A Review and Analysis of Electric Utility Conservation Incentives

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During the energy crisis of the 1970s, consumers were responsible for energy conservation; today, a large part of the burden has shifted to the utility. Common energy saving schemes have proven inadequate, prompting state regulators to introduce demand-side management (DSM) incentives which reward either expenditures, savings, or net-benefits. DSM benefits are intended to induce investor-owned electric utilities to promote energy conservation aggressively. Stoft and Gilbert discuss the difficulties of estimating the net social benefit of an incentive program and examine how information influences regulators to select a particular incentive. Currently, most net-benefit incentives, while offering significant expected total rewards for utility conservation activities, provide only a weak incentive for conservation. This Article describes how these DSM programs can be tailored to achieve greater energy conservation.

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Introduction

From their inception, electric utilities have attempted to influence the demand for electricity. Until the energy crisis of the 1970s, this "demand-side management (DSM)" was almost exclusively of the load-building variety, such as convincing home owners to replace gas stoves with electric ones. Since then, demand-side management has become almost synonymous with utility-run energy conservation programs. The use of DSM conservation programs, which peaked in the early 1980s, declined at the end of the decade because regulators were disenchanted with utility performance and because the utilities resisted the programs outright. As these programs declined, shareholder incentives designed to improve utility DSM performance rapidly gained popularity among conservationists and utility regulators.

In July 1989, the National Association of Regulatory Utility Commissioners adopted a resolution urging state commissions to "adopt appropriate ratemaking mechanisms to encourage utilities to help their customers improve end-use efficiency cost-effectively . . . ."[1] Prior to this resolution only three utilities had adopted incentive mechanisms.[2] After the resolution was adopted, three utilities received approval for incentive mechanisms in 1989, and fourteen more received approval in 1990.[3] As of October 1991, eleven states had approved DSM incentive programs, an additional four states had approved at least a generic form of incentives, and an additional six states were considering incentives.[4]

Incentive programs have been growing in size as well as number. Expenditures on utility DSM incentive programs are estimated at almost one billion dollars in 1992.[5] This figure represents approximately one-half to two-thirds of the total amount of expenditures on utility DSM programs since their inception. One billion dollars is a considerable sum, even though it is only a small fraction of total utility expenditures. The incentive payments to utilities

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[1] David Moskovitz, National Association of Regulatory Utility Commissioners, Profits and Progress Through Least-Cost Planning 57 (1989).

[2] In 1987 Wisconsin Electric became eligible for a DSM incentive. STEVEN M. NADEL ET AL., REGULATORY INCENTIVES FOR DEMAND-SIDE MANAGEMENT 36 (1992). Long Island Lighting Company gained approval on January 4, 1989. BARAKAT & CHAMBERLIN INC., UTILITY DSM SHAREHOLDER INCENTIVE STUDY (1991).

[3] BARAKAT & CHAMBERLIN, INC., *supra* note 2.

[4] Table 1 in Appendix A shows utility expenditures on conservation incentive programs and the incentive payments at 22 utilities originally surveyed by Barakat and Chamberlin in 1991 and subsequently updated. They represent most of the utility incentive programs in effect as of June 1992.

[5] Table 1 in Appendix A reports total 1992 incentive program expenditures of $880 million. Estimates of all 1992 utility DSM expenditures range from $1.3 billion to over $2 billion. *See also* John H. Chamberlin & Ahmad Faruqui, Demand-Side Management: the Next Generation (Sept. 1991) (unpublished manuscript, on file with authors) (estimating total 1990 DSM expenditures at $2 billion); Lawrence Prete et al., Electric Utility Demand-Side Management *in* ELEC. POWER MONTHLY, April 1992, at 19; ERIC HIRST, OAK RIDGE NATIONAL LABORATORY, ELECTRIC UTILITY DSM PROGRAMS: 1990 DATA AND FORECASTS TO 2000 (1992) (estimating 1990 DSM expenditures at $1.2 billion with an expected growth rate of 5% per year).

in these programs have averaged about fifteen percent of program expenditures. That is, for each dollar that utilities have spent on these programs, they have been paid on average $1.15. The incentive payment has varied widely between programs, however, ranging from only $.01 on each dollar to about $.30. In one case, the incentive payment amounted to as much as $.75 on the dollar, but only on expenditures of less than one million dollars.

This Article examines incentive programs at nine utilities and places them into three general categories: markup, bonus, and shared savings. A shared-savings incentive rewards the utility based on the net benefit of its programs, typically paying fifteen percent of net benefit. Markup incentives reward the utility in proportion to its expenditure. The bonus incentive mechanism rewards a utility on the basis of kilowatt hours saved and is generally an inferior version of the shared-savings mechanism. We conclude that just two of these categories, markup and shared savings, are adequate to provide efficient incentives. In addition, we find that a shared-savings incentive scheme with a very high marginal incentive rate should be the principle form of incentive program.[6] Many of the complexities of existing incentive mechanisms are unnecessary and even detrimental. High marginal incentives, the ability to measure net benefit, and simple incentive schemes are the keys to the success of conservation programs in general and to the shared-savings incentives in particular.

Part I briefly reviews the standard arguments for and against intervention on the demand side and examines regulatory incentives which encourage improved utility intervention in that market. Our intent is not to resolve these controversies, but rather to provide a context for examining the programs that are reviewed in subsequent parts of the article. In Part II, we classify incentive mechanisms into the three basic types described above. This Part is supported by two appendices: Appendix A describes thirteen incentive programs, and Appendix B examines and comments on the unnecessary complexities of four specific programs. Part III provides an economic definition of net benefit and reviews some frequently overlooked elements of conservation costs and benefits. Part IV reviews the economic determinants of efficient conservation incentives and contrasts these efficient schemes with some currently used mechanisms.

I. On the Value of Conservation and the Need for Incentives

Although the presence of DSM incentives is well-established, the reasons for their existence should be reviewed. In order to design effective incentives, one must understand why intervention on the demand side of the energy market

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[6] Our analysis assumes the existence of unbiased estimates of savings. Although the estimates may be highly uncertain, no form of incentive will be efficient without unbiased estimates.

can be useful and why utilities might need financial incentives to induce them to intervene efficiently.

A. *Are Utility Conservation Programs Needed?*

Debate over the value of utility conservation programs has long raged in the halls of regulatory commissions. Conservation proponents have argued that energy can be saved more cheaply than it can be produced and that traditional regulation provides inadequate incentives for investment in conservation. Amory Lovins coined the term "negawatt" to describe a unit of saved energy, presumably to give conservation a term analogous to that accorded the kilowatts generated by utilities.[7] Exhorting the potential for conservation, Fickett, Gellings and Lovins claim that opportunities for economic conservation are so vast that conservation "is not a free lunch; it is a lunch you are paid to eat."[8] Other evaluations of conservation opportunities have reached more somber conclusions about costs but have nonetheless maintained that utilities can deliver the equivalent of thousands of megawatts of cheap power by increasing the efficiency with which energy is consumed.[9]

Many economists, schooled in the principle of the rational consumer, have resisted claims that consumers overlook financially attractive opportunities for more efficient energy use.[10] Some argue that conservation advocates have ignored significant components of the costs of conservation alternatives,[11] and that conservation alternatives have not performed as well in practice as supporters have predicted.[12]

Assertions by those on both sides of the conservation debate obscure the fundamental fact that end-use efficiency embraces a wide range of activities with vastly different market characteristics. Consumers may be able to evaluate the costs and benefits of some conservation activities, such as the choice of a new appliance, when its operating costs are clearly labelled. In other circumstances, however, consumers may possess imperfect information about the potential for energy savings and might benefit from intervention by an informed utility. One example of such intervention is utility-provided education programs about the net savings from insulation. Even in circumstances in which the value

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[7] Amory Lovins, *Saving Gigabucks with Negawatts*, PUB. UTIL. FORT., Mar. 21, 1985, at 67.

[8] Arnold P. Fickett et al., *Efficient Use of Electricity*, SCI. AM., Sept. 1990, at 67.

[9] Jonathan G. Koomey et al., The Potential For Electricity Efficiency Improvements in The U.S. Residential Sector (July 1991) (unpublished manuscript, on file with authors).

[10] Ronald J. Sutherland, *Market Barriers to Energy Efficient Investments*, 12 ENERGY J. 15, 19 (1991).

[11] Larry E. Ruff, *Least Cost Planning and Demand-Side Management: Six Common Fallacies and One Simple Truth*, PUB. UTIL. FORT., Apr. 28, 1988, at 19 [hereinafter Ruff, *Least Cost Planning*]; Larry E. Ruff, Planning and Pricing in the Energy Conservation Business (June 1992) (unpublished manuscript, on file with authors) [hereinafter Ruff, *Planning and Pricing*].

[12] Paul L. Joskow & Donald B. Marron, *What Does a Negawatt Really Cost?*, ENERGY J., Oct. 1992 at 41.

of energy conservation is known, consumers may under-invest because they are constrained in their ability to borrow or because there are economies of scale in the provision of conservation that can only be exploited by a regulated provider. For example, John M. Quigley finds that pilot light management programs are highly cost-effective.[13] The local gas utility can offer such a program and spread the cost over a significant population, whereas individual consumers may encounter set-up costs in managing their own pilot lights. The success of actual programs similar to these examples indicates that utilities can intervene beneficially in some areas of the energy efficiency market.[14]

B. *The Arguments for Incentives*

While some economists have promoted the cost-effectiveness of conservation investments, others have argued that traditional regulation cannot provide incentives for conservation that are comparable to incentives for investment in energy generation.[15] The claims against conservation's cost-effectiveness find some support in the traditional Averch-Johnson model (A-J model) of public utility regulation. The A-J model shows that rate of return regulation rewards over-investing when the utility's allowed rate of return exceeds its cost of capital.[16] In this case, conservation would make the utility worse off by reducing sales and consequently limiting the investment in energy generation upon which the utility could earn an excess return. Since traditional regulation does not recognize DSM programs as a form of investment, DSM causes the utility a net loss in profit.

Moskovitz offers another view of regulatory disincentives for investments in conservation. He focuses on the lost revenue effect.[17] This effect is caused by the fact that regulators set prices which are fixed in the short run and typically exceed the utility's marginal cost of service. As a result, the utility has a short-run financial incentive to increase production because each kilowatt-hour sold makes a positive contribution to profit. Every kilowatt-hour success-

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[13] John M. Quigley, *Residential Energy Conservation: Standards, Subsidies, and Public Programs*, *in* REGULATORY CHOICES: A PERSPECTIVE ON DEVELOPMENT IN ENERGY POLICY 290 (Richard Gilbert ed., 1991).

[14] Kenneth E. Train, *The Economic Value of Energy-Saving Investments by Commercial and Industrial Firms*, 12 ENERGY 543 (1987) [hereinafter Train, *The Economic Value*]; Kenneth E. Train, *Incentives for Energy Conservation in Commercial and Industrial Sectors*, 9 ENERGY J. 113 (1988) [hereinafter Train, *Incentives for Energy*].

[15] Ralph C. Cavanaugh, *Responsible Power Marketing in an Increasingly Competitive Era*, 5 YALE J. ON REG. 331 (1988); Chris J. Calwell & Ralph C. Cavanaugh, The Decline of Conservation at California Utilities: Causes, Costs and Remedies (July 1989) (unpublished manuscript, on file with authors).

[16] This overinvesting is not a useless exercise. Rather it is simply an excessive substitution of capital for other inputs which do not earn a rate of return. *See* KENNETH E. TRAIN, OPTIMAL REGULATION 35-60 (1991).

[17] MOSKOVITZ, *supra* note 1.

fully conserved between program implementation and the next rate case[18] costs the utility approximately five cents.[19] Thus, for Moskovitz and many others, conservation could be an opportunity for profitable investments but, under traditional regulation, it remains an opportunity that is systematically under-rewarded.[20]

Ruff and others have argued that energy conservation does not warrant regulation because consumers conserve optimally in response to the price of electricity.[21] However, if there are economic opportunities for utility conservation,[22] Moskovitz's argument provides a justification for pro-conservation regulatory incentives to counteract the anti-conservation incentives inherent in traditional rate-making. Without this, utilities will rationally work to produce DSM programs that appear to succeed while actually accomplishing little. This motivation, coupled with imperfect information on the part of the regulator, makes a well-structured incentive program necessary for efficient conservation.

The goal of regulation should be to identify and select those opportunities where the expected benefits from conservation exceed the social costs and to exclude all others. Much of the debate over the benefits and costs of conservation incentives fails to recognize that there is no standard conservation opportunity and that individual conservation programs have shown a wide range of cost-benefit ratios.[23] The purpose of this Article is neither to analyze the validity of perceptions about the benefits of conservation programs nor to examine the causes of market failure. Rather, we compare the incentive mechanisms currently in place and evaluate them as case studies in incentive mechanism design. Since incentive programs are being used, they should be designed to perform as efficiently as possible. If such programs are useful, implementing more effective programs will result in less waste. If they are unnecessary, then pursuing a path towards their optimization will eventually lead to their elimination.

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[18] Public utility commissions generally hold rate cases roughly every three years, though this varies widely. These cases determine the price of electricity based on costs and historic or expected demand.

[19] This is based on the difference between an average price of 8¢/kWh and a short-run marginal cost of 3¢/kWh.

[20] The lost-revenue problem is addressed for all but one of the utilities in Table 2 of Appendix A.

[21] Ruff, *Planning and Pricing*, *supra* note 11; Richard J. Gilbert & John E. Henly, *The Value of Rate Reform in a Competitive Electric Power Market*, *in* REGULATORY CHOICES: A PERSPECTIVE ON DEVELOPMENTS IN ENERGY POLICY 84 (Richard Gilbert ed., 1991).

[22] These opportunities may exist either because of the informational problems discussed in section I. A., or because of negative externalities to the consumption of electricity which are not covered by the retail price.

[23] *See supra* notes 11-12.

II. A Classification of Current Incentive Mechanisms: Markup, Bonus and Shared Savings

An incentive mechanism consists of a rule for determining the size of the incentive payment and a procedure for recovering this payment together with utility expenditures. All DSM programs currently in place allow for the recovery of expenditures, in addition to incentive payments, either by directly expensing them or by including them in the utility rate base. Although recovery mechanisms can be quite complex, they have a negligible impact on the efficacy of the incentive.[24] We ignore recovery mechanisms, thereby simplifying and clarifying the task of classification.[25] Most incentive mechanisms currently in place can be classified as one of three basic types: markup, bonus, and shared savings.

Markup incentives reward the utility in proportion to its expenditure. Program expenditure is limited by a cap, and the utility is allowed to recover from the ratepayers an amount that exceeds its expenditure by the markup, which is typically around five percent. The utility typically pays all of the cost of a markup program, with no contribution from the program participants. Markup incentives are employed most often for informational and low income programs because it is very difficult to measure the net social benefit of these programs. The advantage of a markup incentive is that it obviates all measurement problems, thereby allowing its use when it is impossible or very costly to verify benefits. Markup incentives may be used when regulators have concluded subjectively that the program provides a net benefit. The problem with this mechanism is that it provides an incentive to spend on conservation programs without tieing that spending to the actual conservation of energy.

The bonus incentive mechanism rewards a utility for kilowatt-hours saved. This requires the measurement of energy savings, which may be based on ex ante engineering estimates, ex post measurement, or a combination of the two. Typically, program participants share costs, but the shares vary dramatically with the details of the program. The key drawback of the bonus incentive is its assumption that all sources of cost and benefit other than kilowatt-hour savings should be ignored. This incentive causes utilities to maximize saved kilowatt-hours. The problem here is that kilowatt-hours may not correlate with

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[24] To the extent that the allowed return on the rate base exceeds a utility's cost of capital, including conservation expenditures, the utility's rate base provides a markup incentive in addition to other incentives explicitly provided by the program.

[25] Previous classifications of shareholder DSM incentives, including those by Moskovitz, Barakat & Chamberlin Inc., and Edison Electric Institute, have categorized incentive mechanisms both by the quantity on which the incentive is based and by the method of payment. Such classification results in overlapping categories and economically irrelevant classifications. MOSKOVITZ, *supra* note 1; BARAKAT & CHAMBERLIN, INC., *supra* note 2; EDISON ELECTRIC INSTITUTE, TYPES OF INCENTIVE REGULATION: A PRIMER FOR THE ELECTRIC UTILITY INDUSTRY (1993).

maximum net benefit. For example, a utility that runs short of economic conservation opportunities would still be motivated, under a bonus incentive, to spend its last program dollar to save only a single kilowatt hour. The incentive program would reimburse the utility one dollar for its expense and provide an additional small incentive payment. Net benefit in this case would be negative because the benefits would be only the few cents[26] saved by not generating one kilowatt-hour while the program costs would be one dollar.

A shared-savings incentive avoids the pitfalls of the bonus mechanism by rewarding the utility based on the net benefit of the program, typically paying fifteen percent of net benefit. This mechanism differs from the bonus system in that it attempts to estimate the net social benefit of the program. Although many procedures are used to compute net benefit, each program subtracts program costs from the benefit of saved kilowatts and sometimes subtracts participant costs and the cost of negative externalities. Like the markup and bonus programs, there is always a cap on total program costs, and usually a cap on the incentive payment.

Although non-linear functions are used by many incentive programs, it is useful to present linear algebraic versions of the three incentive mechanisms. A linear function not only illuminates how the programs differ in the coupling of incentives to program costs (G), social costs (C_s), and to the quantity of energy saved (Q)[27] but also aids in the classification of specific programs. We use the term "program costs" to indicate costs as calculated by the sponsoring utility. Program costs differ from social costs, which are the opportunity costs of resources involved in the program, as the former include transfers from all ratepayers to program participants and exclude costs to participants.

Markup incentives reward the utility with a fraction of the cost of the conservation program. Bonus incentives pay the utility in proportion to the energy saved. In a shared-savings mechanism, the utility earns a fraction of the difference between the value of the energy saved and the cost of the conservation program. The linear versions of these incentive types presented below will help to define the relationship between the incentives and to classify particular incentive programs.

Markup: $I = \lambda \cdot G - \Phi$

Bonus: $I = \lambda \cdot Q - \Phi$

Shared Savings: $I = \lambda \cdot (a \cdot Q - C_s) - \Phi$

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[26] The average price of electricity in the U.S. is about 8¢/kWh and must be close in value to the long-run avoided cost.

[27] Energy savings should be thought of as including capacity savings.

In these equations, (*a*) is the per-unit value of energy and capacity saved, λ is the rate of incentive, Φ is a fixed charge, and (*I*) is the incentive payment. The fixed payment Φ has the property of decoupling the strength of the incentive, which is determined by λ, from the size of the incentive payment. In particular, a positive Φ can produce negative incentive payments in what is called a "penalty region." Incentive mechanisms include a cap on the total program expenditure. The bonus and shared-savings programs also include a cap on the incentive payment. For markup programs, an incentive cap is effectuated by the program expenditure cap.

There is considerable variation among utilities in the types of incentive programs adopted and in the program parameters.[28] Part IV examines the theoretical reasons to favor one type of incentive scheme over another. Differences in program parameters might be explained by the varying opportunities for conservation in individual utility systems. The size of the utility often determines the opportunities available to it.[29]

The shared-savings mechanism rewards the utility based on the difference between the avoided cost of saved energy and some estimate of social costs, $(a \cdot Q - C_s)$, which is often referred to as the program net benefit (NB). Shared savings has an obvious advantage relative to bonus and markup, because the latter two fail to account for either the costs or the benefits in the conservation equation. Yet both bonus and markup mechanisms are encountered in the regulatory arena. For example, Pacific Gas & Electric (PG&E) is allowed a markup on two types of DSM programs: (1) equity programs that are designed to improve the energy efficiency of low-income households at little or no cost to the customer; and (2) energy-management service programs that are informational in nature.[30] A markup program is ideal for these types of programs because energy savings is difficult to measure and because these programs can produce a negative net program benefit.[31]

Two of the programs summarized in Appendix B, Pacific Gas and Electric's (PG&E) and San Diego Gas and Electric's (SDG&E) shared-savings programs, provide examples of mechanisms that suffer from being overly complex. PG&E has adopted a nonlinear approach that results in a wildly fluctuating marginal incentive, and SDG&E has adopted a complex formula that seems to promise subtle motivational benefits, but which reduces, under the application of

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[28] Tables 2-A and 2-B in Appendix A summarize the incentive mechanisms of 13 specific utility programs. The programs were chosen on the basis of size, interest, and data availability. All but three of the programs fall into one of the three categories discussed in this Article.

[29] Table 2-B in the Appendix presents the information in Table 2-A normalized to a 10 TWh/yr utility. This reduces, but hardly eliminates, the variation in incentive programs.

[30] 90-08-068 Dec. Cal. Pub. Util. Comm'n (1990).

[31] *See* PACIFIC GAS AND ELECTRIC COMPANY, ANNUAL SUMMARY REPORT ON DEMAND SIDE MANAGEMENT PROGRAMS IN 1991 AND 1992 (1992). There is an expectation that societal benefits would be positive despite negative measured program benefits.

elementary algebra, to the standard shared-savings formula with a strangely low value for avoided cost.

III. Accounting for Conservation Costs and Benefits

This Part focuses on the definition and measure of net benefit. Net benefit, properly defined, is the social value of energy conservation. Defining and measuring net benefit is important in deciding which projects should be funded. Projects with a positive net benefit should be funded while those with a negative net benefit should be discarded. The correct definition of net benefit includes many components that are often omitted from incentive mechanisms or improperly included, and all aspects pose difficult measurement problems.

The benefit of conservation is the value of the energy saved. The social costs of conservation programs are the costs borne by; the utility, regulators, program participants, and non-participant customers. These costs include actual utility and consumer expenditures on equipment, material, and labor, and the costs of program administration. Social costs also include managerial effort, consumer disutility from program participation and from the conservation measures themselves, and possible inefficiencies caused by higher prices. Social costs are potentially significant, but difficult to quantify. Payments from non-participant ratepayers to program participants are relatively easy to quantify but have complex implications for social cost. As pure transfers from one group to another, these payments do not shrink the available resources and therefore are not true social costs. These transfers tend to be associated with social costs, however, because they may have adverse distributional consequences and may impair economic efficiency through secondary impacts on utility rates.[32]

A. *Costs*

The analysis in this Part is based on the data describing thirteen incentive programs discussed in Appendix A. Utility expenditures, utility transfers to consumers, customer costs, and evaluation costs are tabulated for each program. This Part examines each of these cost categories and the problem of customer disutility. This Part also explains how conservation programs have, and should have, accounted for some of the more elusive social costs, such as the free-rider problem and the rebound effect.

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[32] Transfers have to be paid for by increased rates, which may widen the gap between price and marginal cost. When price exceeds the social or marginal cost of energy, consumption is inappropriately penalized. The social loss from this reduced consumption can be attributed to the small difference between the value of energy not used because of the inappropriate price and the saved marginal cost.

1. *Utility Expenditures*

Utility expenditures on conservation programs include the cost of conservation equipment and associated material, labor costs, payments to consumers, and costs associated with program management and evaluation. Utility expenditures may include some items that are not true social costs, such as transfer payments to consumers, and may exclude some actual social costs, such as consumer costs that have not been reimbursed.[33]

All of the programs allow the utility to recover its expenditures.[34] Aggregating all incentive programs for each utility, program expenditures range from about $15 to $50 million on a normalized basis. Adjusted for size, Massachusetts has the most aggressive program.

2. *Transfer Payments and Customer Costs*

There is considerable variation in the way that conservation programs account for transfer payments, such as rebates, between the utility and participating customers. Three of the seven shared-savings programs include utility transfer payments in computing net benefit. This practice understates the actual net benefit of a conservation program. Two of these programs exclude customer costs, which leads to an overstatement of a program's net benefit. Utilities often hope that this overstatement is compensated for by the erroneous practice of including utility transfer payments. Although transfer payments are a reallocation of rates from one consumer group to another rather than a resource cost, they may serve as a proxy for customer costs that are difficult to measure. Four of the seven shared-savings programs correctly exclude transfer payments and include customer costs in the evaluation of net benefit.

3. *Regulatory Costs*

Regulatory costs are the costs of designing and evaluating the conservation incentive program. Program evaluation is the main component of these costs, and the main functions of evaluation are to reward utilities for conservation activities that produce positive net benefit and to determine the desirability of subsequent DSM activities. To the extent costs can be divided between these two functions, the cost of determining rewards should be included in the net benefit calculation and the cost of determining subsequent DSM activities

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[33] To the extent that transfer payments contribute to pricing distortions, the adverse effects of these distortions, but not the transfer payment, should be counted as a social cost of the conservation program. Similarly, a separate account could be made of the distributive costs of transfer payments. Transfer payments may be a proxy, however, for unobservable customer costs that should be included in a net benefit calculation.

[34] The programs differ on the timing of recovery, but include allowances for interest costs.

should not. Approximately one-half of the utility programs listed in Table 3 include evaluation costs in the measure of net benefit.

4. *Customer Disutility*

All incentive programs omit the non-financial costs consumers sometimes incur from conservation activities—customer disutility. One example of this type of cost is consumer dissatisfaction with the quality of light from a compact fluorescent bulb. These costs should be deducted from the net benefit of these programs. However, customer disutility tends to be ignored in the evaluation of conservation programs because its magnitude is difficult to quantify. For example, in a recent study of demand-side measures completed by Lawrence Berkeley Laboratories, measures such as switching from electric to gas cooking, low-flow shower heads, and compact fluorescent lights were all assumed, without investigation or discussion, to have zero disutility to the customer.[35]

The extent of customer disutility from conservation programs is uncertain. An extreme view is that it must be very large, otherwise efficient conservation would have been undertaken. According to this view, the net benefit of conservation should be reduced by an amount approximately equal to the pecuniary savings from these programs. The theory behind this assertion is that the customer's hidden costs must be at least that large to explain the customer's failure to adopt the conservation technology. Another equally extreme view is that customer disutility is small and that customers' failure to conserve is based on easily corrected information. This view posits that customer disutility is a temporary, initial phenomenon, that does not affect future conservation benefits and has only an insignificant effect on the total present value of net benefit. The true amount of customer disutility depends on the extent and depth of the conservation measures. As utilities induce increasing levels of conservation, customer disutility will inevitably grow in magnitude and thus gain increased importance in program evaluation.

5. *Non-Participant Costs*

Conservation lowers system revenue requirements if the cost per kilowatt hour of conserved energy, C, is less than the system's incremental avoided cost of generation, a. When this condition ($C < a$) is satisfied, ratepayers as a whole are better off when the utility invests in reducing demand rather than increasing supply.[36] A reduction in revenue requirements does not, however, imply a reduction in electricity rates. Under rate-of-return regulation, rates (P), corre-

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[35] Koomey et al., *supra* note 9.

[36] This statement assumes that any customer disutility from energy conservation is included in its cost.

spond to the utility's average production cost, while each kilowatt hour saved by conservation reduces system costs by the utility's avoided cost of generation, a. Conservation reduces the total demand available to generate revenue. For each kilowatt hour saved, the lost revenue is P and the net lost revenue is $P-a$. The net effect is that for each kilowatt hour saved by conservation, rates have to increase by $(P - a)/q$, where q is total demand, to compensate for net lost revenue and by C/q to compensate for the cost of the DSM.[37] System average rates will increase if the sum of the two rate effects is positive, $(P - a) + C > 0$, or equivalently if $C > a-P$. Since avoided cost of generation is less than the average system price for most utilities with excess capacity (thus $a-P$ is negative), conservation will increase rates for these utilities, even if ratepayers as a whole are better off. Conservation is likely to result in lower rates only for systems whose capacity expansion costs are extraordinarily high.[38]

When conservation results in higher rates, the consumers that participate in conservation programs are made better off at the expense of non-participants. Unless program participants compensate the non-participants for the higher rates, there is a subsidy from the latter to the former.[39] Although the participants could be required to compensate the non-participants, this rarely occurs.[40] Instead, conservation programs are frequently implemented with transfer payments to induce customer participation. These transfers further increase the rates that non-participants have to pay.

In addition to the distributional impacts of conservation programs, the effects of these programs on rates can have adverse consequences for economic efficiency. When the average cost of electricity exceeds its marginal cost, a further increase in average cost distorts prices by discouraging consumption. Higher rates lead to reduced demand and in some cases, cause customers to bypass the regulated service. This problem has been particularly important in the past decade, when a surplus of capacity in some jurisdictions led to electricity prices that were several times the marginal generation costs.

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[37] For an alternative derivation, let AC be the system average cost and MC the system marginal cost, both a function of sales, q. A reduction in sales of one kWh increases average cost by $(AC - MC)/q$. Under rate regulation, AC is approximately P, the average system rate, and MC corresponds to the utility's avoided cost, a.

[38] For example, if the system's average rate is 8¢/kWh, and if conservation costs are 3¢/kWh, rates would increase unless adding new capacity was expensive enough to push the cost of new generation above 11¢/kWh.

[39] Investment in new generation facilities also raises distributional issues. If a utility has to build costly facilities to meet new demand, the cost is typically shared by all ratepayers. However, unlike expenditures on demand-side management, consumers pay for generation facilities in approximate proportion to the amount that they use these facilities.

[40] If a conservation program produces positive net benefits, the participants should be able to compensate non-participants in a way that leaves both groups better off.

B. *Benefits*

The benefits of conservation are the reduction of generation costs and associated externalities. The computation of these benefits is complicated by difficulties in estimating conserved energy. It is unclear whether it is better to measure conservation ex post or ex ante.

1. *Value of Conserved Energy*

All the shared-savings and bounty programs give credit for both energy and capacity savings, which are defined as "avoided costs," while markup programs are based solely on costs. The incentive programs appear to measure the savings correctly by using marginal, rather than average, energy and capacity costs. The utilities varied in whether they included environmental externalities in their calculation of conserved energy. The inclusion or exclusion of the externalities and the size of inclusion is an important cause of variance in the conserved energy values. Only two utilities take environmental externalities into account. New York accounted for environmental externalities by adding 1.4 cents/kilowatt hour (kWh) to their calculation of avoided cost, while Massachusetts added 4 cents/kWh.

The measurement of conserved energy is further complicated by uncertainty regarding the duration of conservation savings. Future energy and capacity savings are discounted with one exception: regulators only pay Orange and Rockland an incentive on its first year of energy savings.

2. *Estimation of Energy Savings*

Measurement is perhaps the most difficult problem encountered in conservation initiatives. The inability to verify energy savings is an important reason for the perceived failure of markets to provide adequate investment in conservation. If savings were verifiable, private energy service companies could contract with consumers to provide conservation services and could be paid based on the savings that would result. One cannot conclude from this market failure that utilities can fill the void as providers of conservation services. Without a means to verify energy savings, the ability of regulators to encourage economically efficient conservation is severely constrained.

Utilities use two approaches to estimate energy savings. The ex ante approach relies on engineering estimates of savings from installed conservation technologies. The ex post approach entails measurement of customer energy use after the implementation of demand-side measures. The decision to use ex ante estimates typically reflects an assessment that ex post measurement is too costly. Use of ex post estimates suggests a concern with the biases and poor incentive qualities of ex ante estimates.[41] Joskow and Marron report large differences between ex ante estimates of conserved energy and ex post evaluations of actual energy conservation; the former is notoriously inaccurate.[42] This inaccuracy suggests that there is a strong bias in ex ante estimates and that absolute reliance on such estimates would be unwise. The future of conservation incentive schemes is likely to depend on the development of methods to obtain unbiased estimates of program savings at a reasonable cost.

Because technology advocates, consultants, regulators, and others in the industry have private interests in the outcomes of conservation programs, it is essential that measurement techniques guard against distortions in the evaluation of program benefits. Estimates of energy savings are confounded by the complex interaction of conservation incentives and energy consumption behavior. These interactions produce the "free-rider" and "rebound" problems. Free-riders are consumers who participate in energy conservation programs but would have made conservation expenditures in the program's absence. Rebound refers to an increase in consumption brought about by lower energy costs for consumers who have invested in efficient energy-using durables.

a. *Free-Riders*

It is important to exclude free-riders from the calculation of conserved energy because free-riders absorb program costs without producing any offsetting benefit. All the utilities surveyed claim to account for the free-rider problem but use wholly inadequate estimation techniques. Central Maine Power's (CMP) "quasi-experimental" savings measurement plan is a principal method of accounting for the free-rider problem in the programs we reviewed. Under this plan, a participant sample is compared with a non-participant sample. For members of each sample, pre and post program annual consumption is metered and the change is averaged. CMP then defines net savings per participant as the difference between these two averages. No participants are actually excluded as free-riders. CMP uses this procedure as a correction for the free-rider bias. However, as the following analysis illustrates, this technique can lead to gross under-correction.

If the program attracts mostly customers who would adopt the conservation measure in any case, a free-rider problem is present. As Joskow and Marron suggest, these free-riding customers, the ones most attracted to the conservation incentive, are likely to experience greater than average energy savings from the conservation measure, thereby inflating the measured net savings for program

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[41] Calibration studies can make ex ante measurement quite expensive. Ex ante measurement also leaves the utility with an incentive to install conservation measures poorly in order to reduce net lost revenues.

[42] Joskow & Marron, *supra* note 12; *see also supra* note 14.

participants.[43] In this case the quasi-experimental method will overestimate the savings per genuine participant and will neglect to exclude any of the free-riders, thereby greatly overestimating the effectiveness of conservation incentives.

The quasi-experimental approach is also unsatisfactory because of the dynamic nature of the free-rider problem. As Joskow and Marron point out, "free riding is properly conceptualized not as a simple static decision . . . , but in terms of shifts in the diffusion curve . . . ."[44] A participant who needed to be induced to adopt the measure this year might adopt it voluntarily next year, in which case he would be a free-rider for all but the first year.

Whether ex post or ex ante, in order to account for free-riders, measurements of conservation savings must be compared with predictions of how customers would have behaved without the DSM programs. Utilities currently employ other methods, besides the quasi-experimental approach, to estimate the extent of the free-rider problem, but these approaches are generally more ad-hoc, although equally accurate. Rigorous statistical procedures, such as those used by Train and Strebel,[45] are rarely, if ever, used.

b. *Rebound*

Rebound refers to the increase in the demand for energy services caused by energy-efficiency programs that reduce the cost of these services. For example, a consumer is likely to use an efficient air conditioner more than an inefficient air conditioner because the marginal cost of use is lower. While the free-rider problem may result in attributing too much benefit to conservation measures, rebound tends to cause an underattribution of benefits, particularly when ex post measurement is used.[46] Some observers, among them some of the strongest proponents of DSM, have argued the reverse; they claim that rebound reduces actual net benefit and thereby leads to its over-estimation. This point of view, however, fails to recognize that it is customer utility and not energy conservation per se which matters.

Customers choose to consume rebound energy because it provides them with increased utility. Since this choice is voluntary, the benefit provided by the energy service must be greater than what would have been provided by the cost of the rebound energy. Ex ante measurement fails to capture the net gain in utility from using rebound energy, while ex post measurement fails to capture

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[43] *Joskow & Marron*, *supra* note 12, at 44.

[44] *Id.* at 46.

[45] Train, *Incentives for Energy*, *supra* note 14; Train, *The Economic Value*, *supra* note 14; Kenneth E. Train & Judi E. Strebel, *Energy Conservation and Rebates in Commercial Food Enterprises*, AM. J. AGRIC. ECON., Feb. 1987, at 106.

[46] An argument in favor of ex ante savings estimates is that they are not affected by rebound. This may be small compensation compared to the other biases encountered with ex ante savings estimates.

the gross utility of rebound energy use. Thus, while ex ante measurement simply ignores the benefit of rebound, ex post measurement erroneously considers it as a benefit reduction significant enough to negate the entire benefit of some conservation measures.

IV. Imperfect Information and the Design of Incentives

Recent economic literature on incentive mechanism design reveals that informational problems lie at the heart of incentive design problems.[47] Therefore, this Part will approach the analysis and design of utility incentives from the regulator's informational status. It will analyze four cases in which different informational deficiencies determine the optimal incentive scheme.

If the regulator's information is perfect, the incentive problem can be solved easily through a forcing contract. The markup mechanism is one such contract. If the regulator does not have a publicly verifiable estimate of net benefit, and the utility has private information on how best to implement DSM, the markup mechanism is still optimal even though it achieves only a second best outcome.[48] If the regulator is unable to verify the utility's actions, but has a publicly verifiable estimate of net benefit, it becomes inefficient to use a forcing contract. Instead, a shared-savings mechanism would produce the optimal outcome and would require only a small incentive payment.

Frequently in actual regulation scenarios, the regulator faces a serious informational gap. The regulator may not be able to observe a crucial component of the utility's cost. We term this unobservable cost "effort." When effort is costly, productive, and unobservable, the utility is able to extract information rent from a regulator who is trying to achieve optimal results. Again, the shared-savings mechanism is the appropriate contract form, but in this case a substantial incentive is necessary. There can be a further complication if the regulator cannot make an unbiased estimate of net benefit. In this instance it may be impossible to design a useful incentive mechanism.

A. *Perfect Information*

Although one almost never has perfect information, it is useful to examine this possibility in order to make comparisons with the cases of imperfect information discussed in this work. With perfect information, the regulator can

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[47] JEAN-JACQUES LAFONT & JEAN TIROLE, A THEORY OF INCENTIVES IN PROCUREMENT AND REGULATION (1993).

[48] We will use the term "efficient" to mean the best that could be done with perfect information, and the term "second best" to describe a mechanism or outcome that is the best that can be achieved given informational constraints and self-interested parties.

observe the utility's actions, and calculate the net benefit that results.[49] In addition, observations of actions, costs, and benefits must be publicly verifiable, and the utility must not have more information regarding the implementation of conservation than the regulator. Under these informational conditions, the regulator can employ either a markup or a shared-savings mechanism, and only the smallest incentive beyond cost reimbursement will be necessary to insure compliance.

The first two cases of incomplete information assume the regulator can make unbiased estimates of all relevant quantities. In the first case, the regulator's estimate of net benefit is not publicly verifiable. This circumstance necessitates a markup contract, and will only create a problem if the utility possesses private information on how best to implement DSM. The second case of incomplete information does not have this problem, as the regulator is able to verify its estimate of net benefit.

B. *Case 1: The Regulator Can Verify Actions but Not Net Benefit*

In this case, as in the case of perfect information, the regulator can observe and publicly verify the utility's actions, and the costs and consequences of those actions. But, there is an essential informational gap for the regulator because the cost of verifying its estimate of the net benefit would be prohibitive.

Given this informational constraint, optimal regulation is relatively straightforward. The best incentive mechanism encourages the utility to undertake conservation actions that the regulator has privately determined to be the best alternatives among the known options. An incentive mechanism designed to induce a specific action is called a forcing contract. A markup incentive combined with a cap on program expenditures makes up such a contract and could be used effectively under the assumed informational conditions.

Principle 1: *If the regulator can verify a utility's costs and actions, and has an unbiased but not publicly verifiable estimate of net benefit, then a cost-based forcing contract is efficient.*

The forcing contract should reimburse all expenses, and must specify the amount and manner in which the money is to be spent. If the utility is also allowed to earn a percentage of every dollar spent, without regard to net benefit, the utility will spend up to the expenditure cap and complete the program. This would be a well-implemented markup program. In place of a markup, a penalty could be imposed for failing to complete the program. Either

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[49] Actually, a very imperfect but unbiased estimate of benefits will serve the regulator as well as a perfect estimate, provided the utility is not overly risk averse.

method will be effective and require only the smallest reward or penalty provided that the contract reimburses both direct and indirect utility costs.

Markup programs present a significant danger of inefficiency because the stringent informational assumptions detailed above are often not met. When the regulator finds it difficult to observe the utility's actions, it will reward the utility only for costs incurred and not for actions taken. In such a case, the utility will have an incentive to act perversely. For example, the utility might turn a conservation education program into a disguised public relations campaign.[50] A second danger is that the inability to publicly verify the regulator's private estimate of net benefit may indicate that the estimate is dramatically biased.

The fact that the utility may have private information is the second informational problem that exists in Case 1. That is, the utility may know better ways of conducting the conservation program than the regulator. In this case, the efficient program would be one that makes use of that private information. Such behavior could only be induced, however, if the regulator could publicly verify the benefit of that information. Otherwise, a contract inducing the use of the private information could not be enforced. In this case, a forcing contract (for example, a type of markup program) is still the best that can be done, and thus, qualifies as a second best contract. A markup mechanism, however, provides no incentive for the utility to choose the most effective expenditures.

Informational and educational programs are candidates for a markup incentive if the regulator can estimate, but not easily verify, the effectiveness of these programs.[51] If it is also true that the utility has no private information about the savings produced by such programs, or about the cost of these programs, a markup program is economically efficient, as well as the best that can be done.

The next case removes the assumption that actions are observable and verifiable, and assumes that the outcome, the program's net benefit, can be verifiably estimated. The utility still has good estimates of both costs and benefits, but benefits are verifiable and actions are not. A shared-savings incentive is most appropriate here, and the central incentive-design problem becomes more apparent.

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[50] Letter from C. M. Walwyn, Administrative Law Judge of the California PUC 36 (Oct. 17, 1993) (regarding proposed decision concerning Application 93-04-028 of PG&E) ("We state strongly and unequivocally that DSM funds that would otherwise have been refunded to ratepayers should not have been used for corporate image enhancement . . . .").

[51] This does not preclude offering a reward that depends on the difference between a forecast of energy consumption and actual consumption at a future date, though it would be difficult to verify that actual consumption was influenced by the program.

C. *Case 2: The Regulator Has a Verifiable and Unbiased Estimate of Net Benefit*

In this case, the regulator has an unbiased and publicly verifiable estimate of all costs, and of the program's net benefit. However, the utility's actions are expensive to monitor, or the regulator is relatively uninformed about the connection between utility action and net benefit. Consequently, the regulator prefers to rely on estimated benefits. The utility can be induced to make use of its private information through the use of a true incentive contract rather than the simpler forcing contract.

The net benefit of a conservation project that saves an amount of energy Q with avoided cost (a) is given by $aQ - C_s$, where C_s includes all social costs incurred by the utility, program participants, and non-participants. The following analysis assumes that an optimal outcome maximizes the expected welfare of the regulator, who counts equally both consumer welfare and producer profits.[52]

A regulator whose objective is to promote expected social welfare would desire any conservation program that has a positive expected net benefit. The regulated utility should be willing to pursue any program in which the utility is fully compensated for all of its costs, including managerial effort and indirect costs such as lost revenue. Thus, if the regulator offers the utility a fraction, however small, of program net benefit, the utility would have an incentive to engage in a DSM program. The regulator would want the utility to engage in the program only if it has a positive expected net benefit. Verification is important to ensure that a contract between the utility and the regulator is legally binding. Principle 2 follows from these conditions.[53]

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[52] An abundant body of literature shows how the regulator might wish to alter incentives if the regulator wants to promote the welfare of one group at the expense of another, or if collecting revenues from consumers incurs a social cost. *See, e.g.*, Tracy R. Lewis & David E.M. Sappington, *Regulating a Monopolist with Unknown Demand*, 78 AM. ECON. J. 968 (1988); Tracy R. Lewis & David E.M. Sappington, *Regulating a Monopolist with Unknown Demand and Cost Functions*, RAND J. OF ECON., Autumn 1989, at 438 [hereinafter Lewis & Sappington, *Regulating a Monopolist*]; Tracy R. Lewis & David E.M. Sappington, Incentives for Conservation and Quality-Improvement by Public Utilities (1991) (unpublished manuscript, on file with *Yale Journal on Regulation*) [hereinafter Lewis & Sappington, Incentives for Conservation]. For DSM programs, the regulator may put different weights on participating and non-participating consumers, as well as on the regulated firm. We ignore these important complications and instead emphasize the more basic elements of efficient mechanism design.

[53] This result and the next are subject to an important qualification. The regulated utility should take into account the return it could earn in other activities, such as constructing new generation facilities, when choosing how much effort to allocate to DSM programs. If the utility is rewarded meagerly in these other activities, a large reward for DSM programs might divert the utility's attention from other, more valuable, pursuits. The socially optimal incentive scheme should offer private incentives to the firm for each of its alternative activities that are in proportion to the activity's contribution to social value. This qualification would not be necessary if the firm's cost of effort were properly estimated at its societal opportunity cost.

Principle 2: *If a regulator can obtain a verifiable unbiased estimate of net benefit, any shared-savings incentive scheme is efficient, no matter how small the incentive.*

When the regulator has an unbiased, verifiable estimate of all the social costs and benefits of conservation investments, a shared-savings program makes expected utility profits exactly proportional to social value. Since this result holds for any level of benefit sharing, even the most modest share is adequate to induce the utility to pursue socially productive conservation. The incentives actually offered by the shared-savings programs reviewed in this Article are substantial. This suggests that either regulators are unconcerned about the distributional implications of large rewards for utility DSM programs, or that they believe such rewards are necessary to compensate utilities for unobservable effort or other elements of program costs that are unknown to the regulator. These observations require us to consider the structure of efficient incentive programs when the regulator's information is more limited. The next two cases examine the consequences for efficient incentive design when the regulator is imperfectly and asymmetrically informed about utility costs or net benefit.

D. *Case 3: Some Utility Costs Cannot Be Observed*

The previous case revealed that the utility's private information is sufficient to explain the need for an incentive mechanism, but that the inaccuracy of the measure of net benefit did not cause any additional problems.[54] Specifically, measurement errors did not justify a significant level of incentive payment, which is contrary to the general assertion that conservation measurement problems create the need for substantial incentives. This Part adheres to recent economic theory which suggests that substantial incentives are needed not because of conservation measurement problems, but because the utility's true costs cannot be observed.[55]

In this case, we assume that the regulator knows less about program costs than the utility. Specifically, it is assumed that the regulator cannot measure the cost of the effort required to make a program succeed. The utility has two forms of private information, program costs and its information about efficient program design. The regulator's measure of net benefit is flawed by the omission of the cost of effort, which is real, but not observable by the regulator. However, if the regulator rewards the utility with 100% of its measure of

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[54] It is typical of incentive problems that an unbiased estimate of net benefit is sufficient to provide correct motivation so long as utilities are not risk averse. Provided the programs are small compared with the utility's scale of operation and are repeated so that errors can average out, risk aversion should be a minor consideration.

[55] David Barron & Roger Myerson, *Regulating a Monopolist With Unknown Costs*, 50 ECONOMETRICA 911 (1982).

program net benefit, the utility would be motivated to apply enough effort to the program to maximize social value. This is formalized in Principle 3.

Principle 3: *If a risk neutral regulator can obtain an unbiased estimate of net benefit except for some utility costs, and the utility has private cost information, then a shared-savings incentive scheme with the utility earning 100% of measured net benefit is the only efficient incentive.*

Measured net benefit includes all social costs and benefits except the unobservable costs incurred by the utility while conducting the DSM program. To understand the above result, consider what it means to earn 100% of measured net benefit. Since this incentive payment is in addition to reimbursement for the utility's observed costs, C_u, and transfer payments, T (which are not a social cost and thus are omitted from net benefit), its profit is

$$\pi = -(C_u + T + E) + (C_u + T) + (aQ - C_u - C_c)$$

or $\pi = aQ - C_u - C_c - E$

where π is profit, E is the unobserved cost of effort, and C_c is customer costs.[56] The three parenthetical quantities represent, from left to right, utility expenditure, reimbursement, and incentive payment. Note that while the incentive payment equals measured net benefit, the utility's profit is exactly the true social net benefit including the unobserved cost of utility effort. Thus a profit maximizing firm will automatically maximize social value.[57] Clearly, if the incentive payment were to be changed in any way, the firm's profit would no longer equal true net benefit and the firm would be motivated to maximize something other than social value. Thus, an incentive payment of 100% of measured net benefit is the only optimal level for the incentive.[58]

Having a part of utility costs unobservable causes absolutely no problem in equating profit with true net benefit. An easily verified implication of this property is that the utility's misreporting of costs is of no consequence. Since every dollar of cost reported is reimbursed and then deducted from the incentive payment, the utility bears the full cost of the program. This alleviates some

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[56] These variables should include any allocative or distributional costs that result from transfer payments.

[57] *See* Martin Loeb & Wesley A. Magat, *A Decentralized Method for Utility Regulation*, 22 J.L. & ECON. 399 (1979) (Loeb and Magat first demonstrated the efficiency of this scheme).

[58] This is, again, subject to the qualification that the utility not have competing alternatives for managerial effort where the private and social returns do not coincide.

potentially acrimonious auditing problems recently dramatized by the case of Pacific Gas and Electric's DSM sports marketing contracts.[59]

This incentive mechanism does not call for an enormous transfer of funds from ratepayers to stockholders. Principle 3 is at odds with conventional wisdom because it suggests that while marginal incentives should be very high, net transfers can be very low.[60] The utility could be assessed a fixed charge equal to the expected value of net benefit, so that the expected total incentive payment would be zero.[61] This assessment would not disturb the incentive properties implied by Principle 3, yet it would avoid large transfers of income to the utility. However, none of the shared-savings programs reviewed in this Article offer an incentive close to 100% of marginal net benefit, and generally the incentives offered are not offset by a fixed charge.

E. *Case 4: Benefit Is Not Observable*

The fourth case assumes that program benefits are not observable. Because the benefits cannot be determined, it is impossible to design useful incentive mechanisms. The regulator can deal with private information about a program's costs by putting the utility in the residual claimant's position as to the value of energy savings. This is impossible when program benefits cannot be measured. The regulator lacks a mechanism to penalize a utility's attempts to profit by overstating the program benefits.

Without an unbiased estimate of energy savings, there is no practical way to encourage energy conservation without transferring large rents to regulated firms. If an incentive program rewards claimed energy savings, a utility will claim large savings whether or not they are realized. A regulator can only prevent this erroneous claim if it can observe some aspect of utility operations

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[59] An issue regarding PG&E's sports marketing contracts arose during the review of its annual request for shareholder earnings based on DSM program performance CPUC Docket No. A.93-04-028. The merchandising component of these contracts included, among other things, season tickets, VIP receptions, parking permits, a catered tailgate party, a road trip, and team memorabilia. Letter from C. M. Walwyn, Administrative Law Judge of the California PUC, *supra* note 50, at 22. As a result of publicity over these DSM expenditures, PG&E voluntarily reduced its shareholder incentive request by three million dollars. Opening Brief of PG&E on DSM Shareholder Incentives, October 27, 1993, p.21.

[60] *See* Michael W. Reid & John H. Chamberlin, Financial Incentives for DSM Programs: A Review and Analysis of Three Mechanisms, *in* INTEGRATED RESOURCE PLANNING 5.157 (1990). The Reid article reaches a conclusion completely different from the logic of Principle 2. The authors claim that the critical feature of incentive programs is that they offer total rewards large enough to catch the utility's attention. This presumption does not explain why incentives which are very large on the margin would not also interest a utility or why the prospect of gaining a large sum on the margin would be less motivating than the total return.

[61] Actually, the expected net transfer to the utility should exactly equal E, the cost of effort. Because E cannot be observed, the regulator cannot reimburse the utility for this cost. If expected net transfer does not equal benefit, earnings will suffer and the cost of capital to the utility may increase. This is impossible to obtain since the regulator does not know E. Nonetheless, some rough attempt to compensate the utility for E should be made. This compensation must be done through the fixed charge and not through the variable part of the incentive.

that is correlated with the energy savings. Lewis and Sappington use total output for this purpose.[62] It is difficult to determine the effects of conservation from this type of aggregate statistic, but the incentive mechanism described by Lewis and Sappington gives a utility no incentive to overstate conservation benefits. Their mechanism requires that the results of the program have a measurable impact on utility's marginal production costs and that these costs increase with output. Measurement error would overwhelm applications of their scheme to specific conservation programs. When it is applied to the aggregate of many conservation programs, thereby increasing the correlation of energy savings with total demand, their scheme becomes only slightly more plausible.[63]

A partial lack of information about actual energy savings is not serious if the regulator can make an unbiased estimate.[64] The regulator can base rewards on ex ante expected energy savings or on ex post measured savings, as long as these figures are unbiased. The utility must also be willing to discount the risk of inaccurately calculated rewards for energy savings—not an unreasonable assumption for small conservation programs. When applied to many programs over an extended period of time, aggregate realized rewards should be a close approximation of the correct reward for actual savings.

An unbiased estimate of measured net benefit is the key to successful energy conservation programs. If an unbiased estimate is available and the cost of effort is known, or if the cost of effort is unobserved and the utility has private information with a 100% shared-savings scheme, then the regulator can reward the utility with a small shared-savings incentive.

Conclusion

Utility conservation incentives offer substantial economic gains by focusing appropriate managerial effort on energy conservation programs. They are necessary because the traditional rate structure fails to align the utility's profit motive with the social value of energy conservation. A correctly designed and implemented incentive will motivate only enough conservation to compensate

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[62] Lewis & Sappington, *Regulating a Monopolist*, *supra* note 52; *see also* Lewis & Sappington, Incentives for Conservation, *supra* note 52.

[63] Even if applied to an aggregation of programs, the approach presented by Lewis and Sappington (1991) would involve significant regulatory risk. *See supra* note 61. Their approach requires the regulator to set the price of electricity at a level that induces the correct after-DSM demand level. Small errors in price would result in large errors in induced DSM relative to efficient levels. Since both positive and negative errors in the amount of DSM cause inefficiency, the expected efficiency gain could be substantially negative. A new paper by Lewis takes an approach based on net benefit that avoids these problems. Tracy R. Lewis, Designing Utility-Tailored Incentive Programs for Energy Efficiency and Conservation (June 1992) (unpublished manuscript, on file with *Yale Journal On Regulation*).

[64] Michael H. Riordan & David E.M. Sappington, *Optimal Contracts with Public Ex-Post Information*, 1988 J. OF ECON. THEORY 189.

for market failure and the utility's informational and cost advantages. This Article is a first look at current incentive programs and their effectiveness in stimulating efficient conservation investment.

By ignoring differences in the form of incentive payments, and instead focusing on the economic structure of incentives, this Article classifies most existing programs according to whether incentives are paid based on energy savings (bonus), costs (markup), or net benefit (shared savings). There are two exceptions to these classifications and both appear to have no economic rational. Many existing programs are found to employ unnecessarily complex incentive mechanisms. Other programs exhibit sudden arbitrary changes in marginal incentive from one performance level to the next.

Shared savings is the most appropriate type of incentive and currently the most common. As a result, the correct measurement of net benefit is crucial to the success of DSM incentives. Unfortunately, net benefit is difficult and expensive to measure. On the cost side, the most common and important mistakes are the inclusion of transfer payments, and the exclusion of direct customer costs and customer disutility. Customer disutility is universally ignored because of severe measurement problems, despite its inevitable importance as conservation is pushed towards its economic limits. On the benefit side, problems include improper accounting for free riders and the rebound effect. The rebound effect is often misunderstood as the reason that ex ante engineering estimates overstate the benefits of conservation measures. In fact, while rebound causes a reduction in energy savings relative to engineering estimates, it also causes an increase in net benefit relative to those estimates. Correctly defining net benefit and improving its measurement would dramatically improve current incentive programs; however, such a development is unlikely. An extension of current federal efforts to include properly standardized estimates of net benefit in the collection of DSM data would substantially improve the situation.[65]

The design of an efficient incentive plan depends on what is known to the regulator and the utility about the costs and benefits of conservation programs. The better and more verifiable the regulator's information, the more effective and less costly the best available incentive mechanism will be. If the regulator can observe utility costs and actions and can estimate, but not publicly verify, benefits then the utility's private information about conservation opportunities cannot be used. However, a simple and cost effective markup incentive can induce the utility to implement the regulator's conservation program. If the utility lacks private information about conservation opportunities, this is the

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[65] Currently, the Department of Energy's Energy Information Agency collects DSM data using Schedule V of form EIA-861.

economically efficient solution; if it has private information, this is an optimal but second best outcome.

Only two incentive types, markup and shared savings, provide efficient incentives. If the regulator can make an unbiased estimate of net benefit, the utility's private information can and should be used. Using this information can be done efficiently with a shared-savings mechanism. When the regulator can observe all costs, a shared-savings mechanism should be implemented with a minimal marginal incentive payment. When some utility costs, such as managerial effort, are unobservable by the regulator, the incentive should offer the utility 100% of measured net benefit. The regulator can recover expected payments to the utility by including a large fixed fee in the incentive plan. Existing plans differ from this standard in that they provide a much lower incentive at a much greater cost to the customer.

Conservation programs succeed when savings can be measured. If adequate measurement techniques are established, high-powered incentives can lead to efficient conservation expenditures. Problems arise if estimates of conservation are biased. Although incentive programs can correct for predictable differences between claims and realized benefits, a more serious problem is that there may be no systematic relation between claimed and actual savings or that measurement of actual savings may be subject to unacceptable error.

If net benefit can be measured and the incentive payment is 100% of measured net benefit, ratepayers are, on average, better off with any conservation program that achieves a positive net benefit provided that the mechanism includes a fixed charge. Efficient conservation incentives do not penalize generation investments.[66] Instead, such incentives benefit ratepayers by encouraging the utility to exploit another dimension of service.

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[66] This statement assumes that conservation incentives do not cause utilities to allocate too much managerial effort to DSM at the expense of supply-side investments.

Appendix A

Table 1 illustrates the rapid growth of utility conservation incentive programs since their introduction. Expenditures on utility DSM programs are projected to reach almost \$1 billion in 1992—one-half to two-thirds of total expenditures on utility DSM programs.

Tables 2-A and 2-B summarize the incentive mechanisms of thirteen specific programs chosen on the basis of size, interest, and data availability. The incentive formula is presented as the type of incentive and three parameters: λ, the fraction of the quantity paid as an incentive; ϕ, the fixed charge; and $\bar{I}$, the cap on the incentive payment.[1] Some of the programs are actually composed of several sub-programs. These sub-programs are aggregated in Tables 2-A and 2-B with the assumption that performance is similar in each sub-program. All but two of the mechanisms reported in Tables 2-A and 2-B fall into the three basic categories. These two, Orange and Rockland Utilities Inc. (O&R) and Southern California Edison (SCE), are closely related to our three categories. Several of the programs have different linear incentives for different regions of net benefit, and regulators in California have sponsored more than one style of incentive program at a single utility. In addition, three of the utility incentive programs that include non-zero fixed charges employ a formula for this charge that scales it to the size of the program. However, conditioned on the program size, the charge is independent of program implementation and outcome, and thus is a fixed component of the incentive plan. Some of the differences in program parameters can be explained by the various opportunities for conservation in individual utility systems. A rough index of opportunities is the size of the utility. Table 2-B presents the information in Table 2-A normalized to a 10 TWh/yr utility.[2] This method reduces, but does not eliminate, the variation in incentive programs.[3]

As has been mentioned, the lost-revenue problem penalizes utilities for selling less electricity when price is above the marginal cost of generation. This negative DSM incentive can be corrected with a general mechanism such as California's ERAM or with a mechanism that is aimed only at revenues lost through effective DSM, as is done with Western Massachusetts Electric. The only utility in our study that is not subject to either correction is Massachusetts Electric. Consequently it suffers a disincentive to DSM that should be added to the incentive reported in our tables. The form of this disincentive is a

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[1] Some of the programs in Table 2-A have no incentive cap, which is equivalent to an arbitrarily large $\bar{I}$.

[2] For example, CMP has about 9.136 TWh/yr of net sales. The normalization factor for this utility is therefore 10 TWh/yr ÷ 9.136 TWh/yr = 1.0946, and the normalized incentive cap is \$2.7 million × 1.0946 = \$3.0 million.

[3] Data presented in Part III suggest a lower variation among programs in actual expenditures on conservation.

negative bonus mechanism since losses are proportional to energy saved. Since we do not know the magnitude of this disincentive, we have not tried to combine it with the shared-savings program that is explicitly implemented.

Table 3 summarizes, on a normalized basis, the elements of costs that are included in the programs listed in Tables 2-A and 2-B. The cost categories in Table 3 are utility expenditures, utility transfers to consumers, customer costs, and evaluation costs. The third column in Table 3 shows actual program expenditures.[4] All of the programs in Tables 2-A and 2-B allow the utility to recover its expenditures, either by expensing or by including the expenditure in the rate base.[5] Actual program expenditures range from about $10 to $50 million on a normalized basis. Corrected for size, the most aggressive programs are the Massachusetts shared-savings and bonus incentives. Aggregating all incentive programs for each utility in Table 3, the incentives fall in a relatively narrow expenditure range of $13 to $21 million except for the Massachusetts programs.

Table 3 also shows considerable variation in the way conservation programs account for transfer payments between the utility and participating customers when evaluating net benefit. Three of the seven shared-savings programs in Table 3 include utility transfer payments in the net benefit. This practice understates the actual net benefit of a conservation program. PG&E, O&R, and Central Hudson Gas & Electric include utility transfers in net benefit but exclude customer costs. Excluding customer costs clearly overstates program net benefit, which may or may not be compensated for by the erroneous inclusion of utility transfer payments. Four of the seven shared-savings programs exclude transfer payments and include customer costs in the evaluation of net benefit. Approximately half of the utility programs listed in Table 3 include evaluation costs in the measure of net benefit. Issues associated with program evaluation are discussed in more detail in the measurement of program benefits.

Table 4-A provides avoided costs of energy and capacity for the selected programs. The values are generally consistent with the measures of marginal, rather than average, energy and capacity costs. The most important differences in the value of conserved energy for individual utilities are the inclusion or exclusion of an adder for environmental externalities and the size of the adder. Environmental externalities are only accounted for in New York, at a rate of $0.014-$0.016/kWh, and in Massachusetts, at $0.04/kWh. Table 4-A shows estimates of conserved energy and capacity from the shared-savings and bonus programs for each utility. These are ex ante technical estimates of the savings that are expected from the installation of equipment in 1991. Also shown in Table 4-A is an estimate of the present discounted avoided cost from these

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[4] The data in Table 3 are based on actual annual expenditures.

[5] The programs differ on the timing of recovery but include allowances for interest costs.

1991 installations. There is considerable variation in the expected savings from the different utility programs. Table 4-B shows the estimated savings on a normalized basis. The variance is greatly reduced, but there is still approximately a four-to-one range in savings estimates, excluding environmental adders. The range increases with environmental adders because of Massachusetts utilities' high estimate of expected savings and high environmental externality.

Table 5 is a summary of the expected net benefit of programs in place in 1991 and the incentive payments earned on these programs, all reported on a normalized basis. The data show a somewhat wider range of expected net benefit than the range of normalized costs reported in Table 4-B. Actual incentive payments also show a wide variation. Expressed as a percentage of expected net benefit, the incentive payments range from less than 2% to about 13%, with an average of about 6%.

Together, Tables 4 and 5 show that there is little relation, on either a normalized or nominal basis, between the magnitude of incentives and the level of expected energy savings.[6] This result is not surprising because energy savings depend on many factors, such as the characteristics of conservation opportunities and the experience of utility management, that are not accounted for in these tables.

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[6] The lack of a systematic relation between the size of incentives and energy savings is further confounded by the fact that there are many conservation programs in place where the utility is only allowed to expense costs (or to include costs in the rate base). These programs are not counted as incentive programs in our classification, yet there is no reason to believe that they are not successful in achieving positive net benefits.

Table 1. Utility Incentives and Expenditures

		Incentive and Expenditures in $ Millions								
		1990		1991		1992		Total		
		Inc.	Exp.	Inc.	Exp.	Inc.	Exp.	Inc.	Exp.	Ratio
CA	Pacific G&E	14.9	63.5	47.4	136.0	50.7	141.0	113.0	340.5	0.33
CA	San Diego G&E	9.2	17.0	10.7	36.0	7.1	45.0	27.0	98.0	0.28
CA	So. Calif. Edison	4.0	80.0	9.1	125.0	8.0	153.0	21.1	358.0	0.06
CA	So. Calif. Gas	1.3	52.0	3.7	59.0	6.0	59.0	11.0	170.0	0.06
CO	Public Service Co.	0.1	0.5	0.2	3.3	0.5	11.0	0.8	14.8	0.05
CT	United Illuminating	0.5	7.0	0.3	11.3	0.5	15.2	1.3	33.5	0.04
ME	Central Maine Power	0.0	0.0	3.0	17.0	3.0	25.0	6.0	42.0	0.14
MA	Mass. Electric	5.0	37.0	10.8	55.0	2.2	68.0	18.0	160.0	0.11
MA	Western Mass. Elec.	0.3	9.5	0.9	18.0	1.2	18.7	2.4	46.2	0.05
MI	Consumers Power	0.5	8.0	5.5	32.5	5.5	32.5	11.5	73.0	0.16
MN	Northern States	0.0	0.0	0.1	15.0	0.3	18.0	0.4	33.0	0.01
NH	Granite State Elec.	0.5	1.4	1.0	3.1	1.1	3.8	2.6	8.3	0.31
NY	Central Hudson G&E	0.0	4.5	0.7	7.0	2.2	18.0	2.9	29.5	0.10
NY	Con Edison	0.0	0.0	22.0	76.0	25.0	89.0	47.0	165.0	0.28
NY	Long Island Lighting	0.0	29.0	0.0	32.0	3.2	35.0	3.2	96.0	0.03
NY	New York State E&G	0.0	13.0	2.0	23.0	3.2	34.0	5.2	70.0	0.07
NY	Niagara Mohawk	1.5	7.6	9.0	45.0	7.0	58.0	17.5	110.6	0.16
NY	Orange & Rockland	0.0	0.0	2.7	9.0	NYA	10.0	2.7	19.0	0.14
NY	Rochester G&E	0.8	8.0	0.8	6.2	0.9	7.8	2.5	22.0	0.11
OR	Pacific Power & Light	0.0	0.0	0.3	0.4	0.3	0.4	0.6	0.8	0.75
OR	Portland GE	0.0	0.0	1.8	15.0	1.9	20.0	3.7	35.0	0.11
RI	Narragansett Electric	3.0	14.0	3.0	19.1	2.9	17.7	8.9	50.8	0.18
	Sum	42	352	133	744	131	880	306	1,976	15%
	Ratio	12%		18%		15%		15%		

NYA = Not Yet Available

The data for Table 1 are taken from the following sources: Barakat & Chamberlin, Inc., San Diego Gas & Electric, Utility DSM Shareholder Incentive Study (1991); Central Hudson Gas and Electric Company, Demand-Side Management: Annual Evaluation for the Period 6/1/90–5/31/91 and Estimated Results for the Period 6/1/91–5/31/92 (1991); Central Maine Power Company, Demand-Side Management Quarterly Report (1991); Massachusetts Electric Company, Demand-Side Management, Summary of Budget, Value, KW and KWh by Program (1991); Niagara Mohawk Power Corporation, 1990 Annual Evaluation Report: Demand-Side Management Program (1991); Niagara Mohawk Power Corporation, 1991 Annual Evaluation Report: Demand-Side Management Program (1992); Orange and Rockland Utilities, Inc., Program Evaluation (1992); Pacific Gas and Electric Company, Annual Summary Report on Demand-Side Management Programs in 1990 and 1991 (1992); Pacific Gas and Electric Company, Annual Summary Report on Demand-Side Management Programs in 1991 and 1992 (1992); Pacific Gas and Electric Company, Annual Report on Demand-Side Management Programs in 1991 and 1992: Technical Appendix (1992); United Illuminating Company, Energy Action '92 (1992); San Diego Gas and Electric Company, Annual Summary of Demand-Side Management Activities (1992); Southern California Edison, Demand-Side Management: Annual Report, 1991 Results and 1992 Plans (1992); Southern California Edison, Demand-Side Management: Technical Appendix, 1991 Results (1992); Western Massachusetts Electric Company, Application for Pre-Approval for Conservation and Load Management Program Costs and Recovery (1992) (sources on file with the authors).

Table 2-A. Thirteen Incentive Mechanisms

All Programs		Incentive Mechanism ($ million)				
Utility	State	Mechanism	Region (Described in Terms of Net Benefit)	Incentive Cap[1]	Share λ	Fixed Charge ϕ
PG&E, 1991	CA	Shared Savings	$226 ≤ NB	$53.0	15%	0
			$151 ≤ NB < $226		0%	0
			NB < $151		15%	$15.0
		Markup	All Outcomes	$2.6	5%	0
SDG&E, 1990-91	CA	Shared Savings	$12 ≤ NB	$5.0 Total	33.5%[2]	0
			NB < $12		40%	$4.80
		Bonus	All Outcomes		9%	0
		Markup	All Outcomes		5%	0
SCE, 1990	CA	Variable Bonus	$71 ≤ NB	none	0%	0[4]
			NB < $71		17.6%[3]	$20.1[4]
		Variable Markup	75% ENB ≤ NB[5]	none	5%	0
			NB < 75% ENB		Variable	0
CHG&E, 1990-91	NY	Shared Savings	All Outcomes	$.76	20%	0
NiMo, 1990-91	NY	Shared Savings	All Outcomes	none	10%	none
O&R, 1991	NY	Shared Savings	$6 ≤ NB	$2.8	17.5%[6]	0
			NB < $6		10%	$.62
Mass Elec., 1992	MA	Shared Savings[7]	$0 ≤ NB[8]	none	6.7%	0
			NB < $0		100%	0
WMECO, 1990	MA	Bonus[9]	$16 ≤ NB	none	3.6%[10]	$.58
			NB < $16		0%	0
CMP, 1991	ME	Shared Savings	$10 ≤ NB	$2.7 Total	7.5%	$.80
			$0 ≤ NB < $10		0%	0
			NB < $0		10%	0

Table 2-B. Thirteen Incentive Mechanisms with Normalized Values

All Programs		Incentive Mechanism ($ million)				
Utility	State	Mechanism	Region (Described in Terms of Net Benefit)	Incentive Cap[1]	Share λ	Fixed Charge ϕ
PG&E, 1991	CA	Shared Savings	$32 ≤ NB	$7.4	15%	0
			$21 ≤ NB < $32		0%	0
			NB < $21		15%	$2.15
		Markup	All Outcomes	$0.4	5%	0
SDG&E, 1990-91	CA	Shared Savings	$8 ≤ NB	$3.5 Total	33.5%[2]	0
			NB < $8		40%	$3.30
		Bonus	All Outcomes		9%	0
		Markup	All Outcomes		5%	0
SCE, 1990	CA	Variable Bonus	$10 ≤ NB	$0.0	0%	0[4]
			NB < $10		17.6%[3]	$2.91[4]
		Variable Markup	75% ENB ≤ NB[5]	none	5%	0
			NB < 75% ENB		Variable	0
CHG&E, 1990-91	NY	Shared Savings	All Outcomes	$1.3	20%	0
NiMo, 1990-91	NY	Shared Savings	All Outcomes	none	10%	0
O&R, 1991	NY	Shared Savings	$13 ≤ NB	$6.1	17.5%[6]	0
			NB < $13		10%	$1.40
Mass Elec., 1992	MA	Shared Savings[7]	$0 ≤ NB[8]	none	6.7%	0
			NB < $0		100%	0
WMECO, 1990	MA	Bonus[9]	$42 ≤ NB	none	3.6%[10]	$1.5
			NB < $42		0%	0
CMP, 1991	ME	Shared Savings	$11 ≤ NB	$3.0 Total	7.5%	$0.90
			$0 ≤ NB < $11		0%	0
			NB < $0		10%	0

Abbreviations: PG&E is Pacific Gas and Electric. SDG&E is San Diego Gas and Electric. SCE is Southern California Edison. CHG&E is Central Hudson Gas and Electric. NiMo is Niagara Mohawk Power Corporation. O&R is Orange and Rockland Utilities Inc. Mass Elec. is Massachusetts Electric. WMECO Western Massachusetts Electric Company. CMP is Central Maine Power.

The data for Table 2-B are taken from the following sources: BARAKAT & CHAMBERLIN, INC., SAN DIEGO GAS & ELECTRIC, UTILITY DSM SHAREHOLDER INCENTIVE STUDY (1991); CENTRAL HUDSON GAS AND ELECTRIC COMPANY, DEMAND-SIDE MANAGEMENT: ANNUAL EVALUATION FOR THE PERIOD 6/1/90–5/31/91 AND ESTIMATED RESULTS FOR THE PERIOD 6/1/91–5/31/92 (1991); CENTRAL MAINE POWER COMPANY, DEMAND-SIDE MANAGEMENT QUARTERLY REPORT (1991); MASSACHUSETTS ELECTRIC COMPANY, DEMAND-SIDE MANAGEMENT, SUMMARY OF BUDGET, VALUE, KW AND KWh BY PROGRAM (1991); NIAGARA MOHAWK POWER CORPORATION, 1990 ANNUAL EVALUATION REPORT: DEMAND-SIDE MANAGEMENT PROGRAM (1991); NIAGARA MOHAWK POWER CORPORATION, 1991 ANNUAL EVALUATION REPORT: DEMAND-SIDE MANAGEMENT PROGRAM (1992); ORANGE AND ROCKLAND UTILITIES, INC., PROGRAM EVALUATION (1992); PACIFIC GAS AND ELECTRIC COMPANY, ANNUAL SUMMARY REPORT ON DEMAND-SIDE MANAGEMENT PROGRAMS IN 1990 AND 1991 (1992); PACIFIC GAS AND ELECTRIC COMPANY, ANNUAL SUMMARY REPORT ON DEMAND-SIDE MANAGEMENT PROGRAMS IN 1991 AND 1992 (1992); PACIFIC GAS AND ELECTRIC COMPANY, ANNUAL REPORT ON DEMAND-SIDE MANAGEMENT PROGRAMS IN 1991 AND 1992: TECHNICAL APPENDIX (1992); UNITED ILLUMINATING COMPANY, ENERGY ACTION '92 (1992); SAN DIEGO GAS AND ELECTRIC COMPANY, ANNUAL SUMMARY OF DEMAND-SIDE MANAGEMENT ACTIVITIES (1992); SOUTHERN CALIFORNIA EDISON, DEMAND-SIDE MANAGEMENT: ANNUAL REPORT, 1991 RESULTS AND 1992 PLANS (1992); SOUTHERN CALIFORNIA EDISON, DEMAND-SIDE MANAGEMENT: TECHNICAL APPENDIX, 1991 RESULTS (1992); WESTERN MASSACHUSETTS ELECTRIC COMPANY, APPLICATION FOR PRE-APPROVAL FOR CONSERVATION AND LOAD MANAGEMENT PROGRAM COSTS AND RECOVERY (1992) (unpublished manuscripts, on file with the author).

Notes to Tables 2-A and 2-B

1. All programs also have expenditure caps.
2. The high share value is compensated for by an artificially low value for avoided cost. See text for explanation.
3. The share value derived from holding program costs fixed. The tax markup factor was excluded for analytical simplicity.
4. The fixed charge is calculated with the assumption that rate of return is equal to the utility's cost of capital.
5. The expected Net Benefits (ENB) and Net Benefits (NB) are based on number of units installed.
6. The incentive can range from a ninety basis point upward adjustment of ROE to a downward adjustment of twenty basis points. A change in one basis point equals approximately a $30,800 change in ROE. The exact amount of incentive depends on the combination of energy and resource savings achieved. According to Barakat and Chamberlin, the maximum potential incentive is 17.5% of net resource savings.
7. The Massachusetts Electric Company is the only utility in this table that does not provide a lost-revenue recovery mechanism. Consequently, there is an implicit bonus mechanism being subtracted from the explicit shared-savings mechanism reported here. We are currently unable to determine the strength of this negative incentive component.
8. In the neighborhood of NB=0, the incentives vary slightly from those listed here, but the differences are slight enough that they do not significantly alter the structure of the incentive.
9. The net benefit for this bonus program is calculated as the difference between the avoided cost value of threshold energy and capacity savings and program expenditures. If the utility does not achieve the threshold savings levels, it is not eligible to earn an incentive.
10. For WMECO, we calculated the marginal share (λ) by estimating the corresponding increase in the incentive given a one dollar increase in avoided costs.

Table 3. Program Expenditures and Definitions of Net Benefit

All Programs			Included in Net Benefit?[1]			
Utility	Program	Normalized Utility Expenditure ($ million)	Utility Transfers to Customers	Customer Costs	Evaluation Costs	When Measured
PG&E	Shared Savings	$9.98	Yes	No	No	Ex Ante
	Markup	$7.70	NA	NA	NA	NA
SDG&E	Shared Savings	$12.44	No	Yes	No	Ex Ante
	Bonus[2]	$0.39	No	Yes	No	NYA
	Markup[2]	$3.19	No	Yes	No	NYA
SCE	Variable Bonus[2]	$8.54	Yes	No	No	Ex Ante
	Variable Markup[2]	$4.43	Yes	No	NYA	NYA
CHG&E	Shared Savings	$19.28	Yes	No	Yes	Ex Post
NiMo	Shared Savings	$12.95	No	Yes	Yes	Ex Post
O&R	Shared Savings	$20.43	Yes	No	Yes	Ex Ante
Mass. Elec.	Shared Savings	$49.20	No	Yes	Yes	Ex Post
WMECo.	Bonus†	$40.21	No	Yes	Yes	Ex Post
CMP	Shared Savings	$20.94	No	Yes	Yes	Ex Post

Table 3 is drawn from the same sources as Table 1.

Notes to Table 3

1. The net benefit always includes avoided cost and direct program expenditures, but may or may not include the three items examined here: transfers, unreimbursed customer costs, and program evaluation costs.

2. Many utilities compute net benefit even though it is not used as part of the incentive calculation.

Table 4-A. Cost and Savings

Shared-Savings and Bonus Programs		Avoided Costs in 1992					Lifetime Savings (1991 Programs)		Total PDV Avoided Costs ($ M)
		$/kWh				$/kW-yr			
Utility	Mechanism	On Peak	Off peak	Env. Adder	Avg. Total	Capacity	GWh	MW-yr	
PG&E	Shared Savings	.035	.030	.000	.032	42.12	7,241	1,453.0	426.5
SDG&E	Shared Savings	.040	.030	.000	.033	81.54	985	17.2	48.2
	Bonus	.040	.030	.000	.033	81.54	137	3.2	1.3
SCE	Variable Bonus	.041	.031	.000	.034	96.90	2,664	1306.7	183.4
CHG&E	Shared Savings	.048	.048	.015	.063	26.28	376	35.5	23.4
NiMo	Shared Savings	NA	NA	.016	.050	0.00	2,000	NA	100.0
O&R	Shared Savings	.027	.027	.014	.041	16.64	NYA	NYA	NYA
Mass. E.	Shared Savings	NA	NA	.040	.091	31.32	1,573	654.7	130.4
WMECo.	Bonus	NA	NA	.040	.092	41.48	708	228.9	6.71
CMP	Shared Savings	.046	.023	.000	.030	69.26	409	8.0	32.0

NA = Not Available NYA = Not Yet Available

Note to Table 4-A

This table is based on both a 37.6 GWh reported annual energy savings over a ten-year program lifetime and a 200 GWh average annual savings over an assumed average ten-year program lifetime.

Table 4-B. Total Savings: Normalized

Shared-Savings & Bonus Programs		Normalized Total Savings		Normalized Total $ Avoided Cost	
Utility	Mechanism	GWh	MW	Environmental Adder Included ($ million)	Environmental Adder Excluded ($ million)
PG&E	Shared Savings	1,030	206	62.09	62.09
SDG&E	Shared Savings	684	12	33.33	33.33
	Bonus	95	2	.88	.88
SCE	Variable Bonus	386	189	26.54	26.54
CHG&E	Shared Savings	671	63	41.79	31.75
NiMo	Shared Savings	579	0	31.15	23.38
O&R	Shared Savings	NYA	NYA	NYA	NYA
Mass. Elec.	Shared Savings	1,014	422	83.13	55.85
WMECo.	Bonus	1,863	602	176.54	123.13
CMP	Shared Savings	449	9	35.20	35.20

NYA = Not Yet Available

Normalization adjusts for variations in utility size measured in TWh/year. This table is drawn from the same sources as Table 1.

Table 5. Normalized Incentives

Shared-Savings and Bonus Programs		Net Benefit	Incentive	Incentive per $ Saved[1]	
Utility	Mechanism	($ million)	($ million)	With Envir. Adder	Without Envir. Adder
PG&E	Shared Savings	52.63	7.89	.127	.127
SDG&E	Shared Savings	24.47	3.36	.101	.101
	Bonus	.89	.08	.090	.090
SCE	Variable Bonus	17.95	.71	.026	.026
CHG&E	Shared Savings	24.70	5.12	.122	.160
NiMo	Shared Savings	23.32	2.33	.075	.110
O&R	Shared Savings	NYA	NYA	NYA	NYA
Mass. Elec.	Shared Savings	43.90	1.41	.017	.025
WMECo.	Bonus	130.80	3.19	.018	.026
CMP	Shared Savings	14.26	1.07	.030	.030

NYA = Not Yet Available

This table is drawn from the same sources as Table 1.

Note to Table 5

[1] The incentive rate is calculated as the incentive payment divided by total savings.

Appendix B

An Analysis of Four Actual Incentive Mechanisms

The first set of mechanisms examined in this Appendix demonstrates the unnecessary complexity of many incentives currently in use. A second set of mechanisms that have been complicated to the point at which they no longer fit the classification scheme of this Article, show no apparent economic justification.

Pacific Gas and Electric's (PG&E) and San Diego Gas and Electric's (SDG&E) shared-savings programs both suffer from needless complexity. PG&E has adopted a nonlinear approach that results in a wildly fluctuating marginal incentive. SDG&E has adopted a complex formula that seems to promise subtle motivational benefits but under the application of elementary algebra can be seen to reduce to the standard shared-savings formula with a strangely low value for avoided cost.

The 1991 shared-savings mechanism of PG&E makes the incentive payment a nonlinear function of net benefit. The incentive payment jumps from zero to about $34 million when net benefit reaches 75% of "expected net benefit" (ENB). There is no incentive payment between 50% and 75% of ENB. Below 50% of ENB, PG&E must pay a penalty equal to .15(NB − .5ENB). The penalty region and the normal region above 75% of ENB have the same λ, and in the middle dead band region the incentive vanishes. At the right end of the dead band, the marginal incentive jumps from zero to infinity which does not result in overly high payments but does create extraordinarily large incentives for crossing the 75% boundary. A rationale for such changes in the incentive level is hard to imagine.[7]

In the 1990-91 SDG&E's mechanism, incentives are calculated differently according to whether net benefit exceeds or falls short of a minimum performance target (MPT). When net benefit is below MPT the mechanism is

$$I = 0.4\ NB - 0.4\ MPT,$$

which clearly fits the definition of a shared-savings mechanism with Φ defined as 0.4MPT. However, at higher levels of net benefit the SDG&E mechanism is most directly represented by the following formula:

$$I = 0.135NB + 0.2Q(OTC - G/Q)$$

The first component is a standard shared-savings incentive, but the second part's inclusion of "original target cost,"[8] OTC, program costs, G, and con-

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[7] Experience with expenditures on conservation incentive programs shows that the utility is far more likely to be the normal region than in the dead band or penalty region.

[8] SDG&E calculates the second component of this formula using first year energy savings. However, using lifetime savings in lieu of first year savings yields identical results. Here we apply lifetime savings in both components of the incentive formula for analytical simplicity.

served energy, Q, appears to introduce a whole new type of incentive. However, with the application of simple algebra this equation can be rewritten as

$$I = 0.335(\hat{a}Q - G),$$

which is just ordinary shared savings with a zero fixed charge, Φ, and an unusually low value for the avoided cost of conserved energy, $\hat{a}$. The value used is a weighted average of the avoided cost and the original target cost, with the weights chosen to favor the OTC.[9] In summary, this mechanism collapses to a shared-savings formula, except that conserved energy is, in most cases, compensated at an atypically low rate.

Two of the utility programs summarized in Appendix A use incentive mechanisms that do not fit any of the three categories described in this Article. The mechanisms are presented here to illustrate the random diversity that characterizes this area of regulation. Neither mechanism provides a useful improvement over the current standard mechanisms.

Orange and Rockland (O&R) is the first example of a mechanism that does not fit within our classification scheme. Its 1991 incentive formula is discontinuous at Q_{40}, 40% of the utility's energy savings goal. For savings below this level, the mechanism is a pure bonus scheme, although the payment is negative. For higher values of savings, the incentive is a hybrid bonus/shared-savings formula. In this region, the incentive is proportional to the product of net benefit and saved energy, and is represented algebraically by the following equation:

$$I = \lambda Q(aQ - G)$$

This is simply the first term in the shared-savings formula multiplied by Q, conserved energy. This mechanism makes the incentive payment depend on the square of saved energy. Consequently, the incentive function is nonlinear and becomes steeper as energy savings increase. Since it is steepness that provides motivation, motivation increases with energy saved. It is not clear that this is desirable, but the mechanism is different.

The 1990 Southern California Edison incentive plan provides another exception to our classification. The mechanism is represented in its simplest form below:

$$I = (\lambda_1 Q - \lambda_2)G$$

Q is energy saved and G is program expenditure. A notable feature of this incentive is that its maximum is zero. The maximum is paid whenever savings

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[9] The value of $\hat{a}$ is given by (13.5(a) + 20 OTC)/33.5, where (a) is a best estimate of San Diego's avoided cost equal to about 4.5 ¢/kWh, and OTC ranges from about 0.4 ¢/kWh to 5.4 ¢/Kwh depending on the program.

are at least 75% of the target level. Below that level, the above formula takes effect. Although an incentive with no upside is unusual, this particular feature does not violate our classification scheme. The violation results from the incentive being partly based on the product of savings and costs.[10]

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[10] The Edison program allows the company to include its expenditures in the rate base. This inclusion may provide a positive incentive if the allowed rate of return exceeds the cost of capital and if the company achieves a sufficiently high percentage of its target savings.