UNCERTAINTY AND THE DISTRIBUTION OF BENEFITS FROM UTILITY CONSERVATION PROGRAMS

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ABSTRACT

Distributional and equity issues associated with utility conservation programs are reviewed in the context of proposals made by the Southern California Edison Company. Conventional cost-effectiveness analysis cannot totally explain the structure of such programs. The role of various market, regulatory and consumer behavior uncertainties explains many details of program structure. In addition to the perspectives of society as a whole, program participants and non-participants, the interests of utility shareholders must be considered in the analysis of utility conservation programs.

1. INTRODUCTION

In this paper, I discuss distributional issues arising from utility conservation and load management programs. While the usual focus of equity discussions is on low-income consumers in particular, many questions of a distributional nature arise when utilities promote conservation. Distributive equity affects groups other than those defined by income, i.e., shareholder vs. participating or non-participating rate-payers; and different customer classes.

These equity issues are affected in unforeseen ways by current regulatory practices, and the utility's response to uncertainty in key variables (customer behavior, future fuel prices, future capital costs) which affects its financial health. Specifically, load management programs are favored over conservation programs in ways that are not apparent simply from comparison of their relative aggregate cost-benefit ratios. Load management efforts, at least in the case of Southern California Edison Company, tend to have more modest, but more predictable returns for ratepayers in the aggregate. Load management (capacity) savings have additional benefits for utilities since they can offset capital costs, and thereby bolster shareholder earnings. Successful load management helps utilities counter act the regulatory incentive for fuel cost pass through which itself discourages conservation (energy) savings.

My perspective considers only data publicly available in two applications by the Southern California Edison Company (SCE) before the California Public Utilities Commission(1,2). One of these is a residential conservation plan of financial and cash incentives called ZIP/CIP (Zero-Interest Plan/Cash Incentive Plan). The other is a part of SCE's general rate application and includes proposals for all customer classes. Both applications were filed in late 1981 and adjudicated during 1982.

2. SOUTHERN CALIFORNIA EDISON PROGRAM

Table 1 summarizes the cost and benefits of both SCE applications. These costs and benefits are defined as changes in total utility revenue requirements, and referred to as the utility perspective. The costs represent the sum of 1983 revenues required for administration and incentives to 1983 program participants. Where incentives involve multi-year commitments, the present value of those future obligations is added (discounted at 15%). The benefit side involves estimates of annual savings, the duration (and/or persistence) of those savings and the unit value of future avoided costs.

Each of these benefit factors involves substantial uncertainty and impact variability. At one extreme are informational programs directed at residential customers. Estimates of annual savings from these are speculative at best. Even more uncertain is the persistence of savings induced by informational programs. In Table 1, item 2a2 is based on ten years worth of SCE's annual saving estimate. As indicated by the question mark and in later sensitivity analysis, the benefit of such a program may well be zero. Even it it were positive, it is almost impossible to expect to measure. At the other extreme is the efficient refrigerator incentive proposed in the ZIP/CIP application. Refrigerator energy consumption is routinely tested and the sales distribution is reasonable well known. Therefore, annual savings can be estimated as the difference between the known efficient unit and the average unit sold in the same year. The average refrigerator lifetime which is also reasonably well known corresponds to the duration of the savings. Only the future avoided cost path is uncertain.

Table 1 shows that the Commercial and Industrial Audit Program (C & I = Item 1a) contributes the bulk of total benefits. The Total Program Benefit/Cost ratio falls by two thirds without it. If the residential information program failed and there were no C & I Audit Program, load management would then out perform the remaining total effort (Item 3a: B/C = 2.2 compared to Item 4b: B/C = 1.9).

In addition to the impact uncertainty and variability, there are substantial differences on the benefit side. Avoided costs are the benefits, consisting of capacity (kW) savings and energy (kWh) savings. The former is associated with load management principally and the latter with conservation. In California, utilities and regulators typically interpret avoided capacity to mean combustion turbines, refurbishment of existing oil-fired units or some combination of the two[3,4]. The cost uncertainty of such units can be estimated by examining the Handy-Whitman index of utility construction costs. For the period 1973 - 1981, the real, i.e., inflation adjusted , variation in this index averaged less than 10% of its mean value. This measure of price uncertainty, the co-efficient of variation of a real price series, is useful in studying price instability[5,6]. For the world oil market, the CV of real price over this period was 32%[6]. For comparison, Komanoff's recent analysis of nuclear plant costs indicates a CV of real prices just over 30%.[7]

The far greater instability of oil prices compared to gas turbine costs helps explain some of the data in Table 1. Load management produces only modest benefits, but at least they are relatively certain. The real price of capacity will not vary enough to substantially alter the benefit/cost ratios of these programs. Conservation programs for an oil and gas burning utility like SCE produce benefits that are subject to the price fluctuations of the world oil market. The marginal fuel for SCE has typically been oil. The recent decline in world oil demand and price, and corresponding increased supply of natural gas has produced a dramatic change in the avoided energy price. The benefit calculations in Table 1 are based on estimates of 82 mills/kWh in 1982 escalating at more than 9% per year.[8] Recent SCE estimates of avoided cost for small power producers, however, reflecting the current gas supply situation are for 49 mills/kWh.[9] This 40% decline in value, if permanent, would reduce the estimated value of conservation programs correspondingly. While cheap abundant regulated gas is unlikely to be a permanent feature of the SCE fuel mix, the price instability illustrated in this example shows how difficult it is to estimate accurately the benefit derived from conserving kWh.

Relative price instability is not the only reason for favoring load management programs over conservation or kWh incentives. The nature of public utility rate-making also encourages a shift of utility resources away from displacing fuel toward displacing capital. This happens in a number of ways. First, the use of automatic fuel adjustment mechanisms removes the incentive for utilities to minimize cost by reducing fuel use. Costs incurred will always be recovered.[10] Secondly, the earnings of regulated utilities have typically not been high enough to keep the price of utility stock above its book value per share. In such a situation, capital expenditure financed by the sale of additional stock will reduce further the value of existing shares. Under these conditions, management has an incentive to limit capital spending. Therefore, both central station power plants and conservation/load management programs are equally unattractive unless they can be "expensed", i.e., the total cost recovered immediately, like fuel. Since expensing is feasible for end-use efficiency programs (but not for large scale base load power plants), management has an incentive to opt for programs which defer capital, i.e., load management.

The effect of these regulatory practices is illustrated in Figure 1. Here, we examine a variant on a basic pricing problem for public utilities, the excess of long run marginal cost over current average rates. This imbalance between costs and revenues makes conservation incentive programs justifiable in the first place. As long as utility prices are below marginal cost conservation can lower prices. Avoided cost is greater than lost revenue.

This difference between marginal cost and average price also measures the amount of incentive utilities can offer to conservation program participants without raising rates.[11] As such, it is also interpreted as a distributional benchmark separating the interests of participants from non-participants in conservation programs.

The quantity illustrated in Figure 1 includes only the energy part of avoided cost. The capacity part would be at least 20 mills/kWh more (assuming a levelized cost of $120/kWh-yr and a 50% load factor). With an additional 20 mills avoided capacity cost, the Figure 1 estimates would yield a persistent excess of marginal cost over average price. As presented in Figure 1, however, the data illustrate that without the capacity value, conservation would raise rates. Seen in this light then, a conservation program which reduced kWh, but left kW unaffected is unattractive. The extra value required to reduce rates in the long run stems from kW effects. Since these vary by end-use and are yet critical to over all program cost-effectiveness, a case can be made for a strong emphasis on load management.

Arguments such as these emphasize the perspective of the non-participant. Utility incentives for conservation and load management are paid for by ratepayers, some of whom will not participate in these programs. Their economic interest can be protected by examining the long run effect of incentives on rates. We have already seen that rates will only go down in the long run (relative to their path without utility conservation programs) if the incentive to participants is no more than the difference between marginal cost and lost revenue.

This means that there is a conflict of interest between program participants who want the maximum incentive and non-participants who want the minimum. Figure 2 illustrates this conflict in the case of SCE's ZIP/CIP proposal.

The horizontal axis in Figure 2 represents the size of proposed cash incentives as a fraction of customer cost. Thus, heat pump furnaces in the lower right hand corner would have 41% of their installed cost subsidized, and thermal windows 48%. The vertical axis represents the present value of total non-participant benefits normalized to the total number of program participants. Negative values mean that non-participants do not recover the value of incentives in future avoided costs.

Generally speaking, Figure 2 shows a negative relation between incentive size and non-participant benefit (correlation coefficient = -0.50). A linear fit of this data does not explain all the scatter however. The data could as easily be segregated into one class of measures that clusters around the horizontal axis, and the four extreme values that are labelled in the Figure. Of particular interest among the four extreme points is the mandatory air-conditioner cycling element of the ZIP/CIP proposal. SCE has requested that it be allowed to require this form of load management when it provides incentives for building shell improvement or air-conditioning equipment. The company observes that this requirement will help to "ensure that non-participating ratepayers will receive benefits from the residential financing program."[13]

Without the mandatory load management program, the incentives and costs of the entire ZIP/CIP package would exceed its benefits to non-participants. This is shown in the last column of Table 2. The sum of non-participant benefits is dominated by load management. This is 65% of the total (2769/4257). Further, non-participants must bear the $4.2 million in fixed over head costs. Without the $2.7 million in load management, non-participants lose. Finally, the mandatory nature of the program means that no incentive costs are required.

Load management programs also involve uncertainties. This is best illustrated by a proposed SCE program known as the Demand Subscription Service (DSS)[1]. Under the DSS, all high use residential customers (1200 kWh/mo or more) will be required to have a load control device installed which will limit kW demand to a level selected by the customer. These customers will be placed on a separated rate schedule which will have both a demand charge and an energy charge. The energy charge proposed for DSS would be about 1.7% less than the corresponding rate for ordinary domestic lifeline service and about 1.3% less for energy above lifeline levels.[14] These reduced kWh charges are designed to compensate for the demand charges so that average bills for DSS customers do not change. Subsequent to its rate case filing, SCE has modified the DSS proposal.[24] For purposes of analysis the original proposal is still interesting.

SCE estimates a benefit/cost ratio for its original DSS program of 1.76.[15] For this program, the perspective of utility revenue requirements and the non-participant are identical. Participants incur no costs and receive no benefits. The cost of the load control device would be expensed, i.e., recovered from all ratepayers immediately. The benefits are the avoided costs of capacity, whose magnitude is dependent on the duration of the kW savings induced by DSS. The benefit cost ratio of 1.76 assumes a 15 year duration of 1.2 kW capacity savings per customer. With no incentive to participate, a projection of benefits based on voluntary customer action is unrealistic. Therefore, SCE has argued that DSS be mandatory.

The only exit from this rate schedule would be reducing kWh use below the 1200 per month minimum. In principal, a DSS customer might participate in ZIP/CIP to such a degree that the load device would no longer be necessary. Of course, such participation would entail the mandatory installation of an air-conditioning cycler. This would probably mean removing the DSS device long before it produced its projected benefits. Any number of other scenarios could produce premature exit from the DSS rate schedule. Among two of the more likely are ownership changes that produce conservation effects, and regulatory changes which re-define the DSS target group.

Finally, DSS is vulnerable to imprecision in the estimated load impact. Load research into the kW effects of conservation and load management programs is still in a rather primitive state. Data of this kind is expensive to collect. SCE's optimism about saving 1.2 kW/customer for DSS is balanced by a rather pessimistic expectation of kW impacts from ZIP/CIP.(16) In the latter case, only the average house in SCE's hottest weather zone, Palm Springs/Blythe, could save as much as 1.2 kW. In all other weather zones, the average house could not save this much even if the customer participated maximally.

If DSS only produced 70% of its estimated kW savings for 10 years instead of the projected 15, the program is uneconomic. (B/C = 1.76 x 0.7 x 2/3 = 0.82, B/C less than one means the program costs more than it is worth). Because of its low benefit-cost ratio, this program, like all load management programs, in the residential sector suffers from its relative sensitivity to uncertain benefit estimates. Why then does load management play such a large role in SCE's overall budget? By the estimates of Table 1, load management accounts for 42% of costs, but only 11% of benefits. Everything in Table 1 is dominated by the tremendously productive commercial and Industrial (C & I) Audit Program. Even reducing the benefits by 40% to reflect excess oil prices does not change this. One reason why the C & I Audit Program is so productive is that incentives are limited to 10% of customer cost compared to the much larger fractions indicated in Figure 2. Residential load management programs cannot even bear the cost of incentives to participants so the utility requests that they be made mandatory. The explanation of persistent utility interest in such marginal programs lies in the realm of regulatory constraints and incentives.

There are qualitative differences in avoided capacity costs and avoided energy costs. These have been alluded to earlier but need to be delineated in further detail. Automatic fuel adjustment clauses insure that the utility will achieve dollar for dollar recovery of fuel costs. There is no extensive review and little corresponding risk that costs will be disallowed. The effect of conservation in the short run is essentially illustrated in Figure 1. The utility avoids fuel and loses revenue. If the lost revenue is greater than avoided fuel cost as illustrated in this Figure, then the immediate effect is an erosion in earnings. This occurs because earning changes are always the result of a marginal change in revenues, since earnings is always the last cost covered. There are two circumstances under which no earnings loss need occur in the short run from conservation. First, if there were a perfect forecast of sales, (including conservation) then the rates would already reflect all required revenue including allowed earnings and no loss would occur. This is unlikely since no forecast is ever perfect. The second alternative is an automatic earnings adjustment mechanism which revises rates to reflect forecast error including conservation. The California Public Utilities Commission has recently adopted such a device, known as ERAM (Electric Revenue Adjustment Mechanism).(17)

Assuming that some device like ERAM protects utility earnings on embedded capital from conservation, then some avoided marginal capacity costs are the residual benefit of conservation. This means that capital which might have been invested to meet kW demand is deferred or, avoided entirely. The immediate beneficiary of the reduced capital requirement is the utility shareholder. This "anti-Averch-Johnson" effect, i.e., a bias away from capital, is a result of current technological, financial market and regulatory conditions which make incremental investment by utilities unattractive. The Averch-Johnson theory of a utility bias in favor of capital is based on the assumption that incremental investment is so productive that it can earn more than the cost of capital.(18) While this may have been true once in the electric power industry, it is typically no longer the case.

Critical indicators of the current anti-capital bias are mostly financial in nature. Because utilities have such large requirements for capital, it is important to understand how financial constraints will affect the investment preferences of utility managers and shareholders. The current cost of debt and common equity financing is very high for utilities. Because utility earnings are less than comparable investments, the price of their stock has been commonly less than its nominal or book value. SCE, which is among the strongest companies in the industry, has only recently been selling close to book value. Even this recent strength is uncertain and may not persist. When the utility stock sells below book value, the equity of existing shareholders is diluted by the sale of additional shares. Because capital requirements for transmission and distribution investments are large and largely fixed in nature, incremental capacity for generation will typically require raising new money. This means selling stock below book value and selling bonds at today's high interest rates. Both of these markets are unfavorable to utilities now, and most importantly, their effects are linked.

Utility stock prices are inversely related to interest rates. This interest rate sensitivity is well known and the effect is known to be stronger for utilities than for industrial companies.[19] Before the Federal Reserve Board stopped regulating the level of interest rates in 1979, utility investment programs benefited from debt financing. The real interest rate was often negative in the 1970s and utility bonds sold then are currently discounted by 40% or more. Now interest rates, in real as well as nominal terms, are near historically high levels. Common equity shares which historically had earned 2-4% more than debt now has almost no advantage, or even earns less.[20,21] As long as interest rates stay high, they will continue to depress utility stock prices. On the other hand, assuming interest rates do eventually decline, utility stocks will be among the gainers.

In the current situation, utility capital spending is hostage to the level of interest rates. Expectations play an important role in this process. The incentive to delay capital spending derives in large part from the belief that interest rates must fall significantly at some time in the future. When this happens, not only will the current negative effects of leverage disappear on the debt side, but common equity prices will increase significantly also. Thus, the expectation of a more favorable financial market in the future puts a brake on capital spending today.

It should be noted that the expectation of falling interest rates has been common in recent years and just as commonly been disappointed. The real interest rate, i.e., nominal rates adjusted for inflation, has recently been in excess of 10%. This level was last attained in the early 1930's. During the most extreme part of that economic contraction, the real interest rate reached 15%.[22] Such levels are unsustainable and eventually the real interest rate settles in an area of 2-3% above the inflation rate. This divergence of the current real rate from the long term average is what creates the expectation that interest rates will fall. Since no one understands the mechanism particularly well, it is difficult to say exactly when this will happen. It is however a better guess, that it will take years rather than months.[23] Given the uncertainty, an assumed schedule of falling interest rates amount to speculation. Utilities can be expected to take a more prudent course, delaying capital spending until rates are decidedly lower, not just expected to be lower.

In this light then, load management programs whose costs are expensed (rather than capitalized) amount to capital (and shareholder wealth) conservation efforts. From the consumer point of view, load management programs are relatively unproductive. The estimated benefits are too small to be able to support participant incentives, so a mandatory approach has been proposed. Consumers, both participants and non-participants, benefit more from conservation programs. Here the potential loser is the utility shareholder. Even if short run earnings loses from reduced kWh sales can be avoided, in the long run highly productive conservation programs have the potential of shrinking the utility sales base. This is not in the interest of shareholders, at least as it has been traditionally conceived.

The conflict between utility shareholders and consumers is not the only divisive aspect of conservation and load management programs. Customer classes also have conflicting interests. SCE's commercial and industrial customers will benefit from the highly productive audit and incentive program to a much greater degree than domestic customers will benefit from ZIP/CIP and other SCE residential conservation programs. It is not obvious why one set of programs is so much more productive than the other. These differences cannot be accounted for entirely or even in large part by the relatively small incentives in the C & I program compared to ZIP/CIP and the other residential programs. The choice of measures and program structure also play a role.

Even within a customer class serious equity issues arise. Who will be the participants and who will be excluded? Will low income consumers and small businesses be under represented? It is likely that participation will be biased in favor of large users with sufficient disposable income to share program costs. SCE and other California utilities have allocated extra funds in their programs to target special populations that are less likely to participate. It remains to be seen how successful these efforts will be.

In the long run, distributional issues among various groups of consumers will be more easily resolved if the conflicts between utility shareholders and consumers in general can be resolved. Managers who design utility conservation programs will then be able to make choices which more closely approximate social optima. The roots of the shareholder/consumer conflict, however lie deep in the structure of regulation. They involve fuel adjustment clauses, rate of return policy and larger questions of resource allocation in the utility sector as a whole. Getting the most productive use of the utilities conservation and load management programs will ultimately require reassessment of these fundamental questions.

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TABLE 1. 1983 TOTAL SCE PROPOSED PROGRAM - UTILITY PERSPECTIVE
(Millions of 1983 Dollars)

	Cost	Benefit	Benefit/Cost
1. Commercial & Industrial			
a) Conservation (Audit + Incentives)	28	696	
b) Load Management	18	32	
Total	46	728	
2. Residential			
a) Conservation			
1) ZIP/CIP	18	54	
2) Rate Case	17	58 (?)	
b) Load Management	28	68	
Total	63	180	
TOTAL BUDGET COMMITMENT			
Complete Program	109	908	8.3
3. Selected Elements			
a) Total Load Management	46	100	2.2
b) ZIP/CIP Refrigerators	1.5	23	15.3
c) C & I Audits (=1a)	28	696	24.9
4. Total Program Sensitivity			
a) without C & I Audits	81	212	2.7
b) Without C & I Audits and Residential Information Programs Fail	81	154	1.9

TABLE 2. SCE ZIP/CIP: DISTRIBUTION OF BENEFITS
PRESENT VALUE OF LIFE CYCLE SAVINGS
(Thousands of 1983 Dollars)

	Utility	Participant	Non-Participant
Measure Type			
Building Shell Improvements	1,874	1,502	-4
Appliances			
Heat Pumps	4,048	3,048	-328
Cooling	26,181	19,562	515
Refrigerators	23,125	15,133	1,305
Load Management	2,769	2	2,769
TOTALS	57,997	39,243	4,257
Fixed Costs	-4,201		-4,201
Net Benefit	53,796	39,243	56