under to the landmark Public Utility Regulatory Policy Act of 1978 (PURPA), electric utilities were required to consider pricing policies and other means of demand management. Many state regulators, frustrated with the high costs of the supply side, provided utilities with incentives for implementing demand-management strategies. PURPA also required electric utilities to consider purchasing power from qualifying facilities (that is, independent producers not primarily engaged in generating or selling electrical power, and meeting other conditions). According to PURPA, avoided cost is the cost an electric utility would otherwise incur to generate power if it did not purchase electricity from another source Avoided cost provides the basis of the rate required to be paid to qualifying facilities for purchased power under PURPA. Since PURPA, electricity production by independent producers and cogenerators has been encouraged. But according to

Phillips (1993: 657), a definitive definition of full avoided cost has remained illusive.

PURPA, and the broader context of the energy conservation movement in which it passed, helped put demand management strategies on a "more equal" footing with supply management (usually augmentation) strategies. Demand management releases existing system capacity for other customers or other uses. The freed or redirected utility capacity can be compared to capacity provided through more traditional means.

Efficiency advocates promoted the concept of "negawatts," meaning electricity "produced" through conservation and more efficient use of existing electricity supply resources. A related idea is to establish energy service companies, as compared with traditional electric utilities, who could market efficiency (or demand management), as well as electrical power, because the focus shifts to units of *service* (such as heating or lighting) rather than units of *energy* (that is, kilowatt-hours).

One of the new paradigms for energy is the idea of *distributed resources*. Distributed resources are smaller, incremental units of energy that can be provided through a variety of supply-side and demand-side technologies to create a flexible resource portfolio. These incremental amounts of energy might be controlled by any of a number of participants in the increasingly competitive energy marketplace. The beauty of distributed resources is their adaptability and efficiency in meeting changing needs. Another key advantage is that the use of distributed resources helps keep supply and demand in closer proximity, with less risk and without the adverse economic and environmental impacts that accompany large-scale projects and excess capacity.

In the water sector, the concepts of "negagallons" and water service are readily applicable. In both sectors, the "negaunits" reflect aggregate avoided costs. Although most water utilities have not necessarily experienced substantial excess supply capacity (as have some electric utilities), water managers may have missed opportunities to avoid costs by manipulating water demand. Inefficiency in the water sector can be blamed in part on inflated water usage associated with underpricing and a general neglect of utility load-management techniques.

Although no policy comparable to PURPA has promoted a utility role in water conservation, federal efficiency standards for plumbing fixtures pursuant to the 1992 Energy Policy Act have furthered the cause. (The fact that the standards were embedded in energy legislation is somewhat telling of the federal "absence" in water resource policy (Featherstone, 1996). Some water utilities have begun to recognize that the traditional supply-oriented approach may not be entirely prudent and that efficiency can play a role in controlling costs and meeting future demand. With least-cost and integrated planning gaining attention in the water sector, avoiding costs through the production of negagallons seems to have growing relevance.

THE BENEFITS OF AVOIDED COST

Conceptually, the goal of conventional cost analysis is to help managers determine how much to spend and how to optimize resources for a given project. Conventional cost analyses may lead analysts astray if they do no allow for consideration of unconventional resource management alternatives on both the demand and supply sides. The goal of avoided-cost analysis is to help managers realize opportunities *not* to spend. An avoided-cost analysis provides the utility manager with a broader spectrum of possibilities. Thinking about how to avoid costs can help overcome the bias toward supply-side options inherent in the traditional planning process (Beecher, 1995). Avoided costs can be used to compare demand options to demand options, supply options to supply options, and demand options to supply options. No resource option is inherently better than another.

Avoided costs essentially translate into aggregate or *gross benefits,* and are measurable in terms of production (such as gallons or cubic feet) or supply capacity (such as gallons per day), as well as value (dollars). *Net benefits* can be calculated by subtracting administrative and other costs required to achieve the savings from the estimate of avoided costs. Analysts can vary inputs and assumptions to arrive at a range of net-benefit estimates

A cost-effectiveness or net benefits approach generally is superior to conventional benefit-cost analysis. In benefit-cost analysis, the metric for both benefits and costs can vary and "apples to oranges" comparisons can be made through the use of ratios (in early variations, costs to benefits; in later variations, benefits to costs). These sterilized ratios, however, mask vital planning information. Analysts and decisionmakers are better served by seeking the least-cost means of achieving a specified goal. When applying a cost-effectiveness test, analysts can hold the goal (the benefit) constant and consider the costs associated with different means of achieving the goal. Alternatively, the analyst can hold constant costs and compare the benefits that can be achieved with that level of investment.

WHOSE COST IS IT, ANYWAY?

Strategies that improve economic efficiency always are beneficial, at least from a societal vantage point. But the benefits of alternative methods for efficiency improvement may accrue differently to different participants in cost-saving ventures. Analysts have struggled when answering the question of least cost to whom--utilities, ratepayers, or society as a whole.

Avoided-cost analysis has been widely used in the energy sector to assess the cost-effectiveness (or net benefits) of demand management relative to conventional supply alternatives. The basic methodologies are readily adaptable to the water sector. When calculating the benefits of demand management, analysts begin with avoided costs and make adjustments for administrative or programmatic costs, as well as other costs associated with participating in demand-management programs. Depending on the perspective taken in the analysis, competing views about benefits can emerge. Four basic cost-effectiveness tests used for comparing demand and supply management alternatives are the (Berman and Logan, 1990):

- Utility cost test,
- Total resource cost test,
- Ratepayer impact measure test., and
- Participant-cost test.

Variations in their calculations can be found. A conservation method or management strategy "fails" if net benefits are negative, meaning that the costs of achieving the savings outweigh the value of the achieved savings. Some conservation methods may pass one test while failing others.

Each assessment begins with the gross benefits of demand-side management, measured by the utility's avoided cost, and subtracts the costs associated with the program (such as overhead and program administration costs). The avoided-cost estimate may or may not include indirect costs, such as environmental externalities. The utility cost test emphasizes the use of utility revenue requirements to test effectiveness. According to this test, demand-side options should be implemented only when the end result is to increase utility revenue requirements by an amount *less* than the increase in revenue requirements associated with various supply-side options. The total resource cost test can be used to evaluate the effect of demand management on the total bill for utility services (for both participants and nonparticipants). It also has been defined as a test of not "least cost" but "most value." The effect of conservation programs on utility rates is measured by the ratepayer impact measure test (or RIM). It also is known as the "nonparticipants' test" because it recognizes the potential for lost revenues and the need for nonparticipants to subsidize participants through higher utility rates.

The participant-cost test is not used for resource comparison. Participant costs are used to evaluate whether customers are sufficiently motivated to participate in demand-side management programs by virtue of the net benefits of participation. A variation is the nonparticipant, or "no losers test," which emphasizes the distributional effects of demand-side management among participants as well as nonparticipants.

These tests of cost-effectiveness reflect different vantage points, but they are not entirely independent (Berman and Logan, 1990: 5.9). A demand-side measure passing the ratepayer impact test can be presumed to pass the utility-cost test. Further, the total resource cost test is essentially the sum of the ratepayer-impact test and the participant test. The total resource cost and participant cost formulas can be modified to include indirect costs, such as the investment of time by participants. The ratepayer impact measure and participant cost formulas can be modified as well to reflect shared savings (accruing to utilities and participants).

Berman and Logan (1990: 5.14) suggest a comprehensive two-step approach to demand-side management evaluation. The first step is to use total resource cost, reflecting both indirect participant costs and shared savings, for the purpose of integrated resource or least-cost planning. The second step is program design. Planners can use the ratepayer impact and participant cost tests to design successful programs in which customer will actually participate and benefits and costs will be fairly distributed. This approach has the advantage of consistency of criteria and clarity of method, both of which aid in decisionmaking and implementation.

HOW UTILITIES CAN AVOID COSTS

Avoided-cost analysis has multiple applications. As emphasized throughout this article, some utilities can avoid substantial costs through demand management. Demand management involves any strategy to eliminate or defer the need for an investment in new capacity by the utility, including conservation, load management, and pricing strategies. Conservation can help utilities reduce operating costs (such as chemical and energy costs). Demand reductions, however, generally will not allow water utilities to significantly downsize *existing* operations or offset costs associated with maintaining or replacing the distribution system infrastructure. The primary savings anticipated from water conservation are associated with avoided capital and operating costs in the functional areas of source development and treatment. Conservation can help utilities forestall capacity expansion and calibrate *future* operations to reflect demand patterns modified by permanent water-use efficiency improvements.

Water utilities can promote conservation through pricing signals (Beecher and Mann, 1994). Avoided-cost analysis can help decisionmakers choose among rate design options for achieving efficiency goals. The effect of rates on water usage depends on the rate structure, as well as the demand elasticities of customer groups in the utility's service territory. The cost of supply options also can be incorporated directly into rate design. The Marin Municipal Water District of California (Chesnutt, et al., 1996), for example, used a marginal-cost framework to differentiate among rate tiers; the increasing rates associated with blocks of water usage are linked to increasingly expensive sources of supply. Pricing also can play an important role in developing drought-management strategies; prices during shortages should reflect the higher cost of emergency supply sources.

Efficiency-oriented pricing can be viewed as a necessary, but not necessarily a sufficient condition for efficient water use. Water customers cannot be expected to use water efficiently if the rate for service is too higher or too low. Utilities can amplify the price signal through customer education programs that encourage changes in water-use habits (both indoors and out). Utilities also can accelerate the replacement of water-using fixtures through rebate and retrofit programs. Utilities also might engage in a general program of load management in which load shifting techniques (peak-shaving and valley-filling) are used to smooth demand patterns and make more efficient use of supplies. Load management programs can be targeted to large-volume water users, who might be given price and other incentives to shift load to off-peak periods.

Not all methods of cost avoidance are on the demand side. The supply side involves determining the most efficient method of meeting growing demand, including infrastructure and investments in new capacity. When pursuing economic efficiency, utilities are well-advised to begin by improving the utilization of existing supply capacity. A first step may be to detect and repair leaks in the water distribution system. Lost or unaccounted-for water should be recognized as a potentially valuable resource (Vickers, 1996). The value of the water saved, less detection and repair costs, can be compared to the avoided cost of other supplies. Efficiency practices also can be applied to the other parts of the water delivery infrastructure (source-of-supply, storage, and transmission facilities). Reducing losses on the supply side results in direct savings in the cost of production, without affecting utility revenues (as in the case of demand management).

Another supply-side issue involves finding ways for utilities to meet stringent federal and state drinking water standards. Water utilities should consider a wide range of compliance methods. For example, the cost of purveying water from a contaminated source should be assessed in terms of both alternative *treatment* technologies and alternative water *sources,* including water transfers or purchased water (see Lund and Israel, 1995). The economies of scale in water treatment should lead many utilities to consider interconnection with other water providers in the region and construction of regional treatment plants Consolidated operations may begin to look increasingly attractive in light of the avoided cost of stand-alone treatment operations

For utilities with growing demand, additions to supply capacity may become necessary. Demand management and efficient utilization of existing capacity may not produce enough negagallons to meet growing needs. In this case, avoided-cost analysis can be used to evaluate alternative supply options. These options include traditional sources (such as wells and reservoirs) and water purchases. Less conventional options, such as reuse and desalination, can be subjected to an avoided-cost test to determine whether or not they meet the test of cost-effectiveness. As technologies evolve, costs tend to decline; options that are not plausible today may prove themselves tomorrow.

As noted earlier, more complex opportunities to increase efficiency can be analyzed within an IRP framework and with the use of an avoided-cost analysis. Many of these opportunities also involve regional solutions (Beecher, 1996). Utilities might use avoided costs to evaluate the benefits of participating in wholesale water markets. Purchasing water may prove more cost-effective than developing new supplies for meeting average or peak demand requirements. Utilities might also consider collaborating for supply projects for efficient utilization, management, and protection of regional water supplies. Finally, avoided-cost analysis can be applied to more formal utility merger or acquisition decisions. Again, the avoided cost of stand-alone operations can be compared with the cost of consolidated operations. For some utilities, the least-cost means to better performance and service for customers, including compliance with drinking water standards, may be through major a structural change.

CRITICAL ISSUES IN AVOIDED-COST ANALYSIS

To suggest that avoided costs are simple to estimate would be misleading. Estimating avoided costs involves several critical analytical dimensions. Analysts must make explicit the assumptions that go into the analysis; decisionmakers must be made aware of these assumptions and their implications for the results. Some of the key issues in avoided-cost analysis are:

- Time
- Space
- Scope
- Values

The time frame chosen for the analysis always has been a critical issue in planning. The costs and benefits of resource options will vary over time. For example, short-term spikes in costs may be offset by long-term savings; too short a time frame may not reveal this to the analyst. Many proponents of demand management emphasize the very long-term benefits of conservation, not only for people but for the environment. Of course, longer time horizons introduce greater uncertainty into the analysis. Recognizing the role of uncertainty in planning is an important analytical step in itself (Chesnutt, et al., 1994). Analysts can provide decisionmakers with alternative cost estimates based on different time frames, recognizing that long-range estimates are more volatile.

The second critical issue is space. Spatial issues have been granted less attention in avoided-cost assessment. The spatial dimension is important because utilities generally serve fixed territories with particular physical and demographic characteristics. Generally, an avoided-cost estimate will take these traits as a given. But ignoring the spatial dimension will constrain the resource options considered; true least-cost (or optimal) solutions may not present themselves within the smaller space. A way to broaden the planning perspective is to enlarge the space for which cost estimates are made. Using regional geopolitical boundaries or (better still) watershed boundaries might expand the range of cost avoidance opportunities to the water utility. As mentioned earlier, this type of analysis would be useful in evaluating opportunities to consolidate operations or participate in regional markets to achieve efficiency goals. Spatial variations in avoided costs can be used to identify the optimal treatment plant size for exploiting economies of scale, while also taking into account the diseconomies associated with extending transmission and distribution (see Whitlatch and ReVelle, 1976).

Scope is the third critical issue. Scope refers to the range of management tools and technologies available to water utilities. From a technological standpoint, water supply is a relatively conservative industry. Given water's physical properties, the methods for extracting, transporting, and distributing water are not easily changed; some technical limitations will always apply. Prior to the advent of least-cost and integrated planning, demand management through pricing and other programs was not within the scope of planning alternatives. Conservation remains outside the planning scope for some utilities. The same holds for many unconventional supply alternatives. The challenge for planners is to push the envelope of ideas by incorporating emerging tools and technologies in the analysis of costs. No reasonable option should be excluded from the analysis.

Finally, planning is supposed to be a scientific endeavor. More sophisticated planning tools, including avoided-cost analysis, promote the appearance of objectivity. Science and analysis are essential for better planning. But better planning also recognizes that community values play a role in determining the range of feasible options. Customer preferences shape community values. Some communities value conservation highly, enough so as to sacrifice a degree of reliability; others may value reliability over all else. Some communities may be interested in developing regional solutions; other may place a high value on retaining local control. Analysts can address many of these value issues "scientifically" by incorporating different assumptions in their models, including changes in values over time.

Fortunately, a variety of analytical and decisionmaking tools can aid in the treatment of time, space, scope, and even values. A leading example is simulation modeling, in which the consequences of various assumptions can be shown. Decisionmakers can be provided a range of planning alternatives based on combinations of reasonable assumptions.

A MODERN PLANNING PARABLE

Consider the water agency manager who sees an impending shortage in capacity. Two decades ago, the manager would summon the engineers and cost analysts who would provide three supply alternatives--expansion of an uncontaminated but unprotected well field, expanded use of a surface source, or construction of a new surface reservoir. The largest and most expensive project is the reservoir and it also has the most favorable benefit to cost ratio measured in dollars to gallons over a ten-year time frame. The manager further reasons that the extra capacity will enhance reliability and stimulate local economic growth (as it did twenty years earlier). The manager wins approval for the project, but not without considerable resistance from ratepayers and environmentalists.

Today, the water agency manager seeks out more information. The manager considers the changing character of the service territory. The manager considers a wider range of alternatives and their cost-effectiveness in producing an additional unit of water. The manager considers not only the potential for costs but the potential for cost avoidance. The manager considers the impact of each alternative on rates for service, and the subsequent effects of rate changes on water usage. The manager explicitly considers uncertainties, risks, and the environmental consequences of the utility's decisions. The manager expands the analysis along reasonable time, space, and scope variables. The manager seeks ways to address community values in the course of planning. The manager uses modern decision tools--such as simulation modeling--to design the best possible resource portfolio for the community given the available information and a set of reasonable assumptions.

The manager arrives at a more complex but flexible and well-integrated strategy. In this case, a major reservoir is not selected. The manager opts instead for modifying the rate structure to reduce peak demand, interconnecting with a nearby utility to begin the formation of a regional partnership, and a renovation and expansion of the wellfield on a phased basis subject to ongoing analysis of system needs and development of a source-protection program. In addition, the utility's leak detection and repair program is stepped up and performance targets are established. Customer education efforts, including information resources and outreach to schools, are expanded and a pilot rebate program is designed. Planning is implemented as an ongoing, participatory, and integrative process.

CONCLUSIONS

In the ever changing worlds of water utilities and resource planning, avoided-cost analysis continues to be an essential tool for making informed choices. IRP provides a way to think explicitly about costs avoided not only through demand management but through other utility management strategies as well. Analysts are still moving up the learning curve, but applications of avoided-cost concepts still are necessarily experimental. The need for further research and evaluation is great.

Implementing the results of an avoided-cost analysis raises a variety of additional issues. Utilities continue to face mixed incentives for avoiding costs. Demand management, in particular, may be perceived as a threat to utility revenues and, in the case of investor-owned utilities, profits. But cost avoidance in a rising cost industry is imperative. As prices rise, customers and regulators of water utilities will place increasing pressure on utility managers to control costs and find the least-cost means of meeting future needs.

In the end, not all costs are avoidable. Water utilities, especially in growth areas, will continue to have substantial capital and operating requirements. Utilities that make efficient use of existing demand-side and supply-side resources, and carefully explore the available options for the future, will be better positioned to serve their communities.

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