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RECEIVED
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PUBLIC SERVICE COMMISSION

August 8, 2007

Beth A. O'Donnell
Executive Director
Public Service Commission
PO Box 615
Frankfort, KY 40602-0615

RE: Case No. 2006-00472

Dear Ms. O'Donnell:

Please find enclosed for filing with the Commission in the above-styled proceeding an original and ten (10) copies of the responses of the Cumberland Chapter of the Sierra Club to the first data request of the Commission staff. A copy of this document has been mailed to all parties listed on the attached Certificate of Service.

Sincerely,

Stephen A. Sanders

Stephen A. Sanders
Director

SAS:dek
Enclosure as stated

cc: Parties of Record

CERTIFICATE OF SERVICE

I hereby certify that an original and ten copies of the foregoing responses to the first data request of the Commission staff to the Sierra Club were delivered to the office of Beth A. O'Donnell, Executive Director of the Kentucky Public Service Commission, 211 Sower Boulevard, Frankfort, KY 40601, for filing in the above-styled proceeding and that copies were mailed to the following Parties of Record on this, the 8th day of August, 2007.

Hon. Dennis Howard
Assistant Attorney General
Office of the Attorney General
Utility & Rate Intervention Division
1024 Capital Center Drive, Suite 200
Frankfort, KY 40601-8204

Hon. Michael L. Kurtz
Attorney at Law
Boehm, Kurtz & Lowry
36 East Seventh Street, Suite 1510
Cincinnati, OH 45202- 4434

Hon. Charles A. Lile
Senior Corporate Counsel
East Kentucky Power Cooperative, Inc.
4775 Lexington Road
P.O. Box 707
Winchester, KY 40392-0707

Stephen A. Sanders,
COUNSEL FOR THE SIERRA CLUB

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August 8, 2007

Charles A. Lile, Esq.
Senior Corporate Counsel
East Kentucky Power Cooperative
PO Box 707
Winchester, KY 40392-0707

RE: Case No. 2006-00472

Dear Mr. Lile:

Please find enclosed a copy of the responses of the Cumberland Chapter of the Sierra Club to the first data request of the Commission staff in the above-styled proceeding. A copy of this document has been mailed to all parties listed on the attached Certificate of Service.

Sincerely,

Stephen A. Sanders
Attorney at Law

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August 8, 2007

Dennis Howard, Esq.
Assistant Attorney General
Office of the Attorney General
Utility & Rate Intervention Division
1024 Capital Center Drive, Suite 200
Frankfort, KY 40601-8204

RE: Case No. 2006-00472

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August 8, 2007

Michael L. Kurtz, Esq.
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RE: Case No. 2006-00472

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Sincerely,

Stephen A. Sanders
Attorney at Law

SAS:dek
Enclosure as stated

cc: Parties of record

COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

GENERAL ADJUSTMENT OF ELECTRIC	)	CASE NO.
RATES OF EAST KENTUCKY POWER	)	2006-00472
COOPERATIVE, INC.	)	

RESPONSES OF THE CUMBERLAND CHAPTER OF THE SIERRA CLUB TO THE FIRST DATA REQUEST OF THE COMMISSION STAFF DATED JULY 25, 2007

DATE SUBMITTED: AUGUST 8, 2007

DATA REQUEST RESPONSES BY THE SIERRA CLUB

PSC CASE NO. 2006-00472

PSC STAFF'S FIRST DATA REQUEST DATED JULY 25, 2007

RESPONSIBLE PERSON: Geoffrey M. Young

Request 1.

Refer to the Prepared Testimony of Geoffrey M. Young ("Young Testimony"), page 8 of 41.

Request 1a.

Provide printed copies of the report Mr. Young discusses authored by David Moskovitz entitled "Profits and Progress Through Least-Cost Planning," November, 1989.

Response 1a.

A copy of the entire report is attached.

Request 1b.

The referenced report, "Profits and Progress Through Least-Cost Planning" authored by David Moskovitz, was published 18 years ago. Has Mr. Moskovitz issued any updates or revisions to this report since 1989? If yes, provide printed copies of the updates or revisions.

Response 1b.

Not to my knowledge. The problem is that in the intervening 18 years, very few public utility commissions have developed adequate solutions to the problem of perverse financial incentives that he noted and described so clearly in the late 1980s.

PROFITS & PROGRESS

THROUGH LEAST-COST PLANNING

DAVID MOSKOVITZ
Energy and Regulatory Consultant
Hollywood Boulevard
Alna, Maine 04535
207-586-5838

Foreword by
John Rowe; President
New England Electric System

November, 1989

**National Association of
Regulatory Utility Commissioners
Room 1102 ICC Building; P.O. Box 684
Washington, D.C. 20044**

Telephone No. (202) 898-2200

FOREWORD

By John Rowe
President & Chief Executive Officer
New England Electric System

In "Sir Gawain and the Loathly Lady," high king and chevalier must save no less than the peace of the kingdom and the pleasures of matrimony. While properly daunted by threats of at least greenhouse magnitude, they succeed, through painfully coming to understand that every woman wants her own way. In this white paper, NARUC transcends several sorts of chauvinism and applies similar wisdom to utility executives. That is none to soon, but wisdom is at least as remote on my side of the regulatory woods.

For most of our century, utility management has held to the faith that its product is fundamental to the social and economic well being of society, with positive externalities outweighing any possible negative ones. (This is provided, of course, that we can supply that product in our own way.) For several decades, a growing majority in NARUC has been building a new faith, now called least-cost planning, in which electric service is maintained (it is said) while growth in the consumption of electricity is radically curtailed through utility investment in customer energy efficiency. Meanwhile, the agnostic public (my customers - NARUC'S constituency) has voted for increased electricity supplies with its power switches and, increasingly, voted against such supplies with its ballots. No one is getting his or her own way.

Such discontent is hardly shocking. Public policies are not clear and the incentives to both consumers and producers are not consistent with the apparent trend of those policies (surprised anyone?). While environmental concerns jab at the consciences of commissioners, constrained electricity rates encourage the consumers to use more electricity. The utility is told to sell less of its chosen product and to provide a service it claims no unique ability to deliver. It must do this without being offered additional profit and often without being assured of cost recovery. Slowly, lashed by the misused slogan "duty to serve," utilities respond, but the overall results are credible to no one.

NARUC's 1988 policy statement - "a utility's least-cost plan for consumers should be its most profitable course of conduct" - provided fundamental recognition that the system of financial rewards must be made consistent with today's public policy objectives. This white paper provides a framework for achieving that consistency. Indeed, the words at the beginning of Section 2 should become a common creed for every commissioner and utility executive. Of course, I would quibble with details of this white paper, such as the suggestion that symmetrical treatment is an incentive instead of a minimum right, and the hint that suppressing utility profits is more important than the cost or quality of electric service. There is no time to quibble, however. The policies of the states my companies serve and the interests of those companies require that the theme of this report be implemented.

Successful proposals to implement the NARUC resolution should have the following hallmarks:

> They should be experimental. They should address most of the issues raised in this report, but should not purport to do so for all of the time.
>
> They should be modest. Success should provide retail companies with enough additional earnings to overcome the existing disincentives to the pursuit of energy efficiency.
>
> They should be direct. Utility managers must see immediate rewards.
>
> They should be powerful. Conservation, which for now appears the least-cost component of energy supply plans, must be the most profitable component.

I have had the privilege of leading two utilities with outstanding reputations for conservation efforts. But, neither has exhausted the conservation potential which commissioners and environmental groups believe exists. Incentive measures which are genuinely attractive to utilities provide the necessary means to develop the real potential, whatever it may be. Such incentive measures are equally necessary to obtain public credibility for least-cost planning.

ACKNOWLEDGEMENTS

I greatly appreciate the advice and assistance provided by so many people. To name just a few, Steve Weil, Cheryl Harrington, Joe Eto, Charles Goldman, Ralph Cavanagh, plus all of the usual suspects. Of course, thanks to DOE and the Conservation Committee and Subcommittee for the initiative to undertake this work and for the many useful comments and suggestions along the way.

TABLE OF CONTENTS

SUMMARY

In the broadest sense, this paper discusses issues relating to the earnings implications which flow from the pursuit of least-cost plans. More narrowly, however, the issues, discussion, and conclusions apply with equal force whenever a utility implements cost-effective demand-side measures, whether as part of a least-cost plan or not. To a lesser extent, the paper addresses how these issues relate to many supply-side options, particularly cogeneration and renewable resources.

Least-cost planning (LCP) is a process of examining all electricity-saving and electricity-producing options to select a mixture of options that minimizes total consumer cost, often including consideration of environmental concerns and other responsibilities.

Standing between LCP the idea, and LCP the practical reality, is the fact that the utility industry is responds rationally to its economic environment, a response which is strongly skewed against LCP. The same can be said of utility investment in energy efficiency; it is a clear public policy and regulatory goal, but it is not being pursued in an aggressive fashion. The reason is clear. Traditional regulation creates a strong economic disincentive to the utilities' implementation of least-cost plans or investment in energy efficiency programs. Indeed, the ratemaking process generally used in most states has the following unintended, but nevertheless perverse, incentives.

* Each KWH a utility sells, no matter how much it costs to produce or how little it sells for, adds to earnings.

* Each KWH saved or replaced with an energy efficiency measure, no matter how little the efficiency measure costs, reduces utility profits.

* The only direct financial aspect of regulation that encourages utilities to pursue cost effective conservation opportunities is the risk that if they fail to satisfy regulators costs may be disallowed.

* No matter how cost effective, purchases of power from cogeneration, renewable resources, or other non-utility sources add nothing to utility profits.

The incentives and disincentives created by traditional regulation flow from the interaction of accounting conventions, legal and procedural matters such as regulatory lag and retroactive ratemaking, and more recent additions to regulation such as fuel adjustment clauses. Whatever the cause, the incentives embedded in the current system of regulation present a serious obstacle to the successful implementation of least-cost planning (LCP).

In a Resolution approved in July, 1989, NARUC concluded that regulatory reform was

needed to remove the disincentives to LCP and to make the successful implementation of a utility's least cost-plan its most profitable course of action. (See appendix C for the text of the Resolution.) It follows, therefore, that the single, overarching standard against which proposed incentive plans should be measured lies in the answer to this question:

> Viewed from the perspective of the utility, what course of action would be consistent with a profit-maximizing strategy?

Identifying a profit-maximizing strategy is the most important test of any incentive proposal, but other considerations are also quite important and should be given serious attention while developing or selecting the best plan for each state. These considerations, in general order of importance, are as follows:

Decoupling profits from sales;
Cost minimization;
Administrative simplicity;
Fuel switching;
Balance;
Predictability;
Environmental costs;
Non-participant impacts;
Skimming the cream;
Avoiding gaming; and
Distribution of incentives.

Incentive proposals have been grouped into three general categories based on the approach taken. The categories are:

Rate-of-Return Adjustments,
Shared Savings, and
Bounty.

For each of the approaches, sets of performance criteria are available to address one or more special concerns. All possible modifications to each approach have not been described. For the most part, regulators may mix and match different components of incentive plans until a desirable group of features is found.

To produce a reasonable profit-maximizing strategy, it will be necessary to decouple profits from sales. Under current regulation, increased sales always mean increased profits. As long as every incremental KWH sold adds to profits, the strong likelihood remains that a profit-maximizing strategy will lead to more sales and less DSM, even if DSM programs are profitable.

Because the ability of an incentive plan to decouple profits from sales is critical to a plan's success, a fourth and separate category of decoupling options is discussed. These decoupling options can be combined with any of the incentive plans to produce an overall package of regulatory reforms.

Conclusion

The following table presents a summary of the conclusions reached in this section. Listed across the top of the table are different assumptions of how state regulation might be structured. For example, the first column, "W/O Decoupling, W/O DSM Cost Recovery," describes a state which has not adopted revenue reconciliation mechanisms such as California's Electric Revenue Adjustment Mechanism (ERAM), or any of the other decoupling options, and which has no separate mechanism for recovery of DSM program costs. This means that the incentive plan selected must be capable of decoupling profits from sales while giving reasonable treatment to DSM program costs. Next, proceeding down the rows summarizes the capabilities of alternative incentive plans to produce a desirable result given the assumed status of regulation. A "yes" (Y) response means the incentive approach is a good candidate and attention should turn to the various ways to implement the general approach. A "no" (N) response means the approach is not a good candidate and a "maybe" (M) response means the capability of the approach to perform well depends on other matters.

This White Paper provides commissioners and commission staff with the background and framework needed to move forward with needed regulatory reforms. The remainder of the effort will be pursued with individual utilities in each state.

Clearly, the complexities and variations in regulation and the many factors in addition to regulation that influence utility decision-making and behavior cannot be distilled into one simple conclusion such as "fix the incentives." It would be as naive as it is tempting to say that all that is necessary is to fix the incentives and least-cost planning and energy efficiency will abound. Indeed, the disincentives are so potent that it would be even more naive to believe that least-cost planning or any significant investment in energy efficiency would be a reality without regulatory reform.

A debate, however, about the need for regulatory reform is a debate about the wrong question. Rather, the financial incentives of the existing system should be understood and compared with regulatory and legislative goals. Then, the debate should be about the gains and purposes served, and the beneficiaries of retaining the current system.

<u>*SUMMARY*</u>

ALTERNATIVE INCENTIVE PLANS

Features of State Regulation	W/O Decoupling W/O DSM Cost Recovery	W/Decoupling W/O DSM Cost Recovery	W/O Decoupling W/DSM Cost Recovery	With Decoupling W/DSM Cost Recovery
Rate-of-Return Overall	Y	Y	Y	Y
Rate-of-Return DSM	N	N	N	Y
Rate-of-Return Bills	Y	Y	Y	Y
Shared Savings Resource	N	M (See Note 2)	M (See Note 2)	Y
Shared Savings Bill	M (See Note 2)	Y	M	Y
Bounty	M (See Note 2)	Y	Y	Y

<u>NOTES:</u>

Y - Yes, the approach can produce the right incentives.

N - No, the approach cannot produce the right incentives.

M - Maybe. Under some conditions the approach can be made to produce reasonable incentives.

(Note 1: This approach can address all costs only if average fuel costs exceed marginal fuel costs, which is rarely the case. Otherwise, the approach is sufficient only for low-cost measures.)

(Note 2: This approach is capable only for very low-cost DSM measures and very low-cost revenues.)

All cases assume the use of actual rather than estimated savings.

SECTION 1 -- THE PROBLEM

1.0 OVERVIEW

In the global race for energy efficiency the United States ranks 9th out of the 10 industrialized OECD nations.[1] We use twice as much energy to produce a dollar of GNP as Japan, West Germany, or Sweden. Only about half of the differences in energy use can be explained by factors that do not relate to energy efficiency. Responsible estimates show that cost-effective technologies available today can cut the nation's energy use by 20% (EPRI)[2] to 75% (Lovins)[3] without lifestyle changes or lower GNP growth.

Adopting cost effective energy efficiency as the nation's investment strategy would reduce the United States' annual energy bill by $27 to $120 billion. A savings of this magnitude would produce a substantial improvement in the global competitiveness of U.S. business and industry, our trade deficit, and our dependence on foreign oil.

In the coming decade, when energy policy will be increasingly driven by national and global environmental responsibilities, increased energy efficiency will result in direct and immediate benefit to the environment. Electric utilities now account for 20% of the gases linked to the atmospheric greenhouse effect, 70% of the nation's sulphur dioxide and 33% of the nitric oxide emissions that cause acid rain, and 50% of all nuclear waste.[4] Increasing the efficiency of our energy use, particularly electricity, can produce substantial environmental and health benefits at a fraction of the cost of adding pollution-control equipment or other mitigating approaches.

A growing number of policy makers and utility regulators are pursuing "least-cost planning" (LCP) in the battle against environmental and efficiency problems. LCP is a process of examining all electricity-saving and electricity-producing options to select a mixture of options that minimizes total consumer cost and that includes consideration of environmental concerns and other spheres of responsibility.

While least-cost planning principles have come a long way and have been adopted by a

---

[1] *"Building on Success! The Age of Energy Efficiency," Worldwatch Paper No. 82, March, 1988.*

[2] *"Impact of Demand-Side Management on Future Customer Electricity Demand," Electric Power Research Institute (EPRI), EPRI EM-4815-SR, October, 1986*

[3] *"The Great Demand-Side Bidding Debate Rages On." by Amory Lovins, Electricity Journal, Vol. 2, No. 2, March, 1989.*

[4] *"Acid Rain: Science and Control Issues," Environmental & Energy Study Institute, Washington, D.C., July, 1989; "Breathing Easier: Taking Action on Climate Change, Air Pollution, and Energy Insecurity," World Resources, Inc., Washington, D.C., 1989.*

majority of states, the most vexing problem remains.[5] Specifically, how do regulators translate talk and ideas into action? Restated, how do we ensure that electric utilities fully embrace and implement least-cost planning in their own planning and investment decisions?

The impediment between LCP the idea, and LCP the practical reality, is the fact that the utility industry is responding rationally to its economic environment. Traditional state rate-setting regulation provides a strong economic disincentive to the utilities' implementation of least-cost plans or investment in energy efficiency programs. In particular, the demand-side elements of least-cost plans remain slighted. Indeed, the ratemaking process generally used in most states has the following unintended, but nevertheless perverse incentives.[6]

INCENTIVES INHERENT IN TRADITIONAL REGULATION

1) Each KWH a utility sells, no matter how much it costs to produce or how little it sells for, adds to earnings.

2) Each KWH saved or replaced with an energy efficiency measure, no matter how little it costs, reduces utility profits.

3) The only direct financial aspect of regulation that encourages utilities to pursue cost-effective conservation is the risk that dissatisfied regulators may disallow costs.

4) Purchases of power from cogeneration, renewable resources, or other non-utility sources add nothing to utility profits, no matter how cost-effective they are.

These incentives are inconsistent with otherwise efficient investment by utilities in conservation or many supply-side options. While none were the conscious creation of the rate setting process as it evolved over the last century, these incentives are real and powerful, much so that little progress toward implementing large scale efficiency programs can be expected in an environment controlled by such powerfully opposing economic forces.

Regulators rightly insist upon the implementation of least-cost planning, but regulators also rule over a process which rewards utilities financially when they sell more power. Least-cost

---

[5] *According to EPRI Report # RP 2982-02, 43 States are either employing least-cost planning or are in the process of implementing a least-cost process.*

[6] *Throughout this paper, the terms "earnings" and "profits" are used interchangeably. Except where the context is clearly to the contrary, adding or subtracting from earnings or profits refers to the incremental change in earnings or profits, not the absolute level of either. It matters not whether earnings or profits are 8% or 16%, or whether earnings or profits are above or below an allowed rate-of-return. In all instances, the paper focuses on the incremental increase or decrease in earnings (or profits) that flows from a specified course of conduct.*

planning is likely to find little real success until ways are found to eliminate these mixed messages and align the financial interest of the utility industry with the goals of least-cost planning.

Finally, while the debate over which cost effectiveness test to apply to conservation investments may continue in a few states, the absurdity of the incentives inherent in the current regulatory process persists, and the need for reform is largely unaffected by who wins. Even if a commission selects the most restrictive definition of cost effectiveness, the fact remains that without regulatory reform, cost-effective conservation is unprofitable and every KWH sold adds to profits. Taking action to align the incentives should not be delayed.

1.1 THE DETAILS

What is it about the traditional rate setting process that produces all the wrong incentives?

1.10 Profits are not Fixed

First, as regulated monopolies, utilities are entitled to have their prices for electricity set at a level that will allow recovery of all prudently-incurred operating expenses and fixed costs. These fixed costs include such things as taxes, interest, and a reasonable rate of return, or profit on their rate base (calculated as their capital investment in power plants and other hardware, minus depreciation).

Actual profit levels earned by utilities are not etched in stone. Instead, state public utility commissions examine utilities' historical and forecast expenses in rate cases and set the price of electricity at levels expected to earn the utility a specified rate of return. However, once the price is set, i.e., between rate cases, the utility has an incentive to sell more electricity whenever its marginal revenue from a sale exceeds its marginal cost to produce and distribute the power. Because a utility is virtually always "between rate cases," and because fuel clauses and utility accounting practices assure that marginal revenue exceeds marginal cost, a utility can always improve its earnings by selling more power.[7]

If profits rise too high, regulators can step in and lower the price that the utility can charge for electricity, but only after time-consuming hearings in which the utility will generally oppose any

---

[7] *The result flows directly from the facts that prices are fixed and that fuel clauses are reconciled. The problem is unaffected by the procedure or assumptions used to fix prices; e.g., historic vs. future test year, or the level of sales or conservation used to set rates. The only aspects of regulation that make a difference are provisions that are reconciled, trued-up, or subject to deferred accounting and recovery. Even without fuel adjustment clauses, whenever prices are higher than the marginal fuel cost to produce power, the incentive to sell remains, albeit as a lesser incentive.*

change.[8] Even when rates are lowered, the utility is not required to give refunds or credits to customers to make up for past excess profits. Thus, a utility can keep all the profit it can make.[9]

1.11 The "Fuel Adjustment Clause"

In its understandable quest to maximize profits, a utility's most powerful incentive for selling more electricity is hidden in its regulatory fuel adjustment clause. Some 40 to 50 percent of the price of electricity is determined by the cost of fuel.[10] This cost is subject to considerable volatility, especially for oil and gas. To insulate utility shareholders from the impact of fluctuating fuel prices on earnings, nearly all states allow utilities to adjust customer prices periodically so that changing fuel costs do not affect profits.[11]

1.12 No Reason to Conserve Fuel

The "fuel adjustment" protection operates whether a utility's total fuel bill increases because of rising prices, or because more fuel is used to satisfy an increased demand for electricity. A utility that spends more than it has projected on fuel can raise the price of all electricity to spread the excess cost among its customers. If, however, it spends less than projected, the utility must pass on the savings to consumers through lower rates. Thus, the utility has little (or no) direct economic incentive to conserve fuel or to purchase the lowest cost fuel.[12]

Utilities even make money when they sell power for what initially appears to be less than it costs to produce. For example, to meet increased demand during peak periods, a utility may crank up a relatively inefficient diesel generator that consumes 10 cents worth of fuel to produce one kilowatt-hour (KWH) of electricity. The regulated price of power might be seven cents per KWH, which represents five cents in fixed costs and two cents allotted for the utility's "average" fuel costs. But the utility can recover the extra eight cents in fuel costs later (that is, the generator's ten-cent fuel cost minus the two-cent average fuel cost) by invoking the fuel adjustment clause to raise rates.[13]

---

[8]*Shortening the time to complete rate cases or increasing the frequency of rate cases is not a solution because utilities will still always be "between rate cases."*

[9]*To be sure, the system also provides an incentive to reduce some types of costs. This aspect of the current regulatory system should not be lost when searching for new regulatory mechanisms.*

[10]*In 1987, the national average price of electricity was about 6.5 cents/KWH.*

[11]*Annual Report on Utility & Carrier Regulation, 1986 Edition, National Association of Regulatory Utility Commissioners (NARUC), Washington, D.C., Table 12, pp.415-416, supplemented by telephone conversations.*

[12]*As always, the risk that regulators will detect and punish wasteful practices will be present.*

[13]*In effect, the utility charges customers 15 cents for the KWH, 7 cents now and 8 cents later through the true-up provisions of the fuel clause.*

Meanwhile, the five-cent non-fuel, or base part of its rate remains in place.[14]

1.13 Recovery of Fixed Cost

As a general matter, in the short term, incremental sales of power to an existing customer add no costs other than the fuel needed to produce the power.[15] But, the combination of price-setting and accounting practices means that each KWH sold includes a piece of non-fuel cost-recovery even when there are no additional non-fuel costs.[16] This means each KWH sold adds to earnings.

The incremental contribution to the bottom line occurs whether the sale takes place before or after the utility has reached its projected level of sales. A nickel made on the sale of the first KWH is the same as a nickel made on the sale of the millionth or billionth KWH.[17]

Similarly, the incremental effect on profits remains undisturbed by a utility's achieved rate of return. Stated most simply, an incremental five cents is five cents whether it comes when the utility is earning an 8%, 12%, or 16% rate of return. While much of this discussion has described the effect of sales on profits, the effect of not selling power is the same. Each KWH not sold, or

---

[14] *There are at least two reasons perhaps not to eliminate a fuel adjustment clause entirely, and adopt declining block rates with the tail block rate equal to or less than the utility's marginal fuel cost as a solution to the problem. First, there may be sound reasons for retaining some aspects of fuel clauses. For example, without fuel clauses, for utilities dependent on oil or gas, volatile fuel prices would be the primary determinant of profits. If utilities have no significant control over fuel prices, little could be gained by exposing them to this risk. Second, setting tail block rates at or below the cost of fuel would give customers the wrong price signal and would therefore seriously undermine the goals of LCP. For LCP to work, customer prices for incremental consumption should reflect the full cost of new resources.*

[15] *This is not typically the case for sales to new customers. New customers require new meters, poles, wire, and additional customer accounting costs. Consideration of incremental capacity costs is more complicated but generally does not affect the conclusions reached here. First, in many states, purchased capacity, or at least some types of purchased capacity such as purchases from qualifying facilities, are included as part of the fuel adjustment mechanisms. Second, recovery of the cost of new utility construction (including carrying costs) is generally deferred. This, together with the substantial control utilities have in most states over when to file a rate case, tends to reduce or eliminate these costs as an element in an analysis of incentives. Finally, shortages of generator capacity rarely occur, and when they do, they persist for a short period of time. More often than not utilities have more than the minimum amount of capacity needed to maintain reliability.*

[16] *Even when the marginal sales price is equal to or less than the marginal fuel cost, utility accounting continues to treat a part of the sales price as a contribution to non-fuel cost.*

[17] *A common misconception is that the disincentive to conserve exists only if the utility has sold less electricity than was assumed when prices were set. The incremental effect on earnings of sales or conservation is the same regardless of the level of sales.*

conserved, has a negative effect on earnings.[18]

[18] *The financial impact of an investment in energy efficiency is very large, about twice that of ordinary operating expenses such as plant maintenance or tree trimming. The table in Section 3.101 shows that a $1.6 million investment in DSM reduces earnings by $4.0 million. In comparison, increasing tree trimming spending by $1.6 million would decrease that year's earnings by $1.6 million.*

SECTION 2 --SELECTING AND IMPLEMENTING REGULATORY REFORMS

Perfection is the Enemy of the Good

A regulatory reform plan and its implementation should be compared to the existing regulatory system. For example, under the current regulatory system, utilities operate under financial incentives which encourage all opportunities, whether efficient or inefficient, to sell electricity. Regulators considering a regulatory reform proposal which may discourage utilities from promoting load growth should not ask if the plan is ideal, but whether such an incentive structure is better or worse than the existing incentive structure inherent in the current system.

Similarly, no regulatory system can eliminate the possibility that utilities might engage in actions which, when undetected by regulators, unjustly enrich the utility. The decision to implement an incentive plan which does not eliminate this possibility should be based on whether the motivation to engage in imprudent behavior is great, or whether such behavior would be more difficult to detect in the new plan than it is under the existing system.

There are many solutions available to state regulators to correct the incentive structure of regulation. This section presents a common framework of the most important considerations against which to test and evaluate each current and future alternative solution.[19] Additional considerations are discussed in Appendix A.

2.0 FIRST PRINCIPLES

Incentives and disincentives embedded in the current system of regulation present a serious obstacle to the successful implementation of LCP. NARUC concluded that regulatory reform was needed to remove the disincentives to LCP and to make a utility's least cost-plan its most profitable course of action.[20] It follows, therefore, that the single overarching standard against which proposed incentive plans should be measured is whether the new financial incentives will encourage the utility to implement successfully a least-cost plan.[21]

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[19] *Throughout this section aspects of particular incentive plans are used to help explain the concepts. A more complete discussion of the available options are described and analyzed in Section 3 and Appendix A.*

[20] *See NARUC Resolution, Appendix C.*

[21] *Even though the goal is to create a regulatory structure which is completely compatible with least-cost planning, decisions to proceed with particular proposals should be based on relative improvements to the existing system of regulation. Every proposal, no matter how well conceived, will have its weaknesses and peculiarities. Nevertheless, the plan should be judged in relation to other proposals and the extraordinarily bad incentives in the existing system of regulation. While the ultimate goal is to have a plan which is completely consistent with least-cost planning, as a practical matter, states should pursue*

2.00 Profit Maximizing Strategy

The test for an effective incentive proposal lies in the answer to this question:

> Viewed from the perspective of the utility, what course of action would be consistent with a profit-maximizing strategy?

The utility's most profitable course of conduct should be to implement successfully a least-cost plan. Commissioners should seek an incentive plan which satisfies this most important criterion. If the utility's most profitable course of conduct is to pursue programs that do not reflect a cost-minimizing plan while still promoting sales which are not cost-effective, the incentive plan fails to meet the primary criterion.

Be Creative

Consider as many alternative approaches as possible. As the discussion in Section 3 shows, many different approaches have already been identified and there will be more. Regulators will devise new, creative, and more effective plans if they focus on the particular needs and priorities of their state and do not limit themselves to conventional solutions to the problem.

Often the analyses, discussion, and design of specific incentive proposals begin with quantifying the negative impact DSM programs have on the utility's earnings. The analysis generally separates the adverse earnings impact into three parts: lost revenues, DSM program cost-recovery, and incentive components.

Next, separate incentive plans are designed to address each of the three elements.[22] This approach is not necessarily wrong, but it tends to limit the breadth of plans available for consideration and creates the risk that plans taking a different approach will be rejected solely because the plan does not fit a particular mold. To avoid these limitations, do not allow the framework, or specific deficiencies, of the current regulatory system to impose artificial constraints on the design or selection of incentive plans.

An example of a plan which approaches the problem in an entirely different manner will illustrate how regulation might be changed to produce reasonable incentives using relatively simple solutions. Consider a state which, like most, has a reconciled fuel adjustment clause, full recovery

proposals which significantly improve the status quo.

[22] *It is generally believed that the job is done and the incentives are right when lost revenues have been restored and the utility is made whole for its efforts in the DSM programs and a bonus is provided. In fact, this may or may not be true depending upon how a program is structured.*

of all direct DSM program costs, and which has relatively high marginal fuel or production costs.[23] Assume that "Utility X" has a marginal revenue or marginal price of five cents per KWH and a marginal fuel cost of six cents per kilowatt-hour.[24] At first blush, a marginal KWH sold produces a net loss of one cent and "Utility X" would have no incentive to pursue this sale. On closer examination, however, the existence of the reconciled fuel clause means the entire six-cent marginal fuel cost will be returned to the utility. Because the utility is held harmless from the increased fuel cost, the sale that looked like a loss is, in fact, a profitable sale.

If, on the other hand, "Utility X" pursues conservation, even zero-cost conservation, it will experience a net loss of earnings. The KWH saved means a five-cent revenue loss to "Utility X" which is not offset by any cost reduction because the six-cent fuel cost saving is passed on entirely to customers. "Utility X" realizes a net loss. Thus, the utility has an incentive to pursue a five-cent sale rather than zero-cost conservation, even though the KWH sold "cost" six cents to produce.

Consider how the incentives shift if the fuel clause reconciliation process is changed slightly and fuel costs continue to be reconciled for changes in fuel prices, but not fuel quantity.[25] In this case, the incremental six-cent fuel cost is borne by the utility if it sells another KWH, and it is a cost savings to the utility if it conserves a KWH. Under these conditions, an incremental sale produces a one-cent loss, and zero-cost conservation produces a profit. With this simple change to just one aspect of the fuel adjustment clause, the sale of the marginal kilowatt-hour would not be a profit-maximizing strategy. Instead, the new profit-maximizing strategy for "Utility X" would be to pursue energy conservation over increased sales.[26]

Notice that in this example of an "incentive plan" no elements of the plan restore lost revenues or which provide a separate DSM incentive. Yet, the utility's incentives are tied to the successful

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[23] *The term "reconciled" is used in this paper in a number of areas, most generally relating to fuel clauses. A fully reconciled fuel adjustment clause means utilities recover dollar for dollar all fuel expenses including interest on fuel costs. Several states use partial reconciliation which can take many different forms. In some states, interest costs are not allowed; in others, a portion of the difference between projected and actual fuel cost is left at the utility's risk, to provide an incentive to the utility to minimize fuel costs. For example, in New York a utility recovers only 80% of the difference between projected and actual fuel cost. The manner and extent of reconciliation is a very important consideration in evaluating incentive plans.*

[24] *The five-cent price might be two cents of non-fuel base revenue and three cents of average fuel.*

[25] *If the utility's fuel bill increases because fuel prices increase, it continues to be protected by the reconciliation, or true-up, provisions of the fuel adjustment clause. If, however, the total fuel cost rises because sales increased, the utility must bear the extra cost. Likewise, the utility keeps any reduction in fuel cost caused by lower sales resulting from successful DSM efforts.*

[26] *Recall that "Utility X," like most utilities, recovers its DSM program costs separately so the six-cent fuel cost saving is not offset by the cost of conservation. In addition, recall that for this utility the marginal fuel cost exceeds its marginal revenue. This condition is very rare given today's relatively low fossil fuel costs.*

implementation of DSM programs.[27]

In summary, like good people, good incentive plans can take a wide variety of shapes, sizes, and personalities. Regulators, utilities, and others should remain tolerant and receptive to different approaches.

2.01 Unlimited Scope

Ideally, an incentive plan will encompass all aspects of LCP. Trying to simplify the task of finding the right incentive plan by limiting the scope of the undertaking is probably a mistake.

Limitations can take several different forms. For example, regulatory reform efforts could be targeted only at DSM instead of both demand- and supply-side aspects of LCP.[28] Limiting efforts to making conservation profitable and not trying to remove the incentive to sell more power is another example.[29]

Limiting the scope of the undertaking will narrow the range of options available, and may needlessly eliminate approaches that fit well with ratemaking or accounting practices unique to the state.[30] Moreover, these types of constraints would make it more difficult to get achieve optimum overall incentives, even when successfully addressing the narrow issues. The existing "incentives" are that:

1) all sales, whether cost-effective or not, add to earnings; and
2) all conservation, whether cost-effective or not, is unprofitable[31]

If a plan is limited to making DSM desirable, both sales and conservation would be profitable. While incentives limited to DSM represent a clear improvement, they stop short of producing a strategy that makes pursuing a least-cost plan the most advantageous course of action.

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[27] *The effectiveness of this approach depends on the relationship of marginal fuel cost to the price of electricity. If the price of power exceeds the marginal fuel cost, this approach is only partially effective.*

[28] *Environmental externalities, risk, and diversity are examples of matters which are generally not incorporated into any incentive plans nor are these matters which are reflected in the economic incentives embodied in existing regulation.*

[29] *To date, most proposals tend to be limited to making DSM programs profitable and do not address the incentives to increase sales or any aspect of supply-side options. This should come as no surprise because the existing incentives for DSM are most skewed.*

[30] *For example, an option which changes portions of the fuel adjustment clause would affect both DSM programs and sales incentives. States that narrow the scope of incentive plans to only DSM incentives will needlessly foreclose the use of this type of approach.*

[31] *The aim is to make only cost-effective selections, whether demand-side or supply-side, the profitable choice.*

2.02 Measurement

Incentives resulting from LCP will be greatly influenced by how, what, and when to measure. Consequently, measurement issues should not be viewed as a mere technical issue when policy makers discuss the merits of different incentive options. Many incentive plans, especially those limited to the demand side, require measurement of both capacity and energy savings. Plans that explicitly restore DSM-related lost revenues also generally require a measure of DSM-induced revenue loss.[32]

A combination of engineering and economic judgments instead of actual measurement of capacity and energy savings may be adequate for the purposes of program design. By contrast, regulatory incentive proposals not measuring actual achievements may result in the wrong underlying incentives.[33]

For example, consider the substantially different incentives produced by an electric water heater insulation program under two incentive plans where the only difference is how and when program savings are measured. The first plan has KWH savings based on extrapolating test data, engineering estimates, or measurements made at other times (or in other states). The second plan is the same in all respects except that program savings are based on random, statistically valid, on-site measurements of utility-installed measures.

Suppose, under the first plan, an agreement is reached that an electric water heater insulation blanket will yield 600 kilowatt-hours per year in energy savings. Under this plan, the utility will be allowed to recover direct and indirect program costs, 600 KWH's worth of lost revenues, and an incentive based on any rational approach.[34]

What happens when the utility actually achieves 700 kilowatt hours in savings through better quality-control or other efforts under its control? It loses money!

In contrast, what happens when the utility selects poor quality contractors and has inadequate quality-control efforts? Actual savings drop to 500 or 400 KWH per year, and utility profits

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[32] *California's ERAM is a time-tested approach which does not require the identification of DSM-induced lost revenues. Actual and projected (allowed) revenues are reconciled regardless of the cause of any discrepancy. Thus, the only measurement required is of actual revenues which is simple and verifiable.*

The plan described in Footnote 23, which consisted of changing the fuel clause, is an example of another approach that does not require the measurement of lost revenues. In that plan the fuel cost savings kept by the utility more than offset lost base revenues.

[33] *Cost/benefit analyses of measurement should not be forgotten.*

[34] *For the purpose of this example, the exact nature of the incentive element is not important. The analysis is the same whether it is a shared savings approach or a fixed payment for each KWH saved.*

increase!

Profits increase because the utility still recovers lost revenue based on an assumed 600 KWH savings when in fact not all of these revenues were lost. In addition, the incentive portion is unaffected by the lower actual savings.

Solely as a consequence of a measurement decision, the utility's profit maximizing strategy would be to select measures which would test well under the measurement criteria imposed, but perform poorly.

Under the second plan, where actual measurements of achieved results are used, what happens if the utility is able to achieve 700 KWH in savings? Profits go up. As it should be, earnings go down if the savings are less than 600 KWH. The profit-maximizing strategy is to get more savings rather than fewer.

2.03 Framework for Analysis

To simplify the evaluation process, start with a list of questions that describe important considerations. Consider:

What happens to profits if the utility sells another KWH?

What happens to earnings if sales are reduced by one KWH through conservation programs that cost $0.01 per KWH?, $0.02?, $0.10?

What happens to profits if a utility invests in load control and shifts a KW from on-peak to off-peak?

What happens if the utility pursues a power marketing strategy?

What happens if the utility selects the more costly of two supply-side options; or the more costly of two demand-side options; or a supply-side option which is more costly than a demand-side option?

Starting with just one proposed incentive plan, test the incremental effect on earnings of the alternative courses of action suggested by the questions.[35] The combination of the answers to the questions will unveil the utility's profit-maximizing strategy for that particular incentive plan. When the functioning of one incentive plan is understood, perform the same analysis using another

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[35] *When answering the questions, be very aware of all of the specific ratemaking and accounting practices used in the state. Of special importance are 1) the exact workings of fuel and purchased power clauses and associated reconciliation provisions, 2) any other ratemaking provisions allowing deferred expense accounting, including deferred accounting for conservation cost; and 3) rate design and revenue accounting provisions which affect the level of base revenue contributions of marginal sales of power to each customer class and for each rate period for time-of-use rates.*

incentive plan.

The analysis should not start with a particular course of action, i.e. conservation program "X", and then compare that program's effect on profits under alternative incentive plans. This approach asks the wrong question, and it is unlikely to lead to a useful answer. Knowing that conservation program "X" is more profitable under Plan "A" than it is under Plan "B" or under the existing system of regulation says nothing about the profitability of sales or conservation under Plan "A".

Thus, to evaluate the desirability of a plan, begin with a proposed incentive plan and, regardless of any other plan, test it against a wide range of conduct, and identify the profit-maximizing strategies. If those strategies are consistent with a desired course of conduct, consider it to be a good candidate while you proceed to review other proposed plans.

2.1 PROBLEMS, BENEFITS, AND GOALS

Identifying a profit-maximizing strategy is the most important test of any incentive proposal.

The next set of considerations are also quite important and should be given serious attention while developing or selecting the best plan for each state. The considerations are discussed in general order of importance:[36]

Decoupling profits from sales;
Cost minimization;
Administrative simplicity;
Fuel switching; and
Balance.

A final group of considerations which are of slightly less importance are discussed in Appendix A. These considerations are as follows:

Predictability;
Environmental costs;
Non-participant impacts;
Skimming the cream;
Avoiding gamesmanship; and
Distribution of incentives.

2.11 Decoupling Profits from Sales

Under current regulation increased sales always mean increased profits. As long as every

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[36] *To be sure, there are many, often conflicting, forces which influence utility behavior. Changing the financial incentives is only one, albeit the most important, area that requires attention by regulators.*

incremental KWH sold adds to profits, a strong likelihood remains that a profit maximizing strategy will lead to more sales and less DSM, even if DSM programs are profitable.[37] Thus, incentive plans should be evaluated to see how effectively sales are decoupled from profits.[38]

Decoupling can take either of two forms. First, decoupling may merely eliminate the incentive to increase sales. This approach generally holds the utility harmless from fluctuating sales levels and provides no financial incentive or disincentive to increase or decrease sales. There are several different approaches to accomplish this first type of decoupling. The most widely known is California's Electric Revenue Adjustment Mechanism (ERAM), and it is discussed in Section 3.41.[39]

There are also other, very different, approaches which can accomplish very similar results. For example, fuel revenue accounting changes implemented in Maine set the non-fuel revenues from marginal sales equal to, or near, zero. The result is that incremental sales do not add to profits. This practice has been accomplished by changing accounting rules that generate no changes in retail prices.

Interestingly, plans which incorporate recovery of only lost revenues specifically attributed to efficiency programs do not decouple profits from sales. At most, this approach links conservation to profits the same way sales are already linked to profits. The disincentive towards energy efficiency is removed, but the overall incentive to sell power remains intact. Sales are always profitable regardless of the cost of producing the power.[40]

The second form of decoupling is with the use of plans which provide incentives when sales are decreased by cost-effective DSM measures and disincentives when sales increase. For example, plans which increase a utility's rate of return if customer bills decrease, and decrease rate of return when customer bills increase can decouple profits from sales even though there is no lost revenue adjustment. Because only a few incentive plans decouple profits from sales in this fashion, it is necessary to combine most incentive plans with separate decoupling options to produce the most

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[37] *Even where a plan succeeds in making a KWH conserved more profitable than a KWH sold, perceived risks and unfamiliarity with DSM programs will tend to bias a profit-maximizing strategy toward sales.*

[38] *This does not mean that all sales of electricity should be discouraged for its own sake. Sales, however, should not be profitable regardless of the cost of electricity or the cost of alternatives, including energy efficiency.*

[39] *See also Cavanagh. "Responsible Power Marketing in an Increasingly Competitive Era." Yale Journal on Regulation, New Haven: 1988. Vol. 5, No. 331.*

[40] *Oddly, consumer advocates often favor this approach because it is more limited in scope than an ERAM type approach. In fact, this approach presents the worst choice for consumers. First, this approach does not decouple profits from sales, and second it is an adjustment that always works in one direction, providing more revenue to the utility. In contrast, ERAM does decouple and it refunds money to consumers if sales increase.*

desirable overall incentives.

2.12 Cost Minimization

Will the proposed program encourage the utility to deliver conservation programs at the lowest cost to consumers?

Consider two incentive plans, both of which measure actual achieved conservation results. The first pays the utility a predetermined, fixed amount for each KWH saved. The fixed payment will be less than the utility's avoided cost and will therefore help assure that only cost-effective efficiency is purchased. The payment covers direct program cost and an incentive for the utility. The second plan pays the utility 110% of its actual program costs for each KWH actually saved.

To maximize profits under the first plan, the utility will try to reduce its cost of saving KWHs to maximize the difference between the fixed payment it receives and its out-of-pocket costs. To maximize profits under the second plan, the utility would get as much conservation as it could, regardless of the cost.

Generally, plans should be designed to encourage utilities to obtain DSM savings at the lowest possible cost.

2.13 Administrative Simplicity

Achieving significant reform of a regulatory system that has been in place for nearly a century will require substantial public and political support. Gaining the needed support will be difficult if the proposed plan is too complex or obscure.

Incentive plans should be simple and efficient to administer, or the cost of regulation may outweigh the benefit. The cost of regulation includes items such as the cost to the regulatory commission of administering the system, the cost to the utility of collecting and reporting any additional information, and the cost to all parties of participating in any new regulatory proceedings that may be needed.

In practice, this principle means avoiding incentive plans that rely on complex formulas or unverifiable measurements. For this reason, commissioners may want to avoid approaches which require separate proceedings in favor of plans which can be implemented within the framework of existing regulations.

2.14 Balance

Incentive proposals should have a reasonable risk/reward relationship. Once measurement criteria are set, superior performance should yield higher earnings, and similarly, inferior performance should yield lower earnings. The plan should not provide utilities with unreasonable opportunities to profit at the unnecessary expense of ratepayers, nor should the plan deprive the utilities of a reasonable opportunity to earn a fair return.[41]

To gain public acceptance and increase the likelihood that an incentive plan will produce the desired result, an incentive plan should operate symmetrically, i.e. rewarding superior and punishing inferior performance. Incentive plans which only reward utilities for good performance and has no effect when performance is poor will be criticized as being unfair and ineffective.

[41] *While this discussion may seem self-evident, there are plans discussed in Section 3 that run afoul of this consideration.*

SECTION 3 -- ALTERNATIVE APPROACHES

3.0 GENERAL

This section describes and evaluates alternative approaches to changing the incentives inherent in the current regulatory system. Incentive proposals have been grouped into three general categories based on the approach taken. The categories follow:

Rate-of-Return Adjustments
Shared Savings
Bounty

For each of these approaches, different performance criteria are available to address one or more special concern. All the possible modifications to each approach will not be covered here. Regulators, for the most part, can mix and match different components of incentive plans until they find a desirable group of features.[42]

Although the ability of an incentive plan to decouple profits from sales is critical to a plan's success in changing investment and other decisions, many of the plans fail to accomplish the desired decoupling. Therefore a separate category of decoupling options follows the discussion of the three categories of plans. These decoupling options can be used with any of the incentive plans to produce an overall package of regulatory reforms.

Three questions should be asked when structuring an incentive plan:

One: Will the incentive plan make available enough additional earnings to offset the existing disincentives and which alternative course of action will maximize earnings?[43]

Two: Does the incentive plan decouple profits from sales or must it be combined with a decoupling option?

Three: What behavioral changes does the plan encourage:
-energy savings or spending?
-cream-skimming, fuel switching, cost-minimization?
-can the plan accommodate considerations of environmental externalities?

The first two questions and the most important elements of the third question are discussed in this section. Secondary considerations and factors that are common to all plans are discussed in

[42] *Specific proposals that have been the subject of publications or regulatory decisions are described only in general terms, with citations to more specific materials.*

[43] *Net revenues from a plan equal the incremental revenue minus direct and indirect costs, e.g. lost revenues and DSM program costs.*

Appendix A.

Throughout Section 3, simple quantitative calculations are used to illustrate the different plans' potential to produce enough incremental earnings to offset the disincentives of the current system. To simplify the discussion, the following uniform assumptions are made:

Illustrative Utility Statistics[44]

1) average price	$.07
2) average fuel cost	$.02
3) average non-fuel cost	$.05
4) marginal fuel cost	$.03
5) conservation cost	$.02[45]
6) rate base (total)	1 billion
7) allowed rate of return	12% overall
8) cost of equity	14%
9) cost of debt	10%
10) capital structure	50/50
11) annual sales	8 billion KWH
12) annual revenues	$560 million

Except as noted in the discussion, the state is also assumed to have a fully reconciled fuel adjustment clause.[46] As the following table shows, the incentives are improved by the elimination of fuel adjustment clauses, but the overall direction of the incentives is unchanged.

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[44] *These assumptions are generally consistent with national averages shown in Edison Electric Institute, Statistical Yearbook of the Electric Utility Industry, 1987.*

[45] *Each $1.00 of program cost is assumed to save ten KWH per year for five years. Total savings over the five-year life are 50 KWH, producing a simple average cost of $.02 per KWH. Thus, a $.10 investment in year one will produce one KWH of savings each year for five years.*

[46] *Whether direct program costs are recovered through expensing, ratebasing, or amortization makes no significant difference.*

Incremental Earnings Impacts[47]

	w/fuel clause	w/o fuel clause
Incremental KWH sold	$.05[48]	($.04)[49]
Incremental KWH saved w/DSM program cost recovery	($.05)[50]	($.04)[51]
Incremental KWH saved w/o DSM program cost recovery	($.07)[52]	($.06)[53]
Incremental KWH saved w/rate base treatment	($.0488)[54]	($.0388)[55]

Without a fuel clause the magnitude and direction of the short-term incentives depend on the relationship of retail rates to marginal fuel costs. If retail rates exceed marginal fuel costs, which is the case in most jurisdictions, incremental sales are profitable. With a fuel clause, incremental sales are profitable regardless of the relationship of retail prices to marginal fuel costs.

3.1 RATE-OF-RETURN ADJUSTMENTS

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[47] *This is a simplified illustration of the earnings impacts of DSM programs under typical rate-setting procedures with and without a fully reconciled fuel clause, and with or without separate recovery of program costs.*

[48] *The entire non-fuel component is realized because fuel cost is fully recovered from customers.*

[49] *Utility receives $.07 from retail sale, less the full $.03 marginal fuel cost.*

[50] *The entire non-fuel component is lost. The $.03 marginal fuel cost savings is realized by customers.*

[51] *The utility loses the $.07 retail rate but save $.03 in fuel costs, thereby realizing a net loss of $.04.*

[52] *Same as note 43 except the utility also incurs $.02 cost for DSM program.*

[53] *Same as note 44 except the utility also incurs $.02 cost for DSM program.*

[54] *Same as note 43 except the utility receives return: 12% on the $.10 of rate base associated with one KWH saved. This further assumes no lag in the DSM investment and cost recovery.*

[55] *Same as note 44 except the utility receives return on the $.10 of rate base associated with one KWH saved.*

The most common approach to providing incentives for LCP or energy efficiency investment is to adjust the utility's allowed rate of return (either on equity or total return) in relation to a specified accomplishment, such as achieving a target level of conservation, a reduction in customer bills, a specified level of DSM spending or some other indicator of performance.

In some cases, the adjusted rate of return is applied to the total investment (rate base), and in others, only toward the investment in demand-side measures. These two approaches are discussed separately, followed by a discussion of the use of return adjustments based on customer bills.

3.10 Rate-of-Return Adjustment--Total Rate Base

3.100 General Description

This subsection addresses incentive plans that operate by adjusting the utility's allowed rate of return on its total investment. Within this category there are several variations which establish different performance criteria (or benchmarks) for judging whether and how much to change the utility's rate of return.

Performance criteria discussed thus far tend to fall into two groups. First, adjustments to the rate of return are compared to the utility's ability to achieve a specified level of capacity (or energy) savings. Second, rate-of-return adjustments are measured in relation to changes in customer bills.

Programs which relate rate of return to capacity or energy savings targets can be measured in a number of ways. The particular approach selected will determine the incentive characteristics of the plan. Table 1 summarizes the nature of the underlying incentives for four different performance measurements.[56]

Each of these performance criteria, one based on estimated savings and the others representing different ways to measure achieved savings, produces different incentives. The four performance criteria shown across the top of Table 1 are as follows:

(1) Estimated Savings - DSM savings are based on engineering estimates, experience from other areas, or otherwise agreed-upon levels established in advance. The primary difference between estimated and actual savings is the former does not reflect the savings achieved by a utility's programs.

(2) Actual Savings - DSM program results are measured directly by techniques such as after-the-fact metering of statistically valid samples of installations. In some situations actual savings may include engineering estimates. In general, "actual savings" are the product of careful program evaluation and reflect the savings achieved by the actual DSM accomplishments of a utility.

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[56] *These are not the only four performance criteria which could be used.*

(3) Load vs.Forecast - DSM results can be measured indirectly on an aggregate basis by comparing the utility's actual load against its load forecast. The comparison determines which goals were consistent with DSM and other LCP efforts.[57] The differences between the actual load growth and the adjusted forecast would be used as a measure of overall DSM program performance.

(4) Efficiency Measure - Aggregate program performance can also be judged in terms of measures of efficiency, either BTU per dollar GNP, KWH per dollar GNP, KWH per customer, or other similar scales. The difference between actual and adjusted forecast efficiency is the yardstick.

TABLE 1
RATE OF RETURN ADJUSTMENTS
(Total Investment)

PERFORMANCE CRITERIA	(1) Estimated Savings	(2) Actual Savings	(3) Load vs. Forecast Difference	(4) Efficiency Measure BTU/$GNP KWH
DSM INCENTIVES	Perverse	Good	Good	Good
DECOUPLING	No	No	Yes	Yes
SCOPE	DSM Only	DSM Only	DSM Only	DSM and partial supply-side with certain efficiency measures
COST MINIMIZATION	No - Unless payment includes program cost recovery	No - Unless payment includes program cost recovery	No - Unless payment includes program cost recovery	No - Unless payment includes program cost recovery
ADMINISTRATIVE SIMPLICITY/COST	Low cost	Low incremental cost if good program evaluation	Medium to low	Medium to low

3.101 Incentive Potential

Adjusting the rate of return on a utility's overall investment may produce enough incremental revenue to offset the disincentives in the current ratemaking process. Applying the typical utility

[57] *Before making the comparison, the projected load would have to be adjusted for differences in weather, economic conditions, and other relevant factors which are outside the utility's control.*

data to a modest utility DSM program produces the following results:[58]

Annual DSM Savings (1% of sales)	8 million KWH
DSM Cost (8 million KWH x $.02)	$1.6 million
Lost Revenue (8 million KWH x $.05)	$4.0 million
	============
Total	$5.6 million
Incremental Earnings Each 1% change in Rate of Return (Overall Return) (1% x $1 billion)	$10 million
Required Change in Rate of Return to Produce $5.6 million of Earnings	.56%

These figures show that relatively small changes to a utility's allowed rate of return can produce enough revenue to offset DSM program costs and lost revenue. Any change in return over the amount shown in the table will provide a positive incentive.

Finally, combining this type of approach with other DSM program cost recovery, lost revenue adjustments, or decoupling approaches means the required change in the rate of return will be smaller than the table suggests. The required change in rate of return would also be smaller in a state without a fuel adjustment clause.

3.102 DSM Incentive

Will the performance criteria provide incentives that operate in the right direction?

As discussed in Section 2, approaches which rely on engineering estimates, agreed-upon program benefits, or other estimated savings (Table 1, Column 1) tend to produce perverse

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[58] *This represents about 0.3% of the utility's total revenues, and is slightly less than the relative level of DSM spending for California utilities. It is about 10% of the relative spending of several New England utilities.*

incentives. Under these plans, the utilities' financial rewards are negatively affected by achieved results and positively affected by the number of installations.

Financially, the best course of action for a utility under this scheme would be to implement a large DSM program which produces few results. For example, the company might install a large number of devices which, because of inaccurate estimates, free-rider effects, or low quality materials, produce lower efficiency improvements.

The previous table shows that it requires a .56% (56 basis point) change in the utility's allowed rate of return to compensate for all direct and indirect DSM costs. This change produced $5.6 million in increased earnings which exactly offset DSM program costs and lost revenues. The following table illustrates the incentives produced by a plan which uses estimated savings. The table uses with the $5.6 million incentive payment from the previous table, and shows what would happen when actual DSM savings are 50% higher and, alternatively, 50% lower, than estimated.

DSM SAVINGS

Original Increase in Earnings	$5.6 million
Incremental Earnings with 50% less savings (8 million KWH x 50% x $.05)	$2.0 million
Incremental Earnings with 50% more savings (8 million KWH x 50% x $.05)	($2.0) million

In sharp contrast, each of the three performance criteria in Table 1 which rely on actual measurements will produce incentives which are proportional to performance. If achieved results increase (either because of the number or quality of installations), whether measured by metering, load reductions, or efficiency improvements, the rate-of-return adjustment also increases.

<u>3.103 Decoupling</u>

Are any of the variations of rate-of-return adjustments capable of decoupling profits from sales without relying on a separate decoupling option?

To be fully effective, an incentive plan should decouple profits from sales. As shown in Table 1, the first two performance criteria (which rely on either actual or estimated DSM impacts) do not decouple. In both approaches, increased sales produce increased earnings and have no impact on the apparent success of implementing DSM programs.[59]

The two remaining approaches (actual/forecast load, and actual/forecast efficiency) will accomplish decoupling. In both performance criteria, increased sales reduce the utility's measured results, which means lower profits or negative incentives.

3.104 Scope

Do any of the performance criteria allow the plan to extend to matters beyond DSM programs?

As summarized in Table 1, the first three approaches do not extend beyond demand-side programs. The fourth approach which measures energy efficiency can, however, be used to incorporate at least some efficiency opportunities on the supply side. For example, measures such as BTUs of utility fuel input per customer would capture changes in power plant efficiencies, i.e., heat rates. Because of the operation of fuel adjustment clauses, utilities currently have little or no incentive to pursue these opportunities.

In fact, with reconciled fuel adjustment clauses, utilities are held harmless from increased fuel costs resulting from plant inefficiency. Meanwhile, the deferral of maintenance costs, which causes deteriorating plant efficiency, improves short-term earnings. A plan that creates supply-side efficiency incentives would be an improvement.[60]

3.105 Administrative Simplicity

Do any of the performance criteria pose unreasonably high administrative costs?

The administrative costs of the estimated or measured program performance criteria would be relatively high if savings estimates are made on a program-by-program basis. The incremental costs, however, would be relatively low if the information is already developed for program evaluation or other purposes.

Measuring savings on an aggregate basis may impose fewer procedural and administrative costs on utilities and regulators than disaggregated program-by-program evaluations, assuming that regulators are unable to devote staff resources to program evaluation. An incentive plan that is

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[59] *Depending on the precise method of measuring achieved results, it might not be in the utility's financial interest to pursue programs that increase the load of customers who participate in DSM programs. For example, if demand-side program benefits are measured by comparing consumption of participants vs. non-participants, it would not be in the utility's interest to pursue a load-building program that might be favored by participants in DSM programs. Such a program would tend to increase consumption of the participating customers and thereby reduce the measured savings of a DSM program. This conclusion, however, is very sensitive to the precise method of measurement selected.*

[60] *Incentive plans based on revenue per customer (i.e., customer bills) would go one step further and incorporate fuel and purchase power procurement activities, much of which is now insulated by fuel adjustment clauses.*

based on aggregate performance would place the burden on utilities to use more detailed program evaluations to decide which programs to expand, contract, or modify to achieve the best overall results.

The administrative regulatory costs associated with the remaining performance criteria, load/forecast and efficiency measures, may be lower than these for either of the first two approaches, if the data and necessary adjustments are already subject to regulatory proceedings.

3.106 Cost Minimization

Do any of the performance criteria create the desirable incentive to minimize the cost of delivering supply or demand-side options?

Most rate-of-return plans, either proposed or in effect, incorporate separate mechanisms to recover direct DSM program costs. These DSM cost recovery mechanisms generally rely on regulatory oversight and the accompanying risk of disallowance to assure that program costs are reasonable. If this is the case, none of the four performance criteria in Table 1 (with the possible exception of the fourth-- Efficiency Measure) provide any incentive to minimize the cost of efficiency improvements.

On the other hand, if the rate-of-return adjustment and the resulting payment to the utility includes program cost-recovery, a substantial incentive to minimize the cost of delivering energy efficiency exists. In this case, the utility's financial reward would increase if its cost to achieve any particular result were lower. The utility would be better off if it reached or surpassed a performance goal and at the lowest possible cost.[61]

3.11 Rate-of-Return Adjustment -- On DSM Investment

3.110 General Description

This approach assumes that a state permits or requires ratebasing of DSM investments. In other respects this approach is very similar to the rate-of-return adjustment on total investment, except that the increased rate-of-return is applied only to investments in conservation or load management activities.

The performance criteria shown across the top of Table 2 are the same criteria used in the discussion of return adjustments to total investment. The criteria are as follows:

(1) Estimated Savings - DSM impact on an estimated basis.
(2) Actual Savings - DSM impact on an actual basis.
(3) Load vs.Forecast - DSM impact as measured by actual demand for electricity

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[61] *See Appendix A Section A.2 for a discussion of ways to minimize or eliminate the cream-skimming incentive.*

vs. the adjusted load forecast.

(4) Efficiency Measure - DSM impact based on an efficiency measure.

TABLE 2

RATE-OF-RETURN ADJUSTMENTS
(On DSM Investment Only)

PERFORMANCE CRITERIA	**(1) Estimated Savings**	**(2) Actual Savings**	**(3) Load vs. Forecast Difference**	**(4) Efficiency Measure BTU/$GNP KWH/Customer**
DSM INCENTIVES	Perverse	Good direction but inadequate	Good direction but inadequate	Good direction but inadequate
DECOUPLING	No	No	No-Inadequate revenues	No-Inadequate revenues
SCOPE	DSM Only	DSM Only	DSM Only	DSM and partial supply-side with certain efficiency measures
COST MINIMIZATION	Perverse	Perverse	Perverse	Perverse except with certain measures
ADMINISTRATIVE SIMPLICITY/COST	Low cost	Low incremental cost if good program evaluation is done	Medium to low	Medium to low

3.111 Incentive Potential

The potential of this approach to produce revenues necessary to offset existing disincentives is very limited. The following table shows that the level of DSM investments is so low in relation to the magnitude of the existing disincentives that plausible adjustments to the rate of return have no practical effect.

DSM COSTS AND RETURN[62]

Lost Revenue	$.05/KWH
Incremental Investment in DSM	$.10/KWH

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[62] *Direct DSM program costs are fully recovered through annual amortization or depreciation charges and, therefore, not shown on this table.*

Incremental Return at:	
12%	$0.012/KWH
14%	$0.014/KWH
20%	$0.02/KWH
Required Overall Return on DSM Investment to Produce $.05	50%
Required Equity Return on DSM Investment to Produce $.05	100%

This table shows that the incremental earnings produced by typical ratebasing incentive plans are a tiny fraction of what would be required to change the overall financial incentives. Consequently, this approach is only useful when combined with other cost recovery and decoupling options.

3.112 DSM Incentives

DSM incentives are, once again, perverse if based upon estimated determination of DSM impacts.

The incentives are generally positive for the remaining performance criteria (actual measurements, changes in load growth, or changes in efficiency). Utility earnings increase as actual performance improves; however, because utility earnings would be directly proportional to the amount of DSM investment, cost minimization would be discouraged.

3.113 Decoupling

Neither the first nor the second performance criteria achieve decoupling. Theoretically, the third and fourth criteria can decouple profits from sales. Under both of these variations (change in load growth and change in efficiency), increased sales would tend to reduce the utility's incentive payment. The increased sales, however, would produce far more earnings than would be lost through a lower incentive payment.

Thus, because the earnings potential of these criteria is so small, as a practical matter decoupling would not likely be accomplished.

3.114 Scope

As was the case with rate-of-return adjustments applied to total investment, none of the first three performance criteria is capable of extending efficiency opportunities to the supply side. Depending on the particular efficiency measure selected, the fourth criterion may capture some supply-side efficiency improvements.

3.115 Administrative Simplicity

The conclusions discussed at Section 3.105 is equally applicable here.

3.116 Cost Minimization

Because this approach would relate the level of the incentive payment to the level of DSM investment, the utility's financial interest would be best served by pursuing the more costly DSM opportunities. The incentive to minimize DSM costs would be the same as the incentive to minimize the cost of any investment, i.e., the risk of detection by regulators and the possible disallowance of costs.

3.12 Rate-of-Return Adjustment -- Customer Bills

3.120 General Description

This approach adjusts a utility's rate of return (on total investment) in relation to performance criteria which focus on customer bills. In part, this approach is being treated separately to illustrate some of the different measurement approaches available and the effect of the choices on the resulting incentives.

There are at least four different ways to specify performance criteria, each of which produces a different set of overall incentives.[63] The performance criteria shown in Table 3 are as follows:

(1) Forecast vs.Actual - This performance criterion compares actual average customer bills (by customer class) to prior forecasts of customer bills. The forecast would be consistent with the average bills after implementing a reasonable LCP, and adjusted for factors which are outside of the utility's control, such as economic and weather conditions.

(2) Internal Index - The next criterion is similar to a comparison of average bills for participants with those of non-participants. A statistically valid sample of utility customers would be selected and their future participation in DSM programs monitored. Customers in the sample group who elect to participate in programs during the next year (or two) would be dropped from the sample or control group.

[63] *Throughout this discussion, "average customer bills" refers to average bills for a customer class. Thus, average residential bills would be equal to total residential revenue divided by total number of customers.*

The control group would provide an "internal index" against which all other average customer bills would be compared. The utility would be rewarded or punished based on differences between the average bills of customers in the internal index and bills of customers overall.

(3) External Index - This performance criterion begins with average customer bills for a targeted utility and average customer bills for a group, or index, of other utilities, which in the aggregate have the same fuel mix, weather, and economic conditions as the targeted utility. The targeted utility's allowed rate of return would be adjusted up or down depending on relative changes in the average customer bills for the targeted utility compared to the average customer bills of the index. Thus, if customer bills for the targeted utility increase over a relevant time period by 10%, while bills increase by 12% for the index, the utility would have outperformed the index group and would have a higher rate of return based on the two percentage point differential.[64]

(4) Before/After - The final performance criterion focuses on the difference in customer bills prior to and following participation in the program. The difference in bills would be adjusted for variations in weather conditions and other factors which would have substantially affected bills but are unrelated to the utility's DSM program.

[64] *For a more complete discussion of this approach see Moskovitz and Parker, "How to Change the Focus of Regulation so as to Reconcile the Private Interest With the Public Goals of Least-cost-Planning" (Presented to NARUC's Sixth Biennial Regulatory Information Conference, September, 1988).*

TABLE 3

RATE-OF-RETURN ADJUSTMENTS
(Customer Bills)

PERFORMANCE CRITERIA	**(1) Forecast vs. Actual**	**(2) Internal Index**	**(3) External Index**	**(4) Before vs. After**
DSM INCENTIVE	Good	Good	Good	Good
DECOUPLING	Yes	No-But can offset lost revenues	Yes	Partial
SCOPE	Full coverage except for forecast adjustment	DSM Only	Full coverage	Full coverage except for adjustments
COST MINIMIZATION	Yes	No-Unless payment includes cost recovery	Medium	Partial
ADMINISTRATIVE SIMPLICITY/COST	Medium	Medium	Medium	Medium

3.121 Incentive Potential

Because these plans all operate by adjusting a utility's rate of return on overall investment, the incentive potential is the same as rate-of-return adjustments on total rate base. (See Section 3.1)

3.122 DSM Incentive

Because all of the approaches are designed to capture actual savings, they each produce reasonable incentives to pursue DSM activities . In each case more, or lower-cost, DSM will produce greater incentive payments.

3.123 Decoupling

In both the first (target/actual) and third (external index) criteria, sales promotion to existing customers would negatively impact the utility's measured performance, but would not affect the yardstick against which that performance is compared.[65] Thus, increased sales produce lower or negative incentives. This condition means the first and third criteria can decouple profits from sales.

For the internal index and before/after criteria, increased sales would affect both the yardstick and the utility's measured performance, and there would be no net effect on the incentive measure.[66] These criteria are therefore, not capable of decoupling profits from sales.

3.124 Scope

The first (forecast/actual), third (external index), and fourth (before/after) criteria would credit a utility's performance with all actions which reduce average bills in relation to the yardstick. Because bills are reduced by cost-effective demand-side measures and cost effective supply-side measures (or any cost-cutting opportunities the utility may have), these approaches can provide a wide range of desirable incentives. For example, forecasted average bills would include an assumption about the cost of new power acquisitions which would become the yardstick against which actual performance is measured. Utility power acquisition that is less costly than forecast will increase the utility's incentive payment.[67]

Supply-side decisions affect the yardstick in the second approach (internal index) to the same extent they affect the utility's measured performance. Therefore, this variation is limited to DSM programs.

3.125 Administrative Simplicity

All the criteria are reasonably easy to administer. The first (actual vs. forecast) and fourth (before/after) may involve more substantial regulatory proceedings to determine the scope and impact of any required adjustments. The second (internal index) and third (external index) would require less effort after the system is established, but more effort initially to create a reasonable index.

3.126 Cost Minimization

Approaches which include the cost of DSM programs in average bills, but which are not

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[65] *The addition of new low-use customers would decrease average bills and the addition of new high-use customers would increase bills. As utilities have relatively little influence over their number of customers, the best a utility could realistically do is encourage all new customers to be as efficient as possible.*

[66] *In the fourth approach (before/after), there may be a partial decoupling, but only to the extent that the increased sales affect the group of participating customers.*

[67] *With respect to the first (forecast/actual) and fourth (before/after) approaches, the scope of the program is limited only by those matters taken into account to adjust the forecasted bills. Thus, if forecasted bills are adjusted to reflect actual purchases from qualified facilities, this element would be eliminated from the scope of the incentive plan.*

included in the yardstick, would provide incentives to minimize the cost of the programs. Thus, the first (forecast/actual) and third (external index) criteria would automatically provide an incentive to establish DSM programs at the lowest possible cost. In fact, with both criteria, if the cost of DSM programs exceeds the utility's avoided cost, average customer bills would increase and the utility would be penalized or at least receive no reward.

In the ordinary case, the second criterion (internal index) would not provide an incentive to minimize cost because the cost of DSM programs is borne by both participants and non-participants alike. Because the cost would be included in the average bills of the control group and all other customers, there would be no apparent change in bills and, therefore, no incentive to minimize the cost of DSM programs.

The fourth criterion (before/after) would provide a partial incentive to minimize cost because bills measured before a DSM program would not reflect the program cost, while the bills measured after program implementation would ordinarily reflect DSM program costs. The incentive is limited, however, because bill calculation will reflect only those costs which have been allocated to the participating customer class.[68]

3.2 SHARED SAVINGS

3.20 General Description

In the broadest sense, all incentive plans may be considered shared savings plans. Different approaches (e.g., rate-of- return adjustments, bounty, etc.) use different mechanisms to identify and split available savings, but no approach produces payments to utilities which exceed total savings. This section, however, considers only those incentive plans which explicitly identify a savings and propose a sharing mechanism to compensate utilities for all, or part, of the direct and indirect costs incurred from an energy efficiency improvement.[69]

Table 4 summarizes the incentives associated with the following four variations of shared savings plans:

(1) Resource Savings - Estimated - Shared savings proposals can be divided into two categories, depending on the savings being shared. This approach identifies a net resource savings as the difference between avoided cost and the cost of an energy

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[68] *The incentive would not be limited if the before/after calculation was adjusted solely for the purpose of determining the level of an incentive payment by allocating all DSM program costs to participating customers.*

[69] *For examples of this approach see Wellinghoff, "The Forgotten Factor in Least-Cost Utility Planning: Cost Recovery," P.U.F., March 31, 1988; and "Inquiry of a Ratemaking Methodology for Encouraging Demand-Side Resource Options, Finding and Conclusions," Docket No. 89-651, Nevada Public Service Commission, July 6, 1989.*

efficiency improvement.[70] The net savings is then split between the utility and the consumer. To distinguish this approach from others, it will be referred to as "shared resource savings." In this first performance criterion, the DSM savings are estimated.

(2) Resource Savings - Actual - The second variation is the same as the first except DSM savings are based on actual measurements.

(3) Bill Savings - This approach is similar to the model of third-party energy service companies that identify reductions in customer bills after an energy efficiency improvement. The savings are then split between the efficiency provider and the customer. The provider's share normally covers the installed cost of the efficiency improvement. This approach will be referred to as "shared bill savings."

(4) Unbundled Energy Services - Finally, proposed approaches exist, which in various ways, unbundle energy-supply and energy-savings services. These approaches "buy" or "sell" cost-effective energy conservation services from or to customers. In one variation, the utility (or contractor) installs a demand-side measure and charges the customer for the saved KWHs. The charge for KWHs is equal to the utility's retail rate. For example, the utility may either sell extra KWHs to power an uninsulated electric water heater or sell fewer KWHs plus the energy service of insulating the water heater. If the water heater insulation blanket saves 600 KWHs per year, the

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[70] *Some approaches define this difference in more detail than others. For example, the Nevada Notice of Inquiry provides:*

> *"Net System Benefits are the reduction in revenue requirements resulting from the implementation of demand-side programs. Such benefits are described by the Utility Cost Test contained in Chapter 5 of the California Standard Practice Manual.... After removing the present value (discount and summation) terms and alternate fuel terms (which would apply to another utility) the formula becomes:*
>
> *NSB = [UAC] - [UC + INC + UIC]*
> *[Net System Benefits] [Benefits] [Costs]*
>
> *A sharing fraction g would be determined to allocate the savings between the utility and its customers such that the demand-side incentive (DSI) would be:*
>
> *DSI = g(NSB), where: 0 < g > 1*
>
> *The sharing fraction would be set at the sole discretion of the Commission at the time of its preapproval of capitalizing the applicable demand-side program(s). At a rate case proceeding, the net system benefits accrued since the previous rate case would be allocated."*

utility charges the customer the full retail rate for the saved energy.[71]

Another, and very similar, approach exists which incorporates demand-side bidding procedures into a qualifying facility and supply-side action. In this approach the retail customers or a third-party energy service company could bid to deliver demand-side measures on the same basis as a supply-side proposal, but the bidder would pay the utility for saved KW and KWH at the full retail rate.[72]

Appendix B includes a discussion of the comparison of unbundled bidding plans to shared bill plans. The discussion concludes that unbundled energy plans are essentially shared bill savings plans in which most savings are retained by the utility.

TABLE 4
SHARED SAVINGS

PERFORMANCE CRITERIA	(1) **Resource Savings Estimated**	(2) **Resource Savings Actual**	(3) **Bill Savings****	(4) **Unbundled Energy Services**
DSM INCENTIVE	Perverse and inadequate	Good, but inadequate	Good	Good
DECOUPLING	No	No	Depends on measurement (see Table 3)	No-But offsets lost revenues
SCOPE	DSM and possibly new supply	DSM and possibly new supply	DSM	DSM only
COST MINIMIZATION	No-Unless payment includes cost recovery	No-Unless payment includes cost recovery	Maybe, See Table 3	Yes
ADMINISTRATIVE SIMPLICITY/COST	Low cost	Low cost if data is already produced for program evaluation, otherwise Medium	Low market penetration, Medium cost	Difficult to under-stand, Medium cost

**The measurement variations in Table 3 apply with equal force to shared bill savings.

[71] *Whittaker. "Conservation and Unregulated Utility Profits: Redefining the Conservation Market," Public Utilities Fortnightly, July 7, 1988; and Katz. "Proper Utility Incentives: Everybody Wins," presented at Western Conference of Public Utility Commissioners, June, 1989.*

[72] *See Cicchetti and Hogan. "Including Unbundled Demand-Side Options in Electric Utility Bidding Programs," Public Utilities Fortnightly, June 8, 1989.*

3.21 Incentive Potential

Some, but not all, of the shared savings plans can produce enough incremental earnings to offset existing financial disincentives. For example, in shared resource plans, the savings (Savings = Avoided Cost - DSM Cost) available to be shared approaches zero as the DSM cost approaches full avoided cost. This is why incentive plans which incorporate shared resource concepts are combined with other cost recovery and decoupling approaches.[73]

The savings available from a bill savings plan can be large enough to offset lost revenues and DSM costs. For example, using the typical utility data shown in Section 3.0, the bill savings to the participating customers would be $.07 per KWH. This savings would be adequate, albeit barely, to compensate the utility for a $.05 non-fuel revenue loss, plus the $.02 cost of conservation. In addition, a further $.01 net savings associated with fuel costs (the difference between the $.02 average and $.03 marginal fuel cost) would result which, under ordinary circumstances, would be shared by all customers.[74]

3.22 DSM Incentives

Table 4 summarizes the incentive structure of various shared savings approaches. Like other incentive plans, shared savings plans which rely upon estimated savings produce the wrong incentives. Under this variation, superior results will yield lower earnings and vice versa.

Either the shared resource or bill savings approach can yield reasonable incentives if the savings to be shared are based on actual achievements.[75]

3.23 Decoupling

The extent of decoupling depends on the specific performance criteria. For example, if bill savings are identified using either before/after or participant/non-participant comparisons, the incentive to increase sales is largely unaffected, and decoupling is not achieved. On the other hand, measuring shared bill savings by the target/actual or external index approaches can decouple profits from sales.[76]

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[73] *For example, the preferred approach in Nevada correctly combines a shared resource savings approach with DSM cost recovery and a mechanism to restore lost revenues. Likewise, New York has recently approved temporary incentive plans for Niagara Mohawk and Orange and Rockland, which combine a shared revenue approach with DSM cost recovery and lost revenue recovery.*

[74] *The $.01 fuel savings is not available for use in a shared savings plan because it is shared by all customers.*

[75] *By the nature of the plan, bill sharing approaches tend to be ex post or actual measurements.*

[76] *Measuring on this basis is more amenable to plans that focus on average bills for large groups of customers, as opposed to plans that are limited to customer specific bill savings. See Geller, "Use of Financial Incentives to Encourage LCUP and Energy Efficiency," June 1988, for a fuller discussion of the*

Shared resource savings approaches do not result in decoupling. Consequently, this approach will produce the desired incentives only if it is combined with other plans which decouple profits from sales.

3.24 Scope

The shared resource savings approaches proposed have focused only on demand-side measures. There is no reason, however, why supply-side resource saving cannot be measured and shared in a similar fashion.

The efficiency of supply-side decisions is ultimately reflected in customer bills. Therefore, depending on the precise performance criteria selected (see Table 3), bill sharing plans can capture efficiency gains for both demand- and supply-side resources.

3.25 Administrative Simplicity

Resource savings approaches require the measurement of avoided costs, as well as the cost and quantity of capacity and energy saved by efficiency programs. As a general matter, commissions and utilities already calculate avoided costs for other purposes and therefore will not need to undertake complicated administrative requirements. Deriving program-by-program savings estimates will require significant effort unless the data is already gathered for DSM program evaluation or other purposes.[77]

Different measurement issues are raised for a shared bill approach. The principal information required to conduct a shared bill plan is readily available customer billing information. Additionally, methods of identifying changes in customer bills such as before/after or participant/nonparticipant comparisons must be developed.

The unbundled approaches involve measurement issues similar to those of shared bill plans. However, unbundled plans raise serious questions of public understanding and customer acceptance. For example, it is unlikely that any but the most sophisticated customers will accept plans which require the participating customer to continue paying for saved KWHs.

3.26 Cost Minimization

Some variations of shared savings approaches can provide incentives for utilities to maximize net savings and to obtain efficiency or other resources at the lowest possible cost.

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target/actual approach. Also, see Section 3.12 for additional discussion of the difference between the various bill savings measurement approaches.

[77] *While a shared resource savings approach could be administered on a program-by-program basis, the same result would occur if measured on an aggregate basis. Measuring aggregate program impacts may pose fewer problems than attempting to disaggregate to the program level.*

Shared resource savings approaches which include DSM program cost-recovery as part of the utility's share of the savings will provide an incentive to achieve savings at the lowest possible cost. If DSM program costs are recovered through separate ratemaking procedures, the plan itself will not provide a financial incentive to be cost effective and other procedures must be used.[78]

Shared bill savings approaches ordinarily include DSM program cost recovery as part of the utility's or ESCO's savings share. Therefore, these approaches provide a financial incentive to minimize the cost of DSM programs.[79]

3.27 Non-Participant Impacts

The ability of different incentive approaches to create incentives to minimize non-participant impacts is discussed in Appendix A. It is also noted here because two of the shared savings approaches, shared bill savings and unbundled energy services, are designed to eliminate non-participant impacts. In the ordinary form of both of these variations, all of the DSM program's direct and indirect costs are borne by the participating customers and there are, consequently, no non-participant impacts.

3.3 BOUNTY

3.30 General Description

Bounty approaches provides payment, i.e. a bounty, to utilities in return for specified achievements. For example, a utility might be paid a bounty of "x" cents for each KWH saved, or "y" dollars for each block of power saved.[80]

Table 5 summarizes the incentives produced by five different performance criteria for bounty plans. Any of the criteria can be implemented based on bounty per KWH, KW, or a combination of the two. The performance criteria are as follows:

(1) Estimated Savings - In the first criterion, DSM impacts are based on estimated savings determined prior to program implementation. A bounty, or payment, is made to the utility for each KW or KWH of estimated savings.

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[78] *The incentives to deliver lowest-cost DSM programs will be determined by the characteristics of the separate cost-recovery mechanism, not the shared savings plan.*

[79] *The specific incentives, however, depend on the way bill savings are measured. The conclusions contained in the discussion of "Rate-of-Return Adjustment - Customer Bills," apply with equal force here.*

[80] *The payment is always less than avoided cost; thus, this approach can also be considered a shared savings plan.*

(2) Actual Savings - The next criterion measures DSM program impacts after the fact to identify actual results.

(3) Single Price - This criterion is a particular variation of (2) in which the bounty is a single fixed payment for each KWH saved. Thus, if a bounty is established at $.02 per KWH saved, $.02 would be paid whether the KWH were saved by a lighting program, an insulation program, or a motor replacement program.

(4) Multiple Price - This criterion is another variation of (2), but different prices are set for different programs. The bounty amount depends upon the type and cost of the program and its on-peak/off-peak resource-savings characteristics.

(5) Load vs.Forecast - The last criterion shown in Table 5 pays the utility based on achieved savings measured by comparing actual power demands to previously forecast demands adjusted for major variables such as weather and economic conditions (target/actual).

TABLE 5

BOUNTY

PERFORMANCE CRITERIA	**(1) Estimated Savings**	**(2) Actual Savings**	**(3) Single Price**	**(4) Multiple Price**	**(5) Load vs. Fore-Cast**
DSM INCENTIVE	Perverse	Good, but insufficient	Good, but insufficient	Good, but insufficient	Good, but insufficient
DECOUPLING	No	No	No	No	Yes
SCOPE	DSM and possibly supply	DSM and possibly supply	DSM and possibly supply	DSM and possibly supply	DSM only
COST MINIMIZATION	No-Unless bounty includes program cost recovery	No-Unless bounty includes program cost recovery	Yes-But risk of cream skimming	Yes	No-Unless bounty include program cost recovery
ADMINISTRATIVE SIMPLICITY/COST	Low cost	Medium cost	Medium cost	High cost	Medium cost

3.31 Incentive Potential

Bounty payments are ordinarily limited to full avoided cost and, therefore, can compensate utilities for only direct DSM costs which, at the extreme, are equal to avoided costs. Consequently, bounty plans must be combined with other cost recovery and decoupling options to be fully effective.

3.32 DSM Incentives

As was the case for all of the other incentive criteria, basing the incentive payment on estimated results produces perverse incentives. Alternatively, the incentives are reasonably good for bounty programs when performance criteria based on actual program achievements are measured on a program-by-program or aggregate basis.

The principal difference between the single price and multiple price variations in bounty plans (both assumed to be measured with actual figures) is that the single price plan will provide the greatest incentives to obtain the lowest cost efficiency opportunities.

In the multiple price plan, bounty prices would be set lower for low cost savings and higher for high cost efficiency opportunities. Generally, the different bounties would be priced to produce the same level of incentives to pursue cost effective DSM opportunities, regardless of the cost of the opportunity.[81]

For the fifth criterion (target/actual), the utility would have an incentive to achieve the greatest possible savings.

3.33 Decoupling

In each of the first four variations (estimated, actual, single price, multiple price), increased sales, regardless of the cause, have no effect on the apparent success in meeting a performance measure. Therefore, none of these criteria decouple profits from sales.

The fifth criterion (target/actual) can at least partially decouple because increased sales lead to a higher level of actual load, which reduces the bounty paid to the utility. This characteristic can be used to decouple profits completely from sales, but only if the level of the bounty is adequate.[82]

3.34 Scope

While bounty plans have been implemented or discussed only in conjunction with demand-side programs, there is no theoretical reason why these criteria cannot be applied to supply-side resources. A bounty can be offered for each MW of cost effective capacity, each MW of a renewable resource, or each MW of an environmentally benign source.

3.35 Administrative Simplicity

Administrative costs are the highest with the fourth criteria (multiple prices), due to the need to track separate program savings and incentive payments.

3.37 Cost Minimization

The bounty criteria provides the impetus to minimize delivered efficiency improvement costs only if the bounty payments include compensation for DSM program expenditures.

3.4 DECOUPLING

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[81] *This discussion of the distinction between single- and multiple-price bounty plans assumes that the bounty payment includes the utility's program cost recovery. If a utility's program cost are recovered in another fashion, then the single price approach will provide an equal incentive, regardless of the direct program cost.*

[82] *The extent of decoupling depends on the difference between the added earnings from increased sales and the earnings reduction due to lower measured load reductions.*

3.4 DECOUPLING

3.40 General Description

Breaking the link between profits and sales is an important step towards correcting the current regulatory system's incentives.

Some variations of the three general incentive plan categories involve performance measures that tie incentive payments to sales levels. In these instances, the utility is not explicitly made whole.[83] Instead, higher sales lead to a smaller or even negative incentive and lower sales lead to greater incentive. Decoupling profits from sales is accomplished when the incremental earnings from increased sales is equal to or less than the incremental reduction in earnings produced by the incentive plan. Many of the plans discussed and described in the tables, however, cannot decouple profits from sales. Nevertheless, these plans can be used if combined with separate regulatory reforms which decouple. Indeed, any of the plans described, even those capable of decoupling, can be combined with separate decoupling approaches. In that case, the need for the incentive plan would be significantly reduced.

3.41 Electric Revenue Adjustment Mechanism (ERAM)

In 1978, the California Public Utilities Commission adopted the Electric Revenue Adjustment Mechanism (ERAM). At the time of a rate case, the California Commission, using a future test year approach, established the utility's non-fuel revenue requirement. ERAM uses the revenue limit established in the rate case and, on a going-forward basis, tracks non-fuel revenue as it is received by the utility from customers. To the extent that actual annual non-fuel revenue collected by the utility deviates from the allowed revenue, the company either surcharges or refunds ratepayers.[84]

If sales and, therefore, revenues are lower than expected, the revenue shortfall is returned to the utility though a rate adjustment. If sales and, therefore, revenues are higher than expected, the utility must return the over-collection to customers. These adjustments are made regardless of the cause of the revenue difference.[85] Since 1978, ERAM has produced ratepayer refunds about as often as it has produced utility surcharges.

The important difference between ERAM and approaches which restore DSM-induced lost revenue is the different treatment of revenue from increased sales. This is the ERAM element that removes the profits from increased sales.

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[83] *California's ERAM is an example of an effective decoupling approach which does operate as a make-whole mechanism.*

[84] *Because revenues are fixed and not earnings or profits, the incentive to cut costs and thereby increase the level of earnings remains unchanged.*

[85] *Besides conservation, the major factors that affect sales and revenue levels are weather and economic conditions. While making utility revenues indifferent to sales, ERAM also makes utilities indifferent to weather and general economic conditions. Because neither weather nor economic conditions are within the utilities' control, little is lost by removing the risks from utilities.*

Finally, because ERAM operates on an overall revenue level, measurement of energy efficiency is not required. The only measurement requirements, namely revenues, are straightforward and easily verifiable.

3.42 ERAM on a Per-Customer Basis

Because ERAM fixes revenue requirements for a future period, it requires a forecast of all rate case components that will influence the utilities' future revenue requirements. This means ERAM, as implemented in California, fits well only with states using a future test year approach to rate-making or an historic test year supplemented with attrition analysis.[86]

A variation on the California ERAM exists, which can be implemented in states using either historic or future test year. At the time of a rate case, revenue requirement is divided by the corresponding number of customers (by customer class). This produces a revenue-per-customer limit which would then operate like ERAM. While new rates are in effect, the utility tracks non-fuel revenues received from customers, as well as the number of customers. Rates are adjusted annually so the utility retains only the allowed non-fuel revenue per customer.

The theory behind setting rates on an historic test year basis is that the test year establishes a constant relationship between costs, investments, and revenues. Increased revenues, realized in the period during which rates are to be in effect, are supposed to offset higher costs incurred after the test year and no more. In fact, in the short term, increased sales to existing customers do not produce increased non-fuel related costs.

Using a revenue-per-customer approach is a practical way to reconcile the realities of utility economics with the theoretical basis of historic test year ratemaking. This approach allows utilities to retain incremental revenues associated with higher sales due to changes in the number of customers. Because new customers often mean new non-fuel related costs, including poles, wire, meters and capacity, this modification tends to reduce earnings erosion that would occur if a strict revenue cap were imposed. Meanwhile, increased revenue (net of fuel costs) that results from increased sales to existing customers would be returned to customers instead of increasing utility earnings.

3.43 Fuel Revenue Accounting

An approach implemented in Maine in 1986 can be used to decouple profits from sales in states with a reconciled fuel adjustment clause.

Most states with a reconciled fuel adjustment clause either explicitly or implicitly allocate

[86] *An attrition analysis also requires forecasted sales and expense levels and is, therefore, amenable to a California ERAM approach.*

average fuel cost to each KWH sold. Thus, a \$.07 commercial rate and a \$.05 industrial rate each include \$.02 of average fuel cost. This means that the non-fuel contribution to earnings is \$.05 for the commercial rate and \$.03 for the industrial rate (rate minus average fuel cost).

Similarly, for a utility with time-of-use or seasonal rates, the higher on-peak rates make a greater contribution to profits. For example, a utility may have a \$.10 per KWH on-peak rate and a \$.05 per KWH off-peak rate. In most states, both prices include an average fuel cost of \$.02. This means the non-fuel component of the on-peak rate is \$.08 and only \$.03 for the off-peak rate. On-peak sales, therefore, add substantially more to earnings than off-peak sales, and a utility able to shift load from off-peak to on-peak periods realizes higher, not lower, profits.[87] This is exactly the opposite of what regulators would like to have happen. Of course, the more likely response to these incentives is that the utility would not actively encourage or assist customers in shifting on-peak load to off-peak periods.

These issues, along with decoupling profits from sales, can be addressed by changing the accounting treatment of fuel and non-fuel revenues.[88] Rather than account for all fuel revenues on a flat average per KWH basis, a greater proportion of on-peak (or tail-block) prices can be treated as fuel revenue, leaving a smaller portion of on-peak (or tail-block) rates to contribute to earnings.[89]

The following table illustrates the changes in accounting using the previous example of a utility with time-of-use prices.

	ON-PEAK	OFF-PEAK
BEFORE		
Fuel (cents/KWH)	\$.02	\$.02
Non-Fuel (cents/KWH)	\$.08	\$.03
Price (cents/KWH)	\$.10	\$.05
AFTER		
Fuel (cents/KWH)	\$.08	\$.01
Non-Fuel (cents/KWH)	\$.02	\$.04
Price (cents/KWH)	\$.10	\$.05

[87] *Boston Edison recently implemented time-of-use rates which resulted in customers shifting load from on-peak to off-peak periods. The difference between on-peak and off-peak contribution to earnings meant Boston Edison experienced a significant drop in its earnings.*

[88] *Changing the accounting treatment does not require any change to actual retail prices. The accounting changes are invisible at the customer level but very visible to the utility.*

[89] *A utility's price structure might charge \$.05 per KWH for the first 300 KWH's and \$.06 per KWH for all additional KWHs. The \$.06 portion of the price structure is called the tail-block.*

This table points out three important features of fuel revenue accounting:

* Prices are unchanged by the accounting change. Rate design questions do not arise from such an approach.

* Shifting consumption from on-peak to off-peak previously cost the utility $.05 in lower earnings. After the accounting change, utility earnings would increase by $.02.

* Increased on-peak sales used to be very profitable. After the change, increased on-peak sales may not be profitable at all.[90]

The same approach can be used for rates without time-of-use or block features. For these rates, new "accounting blocks" can be created that accomplish the same result. For example, a flat $.07 per KWH residential rate can be turned into a two-block rate schedule. The first 300 KWH would be billed to customers at $.07 per KWH but accounted for as $.05 non-fuel revenue and $.02 of fuel revenue. Sales in excess of 300 KWH would also be billed to customers at $.07 per KWH but accounted for as $.02 non-fuel and $.05 fuel.

These changes are illustrated in the following table:

	FIRST 300 KWH	EXCESS SALES
BEFORE		
Fuel (cents/KWH)	$.02	$.02
Non-Fuel (cents/KWH)	$.05	$.05
Price (cents/KWH)	$.07	$.07
AFTER		
Fuel (cents/KWH)	$.02	$.05
Non-Fuel (cents/KWH)	$.05	$.02
Price (cents/KWH)	$.07	$.07

Making these changes in the accounting treatment of fuel substantially reduces and possibly eliminates the non-fuel contribution of the marginal KWHs sold. Decoupling is accomplished when incremental sales add only that revenue needed to offset incremental costs.[91] Meanwhile, in all other

[90] *If the $.08 fuel revenue attributed to the on-peak KWH sales exceeds the actual marginal fuel costs, the difference would be returned to customers because of the fuel clause reconciliation provisions. This reimbursement to customers would further reduce the on-peak contribution to earnings below the apparent $.02 level.*

[91] *In addition to decoupling of profits from sales, this approach tends to level utility earnings over the course of a year, thereby reducing earnings volatility and reducing earnings sensitivity to weather and other uncontrolled factors.*

respects the fuel clause mechanism remains intact. During each fuel clause period, an effort is made to match fuel costs with fuel revenues, and any differences are made up in subsequent periods.

3.44 Fuel Clause Reform

Another approach for states with fully reconciled fuel adjustment clauses is to eliminate or reduce the extent or scope of reconciliation. Abolishing the reconciliation features of a fuel adjustment clause would mean that incremental revenues from increased sales would be at least partially offset by incremental fuel costs. Conversely, saving a KWH would produce cost savings equal to the marginal cost of fuel. This cost savings would at least partially offset the revenue lost by foregoing a sales opportunity. Incremental sales would continue to add to earnings, but only to the extent that the marginal price of electricity exceeds the marginal fuel cost of producing the electricity.[92]

A milder reform to accomplish a similar result would be to continue the reconciliation provisions of fuel clauses, but limit the scope of reconciliation to changes in fuel prices. For example, fuel clauses might initially be established based on projected fuel prices expressed as dollar per barrel, dollar per ton, etc. Reconciliation, or true-up, provisions would then be limited to adjustments which reflect the difference between the assumed fuel prices and actual prices. Fuel quantities, a function of plant performance and sales levels, would not be reconciled. An incremental KWH sold would increase fuel quantity without regard to what may have happened to fuel prices. Similarly, saving a KWH would reduce fuel quantity and save the utility the marginal cost of fuel used to produce the KWH.

The effect of this change on the DSM incentives would be the same as eliminating the reconciliation features entirely. This approach, however, would continue to insulate utility earnings from the volatility of fuel prices.

The attributes of these four decoupling approaches are summarized in Table 6.

TABLE 6

DECOUPLING

	ERAM	ERAM CUSTOMER	FUEL ACCOUNTING	FUEL REFORM

[92] *Currently, retail prices almost always exceed the utilities' marginal fuel cost.*

EXTENT OF DECOUPLING	Complete	Complete	Partial to Complete	Partial
LIMITATIONS	Requires future test year	Future or historic test year	Requires reconciled fuel clause	Limited ability to correct incentives

Conclusion

Table 7 presents a summary of the conclusions reached in this Section. Listed across the top of the Table are different assumptions of how state regulation of incentive plans might be structured. For example, the first column, "W/O Decoupling, W/O DSM Cost Recovery," describes a state which has not adopted ERAM or any of the other decoupling options and which has no separate DSM program cost-recovery mechanism. This means that the incentive plan selected must be capable of decoupling profits from sales and also give reasonable treatment to DSM program costs. Next, the table summarizes the capabilities of alternative incentive plans to produce a desirable result given the assumed regulatory status. A "yes" (Y) response means the incentive approach is a good candidate and attention should turn to the various ways that the general approach can be implemented. A "no" (N) response means the approach is not a good candidate and a "maybe" (M) response means the performance of the approach depends on other factors.

TABLE 7

SUMMARY
ALTERNATIVE INCENTIVE PLANS

	W/O Decoupling W/O DSM Cost Recovery	**W/Decoupling W/O DSM Cost Recovery**	**W/O Decoupling W/DSM Cost Recovery**	**With Decoupling W/DSM Cost Recovery**
Rate-of-Return Overall	Y	Y	Y	Y
Rate-of-Return DSM	N	N	N	Y
Rate-of-Return Bills	Y	Y	Y	Y
Shared Savings Resource	N	M (See Note 2)	M (See Note 2)	Y
Shared Savings Bill	M (See Note 1)	Y	M	Y
Bounty	M (See Note 1)	Y	Y	Y

Y - Yes, the approach is capable of producing the right incentives.

N - No, the approach is not capable of producing the right incentives.

M - Maybe. Under some conditions the approach can be made to produce reasonable incentives.

(Note 1: This approach can address all costs only if average fuel costs exceed marginal fuel costs, which is rarely the case. Otherwise, they are sufficient only for low-cost measures.)

(Note 2: This approach is possible only for very low-cost DSM measures and very low-cost revenues.)

All cases assume the use of actual rather than estimated savings.

APPENDIX A

There are a number of factors slightly less important than the factors discussed in Sections 2 or 3 but which should nevertheless be considered when designing or selecting an incentive plan. These items include consideration of fuel-switching, environmental externalities, minimization of non-participant impact, cream-skimming, and predictability.

A.0 Fuel Switching

Will the plan reward programs that achieve cost effective fuel switching by customers?

Instances exist in which large electricity and overall energy efficiency savings are feasible through fuel switching programs.[93] In some instances, switching may occur from electricity to natural gas, while in others, electricity is exchanged for a renewable fuel, for example, solar or wood. In either case, alternative incentive plan evaluations should consider how electric utility profits change as a result of customer fuel switching. Under the current system, electric utilities discourage fuel switching, no matter how cost effective, because it always means lower profits.[94]

All of the incentive plans described in Section 3 can accommodate fuel switching programs. However, some plans require a conscious decision to treat fuel switching programs like all other efficiency programs while others automatically reflect fuel switching electricity savings. For example, rate-of-return adjustments to either estimated or actual DSM savings would capture the savings of cost-effective fuel switching, but only if the fuel-switching programs are specifically treated as eligible DSM programs for which savings are estimated or measured. In contrast, rate-of-return adjustments based on load/forecast comparisons would automatically reward fuel-switching efforts.

A.1 Environmental Costs

Many states which have adopted LCP also attempt to incorporate environmental externalities in the planning and decision making process. Traditional utility planning has always included consideration of a utility's directly incurred environmental control costs. Thus, the cost of building and operating a sulfur dioxide scrubber is reflected in the cost of a new coal-fired power plant. Even a scrubbed coal plant, however, emits pollution whose environmental damage is not borne by the utility or reflected in its prices. In increasing numbers, states attempt to take these externalized costs and reflect them in the LCP decision process.[95]

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[93] *The availability of fuel switching as an element of a least cost plan varies from state to state. States with combined gas and electric utilities are more likely to look favorably on fuel switching as an option.*

[94] *The impact will be different for combined gas and electric utilities.*

[95] *External benefits from new power supplies, such as construction jobs, tax revenue, and backing-out foreign oil, are often given weight in investment decisions. External costs should be given as much consideration as external benefits.*

None of the general approaches to incentive plans expressly consider environmental externalities. Nevertheless, once a state has decided how to incorporate environmental concerns in its decision-making process, reflecting that decision in any of the alternative plans is not a difficult task.

To illustrate, a state might decide that its consumers and society overall would be served by imposing a 20% economic penalty for fossil fuel sources of generation when making its resource decisions. In other words, a state might decide that ratepayers and society would be better off paying 20% more for electricity, but saving the costs that higher levels of pollution would cause. Incorporating this type of decision into an incentive plan means that the utility's correct decision to select a 20% more expensive but cleaner option should not jeopardize its efforts to achieve the same earnings level it would have without the clean option selection. Thus, special attention should be paid to any incentive plan that measures performance against a standard without the same 20% environmental concern cost premium.

For example, consider a plan that focuses on the utility's relative ability to control customers' bills, as compared to an index of other companies. Adding 20% to the cost of the utility's new resource acquisitions (demand- or supply-side) would make the utility appear to be less efficient than the utility index group (assuming the other utilities have not had a similar policy imposed on their resource decisions). To make the bill comparison fair, 20% of the cost of all of the target utility's added demand-and supply-side resources should be subtracted from the utility's average bills before comparing its performance to the index.

A.2 Non-Participant Impacts

Is the proposed program designed to minimize nonparticipant impacts? Depending on the utility's average and marginal costs and the state specific mechanisms for DSM cost recovery, DSM programs may have an adverse impact on average prices, thereby raising prices and bills for customers who do not participate in DSM programs.[96]

As a general matter, the non-participant impact of even very large DSM programs is small, much smaller than the impact of supply-side options.[97] However, with the exception of the shared bill savings, unbundled approaches, and some of the customer bill approaches, incentive plans generally do not provide financial incentives to minimize non-participant impacts. Nevertheless, incentive plans can be structured to encourage utilities to design DSM programs in ways that minimize non-participant impacts. Generally, however, there are three steps to be taken which may address this concern.

First, a number of the variations of alternative plans provide an incentive to minimize the

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[96] *Rates for participating customers increase as well, but the DSM program causes their bills to decrease.*

[97] *For a more complete discussion of this and related issues see Cavanagh, "Responsible Power Marketing in an Increasingly Competitive Era," 5 Yale Journal on Regulation 331, 1988.*

cost of energy efficiency programs. Minimizing the cost of energy efficiency will tend to minimize non-participant impacts.

Second, plans can be designed to provide incentives for utilities to obtain as much contribution as possible from participating customers. The greater the customer contribution toward energy efficiency, the lower any non-participant impacts. For example, rate-of-return adjustments based on average customer bills can exclude from the bill calculation any direct participant contribution. The greater the participant contribution, the larger the apparent bill savings and the larger the incentive. This approach, however, tends to undermine the level of participation in energy efficiency programs and, thus, may be counterproductive.

Finally, non-participant impacts may also be addressed by assuring that energy efficiency programs are widely available to all customers and all customer classes. Wide program availability will tend to minimize the number of non-participating customers.

A.3 Skimming the Cream

Will the proposed incentive plan encourage the utility to engage in cream-skimming programs, and, if so, how much of a concern is that practice?

Skimming the cream in this context means designing and carrying out only the lowest-cost measures while leaving behind other cost-effective opportunities for energy efficiency. The most common example occurs in new construction where cost-effective measures left out at the time of construction are prohibitively expensive to fix later.

In another example, commercial lighting retrofits might cost two cents per KWH saved, while heating and cooling improvements might cost four cents if done on the same trip, but six cents if done separately. An incentive program that paid the utility five cents for each saved KWH might cause the utility to improve the lighting and earn three cents while foregoing the four cent cooling improvement that would have netted only one cent. An incentive plan that paid the utility three cents for lighting and five cents for heating and cooling would net the utility the same one cent for both projects.[98]

The most important reason to avoid cream-skimming is that cost effective opportunities will be permanently lost and consumers will pay more than necessary for energy services.[99]

Of course, in comparison to existing regulations, a plan which suffered only from the potential for cream-skimming would be a vast improvement over the current system. Nevertheless, one should be aware of the possible problem and the available solutions, including solutions outside

[98] *In this case one might still encounter another type of cream-skimming where the utility pursues only the easiest lighting and heating opportunities.*

[99] *In all cases, the DSM opportunities at risk are cost effective, but the payback on the less cost-effective measures is below the hurdle rate for the investing entity.*

of an incentive plan itself. Cream-skimming potential is generally the greatest with plans which provide strong incentives to utilities to minimize the cost of energy efficiency.

In general, there are three ways to lessen the potential for cream-skimming. First, some level of regulatory oversight of program design can be retained to assure that cream-skimming programs are not implemented. This is the current approach, and this level of regulatory oversight could continue even with significant reforms of financial incentives associated with DSM program implementation.[100]

Second, any of the incentive plans may be implemented in a more disaggregated fashion. For example, bounty plans can be established to create different bounty levels for different types of programs. Lower bounties for relatively inexpensive conservation measures, and higher bounties for more expensive programs, would tend to minimize any financial incentive to pursue cream-skimming opportunities.

Third, plans which allow utilities to recover actual program costs separately from incentive plans tend to remove cream-skimming incentives. This approach, however, also removes the incentive to minimize program costs.

A.4 Predictability

While regulators will always maintain a wide range of discretion in rate-setting proceedings, incentive proposals that clearly lay out guidelines and expectations are likely to motivate utility managers more than alternatives that rely heavily upon the exercise of commission discretion.[101] Regardless of how responsible, consistent, and objective regulators are, suspicion will always exist between regulatory commissions and utilities.[102] Consequently, incentive proposals which rely upon the discretion of commissioners may not achieve full potential in motivating utility managers, even if the commission discretion is always exercised in a responsible manner.

Predictability does not mean that the utility should know in advance, or be guaranteed a particular level of earnings. Rather, the utility must know that a specific accomplishment will produce a particular and predetermined effect. The greater and more immediate the cause and effect, the more likely it is that the regulatory incentives will have a positive influence on utility managers. Similarly, incentives that reward promptly, rather than in the distant future, will be most effective.

Any of the incentive plans described in Section 3 can provide the needed level of predictability by assuring that the rules are clearly articulated prior to implementing the incentive plan. For example, in the rate-of-return adjustment criteria, it would be important to state in advance

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[100] *In addition, experience with collaborative design efforts in New England suggests utilities and energy efficiency advocates can work together to design conservation programs in which cream-skimming potential is minimized.*

[101] *An extreme example of a plan that relies on commission discretion consists of a general promise by regulators that a utility will be treated generously if it successfully pursues any LCP.*

[102] *Even where there is no distrust the relatively short tenure of most commissioners -- about 4 years in the U.S. -- adds to the lack of predictability of approaches that rely on commission discretion.*

how much the rate of return would be adjusted for a particular level of results.

With respect to measurement related issues, establishing measurement criteria in advance is all that is required. For example, a plan could require program savings to be measured by randomly testing and sub-metering a sample of 2% of the installations per year. Indeed, going further and specifying that each installation will be assumed to save "x" KWH is counterproductive.

A.5 Avoid Gaming

Any regulatory system, including traditional utility regulation, is subject to efforts by parties to engage in short-term "gaming." Simple manipulations, like the timing of rate case filings, or the timing of certain maintenance expenses (such as plant maintenance or tree trimming) which can be deferred or accelerated, can all have a significant effect on the utility's bottom line. Care should be taken when selecting and designing regulatory proposals so that the opportunity for gaming is no greater than it is already.

One way to lessen the incentive for manipulation is to assure that the implemented plan will remain in effect long enough to make such gaming risky. In addition, short term gaming temptations would be minimized by allowing the capitalization and amortization of DSM program costs in a way that bears some relationship to program benefits. A recent study by the Alliance to Save Energy includes an excellent discussion of this issue.[103]

A.6 Distribution of Incentives

The effectiveness of economic incentives is a function of where the incentives are directed within the utility company, i.e., shareholders, managers, employees, etc. The implementation of regulatory incentives which serve to benefit only distant stockholders will not be as effective as regulatory incentives which are at least in part directed toward utility executives and managers responsible for the successful (or unsuccessful) implementation of the least-cost plan.

Many utilities already have incentive compensation plans in effect. These plans may not be consistent with LCP incentive plans. For example, a compensation plan that weds the salary of a plant manager to heat rate may be compatible with LCP while a compensation plan tied to sales levels would not.[104]

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[103] *"Ratebasing of Conservation Program Costs", The Alliance to Save Energy, Discussion Paper, Washington, D.C., November, 1987.*

[104] *Central Maine Power Company has instituted a management compensation plan which rewards top managers based on CMP's rates relative to other New England utilities and the level of the company's earnings per share. By selecting relative rates instead of bills, managers' salaries go up if there is little or no conservation and salaries go down if the company succeeds in implementing substantial amounts of cost-effective efficiency. The same is true for earnings per share. Earnings will go up if sales increase.*

APPENDIX B

OTHER CONSIDERATIONS

A number of other considerations and questions frequently arise in discussions concerning the implementation of regulatory incentives. The most frequent subjects are discussed briefly below.

B.0 Effects of External Causes

One criticism of some proposals is that they fail to hold utilities harmless from factors outside the utility's control.[105] Generally, it makes little sense to have regulatory incentives in place when there is no ability on the part of the utility manager to respond to the incentive. Therefore, regulatory incentive plans should attempt to hold utilities harmless from factors truly outside their control. This policy must be considered with an appreciation of the extent to which existing regulation accomplishes this goal. For example, while weather is outside a utility's control, profits are subject to sales fluctuations caused by weather under current regulations.

Unless utility profitability is somewhat insulated from the influence of outside factors, the earning fluctuations occasioned by some factors (i.e., price of fuel) may be so large in relation to the desired regulatory incentives that the incentives become ineffective. For example, consider a plan that allows a utility's rate of return to rise or fall up to 100 basis points based on DSM program performance, but also removes all financial protection from changes in fuel prices. Once the 100 basis point cap is reached, the incentive plan is ineffective. Thus, if utility managers reasonably expect that the cap will always be hit due to changing fuel prices, the incentive plan will be much less effective than intended.[106] This is not to say that utilities should be insulated from all of the risks that bear on competitive firms.

Again, this factor should also be considered in the context of existing regulations. Under the present system, for example, utilities are not held harmless from the effects of weather and economic conditions.[107] Both these factors can have a very significant effect on utility earnings, and the fact that incentive plans also do not hold utilities harmless from changes in weather and economic conditions, therefore should not be a sufficient reason for dismissal.

B.1 Role of Unregulated DSM Subsidiaries

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[105] *The entire notion of holding utilities harmless from factors outside their control is a subject in itself, and is unique to regulated industries. In the context of regulatory reform, critics often point out that particular proposals result in benefit or harm that flow from plant performance, fuel prices, economic conditions, etc. While regulators are generally sympathetic to some or all of these concerns, it is worth noting that competitive businesses are subject to the same considerations and are not held harmless. To be sure, these differences in the risk profiles of various industries can and should be reflected in allowed rates of return.*

[106] *For the purpose of this discussion it is assumed that fuel price changes are outside the utility's control.*

[107] *Indeed, the strong economy and hot weather of recent years has had a positive effect on utility earnings.*

Some utilities already have unregulated energy service subsidiaries, and others may be in the process of seeking similar approvals. The operation of unregulated DSM subsidiaries may prove to be a useful adjunct, but the creation of such subsidiaries is no substitute for regulatory reform.

With an unregulated subsidiary, but without regulatory reform, a situation would exist where the successful operation of the unregulated subsidiary has an adverse impact on the parent utility's earnings. The question would remain whether a profit maximizing-strategy for the overall entity (the combined business of the utility and its unregulated subsidiaries) would be best served by the successful or unsuccessful operation of the unregulated subsidiary.

B.2 Distribution Utilities

Distribution companies generally purchase power from other utilities under rates or contracts approved by the Federal Energy Regulatory Commission (FERC).

In addition to factors which affect the financial incentives for other utilities (fuel clauses, rate structures, etc.) the terms of wholesale rates or contracts influence the distribution companies' incentives.

These terms are very similar to those contained in rates or contract charges between utilities and large industrial companies. In particular, the distribution company will incur a monthly demand charge and an energy charge for all power. The distribution company's costs of purchased power (capacity and energy) are ordinarily passed on to its retail customers through purchased power clauses which operate similar to a utility's fuel adjustment clause. Meanwhile, each KWH sold by the distribution company to its retail customers includes an additional component which recovers all other fixed costs. Because increased sales (to existing customers) do not increase fixed costs, each KWH has the same type of impact on revenues as it does for other utilities, albeit at a lower level.

B.3 Multi-State Utilities

Designing incentive plans for a utility that is part of a multi-state holding company presents additional considerations.

Most importantly, correcting the incentives for the state-regulated retail utility will not affect the incentives for the parent company or for the combined company. If planning and investment decisions are controlled or substantially influenced by an entity other than a state-regulated utility, and the correct incentives do not extend beyond the state-regulated utility, any improved incentives will have little effect. To have a meaningful effect on utility behavior and investment decisions will require the Federal Energy Regulatory Commission to reform federal regulatory mechanisms. Thus far the FERC has shown no interest in LCP or any related regulatory reforms.

B.4 Combined Gas and Electric Utilities

While this entire discussion has focused on electric utilities, the incentives are essentially the same for gas utilities. Therefore, the only complication for a combined gas and electric utility relate to fuel-switching. There appears to be no general rule concerning which fuel would be more profitable to the combined entity. Thus, if this is an area of concern, a utility-specific analysis is necessary.

B.5 Unbundled Energy Services

In an ordinary shared savings approach, an energy service company[108] (ESCO) enters into a contract with a customer. The ESCO installs an energy efficiency improvement at its expense and the customer pays for it over time by paying the ESCO a share of the savings in the customer's electric bill. The customer retains the remaining savings.

Assuming a reasonably competitive market and arms-length negotiation between the ESCO and the customer, the ESCO's share of the savings compensates the ESCO for all of its costs, including a reasonable rate of return. Thus, in the context of a competitive demand-side bidding process, the ESCO's bid price to the utility will be the same as its share of the savings (adjusted for any differences in the transaction costs).

In the ordinary shared savings model, the total benefit available to be shared by the customer and the ESCO is the difference between the retail rate and the cost of conservation. The unbundled energy service proposals are structured differently.[109] The ESCO (for this first example, the ESCO is the utility) buys and installs the device and charges the customer the full retail rate for all the saved energy. Any difference between the price and the cost of the efficiency improvement is retained by the utility. Thus, in the simplest form the unbundled energy service is like a shared savings plan in which the ESCO (in this case, the utility) keeps 100% of the savings.

The unbundled bidding version adds a little complexity because it can more easily occur in a three-party transaction involving utility, customer, and a separate ESCO.[110]

First, the two-party case: This case is similar to the unbundled example described above except that the utility makes a cash payment equal to the bid price instead of buying and selling the efficiency measure, and the efficiency measure is installed by the customer. Meanwhile, the customer continues to pay the full retail rate for all saved KWHs.

Thus, if the bid price is equal to the cost of the efficiency improvement, this is also a shared

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[108] *The ESCO may be a utility.*

[109] *Whittaker, "Conservation and Unregulated Utility Profits: Redefining the Conservation Market",* *__Public Utilities Fortnightly__, July 7, 1988; see also Katz, "Proper Utility Incentives: Everybody Wins", Western Conference of Public Utility Commissioners, June, 1989.*

[110] *Cicchetti and Hogan, "Including Unbundled Demand-Side Options in Electric Utility Bidding Programs", __Public Utilities Fortnightly__, June 8, 1989.*

savings plan where the utility retains 100% of the savings. If the bid price exceeds the cost of the efficiency improvement, the arrangement looks more like an ordinary shared savings plan.[111] From the perspective of the customer, the only situation in which this type of arrangement is superior to an ordinary shared savings plan is when the customer prefers cash to hardware. In return for this difference, the customer must participate in the bid process.

The three-party case (ESCO, utility, and customer) is more complex. These arrangements can take at least two forms. In the first, the ESCO buys and installs an energy efficiency device, the customer continues to pay the same retail bills (pays the retail price for each saved KWH), and the utility pays the ESCO the bid price.[112]

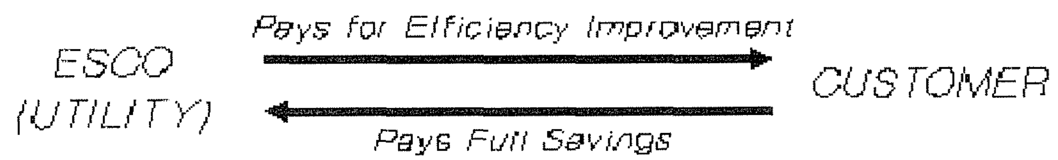

Fig. 1

This form illustrates several important matters. First, without a payment from the ESCO to the customer, this will appear to the customer to be a shared savings plan in which 100% of the savings goes to others. Because shared savings plans have very low market penetration without a substantial payback to the customer, this approach is unlikely to produce significant results.

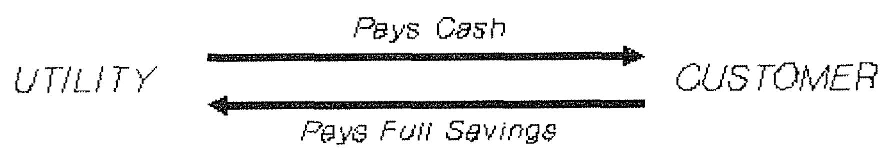

Fig. 2

[111] *If the purpose of bidding is to use competition to reduce the price of efficiency improvements, the bid price will equal the efficiency improvement's cost.*

[112] *A portion of the bid price may have to be returned to the customer to entice him to participate.*

Second, because the bid price cannot exceed avoided cost, any payment made by the ESCO to the customer will reduce the maximum investment the ESCO can make in efficiency equipment.

In the second form, the ESCO (the bidder) pays the utility the retail rate for bid KWHs and receives the bid price from the utility. The ESCO buys and installs an energy efficiency device and may or may not charge the customer for the service provided.

The left portion of the diagram points out that the utility payment for energy efficiency is

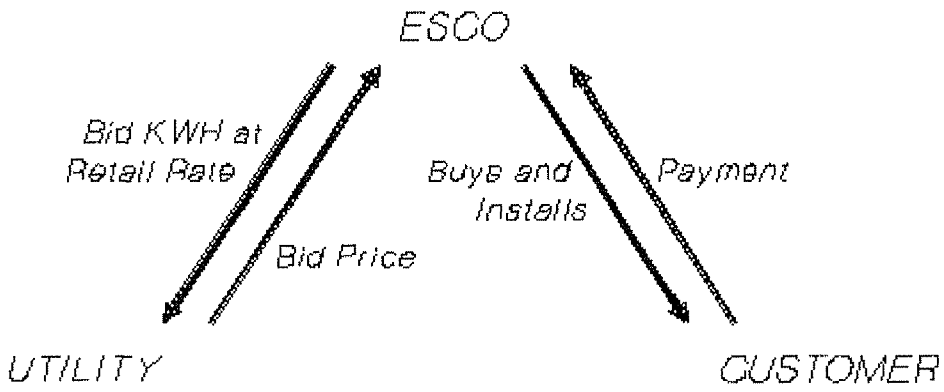

Fig. 4

Fig. 3

limited to the difference between average and marginal cost. Assuming the left portion of the diagram produces no net payment, what remains is the ordinary ESCO/customer shared savings plan. If average cost exceeds marginal cost, which is the case in many parts of the country, the net utility payment is negative. To offset this impact, the ESCO would require a correspondingly higher share of the savings from the customer, reducing further the likelihood that a contract between the ESCO and the customer will be executed.

APPENDIX C

Resolution in Support of Incentives for Electric Utility Least-Cost Planning

WHEREAS, National and International economic and environmental conditions, long-term energy trends, regulatory policy, and technological innovations have intensified global interest in the environmentally benign sources and uses of energy; and

WHEREAS, The business strategy of many electric utilities has extended to advance efficiency of electricity end-use and to manage electric demand; and

WHEREAS, Long-range planning has demonstrated that utility acquisition of end-use efficiency, renewable resources, and cogeneration are often more responsible economically and environmentally than traditional generation expansion; and

WHEREAS, Improvements in end-use efficiency generally reduce incremental energy sales; and

WHEREAS, The ratemaking formulas used by most state commissions cause reductions in utility earnings and otherwise may discourage utilities from helping their customers to improve end-use efficiency; and

WHEREAS, Reduced earnings to utilities from relying more upon demand-side resources is a serious impediment to the implementation of least-cost planning and to the achievement of a more energy-efficient society; and

WHEREAS, Improvements in the energy efficiency of our society would result in lower utility bills, reduced carbon dioxide emissions, reduced acid rain, reduced oil imports leading to improved energy security and a lower trade deficit, and lower business costs leading to improved international competitiveness; and

WHEREAS, Impediments to least-cost strategies frustrate efforts to provide low-cost energy services for consumers and to protect the environment; and

WHEREAS, Ratemaking practices should align utilities pursuit of profits with least-cost planning; and

WHEREAS, Ratemaking practices exist which align utility practices with least-cost planning; now, therefore, be it

RESOLVED, That the Executive Committee of the National Association of Regulatory Utility Commissioners (NARUC) assembled in its 1989 Summer Committee Meeting in San Francisco, urges its member state commissions to:

1) consider the loss of earnings potential connected with the use of demand-side resources; and

2) adopt appropriate ratemaking mechanisms to encourage utilities to help their customers improve end-use efficiency cost-effectively; and

3) otherwise ensure that the successful implementation of a utility's least-cost plan is its most profitable course of action.

Sponsored by the Committee on Energy Conservation
Adopted July 27, 1989

DATA REQUEST RESPONSES BY THE SIERRA CLUB

PSC CASE NO. 2006-00472

PSC STAFF'S FIRST DATA REQUEST DATED JULY 25, 2007

RESPONSIBLE PERSON: Geoffrey M. Young

Request 2.

Refer to the Young Testimony, pages 11 and 12 of 41. Mr. Young states that the result of allowing industrial customers to opt out of utility-assisted demand side management ("DSM") programs and utilities' removal of any plans to develop DSM programs for the industrial sector has deprived that class of the opportunity to participate in utility-assisted DSM programs.

Request 2a.

If the industrial customers have opted out of participating in utility sponsored DSM programs, explain further how industrial customers are deprived when their participation is voluntary.

Response 2a.

If a high enough proportion of industrial customers opt out, the DSM programs' administrative-type costs must be borne by too small a number of remaining industrial customers. The level of a "critical mass" of customers will not be reached. At that point, the utility generally concludes that it is inefficient or inequitable to offer DSM programs that must be paid for by only a small number of industrial customers. The result is that the utility ends up developing and offering no industrial DSM programs at all. Even those customers that had expressed a desire to participate and contribute to the costs of industrial DSM programs are unable to do so.

A fundamental problem is that most industrial customers are unaware of the massive, cost-effective investment opportunities that are available to them that would save large amounts of energy and provide a host of other economic benefits at the same time. Economists call the phenomenon an example of market failure based primarily on incomplete information.

The following essay by Amory Lovins of the Rocky Mountain Institute makes this point in a provocative yet instructive way:

> $100,000 Bills on the Shop Floor
>
> Theoretical economists commonly assume that cost-effective opportunities to save resources don't exist, for the same reason you don't see $20 bills lying in the street: If they existed, economists figure, somebody would have found and pocketed them long ago. But the real world seldom works that way.
>
> In 1981, energy efficiency coordinator Ken Nelson organized a contest among Dow Chemical's 2,400-worker Louisiana Division. Staff were encouraged to suggest projects that would save energy or reduce waste, pay for themselves within one year, and cost less than $200,000. Submissions were peer-reviewed, and the most promising and profitable ones were implemented. The contest proved so successful that it became an annual event. From nearly a thousand projects, a startling pattern emerged.
>
> The confirmed return on investment for 575 audited projects averaged 204 percent per year, with average annual savings of $110 million. In only one year did the average annual return for the implemented projects even slip below triple digits (to 97 percent). Dow Louisiana found not $20 bills but $100,000 bills lying all over its shop floors.
>
> And the energy savings became even larger and more profitable. Far from exhausting the cheapest opportunities, Nelson's contests expanded them even faster through institutional learning and better technologies. It's as if each $100,000 bill they picked up exposed a couple of new ones underneath.
>
> In the first year, 27 projects costing a total of $1.7 million had an average annual return on investment of 173 percent, and according to Nelson, "many people felt there couldn't be others with such high

> returns." They were wrong. The next year, 32 projects costing a total of $2.2 million returned an average of 340 percent per year. Learning quickly, Nelson changed the rules to eliminate the $200,000 limit — with such lucrative opportunities, why stick to the small ones? — and to include projects that would raise manufacturing output. In 1989, 64 projects costing $7.5 million yielded a 470 percent annual return on investment (the best so far). Even in the 12th year of the contests, 1993, the 140 winning projects averaged a 298 percent annual return.
>
> Though meticulously measured and documented, Nelson's additions to Dow's bottom line do not come from fancy management theories, quality circles, empowerment processes, or other managerial rituals. Rather, they come from a practical shop-floor process that translates volunteer ingenuity into profits.
>
> But here's the most surprising part. Far from instantly spreading throughout the chemical industry, Nelson's techniques have hardly even spread through Dow. Worse, in 1993, Nelson retired; reorganization wiped out his coordinating committee; and any continuing efforts can no longer be tracked.
>
> It's a pity so few market economists have ever met anyone like Ken Nelson. Most would be hard pressed to believe the many examples like his; they can hardly conceive that such juicy savings would have lain untapped for decades, let alone that exploiting them should turn up even bigger and juicier ones. The faith that what's worth doing has already been done is unfortunately not just an intellectual error; it has the disastrous practical consequence of concealing what can be done.
>
> How many market economists does it take to screw in a compact fluorescent light bulb? None (goes the joke) — the free market will do it. But without a Ken Nelson and without the common sense and hard work of the employees he inspires, the lamp will never get from the shelf into the socket.
>
> [Source: Rocky Mountain Institute Newsletter, Fall/Winter 1995]

Another important example of the large energy savings that may be harvested in the industrial sector by means of energy-efficient whole-system design is provided in Section 4.1 of the attached article titled, "Energy Efficiency, Taxonomic Overview," by Amory B. Lovins, 2004, published in Volume 2 of the *Encyclopedia of Energy*, Elsevier, Inc. The designer of an industrial pumping loop system was able to achieve an energy savings of 92% at a lower capital cost than the standard industrial design, by using larger-diameter pipes and smaller pumps, and by laying out the pipes first and then the equipment. Because the capital cost of the energy-efficient system was lower than that of the standard system, the simple payback period for this redesign was instantaneous.

The Kentucky Pollution Prevention Center (KPPC) provides free, on-site waste reduction assistance to industrial firms, including the reduction of energy waste. The following three paragraphs are from the minutes of the October 2, 2006 meeting of the Utility Working Group on Energy Efficiency and Cogeneration, which was later renamed the Kentucky Energy Efficiency Working Group. The experience of the KPPC staff indicates that a very high proportion of industrial companies are currently overlooking simple, cost-effective energy-saving measures; that a great many firms could benefit economically by having outside people look at and make suggestions about the energy-using systems within their plants; and that even firms that compete against each other for markets and in other ways are often willing to cooperate with their competitors to modernize the production equipment and systems that are used by their entire industry:

> Cam Metcalf and Seiglinde Kinne of the Kentucky Pollution Prevention Center (KPPC; web site http://www.kppc.org/) described how their organization helps industrial firms reduce their generation of hazardous waste and solid waste and improve energy efficiency. KPPC is nonregulatory and confidential and provides its services at no cost (other than public funds that the companies have already paid via their taxes). KPPC emphasizes the need to institutionalize waste reduction activities and develop metrics so progress is routinely measured. Improvements that companies commonly make include better communications and tightening up their compressed air systems, often called the "fourth utility." Turning off equipment that is not in use is a surprisingly common energy-saving opportunity.
>
> Cam described KPPC's Technology Diffusion Initiative, which surveys opinion leaders within an industry about new technologies that work or are about to be introduced. They try to get one or two firms to try out

> the most interesting technologies and report how well they work. This kind of program, as well as tax incentives, can create "peer pressure" among companies in an industry. Dick Stevie noted that Toyota has "treasure hunt" teams of employees who go around the plant looking for energy efficiency opportunities. Cam noted that although companies in the same industry compete with each other, they are often willing to share information about new energy-saving technologies that are being introduced. Wallace McMullen referred to a study that had been done in Illinois on industrial energy efficiency.
>
> Geoff asked if the KPPC team ever goes into an industrial firm where there are no cost-effective opportunities to save energy because the company has implemented them all. Cam and Seiglinde answered that in their experience that has never been the case.

I would conclude from these real-world examples that when industrial customers opt out of participation in DSM programs, virtually all of them are doing so on the basis of incomplete information. If Lovins and his colleagues are right, even customers that have already implemented several cost-effective energy efficiency measures in their production plants could profitably continue looking for, and finding, additional cost-effective ways to reduce their costs and improve their production systems even more. Utility-assisted industrial DSM programs could help companies identify, finance, and implement highly cost-effective energy-saving measures that they would not otherwise have seen.

Energy Efficiency, Taxonomic Overview

AMORY B. LOVINS
Rocky Mountain Institute
Snowmass, Colorado, United States

Glossary

conversion efficiency The physical ratio of desired output to total input in an energy conversion process, such as converting fuel to electricity or fuel to heat. Undesired or nonuseful outputs are excluded, making the ratio less than unity for most devices (except in such cases such as heat pumps and heat-powered chillers, where it can exceed unity and is called a coefficient of performance). The definition is thus based partly on what each individual finds useful. Synonymous with the thermodynamic concept of First Law efficiency, but counts only the quantity of energy, not also the quality, and hence differs from Second Law efficiency, which counts both.

customer The ultimate recipient of energy services, regardless of intermediate transactions.

delivered energy Secondary energy provided at the place where it is used to provide the desired energy service (e.g., electricity or fuel entering the end-use device that performs that final conversion). Further losses between that device and the customer may or may not be included. Delivered energy is net of distribution efficiency (1) to the end-use device, but may or may not be net of distribution efficiency (2) between end-use device and customer.

distribution efficiency (1) The fraction of centrally supplied energy shipped out (such as electricity from a power station, petroleum products from a refinery, or natural gas from a treatment plant) that is delivered to the end-use device, net of energy "lost" or "consumed" in its delivery. For electricity, this conversion into unwanted forms, chiefly low-temperature heat, comprises transmission as well as distribution losses, and is conventionally measured from the generator's busbar to the customer's meter. (2) The fraction of energy services produced by the end-use device that reaches the customer (e.g., the fraction of the heat produced by a furnace that provides warmth in a room, net of nonuseful heat escaping from pipes or ducts).

end use (1) The category of desired physical function provided by an energy service, such as heating, cooling, light, mechanical work, electrolysis, or electronic signal processing. (2) The physical quantity of such end use delivered to the customer, whether or not it is useful energy.

end-use device Equipment converting delivered energy into energy service.

end-use efficiency The physical ratio of end use (2) provided to delivered energy converted in the end-use device.

energy conservation An ambiguous term best avoided; considered by some as synonymous with increased energy efficiency but to many others connoting the opposite: privation, curtailment, and discomfort, i.e., getting fewer or lower quality energy services. The degree of confusion between these meanings varies widely by individual, culture, historic period, and language spoken. Some analysts, chiefly outside the United States, embrace energy conservation as an umbrella term for energy efficiency plus changes in personal habits plus changes in system design (such as spatial planning or design for product longevity and materials recovery/reuse).

energy efficiency Broadly, any ratio of function, service, or value provided to the energy converted to provide it. Herein, energy efficiency and its components all use (a) physical rather than economic metrics and (b) engineering, not economic, definitions (this physical convention can, however, become awkward with multiple inputs or outputs). Energy efficiency may or may not count thermodynamic quality of energy (ability to do work); see the distinction between First Law and Second Law efficiency.

energy intensity Energy (primary, delivered, or otherwise defined) "used" per unit of service or value provided.

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Intensity can be expressed in economic or in physical terms (e.g., the very crude and aggregated metric of primary energy consumption per dollar of real gross domestic product).

energy service The desired function provided by converting energy in an end-use device (e.g., comfort, mobility, fresh air, visibility, electrochemical reaction, or entertainment). These functions, which together contribute to a material standard of living, are generally measured in physical units, not by energy used or money spent. Because diverse services are incommensurable, they cannot be readily added to express a meaningful "total end-use efficiency" for a person, firm, or society. Economic surrogates for such totals are seldom satisfactory.

extractive efficiency The fraction of a fuel deposit that is recovered and sent out for processing and use, net of energy employed to conduct those extractive processes.

hedonic (functional) efficiency How much human happiness or satisfaction (equivalent to economists' welfare metrics) is achieved per unit of energy service delivered. Some analysts similarly distinguish the task (such as delivering heat into a house) from the goal it seeks to achieve (such as the human sensation of indoor comfort in winter).

primary energy (1) Fossil fuel extracted and then converted, typically at a central facility, into a secondary form (e.g., crude oil into refined products or coal into electricity) for delivery to end-use devices. (2) Nuclear, hydroelectric, and renewable energy captured for such delivery; if electric, conventionally expressed as the imputed amount of fossil fuel used to produce that much electricity in a typical thermal power station. (3) The quantity of energy described in (1) or (2). Most analysts exclude from primary energy consumption the metabolic energy in human food, but include the nonsolar energy needed to grow, process, deliver, and prepare it.

secondary energy Any processed, refined, or high-quality form of useful energy converted from primary energy, such as electricity, refined petroleum products, dry natural gas, or district heat. Excludes undesired and nonuseful conversion products.

Second Law efficiency The ratio of First Law thermodynamic efficiency to its maximum theoretically possible value; equivalently, the ratio of the least available work that could have done the job to the actual available work used to do the job. For a device that produces useful work or heat (not both), such as a motor, heat pump, or power plant, Second Law efficiency is the amount of output heat or work usefully transferred, divided by the maximum possible heat or work usefully transferable for the same function by any device or system using the same energy input. This maximum is defined by the task, not the device: to maximize how much heat is delivered from fuel into a building, an ideal fuel cell and an ideal heat pump would be used. Second Law efficiency thus measures the effectiveness of a device in approaching the constraints of the First and Second Laws of thermodynamics. First and Second Law efficiencies are nearly equal for a power plant, but are very different when high-quality energy is converted into a low-energy useful form: a 60%-efficient (First Law) furnace delivering 43°C heat into a house in a 0°C environment has a Second Law efficiency of only 8.2%.

service substitution Providing a desired energy service by a different means (e.g., providing illumination by opening the curtain in the daytime rather than turning on an electric light).

useful energy The portion of an energy service that is actually, not just potentially, desired and used by customers (e.g., lighting an empty room, or overheating an occupied room to the point of discomfort, is seldom useful).

Efficient use of energy is in all countries the most important, economical, prompt, underused, overlooked, and misunderstood way to provide future energy services. It is rapidly becoming even larger, faster, and cheaper as technologies, delivery methods, and integrative design improve. Whole-system design can indeed make very large energy savings cost less than small ones. But capturing energy efficiency's remarkable potential requires careful terminology, prioritization, attention to engineering details and to market failures, and willingness to accept measured physical realities even if they conflict with economic theories. If well done, such energy efficiency can displace costly and disagreeable energy supplies, enhance security and prosperity, speed global development, and protect Earth's climate—not at cost but at a profit.

1. DEFINITION AND IMPORTANCE OF ENERGY EFFICIENCY

Energy efficiency is generally the largest, least expensive, most benign, most quickly deployable, least visible, least understood, and most neglected way to provide energy services. The 39% drop in U.S. energy intensity (primary energy consumption per dollar of real gross domestic product) from 1975 to 2000 represented, by 2000, an effective energy "source" 1.7 times as big as U.S. oil consumption, three times net oil imports, five times domestic oil output, six times net oil imports from Organization of Petroleum Exporting Countries (OPEC) members, and 13 times net imports from Persian Gulf countries. It has lately increased by 3% per year, outpacing the growth of any source of supply (except minor renewables). Yet energy efficiency has gained little attention or respect for its achievements, let alone its far larger untapped potential. Physical scientists, unlike engineers or economists, find that despite energy efficiency's leading role in providing energy services today, its profitable potential has barely begun to be tapped. In contrast, many engineers tend to be limited by adherence to past practice, and most economists are constrained by their assumption that any profitable savings must already have occurred.

The potential of energy efficiency is increasing faster through innovative designs, technologies, policies, and marketing methods than it is being used up through gradual implementation. The uncaptured "efficiency resource" is becoming bigger and cheaper even faster than oil reserves have lately done through stunning advances in exploration and production. The expansion of the "efficiency resource" is also accelerating, as designers realize that whole-system design integration (see Section 4) can often make very large (one or two order-of-magnitude) energy savings cost less than small or no savings, and as energy-saving technologies evolve discontinuously rather than incrementally. Similarly rapid evolution and enormous potential apply to ways to market and deliver energy-saving technologies and designs; research and development can accelerate both.

1.1 Terminology

Efficiency unfortunately means completely different things to the two professions most engaged in achieving it. To engineers, efficiency means a physical output/input ratio. To economists, efficiency means a monetary output/input ratio, though for practical purposes many economists use a monetary output/physical input ratio. Only physical output/input ratios are used here, but the common use of monetary ratios causes vast confusion, especially to policymakers using economic jargon.

Wringing more work from energy via smarter technologies is often, and sometimes deliberately, confused with a pejorative usage of the ambiguous term energy conservation. Energy efficiency means doing more (and often better) with less—the opposite of simply doing less or worse or without. This confusion unfortunately makes the honorable and traditional concept of energy conservation no longer useful in certain societies, notably the United States, and underlies much of the decades-long neglect or suppression of energy efficiency. However, deliberately reducing the amount or quality of energy services remains a legitimate, though completely separate, option for those who prefer it or are forced by emergency to accept it. For example, the 2000–2001 California electricity crisis ended abruptly when customers, exhorted to curtail their use of electricity, cut their peak load per dollar of weather-adjusted real gross domestic product (GDP) by 14% in the first 6 months of 2001. Most of that dramatic reduction, undoing the previous 5–10 years of demand growth, was temporary and behavioral, but by mid-2002, the permanent and technological fraction was heading for dominance. Even absent crises, some people do not consider an ever-growing volume of energy services to be a worthy end in itself, but seek to live more simply—with elegant frugality rather than involuntary penury—and to meet nonmaterial needs by nonmaterial means. Such choices can save even more energy than can technical improvements alone, though they are often considered beyond the scope of energy efficiency.

Several other terminological distinctions are also important. At least five different kinds of energy efficiency can be measured in at least five different stages of energy conversion chains; these are discussed in Section 1.2. Also, technical improvements in energy efficiency can be broadly classified into those applicable only to new buildings and equipment, those installable in existing ones (retrofitted), those addable during minor or routine maintenance (slipstreamed), and those that can be conveniently added when making major renovations or expansions for other reasons (piggybacked).

Efficiency saves energy whenever an energy service is being delivered, whereas "load management" (sometimes called "demand response" to emphasize reliance on customer choice) changes only the time when that energy is used, either by shifting the timing of the service delivery or by, for example, storing heat or coolth so energy consumption and service delivery can occur at different times. In the context chiefly of electricity, demand-side management, a term coined by the Electric Power Research Institute, comprises both of these options, plus others that may even increase the use of electricity. Most efficiency options yield comparable or greater savings in peak loads; both kinds of savings are valuable, and both kinds of value should be counted. They also have important but nonobvious linkages: for example, because most U.S. peak electric loads are met by extremely inefficient simple-cycle gas-fired combustion turbines, saving 5% of peak electric load in 2000 would have saved 9.5% of total natural gas consumption, enough to reequilibrate high 2003 gas prices back to ~ $2/GJ lower historic levels.

Conflating three different things—technological improvements in energy efficiency (such as thermal insulation), behavioral changes (such as resetting thermostats), and the price or policy tools used to induce or reward those changes—causes endless misunderstanding. Also, consider that the theoretical potential for efficiency gains (up to the maximum permitted by the laws of physics) exceeds the technical potential, which exceeds the economic potential based on social value, which exceeds the economic potential based on private internal value, which exceeds the actual uptake not blocked by market failures, which exceeds what happens spontaneously if no effort is made to accelerate efficiency gains deliberately; yet these six quantities are often not clearly distinguished.

Finally, energy statistics are traditionally organized by the economic sector of apparent consumption, not by the physical end uses provided or services sought. End uses were first seriously analyzed in 1976, rarely appear in official statistics even a quarter-century later, and can be difficult to estimate accurately. But end-use analysis can be valuable because matching energy supplies in quality and scale, as well as in quantity, to end-use needs can save a great deal of energy and money. Supplying energy of superfluous quality, not just quantity, for the task is wasteful and expensive. For example, the United States now provides about twice as much electricity as the fraction of end uses that economically justify this special, costly, high-quality form of energy, yet from 1975 to 2000, 45% of the total growth in primary energy consumption came from increased conversion and grid losses in the expanding, very costly, and heavily subsidized electricity system. Much of the electric growth, in turn, provided low-temperature heat, a physically and economically wasteful use of electricity.

Many subtleties of defining and measuring energy efficiency merit but seldom get rigorous treatment, such as the following losses, services, or metrics:

- Distribution losses downstream of end-use devices (an efficient furnace feeding leaky ducts yields costlier delivered comfort).
- Undesired or useless services, such as leaving equipment on all the time (as many factories do) even when it serves no useful purpose.
- Misused services, such as space-conditioning rooms that are open to the outdoors.
- Conflicting services, such as heating and cooling the same space simultaneously (wasteful even if both services are provided efficiently).
- Parasitic loads, as when the inefficiencies of a central cooling system reappear as additional fedback cooling loads that make the whole system less efficient than the sum of its parts.
- Misplaced efficiency, such as applying energy-using equipment, however efficiently, to a task that does not need it—say, cooling with a mechanical chiller when groundwater or ambient conditions can more cheaply do the same thing.
- Incorrect metrics, such as measuring lighting by raw quantity (lux or footcandles) unadjusted for its visual effectiveness, which may actually decrease if greater illuminance is improperly delivered.

To forestall a few other semantic quibbles, physicists (including the author) know energy is not "consumed," as the economists' term "consumption" implies, nor "lost," as engineers refer to unwanted conversions into less useful forms. Energy is only converted from one form to another; yet the normal metaphors are clear, common, and adopted here. Thus an 80%-efficient motor converts its electricity input into 80% torque and 20% heat, noise, vibration, and stray electromagnetic fields; the total equals 100% of the electricity input, or roughly 30% of the fuel input at a classical thermal power station. (Note that this definition of efficiency combines engineering metrics with human preference. The motor's efficiency may change, with no change in the motor, if changing intention alters which of the outputs are desired and which are unwanted: the definition of "waste" is as much social or contextual as physical. A floodlamp used to keep plates of food warm in a restaurant may be rather effective for that purpose even though it is an inefficient source of visible light).

More productive use of energy is not, strictly speaking, a physical "source" of energy but rather a way to displace physical sources. Yet this distinction is rhetorical, because the displacement or substitution is real and makes supply fully fungible with efficiency. Also, energy/GDP ratios are a very rough, aggregated, and sometimes misleading metric, because they combine changes in technical efficiency, human behavior, and the composition of GDP (a metric that problematically conflates goods and services with "bads" and nuisances, counts only monetized activities, and is an increasingly perverse measure of well being). Yet the two-fifths drop in U.S. energy intensity and the one-half drop in oil intensity during the period 1975–2001 reflect mainly better technical efficiency. Joseph Romm has also shown that an important compositional shift of U.S. GDP—the information economy emerging in the late 1990s—has significantly decreased energy and probably electrical energy intensity, as bytes substituted for (or increased the capacity utilization of) travel, freight transport, lit and conditioned floorspace, paper, and other energy-intensive goods and services.

The aim here is not to get mired in word games, but to offer a clear overview of what kinds of energy efficiency are available, what they can do, and how best to consider and adopt them.

1.2 Efficiency along Energy Conversion Chains

The technical efficiency of using energy is the product of five efficiencies successively applied along the chain of energy conversions: (1) the conversion efficiency of primary into secondary energy, times (2) the distribution efficiency of delivering that secondary energy from the point of conversion to the point of end use, times (3) the end-use efficiency of converting the delivered secondary energy into such desired energy services as hot showers and cold beer. Some analysts add another term at the upstream end, (4) the extractive efficiency of converting fuel in the ground or power from wind or from sun in the atmosphere, etc. into the primary energy fed into the initial conversion device, and another term at the downstream end, (5) the hedonic efficiency of converting delivered energy services into human welfare. (Delivering junk mail with high technical efficiency is futile if the recipients did not want it.) Counting all five efficiencies permits comparing ultimate means, the primary energy tapped, with ultimate ends, the happiness or economic welfare created. Focusing only on intermediate means and ends loses sight of what human purposes an energy system is to serve. Most societies pay attention to only three kinds of energy efficiency: extraction (because of its cost, not because the extracted fuels are assigned any intrinsic or depletion value), conversion, and perhaps distribution. End-use and hedonic efficiency are left to customers, are least exploited, and hence hold the biggest potential gains.

They also offer the greatest potential leverage. Because successive efficiencies along the conversion chain all multiply, they are often assumed to be equally important. Yet downstream savings—those nearest the customer—are the most important. Figure 1 shows schematically the successive energy conversions and losses that require about 10 units of fuel to be fed into a conventional thermal power station in order to deliver one unit of flow in a pipe. But conversely, every unit of flow (or friction) saved in the pipe will save approximately 10 units of fuel, cost, and pollution at the power station. It will also make the pump's motor (for example) nearly two and a half units smaller, hence cheaper. To save the most primary energy and the most capital cost, therefore, efficiency efforts should start all the way downstream (see Section 4.2), by asking: How little flow can actually deliver the desired service? How small can the piping friction become? How small, well matched to the flow regime, and efficient can the pump be made? Its coupling? Its motor? Its controls and electrical supplies?

Analyses of energy use should start with the desired services or changes in well being, then work back upstream to primary supplies. This maximizes the extra value of downstream efficiency gains and

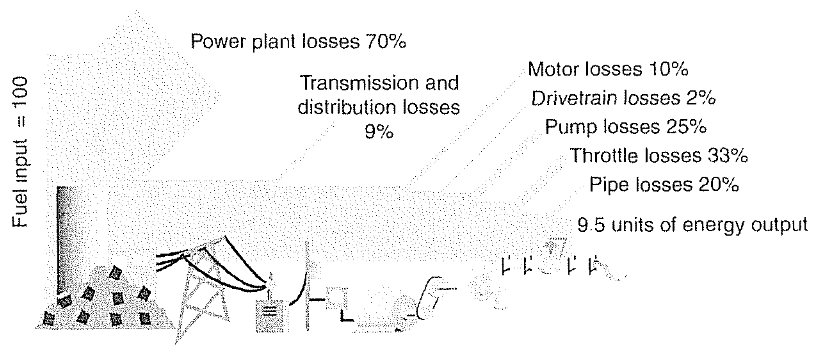

FIGURE 1 To deliver one unit of flow in the pipe requires about 10 units of fuel at the power plant, thus those 10-fold compounding losses can be turned around backward, yielding 10-fold compounding savings of fuel for each unit of reduced friction or flow in the pipe. From the E SOURCE "Drivepower Technology Atlas," courtesy of Platts Research & Consulting.

the capital-cost savings from smaller, simpler, cheaper upstream equipment. Yet it is rarely done. Similarly, most energy policy analysts analyze how much energy could be supplied before asking how much is optimally needed and at what quality and scale it could be optimally provided. This wrong direction (upstream to downstream) and supply orientation lie at the root of many if not most energy policy problems.

Even modest improvements in efficiency at each step of the conversion chain can multiply to large collective values. For example, suppose that during the years 2000–2050, world population and economic growth increased economic activity by six- to eightfold, in line with conventional projections. But meanwhile, the carbon intensity of primary fuel, following a two-century trend, is likely to fall by at least two- to fourfold as coal gives way to gas, renewables, and carbon offsets or sequestration. Conversion efficiency is likely to increase by at least 1.5-fold with modernized, better-run, combined-cycle, and cogenerating power stations. Distribution efficiency should improve modestly. End-use efficiency could improve by four- to sixfold if the intensity reductions sustained by many industrial countries, when they were paying attention, were sustained for 50 years (e.g., the United States decreased its primary energy/GDP intensity at an average rate of 3.4%/year from 1979 to 1986 and 3.0%/year from 1996 to 2001). And the least understood term, hedonic efficiency, might remain constant or might perhaps double as better business models and customer choice systematically improve the quality of services delivered and their match to what customers want. On these plausible assumptions, global carbon emissions from burning fossil fuel could decrease by 1.5- to 12-fold despite the assumed six- to eightfold grosser world product. The most important assumption is sustained success with end-use efficiency, but the decarbonization and conversion-efficiency terms appear able to take up some slack if needed.

1.3 Service Redefinition

Some major opportunities to save energy redefine the service being provided. This is often a cultural variable. A Japanese person, asked why the house is not heated in winter, might reply, "Why should I? Is the house cold?" In Japanese culture, the traditional goal is to keep the person comfortable, not to heat empty space. Thus a modern Japanese room air conditioner may contain a sensor array and moveable fans that detect and blow air toward people's locations in the room, rather than wastefully cooling the entire space. Western office workers, too, can save energy (and can often see better, feel less tired, and improve esthetics) by properly adjusting venetian blinds, bouncing glare-free daylight up onto the ceiling, and turning off the lights. As Jørgen Nørgård remarks, "energy-efficient lamps save the most energy when they are turned off"; yet many people automatically turn on every light when entering a room. This example also illustrates that energy efficiency may be hard to distinguish from energy supply that comes from natural energy flows. All houses are already ~98% solar-heated, because if there were no Sun (which provides 99.8% of Earth's heat), the temperature of Earth's surface would average approximately −272.6°C rather than +15°C. Thus, strictly speaking, engineered heating systems provide only the last 1–2% of the total heating required.

Service redefinition becomes complex in personal transport. Its efficiency is not just about vehicular fuel economy, people per car, or public transport alternatives. Rather, the underlying service should often be defined as access, not mobility. Typically, the best way to gain access to a place is to be there already; this is the realm of land-use management—no novelty in the United States, where spatial planning is officially shunned, yet zoning laws mandate dispersion of location and function, real-estate practices segregate housing by income, and other market distortions maximize unneeded and often unwanted travel. Another way to gain access is virtually, moving just the electrons while leaving the heavy nuclei behind, via telecommunications, soon including realistic "virtual presence." This is sometimes an effective alternative to physically moving human bodies. And if such movement is really necessary, then it merits real competition, at honest prices, between all modes—personal or collective, motorized or human-powered, conventional or innovative. Creative policy tools can enhance that choice in ways that enhance real-estate value, saved time, quality of life, and public amenity and security. Efficient cars can be an important part of efficient personal mobility, but also reducing the need to drive can save even more energy and yield greater total benefit.

1.4 Historic Summaries of Potential

People have been saving energy for centuries, even millennia; this is the essence of engineering. Most savings were initially in conversion and end use:

preindustrial households often used more primary energy than modern ones do, because fuelwood-to-charcoal conversion, inefficient open fires, and crude stoves burned much fuel to deliver sparse cooking and warmth. Lighting, materials processing, and transport end uses were also very inefficient. Billions of human beings still suffer such conditions today. The primary energy/GDP intensities in developing countries average about three times those in industrialized countries. But even the most energy-efficient societies still have enormous, and steadily expanding, room for further efficiency gains. Less than one-fourth of the energy delivered to a typical European cookstove ends up in food, less than 1% of the fuel delivered to a standard car actually moves the driver, U.S. power plants discard waste heat equivalent to 1.2 times Japan's total energy use, and even Japan's economy does not approach one-tenth the efficiency that the laws of physics permit.

Detailed and exhaustively documented engineering analyses of the scope for improving energy efficiency, especially in end-use devices, have been published for many industrial and some developing countries. By the early 1980s, those analyses had compellingly shown that most of the energy currently used was being wasted—i.e., that the same or better services could be provided using severalfold less primary energy by fully installing, wherever practical and profitable, the most efficient conversion and end-use technologies then available. Such impressive efficiency gains cost considerably less than the long-run, and often even the short-run, marginal private internal cost of supplying more energy. Most policy-makers ignore both these analyses, well known to specialists, and less well-known findings show even bigger and cheaper savings from whole-system design integration (see Section 4).

Many published engineering analyses show a smaller saving potential because of major conservatisms, often deliberate (because the real figures seem too good to be true), or because they assume only partial adoption over a short period rather than examining the ultimate potential for complete practical adoption. For example, the American Council for an Energy-Efficient Economy estimates that just reasonable adoption of the top five conventional U.S. opportunities—industrial improvements, 40-mile per gallon (U.S. gallons; = 4.88 liters/100 km) light-vehicle standards, cogeneration, better building codes, and a 30% better central-air-conditioning standard—could save 530 million T/year of oil equivalent—respectively equivalent to the total 2000 primary energy use of Australia, Mexico, Spain, Austria, and Ireland. But the full long-term efficiency potential is far larger, and much of it resides in innumerable small terms. Saving energy is like eating an Atlantic lobster: there are big, obvious chunks of meat in the tail and the front claws, but a similar total quantity of tasty morsels is hidden in crevices and requires some skill and persistence to extract.

The whole-lobster potential is best, though still not fully, seen in bottom-up technological analyses comparing the quantity of potential energy savings with their marginal cost. That cost is typically calculated using the Lawrence Berkeley National Laboratory methodology, which divides the marginal cost of buying, installing, and maintaining the more efficient device by its discounted stream of lifetime energy savings. The levelized cost in dollars of saving, say, 1 kWh, then equals $Ci/S[1-(1+i)^{-n}]$, where C is installed capital cost (dollars), i is annual real discount rate (assumed here to be 0.05), S is energy saved by the device (kilowatt-hours/year), and n is operating life (years). Thus a \$10 device that saved 100 kWh/year and lasted 20 years would have a levelized "cost of saved energy" (CSE) of 0.8¢/kWh. Against a 5¢/kWh electricity price, a 20-year device with a 1-year simple payback would have CSE = 0.4¢/kWh. It is conventional for engineering-oriented analysts to represent efficiency "resources" as a supply curve, rather than as shifts along a demand curve (the convention among economists). CSE is methodologically equivalent to the cost of supplied energy (e.g., from a power station and grid): the price of the energy saved is not part of the calculation. Whether the saving is cost-effective depends on comparing the cost of achieving it with the avoided cost of the energy saved. (As noted in Section 2, this conventional engineering–economic approach actually understates the benefits of energy efficiency.)

On this basis, the author's analyses in the late 1980s found, from measured cost and performance data for more than 1000 electricity-saving end-use technologies, that their full practical retrofit could save about three-fourths of U.S. electricity at an average CSE ~ 0.6¢/kWh (1986 dollars)—roughly consistent with a 1990 Electric Power Research Institute analysis in which the differences were mainly methodological rather than substantive. Similarly, the author's analysis for Royal Dutch/Shell Group found that full use of the best 1987–1988 oil-saving end-use technologies, assuming turnover of vehicle stocks, could save about 80% of U.S. oil use at an average levelized CSE below \$2.5/barrel (1986 dollars). Both analyses have proven systematically conservative: today's potential is even larger and cheaper. (The analyses explicitly excluded financing and transaction costs, but those would only slightly affect the results. There is also a huge literature accurately predicting and rigorously measuring the empirical size, speed, and cost of efficiency improvements delivered by actual utility and government programs.) Such findings are broadly consistent with equally or more detailed ones by European analysts: for example, late-1980s technologies could save three-fourths of Danish buildings' electricity or half of all Swedish electricity at \$0.016/kWh (1986 dollars), or four-fifths of German home electricity (including minor fuel switching) with a ~40%/year aftertax return on investment. Such findings with ever greater sophistication have been published worldwide since 1979, but have been rejected by nontechnological economic theorists, who argue that if such cost-effective opportunities existed, they would already have been captured in the marketplace, even in planned economies with no marketplace or mixed economies with a distorted one. This mental model—"don't bother to bend over and pick up that banknote lying on the ground, because if it were real, someone would have picked it up already"—often dominates government policy. It seems ever less defensible as more is learned about the reality of pervasive market failures (see Section 5) and the astonishing size and cheapness of the energy savings empirically achieved by diverse enterprises (discussed in Section 3). But by now, the debate is theological—about whether existing markets are essentially perfect, as most economic modelers assume for comfort and convenience, or whether market failures are at least as important as market function and lie at the heart of business and policy opportunity. To technologists and physical scientists, this seems a testable empirical question.

1.5 Discontinuous Technological Progress

This engineering/economics divergence about the potential to save energy also reflects a tacit assumption that technological evolution is smooth and incremental, as mathematical modelers prefer. In fact, although much progress is as incremental as technology diffusion, discontinuous technological leaps, more like "punctuated equilibrium" in evolutionary biology, can propel innovation and speed its adoption, as with 5×-efficiency light vehicles (see Section 4.1).

Technological discontinuities can even burst the conventional boundaries of possibility by redefining the design space. Generations of engineers learned that big supercritical-steam power plants were as efficient as possible (~40% from fuel in to electricity out). But through sloppy learning or teaching, these engineers overlooked the possibility of stacking two Carnot cycles atop each other. Such combined-cycle (gas-then-steam) turbines, based on mass-produced jet engines, can exceed 60% efficiency and are cheaper and faster to build, so in the 1990s, they quickly displaced the big steam plants. Fuel cells, the next innovation, avoid Carnot limits altogether by being an electrochemical device, not a heat engine. Combining both may soon achieve 80–90% fuel-to-electric efficiency. Even inefficient distributed generators can already exceed 90% system efficiency by artfully using recaptured heat.

As another example, most authors today state that the theoretical efficiency limit for converting sunlight into electricity using single-layer photovoltaic (PV) cells is 31% (~50% using multicolor stacked layers; the best practical values so far are around 25 and 30%). This is because semiconductor bandgaps have been believed too big to capture any but the high-energy wavelengths of sunlight. But those standard data are wrong. A Russian-based team suspected in 2001, and Lawrence Berkeley National Laboratory proved in 2002, that indium nitride's bandgap is only 0.7 eV, matching near-infrared (1.77 μm) light and hence able to harvest almost the whole solar spectrum. This may raise the theoretical limit to 50% for two-layer and to ~70% for many-layer thin-film PVs.

Caution is likewise vital when interpreting Second Law efficiency. In the macroscopic world, the laws of thermodynamics are normally considered ineluctable, but the definition of the desired change of state can be finessed. Ernie Robertson notes that when turning limestone into a structural material, one is not confined to just the conventional possibilities of cutting it into blocks or calcining it at ~1250°C into Portland cement. It is possible instead grind it up and feed it to chickens, in which ambient-temperature "technology" turns it into eggshell stronger than Portland cement. Were we as smart as chickens, we would have mastered this life-friendly technology. Extraordinary new opportunities to harness 3.8 billion years of biological design experience, as described by Janine Benyus in *Biomimicry*, can often make heat-beat-and-treat industrial processes unnecessary. So, in principle, can the emerging techniques of nanotechnology using molecular-scale self-assembly, as pioneered by Eric Drexler.

More conventional innovations can also bypass energy-intensive industrial processes. Making artifacts that last longer, use materials more frugally, and are designed and deployed to be repaired, reused, remanufactured, and recycled can save much or most of the energy traditionally needed to produce and assemble their materials (and can increase welfare while reducing GDP, which swells when ephemeral goods are quickly discarded and replaced). Microfluidics can even reduce a large chemical plant to the size of a watermelon: millimeter-scale flow in channels etched into silicon wafers can control time, temperature, pressure, stoichiometry, and catalysis so exactly that a very narrow product spectrum is produced, without the side-reactions that normally require most of the chemical plant to separate undesired from desired products. Such "end-run" solutions (rather like the previous example of substituting sensible land-use for better vehicles, or better still, combining both) can greatly expand the range of possibilities beyond simply improving the narrowly defined efficiency of industrial equipment, processes, and controls. By combining many such options, it is now realistic to contemplate a long-run advanced industrial society that provides unprecedented levels of material prosperity with far less energy, cost, and impact than today's best practice. The discussion in Section 4.1, drawn from Paul Hawken *et al.*'s synthesis in *Natural Capitalism* and Ernst von Weizsäcker *et al.*'s earlier *Factor Four*, further illustrates recent breakthroughs in integrative design that can make very large energy savings cost less than small ones; and similarly important discontinuities in policy innovation are summarized in Section 6.

In light of all these possibilities, why does energy efficiency, in most countries and at most times, command so little attention and such lackadaisical pursuit? Several explanations come to mind. Saved energy is invisible. Energy-saving technologies may look and outwardly act exactly like inefficient ones, so they are invisible too. They are also highly dispersed, unlike central supply technologies that are among the most impressive human creations, inspiring pride and attracting ribbon-cutters and rent- and bribe-seekers. Many users believe energy efficiency is binary—you either have it or lack it—and that they already did it in the 1970s. Energy efficiency has relatively weak and scattered constituencies, and major energy efficiency opportunities are disdained or disbelieved by policymakers indoctrinated in a theoretical economic paradigm that claims they cannot exist (see Section 3).

2. BENEFITS OF ENERGY EFFICIENCY

Energy efficiency avoids the direct economic costs and the direct environmental, security, and other costs of the energy supply and delivery that it displaces. Yet the literature often overlooks several key side-benefits (economists call them "joint products") of saving energy.

2.1 Indirect Benefits from Qualitatively Superior Services

Improved energy efficiency, especially end-use efficiency, often delivers better services. Efficient houses are more comfortable; efficient lighting systems can look better and help you see better; efficient motors can be more quiet, reliable, and controllable; efficient refrigerators can keep food fresher for longer; efficient cleanrooms can improve the yield, flexibility, throughput, and setup time of microchip fabrication plants; efficient fume hoods can improve safety; efficient supermarkets can improve food safety and merchandising; retail sales pressure can rise 40% in well-daylit stores; and students' test scores suggest 20–26% faster learning in well-daylit schools. Such side-benefits can be one or even two more orders of magnitude more valuable than the energy directly saved. For example, careful measurements show that in efficient buildings, where workers can see what they are doing, hear themselves think, breathe cleaner air, and feel more comfortable, labor productivity typically rises by about 6–16%. Because office workers in industrialized countries cost about 100 times more than office energy, a 1% increase in labor productivity has the same bottom-line effect as eliminating the energy bill, and the actual gain in labor productivity is about 6–16 times bigger than that. Practitioners can market these attributes without ever mentioning lower energy bills.

2.2 Leverage in Global Fuel Markets

Much has been written about the increasing pricing power of major oil-exporting countries, especially Saudi Arabia, with its important swing production capacity. Yet the market power of the United States—the Saudi Arabia of energy waste—is even greater on the demand side. The United States can raise its oil productivity more and faster than any oil exporter can adjust to reducing its oil output. This was illustrated from 1977 to 1985, when U.S. GDP rose 27% while total U.S. oil imports fell by 42%, or 3.74 million barrels (bbl)/day. This was largely due to a 52% gain in oil productivity, causing U.S. oil consumption to fall by 17% and oil imports from the Persian Gulf to fall by 91%. That took away an eighth of OPEC's market. The entire world oil market shrank by a tenth; OPEC's share was slashed from 52 to 30%, and its output fell by 48%. The United States accounted for one-fourth of that reduction. More efficient cars, each driving 1% fewer miles on 20% less gasoline—a 7-mile per (U.S.) gallon gain in 6 years for new American-made cars—were the most important single cause; 96% of those savings came from smarter design, with only 4% deriving from smaller size.

Those 8 years around the second oil shock (1979) demonstrated an effective new source of energy security and a potent weapon against high oil prices and supply manipulations. The United States showed that a major consuming nation could respond effectively to supply disruptions by focusing on the demand side and boosting oil productivity at will. It could thereby exercise more market power than suppliers, beat down their prices (breaking OPEC's pricing power for a decade), and enhance the relative importance of less vulnerable, more diversified sources of supply. Had the United States simply continued its 1979–1985 rate of improvement of oil productivity, it would not have needed a drop of oil from the Persian Gulf after 1985. That is not what happened, but it could be if the United States chose to repeat and expand its previous oil savings.

2.3 Buying Time

Energy efficiency buys time. Time is the most precious asset in energy policy, because it permits the fullest and most graceful development and deployment of still better techniques for energy efficiency and supply. This pushes supply curves downward (larger quantities at lower prices), postpones economic depletion, and buys even more time. The more time is available, the more information will emerge to support wiser and more robust choices, and the more fruitfully new technologies and policy options can meld and breed new ones. Conversely, hasty choices driven by supply exigencies almost always turn out badly, waste resources, and foreclose important options. Of course, once bought, time should be used wisely. Instead, the decade of respite bought by the U.S. efficiency spurt of 1979–1985 was almost entirely wasted as attention waned, efficiency and alternative-supply efforts stalled, research and development teams were disbanded, and underlying political problems festered. From the perspective of 2004, that decade of stagnation looked like a blunder of historic proportions.

2.4 Integrating Efficiency with Supply

To the first order, energy efficiency makes supply cheaper. But second-order effects reinforce this first-order benefit, most obviously when efficiency is combined with onsite renewable supplies, making them nonlinearly smaller, simpler, and cheaper. Consider the following examples:

- A hot-water-saving house can achieve a very high solar-water-heat fraction (e.g., 99% in the author's home high in the Rocky Mountains) with only a small collector, so it needs little or no backup, partly because collector efficiency increases as stratified-tank storage temperature decreases.
- An electricity-saving house needs only a few square meters of PVs and a simple balance-of-system setup (storage, inverter, etc.). This can cost less than connecting to the grid a few meters away.
- A passive-solar, daylit building needs little electricity, and can pay for even costly forms of onsite generation (such as PVs) using money saved by eliminating or downsizing mechanical systems.
- Such mutually reinforcing options can be bundled: e.g., 1.18 peak MW of photovoltaics retrofitted onto the Santa Rita Jail in Alameda County, California, was combined with efficiency and load management, so at peak periods, when the power was most valuable, less was used by the jail and more was sold back to the grid. This bundling yielded a internal rate of return of over 10% including state subsidies, and a customer present-valued benefit/cost ratio of 1.7 without or 3.8 with those subsidies.

2.5 Gaps in Engineering Economics

Both engineers and economists conventionally calculate the cost of supplying or saving energy using a rough-and-ready tool kit called "engineering economics." Its methods are easy to use but flawed, ignoring such basic tenets of financial economics as risk-adjusted discount rates. Indeed, engineering economics omits 207 economic and engineering considerations that together increase the value of decentralized electrical resources by typically an order of magnitude. Many of these "distributed benefits," compiled in the author's *Small Is Profitable*, apply as much to decentralized efficiency as to generation. Most of the literature on the cost of energy alternatives is based solely on accounting costs and engineering economics that greatly understate efficiency's value. Properly counting its benefits will yield far sounder investments.

Efficient end use is also the most effective way to make energy supply systems more resilient against mishap or malice, because it increases the duration of buffer stocks, buying time to mend damage or arrange new supplies, and it increases the share of service that curtailed or improvised supplies can deliver. Efficiency's high "bounce per buck" makes it the cornerstone of any energy system designed for secure service provision in a dangerous world.

3. ENGINEERING VS. ECONOMIC PERSPECTIVES

Engineering practitioners and economic theorists view energy efficiency through profoundly different lenses, yet both disciplines are hard pressed to explain the following phenomena:

1. During the period 1996–2001, U.S. aggregate energy intensity fell at a near-record pace despite record low and falling energy prices. (It fell faster only once in modern history, during the record high and rising energy prices of 1979–1985.) Apparently, something other than price was getting Americans' attention.

2. During the period 1990–1996, when a kilowatt-hour of electricity cost only half as much in Seattle as in Chicago, people in Seattle, on average, reduced their peak electric load 12 times as fast, and their use of electricity about 3640 times as fast, as did people in Chicago—perhaps because Seattle City Light encouraged savings while Commonwealth Edison Co. discouraged them.

3. In the 1990s, DuPont found that its European chemical plants were no more energy efficient than its corresponding U.S. plants, despite long having paid twice the energy price—perhaps because all the plants were designed by the same people in the same ways with the same equipment; there is little room for behavioral change in a chemical plant.

4. In Dow Chemical Company's Louisiana Division during the period 1981–1993, nearly 1000 projects to save energy and reduce waste added $110 million/year to the bottom line and yielded returns on investment averaging over 200%/year, yet in the latter years, both the returns and the savings were trending upward as the engineers discovered new tricks faster than they used up the old ones. (Economic theory would deny the possibility of so much "low-hanging fruit" that has fallen down and is mushing up around the ankles: such enormous returns, if real, would long ago have been captured. This belief was the main obstacle to engineers' seeking such savings, then persisting after their discovery.)

5. Only about 25–35% of apartment dwellers, when told that their air conditioner and electricity are free, behave as economists would predict—turning on the air conditioner when they feel hot and setting the thermostat at a temperature at which they feel comfortable. The rest of the apartment dwellers show no correlation between air-conditioning usage and comfort; instead, their cooling behavior is determined by at least six other variables: household schedules, folk theories about air conditioners (such as that the thermostat is a valve that makes the cold come out faster), general strategies for dealing with machines, complex belief systems about health and physiology, noise aversion, and wanting white noise to mask outside sounds that might wake the baby. Energy anthropology reveals that both the economic and the engineering models of air-conditioning behavior are not just incomplete but seriously misleading.

6. The United States has misallocated $1 trillion of investments to about 200 million refrigerative tons of air conditioners, and 200 peak GW (two-fifths of total peak load) of power supply to run them, that would not have been bought if the buildings had been optimally designed to produce best comfort at least cost. This seems explicable by the perfectly perverse incentives seen by each of the 20-odd actors in the commercial real-estate value chain, each systematically rewarded for inefficiency and penalized for efficiency.

7. Not just individuals but also most firms, even large and sophisticated ones, routinely fail to make essentially riskless efficiency investments yielding many times their normal business returns: most require energy efficiency investments to yield roughly six times their marginal cost of capital, which typically applies to far riskier investments.

Many economists would posit some unknown error or omission in these descriptions, not in their theories. Indeed, energy engineers and energy economists seem not to agree about what is a hypothesis and what is a fact. Engineers take their facts from tools of physical observation. Three decades of conversations with noted energy economists suggest to the author that most think facts come only from observed flows of dollars, interpreted through indisputable theoretical constructs, and consider any contrary physical observations aberrant. This divergence makes most energy economists suppose that buying energy efficiency faster than the "spontaneous" rate of observed intensity reduction (for 1997–2001, 2.7%/year in the United States, 1.4%/year in the European Union, 1.3%/year worldwide, and 5.3%/year in China) would require considerably higher energy prices, because if greater savings were profitable at today's prices, they would already have been bought; thus the engineers' bottom-up analyses of potential energy savings must be unrealistically high. Economists' estimates of potential savings at current prices are "top-down" and very small, based on historic price elasticities that confine potential interventions to changing prices and savings to modest size and diminishing returns (otherwise the economists' simulation models would inconveniently explode). Engineers retort that high energy prices are not necessary for very large energy savings (because they are so lucrative even at present prices) but are not sufficient either (because higher prices do little without enlarged ability to respond to them).

Of course, engineering-based practitioners agree that human behavior is influenced by price, as well as by convenience, familiarity, fashion, transparency, competing claims on attention, and many other marketing and social-science factors—missing from any purely technological perspective but central to day-to-day fieldwork. The main difference is that they think these obstacles are "market failures" and dominate behavior in buying energy efficiency. Most economists deny this, and say the relatively slow adoption of efficiency must be due to gross errors in the engineers' claims of how large, cheap, and available its potential really is. This theological deadlock underlies the debate about climate protection. Robert Repetto and Duncan Austin showed in 1997 that all mainstream climate-economics models' outputs are hard-wired to the input assumptions, and that realistic inputs, conforming to the actual content of the Kyoto Protocol and its rules, show that climate protection increases GDP. Florentin Krause has shown that the main official U.S. government analyses, taken together, concur. Yet the official U.S. position at the end of 2003 was still that climate protection, even if desirable, cannot be mandated because it is too costly.

In fact, climate protection is not costly but profitable; its critics may have the amount about right, but they got the sign wrong. The clearest proof is in the behavior and achievements of the smart companies that are behaving as if the United States had ratified the Kyoto Protocol, because energy efficiency is cheaper than the energy it saves. For example, large firms such as DuPont, IBM, and STMicroelectronics (ST; one of the world's largest chipmakers) have lately been raising their energy productivity by 6%/year with simple paybacks of a few years. DuPont expects by 2010 to cut its greenhouse gas emissions by 65% below the 1990 level; ST expects to achieve zero emissions (despite making 40 times more chips). British Petroleum announced that its 10% reduction by 2010 had been achieved 8 years early at zero net cost; actually, the 10-year net-present-valued saving was $650 million. Other examples abound; the Web sites www.cool-companies.org and www.pewclimate.org contain examples of the achievements of actively engaged businesses. The companies involved, many of them well known in the business world, are hardly naïve or deluded. Anyone ignoring this market reality is mistaking the econometric rearview mirror for a windshield. Econometrics measures how human populations behaved under past conditions that no longer exist and that it is often a goal of energy policy to change. Where price is the only important explanatory variable, econometrics can be a useful tool for extrapolating history into how price may influence near-term, small, incremental changes in behavior. But limiting our horizons to this cramped view of technical possibilities and human complexity rules out innovations in policies, institutions, preferences, and technologies—treating the future like fate, not choice, and thus making it so.

4. DIMINISHING VS. EXPANDING RETURNS TO INVESTMENTS IN ENERGY EFFICIENCY

Among the most basic, yet simply resolved, economic/engineering disagreements is whether investing in end-use efficiency yields expanding or diminishing returns. Economic theory says diminishing: the more efficiency we buy, the more steeply the marginal cost of the next increment of savings rises, until it becomes too expensive (Fig. 2). But engineering practice often says expanding: big savings can cost less than small or no savings (Fig. 3) if the engineering is done unconventionally but properly.

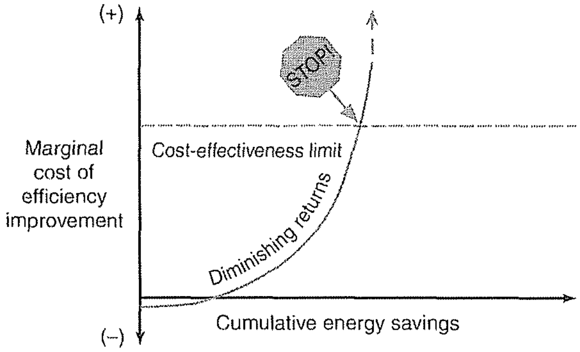

FIGURE 2 Diminishing returns (greater energy savings incur greater marginal cost) can be true for some (not all) components, but need not be true for most systems.

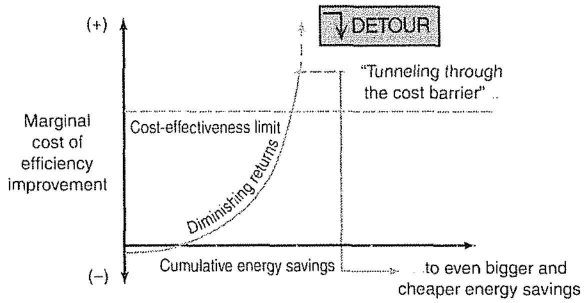

FIGURE 3 Optimizing whole systems for multiple benefits, rather than isolated components for single benefits, can often "tunnel through the cost barrier" directly to the lower-right-corner destination, making very large energy savings cost less than small or no savings. This has been empirically demonstrated in a wide range of technical systems.

4.1 Empirical Examples

Consider, for example, how much thermal insulation should surround a house in a cold climate. Conventional design specifies just the amount of insulation that will repay its marginal cost out of the present value of the saved marginal energy. But this is methodologically wrong, because the comparison omits the capital cost of the heating system: furnace, ducts, fans, pipes, pumps, wires, controls, and fuel source. The author's house illustrates that in outdoor temperatures down to −44°C, it is feasible to grow bananas (28 crops at this writing) at 2200 m elevation in the Rocky Mountains with no heating system, yet with reduced construction cost, because the superwindows, superinsulation, air-to-air heat exchangers, and other investments needed to eliminate the heating system cost less to install than the heating system would have cost to install. The resulting ~99% reduction in heating energy cost is an extra benefit.

Similarly, Pacific Gas and Electric Company's Advanced Customer Technology Test for Maximum Energy Efficiency (ACT^2) demonstrated in seven new and old buildings that the "supply curve" of energy efficiency generally bent downward, as shown schematically in Fig. 3. For example, an ordinary-looking new tract house was designed to save 82% of the energy allowed by the strictest U.S. standard of the time (1992 California Title 24); if this design were widely implemented rather than restricted to a single experiment, it was estimated by PG&E that it would cost about $1800 less than normal to build and $1600 less (in present value) to maintain. It provided comfort with no cooling system in a climate that can reach 45°C; a similar house later did the same in a 46°C-peak climate. Another example, the 350-m^2 Bangkok home of architecture professor Suntoorn Boonyatikarn, provided normal comfort, with 10% the normal air-conditioning capacity, at no extra construction cost. These examples illustrate how optimizing a house as a system rather than optimizing a component in isolation, and optimizing for life-cycle cost (capital plus operating cost, and preferably also maintenance cost), can make a superefficient house cheaper to build, not just to run, by eliminating costly heating and cooling systems. Similarly, a retrofit design for a 19,000-m^2 curtainwall office building near Chicago found 75% energy-saving potential at no more cost than the normal 20-year renovation that saves nothing, because the $200,000 capital saving from making the cooling system four times smaller (yet four times more efficient), rather than renovating the big old system, would pay for the other improvements.

In a striking industrial example, a pumping loop for heat transfer originally designed to use 70.8 kW of pumping power was redesigned to use 5.3 kW, 92% less, with lower capital cost and better performance. No new technologies were used, but only two changes in the design mentality:

1. Use big pipes and small pumps rather than small pipes and big pumps. The friction in a pipe falls as nearly the fifth power (roughly −4.84) of its diameter. Engineers normally make the pipe just fat enough to repay its greater cost from the saved pumping energy. This calculation improperly omits the capital cost of the pumping equipment—the pump, motor, inverter, and electricals that must overcome the pipe friction. Yet the size and roughly the cost of that equipment will fall as nearly the fifth power of pipe diameter, while the cost of the fatter pipe will rise as only about the second power of

diameter. Thus conventionally optimizing the pipe as an isolated component actually pessimizes the system! Optimizing the whole system together will clearly yield fat pipes and tiny pumps, so total capital cost falls slightly and operating cost falls dramatically.

2. Lay out the pipes first, then the equipment. Normal practice is the opposite, so the connected equipment is typically far apart, obstructed by other objects, at the wrong height, and facing the wrong way. The resulting pipes have about three to six times as much friction as they would have with a straight shot, to the delight of the pipefitters, who are paid by the hour, who mark up a profit on the extra pipes and fittings, and who do not pay for the extra electricity or equipment sizing. But the owner would do better to have short, straight pipes than long, crooked pipes.

Together, these two design changes cut the measured pumping power by 12-fold, with lower capital cost and better performance. They also saved 70 kW of heat loss with a 2-month payback, because it was easier to insulate short, straight pipes. In hindsight, however, the design was still suboptimal, because it omitted seven additional benefits: less space, weight, and noise; better maintenance access; lower maintenance cost; higher reliability and uptime; and longer life (because the removed pipe elbows will not be eroded by fluid turning the corner). Properly counting these seven benefits would have saved not 92% but nearer 98% of the energy, and cost even less, so about a factor-four potential saving was left uncaptured.

Other recent design examples include a 97% reduction in air-conditioning energy for a California office retrofit, with attractive returns and better comfort; lighting retrofit savings upward of 90% with better visibility and a 1- to 2-year payback; an energy cost reduction >40% with a 3-year payback in retrofitting an already very efficient oil refinery; ~75% electrical savings in a new chemical plant, with ~10% lower construction time and cost; ~89% in a new data center at lower cost; and ~70–90% in a new supermarket at probably lower cost. The obvious lesson is that optimizing whole systems for multiple benefits, not just components for single benefits, typically boosts end-use efficiency by roughly an order of magnitude at negative marginal cost. These enormous savings have not been widely noticed or captured because of deficient engineering pedagogy and practice. Whole-system design integration is not rocket science; rather, it rediscovers the forgotten tradition of Victorian system engineering, before designers became so specialized that they lost sight of how components fit together.

It is not even generally true, as economic theory supposes, that greater end-use efficiency costs more at the level of components. For example, the most common type of industrial motor on the 1996 U.S. market, the 1800-revolution per minute (rpm) totally enclosed fan-cooled (TEFC) motor (National Electrical Manufacturers' Association Design B), exhibited no empirical correlation whatever between efficiency and price up to at least 225 kW. (Premium-efficiency motors should cost more to build because they contain more and better copper and iron, but they are not priced that way.) The same is true for most industrial pumps and rooftop chillers, Swedish refrigerators, American televisions, and many other products. But even if it were true, artfully combining components into systems can definitely yield expanding returns.

Perhaps the most consequential example is in light vehicles. A small private company (see its Web site at www.hypercar.com) completed in 2000 the manufacturable, production-costed virtual design of a midsize sport utility vehicle (SUV) concept car that is uncompromised, cost-competitive, zero emission, and quintupled efficiency. It is so efficient (2.38 liters/100 km, 42 km/liter, 99 mpg, U.S. gallons) not just because its direct-hydrogen fuel cell is about twice as efficient as a gasoline-fueled Otto engine, but also because it is so lightweight (but crashworthy) and so low in aerodynamic drag and rolling resistance that it can cruise at highway speed on no more power to the wheels than a conventional SUV uses on a hot day just for air conditioning. This design suggests that cars, too, can "tunnel through the cost barrier," achieving astonishing fuel economy at no extra cost and with many other customer and manufacturing advantages. With aggressive licensing of existing intellectual property, such vehicles could start ramping up production as early as 2008. All major automakers have parallel development programs underway, totaling ~$10 billion of commitments through 2000, since the basic concept was put into the public domain in 1993 to maximize competition.

A full U.S. fleet of such light vehicles of various shapes and sizes would save about as much oil as Saudi Arabia produces (~8 million bbl/day); a global fleet would save as much oil as OPEC sells. Moreover, such vehicles can be designed to plug into the grid when parked (which the average car is ~96% of the time), acting as a power station on wheels, selling back enough electricity and ancillary services to repay most of its cost. A U.S. fleet of light vehicles doing this would have ~5–10 times as much electric generating capacity as all power companies now own. This is part of a wider strategy that combines hydrogen-ready vehicles with integrated deployment of fuel cells in stationary and mobile applications to make the transition to a climate-safe hydrogen economy profitable at each step, starting now (beginning with ultrareliable combined heat and power in buildings). The resulting displacement of power plants, oil-fueled vehicles, and fossil-fueled boilers and furnaces could decrease net consumption of natural gas, could save about $1 trillion of global vehicle fueling investment over the next 40 years (compared with gasoline-system investment), and could profitably displace up to two-thirds of CO_2 emissions. It could also raise the value of hydrocarbon reserves, in which hydrogen is typically worth more without than with the carbon. It is favored by many leading energy and car companies today, and it is not too far off: over two-thirds of the fossil fuel atoms burned in the world today are already hydrogen, and global hydrogen production (~50 MT/year), if diverted from its present uses, could fuel an entire fleet of superefficient U.S. highway vehicles.

4.2 The Right Steps in the Right Order

Breakthrough energy efficiency results need not just the right technologies but also their application in the right sequence. For example, most practitioners designing lighting retrofits start with more efficient luminaires, improving optics, lamps, and ballasts. But for optimal energy and capital savings, that should be step six, not step one. First come improving the quality of the visual task, optimizing the geometry and cavity reflectance of the space, optimizing lighting quality and quantity, and harvesting daylight. Then, after the luminaire improvements, come better controls, maintenance, management, and training. Likewise, to deliver thermal comfort in a hot climate, most engineers retrofit a more efficient and perhaps variable-speed chiller, variable-speed supply fans, etc. But these should all be step five. The previous four steps are to expand the comfort range (by exploiting such variables as radiant temperature, turbulent air movement, and ventilative chairs); reduce unwanted heat gains within or into the space; exploit passive cooling (ventilative, radiative, ground coupling); and, if needed, harness nonrefrigerative alternative cooling (evaporative, desiccant, absorption, and hybrids of these). These preliminary steps can generally eliminate refrigerative cooling. If refrigerative cooling is still nonetheless desired, it can be made superefficient (e.g., system coefficient of performance 8.6 measured in Singapore), then supplemented by better controls and by coolth storage. Yet most designers pursue these seven steps in reverse order, worst buys first, so they save less energy, pay higher capital costs, yet achieve worse comfort and greater complexity.

Whole-system engineering optimizes for many benefits. There are, for example, 10 benefits of superwindows and 18 benefits of premium-efficiency motors or dimmable electronic lighting ballasts, not just the one benefit normally counted. (The arch that holds up the middle of the author's house has 12 different functions but is paid for only once.) Superwindows cost more per window, but typically make the building cost less because they downsize or eliminate space-conditioning equipment. Similarly, 35 retrofits to a typical industrial motor system, properly counting multiple benefits, can typically save about half its energy (not counting the larger and cheaper savings that should first be captured further downstream, e.g., in pumps and pipes) with a 16-month simple payback against a 5¢/kWh tariff. The saving is so cheap because buying the correct seven improvements first yields 28 more as free by-products. Such motor-system savings alone, if fully implemented, could save about 30% of all electricity worldwide. Such design requires a diverse background, deep curiosity, often a transdisciplinary design team, and meticulous attention to detail. Whole-system design is not what any engineering school appears to be teaching, nor what most customers currently expect, request, reward, or receive. But it represents a key part of the "overhang" of practical, profitable, unbought energy efficiency absent from virtually all official studies so far.

5. MARKET FAILURES AND BUSINESS OPPORTUNITIES

In a typical U.S. office, using one-size-fatter wire to power overhead lights would pay for itself within 20 weeks. Why is that not done? There are several answers: (1) The wire size is specified by the low-bid electrician, who was told to "meet code," and the wire-size table in the National Electrical Code is meant to prevent fires, not to save money. Saving money by optimizing resistive losses requires wire about twice as fat. (2) The office owner or occupant will buy the electricity, but the electrician bought the wire. An electrician altruistic enough to buy fatter wire is not the low bidder and does not win the job. Correcting this specific market failure requires attention both to the split incentive and to the misinterpretation of a life-safety regulation as an economic optimum. This microexample illustrates the range and depth of market failures that any skilled practitioner of energy efficiency encounters daily. A 1997 compendium, *Climate: Making Sense and Making Money*, organizes 60–80 such market failures into eight categories and illustrates the business opportunity each can be turned into. Some arise in public policy, some are at the level of the firm, and some are in individuals' heads. Most are glaringly perverse. For example, in all but two states in the United States, regulated distribution utilities are rewarded for selling more energy and penalized for cutting customers' bills, so naturally they are unenthusiastic about energy efficiency that would hurt their shareholders. Nearly all architects and engineers, too, are paid for what they spend, not for what they save; "performance-based fees" have been shown to yield superior design, but are rarely used. Most firms set discounted-cashflow targets for their financial returns, yet tell their operating engineers to use a simple-payback screen for energy-saving investments (typically less than 2 years), and the disconnect between these two metrics causes and conceals huge misallocations of capital. When markets and bidding systems are established to augment or replace traditional regulation of energy supply industries, negawatts (saved watts) are rarely allowed to compete against megawatts.

In short, scores of market failures—well understood but widely ignored—cause available and profitable energy efficiency to get only a small fraction of the investment it merits. Thus most of the capital invested in the energy system is being misallocated. The most effective remedy would be to put systematic "barrier-busting" atop the policy agenda, turning obstacles into opportunities and stumbling-blocks into stepping-stones, so market mechanisms could work properly, as economic theory correctly prescribes.

Using energy in a way that saves money is not only a perquisite of the rich, it is also arguably the most powerful key to global economic development for the poor. Using quintupled-efficiency compact fluorescent lamps in Bombay or installing superwindows in Bangkok takes about a thousand times less capital compared to expanding the supply of electricity to produce the same light and comfort via inefficient lamps and office/retail air conditioners. The efficiency investment is also repaid about 10 times faster. The resulting ~10,000-fold decrease in capital requirements could turn the power sector, which now uses about one-fourth of global development capital, into a net exporter of capital to fund other development needs. This is also true at the microscale of a rural village: a package of photovoltaics and superefficient end-use devices (lamps, pumps, mobile phone, water purification, vaccine refrigerator, etc.), with normal utility financing and no subsidy, often incurs debt service lower than what the villagers were already paying for lighting kerosene, candles, and radio batteries, so they have a positive cash flow from day one. Conversely, when Chinese authorities imported many assembly lines to make refrigerators more accessible, the saturation of refrigerators in Beijing households rose from 2 to 62% in 6 years, but the refrigerators' inefficient design created unintended shortages of power and of capital to generate it (an extra half-billion dollars' worth). A Chinese Cabinet member said this error must not be repeated: energy and resource efficiency must be the cornerstone of the development process. Otherwise, resource waste will require supply-side investment of the capital meant to buy the devices that were supposed to use those resources. This realization contributed to China's emphasis on energy efficiency (halving primary energy/GDP elasticity in the 1980s and nearly re-halving it since), laying the groundwork for the dramatic 1996 initial shift from coal to gas, renewables, and efficiency. This greatest contribution of any nation so far to reducing carbon emissions was a by-product of two other domestic goals: eliminating the bottleneck in China's development and improving public health.

6. *OLD AND NEW WAYS TO ACCELERATE ENERGY EFFICIENCY*

6.1 Old but Good Methods

In the 1980s and 1990s, practitioners and policymakers greatly expanded their tool kits for implementing energy efficiency. During the period 1973–1986, the United States doubled its new-car efficiency, and from 1977 to 1985, cut its oil use 4.8%/year. From 1983 to 1985, 10 million people served by Southern California Edison Company were cutting the decade-ahead forecast of peak load by

$8\frac{1}{2}$%/year, at ~1% of the long-run marginal cost of supply. In 1990, New England Electric System signed up 90% of a pilot market for small-business retrofits in 2 months. In the same year, Pacific Gas and Electric Company (PG&E) marketers captured a fourth of the new commercial construction market for design improvements in 3 months, so in 1991, PG&E raised the target, and got it all in the first 9 days of January.

Such impressive achievements resulted from nearly two decades of refinement of program structures and marketing methods. At first, utilities and governments wanting to help customers save energy offered general, then targeted, information, and sometimes loans or grants. Demonstration programs proved feasibility and streamlined delivery. Standards knocked the worst equipment off the market. (Congress did this for household appliances without a single dissenting vote, because so many appliances are bought by landlords, developers, or public housing authorities—a manifest split incentive with the householders who will later pay the energy bills.) Refrigerator standards alone cut electricity usage by new U.S. units by fourfold from 1975 to 2001 (5%/year), saving 40 GW of electric supply. In Canada, labeling initially did nearly as well. Utilities began to offer rebates—targeted, then generic—to customers, then to other value-chain participants, for adopting energy-saving equipment, or scrapping inefficient equipment, or both. Some rebate structures proved potent, such as paying a shop assistant a bonus for selling an energy-efficient refrigerator but nothing for selling an inefficient one. So did leasing (20¢ per compact fluorescent lamp per month, so that it is paid for over time), paying for better design, and rewarding buyers for beating minimum standards. Energy-saving companies, independent or utility owned, provided turnkey design and installation to reduce hassle. Sweden aggregated technology procurement to offer "golden carrot" rewards to manufacturers bringing innovations to market; once these new products were introduced, competition quickly eliminated their modest price premia. These engineered-service/delivery models worked well, often spectacularly well. Steve Nadel's 1990 review of 237 programs at 38 U.S. utilities found many costing <1¢/kWh (1988 dollars). From 1991 to 1994, the entire demand-side management portfolio of California's three major investor-owned utilities saved electricity at an average program cost that fell from about 2.8 to 1.9 current ¢/kWh (1.2¢ for the cheapest), saving society over $2 billion more than the program cost.

6.2 New and Better Methods

Since the late 1980s, another model has been emerging that promises even better results: not just marketing negawatts (saved watts), maximizing how many customers save and how much, but making markets in negawatts, i.e., also maximizing competition in who saves and how, so as to drive quantity and quality up and cost down. Competitive bidding processes let saved and produced energy compete fairly. Savings can be made fungible in time and space; transferred between customers, utilities, and jurisdictions; and procured by "bounty hunters." Spot, futures, and options markets can be expanded from just megawatts to embrace negawatts too, permitting arbitrage between them. Property owners can commit never to use more than x MW, then trade those commitments in a secondary market that values reduced demand and reduced uncertainty of demand. Efficiency can be cross-marketed between electric and gas distributors, each rewarded for saving either form of energy. Revenue-neutral "feebates" for connecting new buildings to public energy supplies (fees for inefficiency, rebates for efficiency) can reward continuous improvement. Standardized measurement and reporting of energy savings allow savings to be aggregated and securitized like home mortgages, sold promptly into liquid secondary markets, and hence financed easily and cheaply (see the Web site of the nonprofit International Performance Measurement and Verification Protocol, Inc., www.ipmvp.org). Efficiency techniques can be conveniently bundled and translated to "vernacular" forms, which are easily chosen, purchased, and installed. Novel real-estate value propositions emerge from integrating efficiency with on-site renewable supply (part of the revolutionary shift now underway to distributed resources) so as to eliminate all wires and pipes, the trenches carrying them, and the remote infrastructure to which they connect. Performance-based design fees, targeted mass retrofits, greater purchasing aggregation, and systematic barrier busting all show immense promise. Aggressively scrapping inefficient devices, paying bounties to destroy them instead of reselling them, could both solve many domestic problems (e.g., oil, air, and climate in the case of inefficient vehicles) and boost global development by reversing "negative technology transfer."

Altogether, the conventional agendas for promoting energy efficiency—prices and taxes, plus regulation or deregulation—ignore nearly all the most effective, attractive, transideological, and quickly spreadable methods. And they ignore many of the new marketing "hooks" just starting to be exploited: security (national, community, and individual), economic development and balance of trade, protection from disruptive price volatility, avoiding costly supply overshoot, profitable integration and bundling with renewables, and expressing individual values. Consider, for example, a good compact fluorescent lamp. It emits the same light as an incandescent lamp but uses four to five times less electricity and lasts 8–13 times longer, saving tens of dollars more than it costs. It avoids putting a ton of carbon dioxide and other pollutants into the air. But it does far more. In suitable numbers (half a billion are made each year), it can cut by a fifth the evening peak load that causes blackouts in overloaded Mumbai, it can boost profits of poor American chicken farmers by a fourth, or it can raise the household disposable cash income of destitute Haitians by up to a third. As mentioned previously, making the lamp requires 99.97% less capital than does expanding the supply of electricity, thus freeing investment for other tasks. The lamp cuts power needs to levels that make solar-generated power affordable, so girls in rural huts can learn to read at night, advancing the role of women. One light bulb does all that. It can be bought at the supermarket and self-installed. One light bulb at a time, the world can be made safer. "In short," concludes Jørgen Nørgård, by pursuing the entire efficiency potential systematically and comprehensively, "it is possible in the course of half a century to offer everybody on Earth a joyful and materially decent life with a per capita energy consumption of only a small fraction of today's consumption in the industrialized countries."

6.3 Deemphasizing Traditionally Narrow Price-Centric Perspectives

The burgeoning opportunities for adoption of energy efficiency approaches suggest that price may well become the least important barrier. Price remains important and should be correct, but is only one of many ways to get attention and influence choice; ability to respond to price can be far more important. End-use efficiency may increasingly be marketed and bought mainly for its qualitatively improved services, just as distributed and renewable supply-side resources may be marketed and bought mainly for their distributed benefits. Outcomes would then become decreasingly predictable from economic experience or using economic tools. Meanwhile, disruptive technologies and integrative design methods are clearly inducing dramatic shifts of, not just along, demand curves, and are even making them less relevant by driving customer choice through nonprice variables. Ultralight cars, for example, would do a complete end run around two decades of trench warfare in the U.S. Congress (raising efficiency standards vs. gasoline taxes). They would also defy the industry's standard assumption that efficient cars must trade off other desirable attributes (size, performance, price, safety), requiring government intervention to induce customers to buy the compromised vehicles. If advanced cars can achieve not incremental but fivefold fuel savings as a by-product of breakthrough design integration, yet remain uncompromised and competitively priced, then the energy-price-driven paradigm becomes irrelevant. People will prefer such vehicles because they are better, not because they are clean and efficient, much as most people now buy digital media rather than vinyl phonograph records: they are simply a superior product that redefines market expectations. This implies a world in which fuel price and regulation become far less influential than today, displaced by imaginative, holistic, integrative engineering and marketing. In the world of consumer electronics—ever better, faster, smaller, cheaper—that world is already upon us. In the wider world of energy efficiency, the master key to so many of the world's most vexing problems, it is coming rapidly over the horizon. We need only understand it and do it.

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Energy Efficiency, Taxonomic Overview

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Please note the following updates to the published article:

p. 396, col. 2, full para. 2 ("Perhaps..."): The vehicle efficiency stated is from a simulation of on-road performance, obtained by multiplying each vector in the standard EPA test cycles by 1.3. The equivalent EPA adjusted efficiency (the kind used for official efficiency ratings and shown on the window stickers of market vehicles) is 2.06 L-equivalent per 100 km, 48.5 km/L-equivalent, or 114 miles per U.S. gallon-equivalent. Resimulation in 2004 with a gasoline hybrid-electric powertrain as efficient as that of the 2004 Toyota Prius, and conservatively adjusted to all-wheel-drive operation like the fuel-cell version, yields simulated EPA adjusted efficiency of 3.56 L/100 km, 28.1 km/L, or 66 miles per U.S. gallon.

p. 397, col. 2, line 5: for 8.6 read 6.

p. 401, col. 2, lines 3-6: the Lovins et al. 2002 reference *Small Is Profitable* can be obtained at least cost via www.smallisprofitable.org.

p. 401, col. 2, lines 7-10: the Lovins et al. 2004 reference should read: Lovins, A.B., Datta, E.K., Bustnes, O.-E., Koomey, J.G., & Glasgow, N. 2004: *Winning the Oil Endgame*, Rocky Mountain Institute, Snowmass, Colorado, www.oilendgame.org, in press for release 20 September 2004.

Request 2b.

If known, provide the reasons that industrial customers have given for opting out of the utility-assisted DSM programs.

Response 2b.

Based on my experience working with the DSM Collaboratives at E.ON and AEP (Kentucky Power), utility companies generally do not devote much effort to finding out from industrial customers who wish to opt out what their reasons were. Typically, the utilities simply send them a letter or form asking them whether they want to opt out. Not surprisingly, most have chosen to do so. To my knowledge, no Kentucky utility company has ever tried to challenge an industrial customer's decision to opt out of DSM programs.

Realistically, I believe that many industrial firms have opted out because in the letters the utilities send to these customers, they have tended to highlight the advantages of opting out and the drawbacks of opting in. The letters sent by E.ON and AEP have conveyed the following message (in effect though not in so many words): You, the customer, can either agree to have a new cost line added to your electric bill and pay higher electric rates every month from now on, in which case the utility will design some nice demand-side management programs for you (and incidentally, for your competitors as well) that might enable you to save some energy at some future date, if you decide to participate in the particular program that the utility may develop; or you can check the opt-out box on the enclosed form, keep your electric bill exactly the same as it was before, and never hear from the utility about this topic again. If you were the chronically overworked and stressed-out employee at the industrial firm whose desk was the first stop for such a letter, which option would you choose? How would you report your decision to your supervisor, assuming you told your supervisor about it at all?

Request 2c.

Could one reason that industrial customers opt out of the programs be that they develop their own DSM programs?

Response 2c.

Although many customers have indeed developed and implemented some energy-saving measures or programs, the experience of Lovins and many other energy efficiency practitioners over the past several decades indicates that there are always cost-effective opportunities to save more. Please refer to Response 2a above.

Request 2d.

Would Mr. Young agree that given the competitive environment faced by industrial customers, those customers may have already undertaken and implemented every reasonable energy-efficient measure practicable in order to minimize costs and maximize net income? Explain the response.

Response 2d.

No. Please refer to Response 2a above and to Sections 3 and 5 of the attached article, "Energy Efficiency, Taxonomic Overview." Section 3 describes some of the ways in which customers, including industrial customers, chronically and persistently fail to implement energy-related measures and policies that would be considered "rational" by an economist. Section 5 discusses market failures in the business sector, including the problems of split incentives and economically "irrational," yet widespread, corporate policies that require energy-saving investments to meet return-on-investment hurdles of

50% or higher. This type of requirement represents a dramatic mismatch between the implicit discount rate of the customer compared to that of the utility, which is required by law to think in terms of much longer-term investments. It has been called the "payback gap" in the energy efficiency literature.

Request 2e.

What percentage of the total sales of the 16 member distribution cooperatives ("16 member coops") is classified as sales to the industrials?

Response 2e.

Recognizing that the following calculation will contain a certain amount of inaccuracy because the data is from two different time periods (i.e., the year 2005 versus the historic test year), it represents the best estimate I can provide given the time available. According to 2005 data provided by EKPC to the Utility Working Group, which was later renamed the Kentucky Energy Efficiency Working Group, the energy sales by EKPC and its member distribution cooperatives to 140 industrial customers was 3,021,366 MWh (see the attached one-page printout of an Excel spreadsheet). Total sales to all customer classes for the same period were 11,551,046 MWh. The attached workpaper adds up the energy sales to five large industrial customers served directly by EKPC, as listed in Exhibit I of EKPC's application in this case (pages 4 and 5 of 7). Direct sales totaled 1,834,046 MWh. To estimate the amount of energy sold to industrial customers by the 16 member coops, I subtracted EKPC's direct sales from 3,021,366 MWh. The result was 1,187,320 MWh. To estimate the amount of energy sold to all customers by the 16 member coops, I subtracted EKPC's direct sales from 11,551,046 MWh. The result was 9,717,000 MWh. The industrial percentage of the total sales of the 16 member coops is thus approximately 1,187,320 divided by 9,717,000 = 12%. If we consider the EKPC system as a whole, the industrial percentage is approximately 3,021,366 divided by 11,551,046 = 26%. The reason I am including the estimate for the EKPC system as a whole is that over time, some or all of the large industrial customers that EKPC serves directly may come to see enough economic potential in the utility's DSM programs to decide to opt in. One of EKPC's goals should be to develop a broad enough range of cost-effective industrial DSM programs to attract the interest and participation of even its largest customers.

Information requested	2005 Data (if available)	Units	
Name of utility company	East KY Power Cooperative		
# of residential electric customers	461,679		
# of residential gas customers	0		
# of commercial electric customers	30,607		
# of commercial gas customers	0		
# of industrial electric customers	140		
# of industrial gas customers	0		
Residential electric consumption (annual)	6,796,291	MWh	
Residential gas consumption	0	MCF	
Commercial electric consumption	1,733,389	MWh	
Commercial gas consumption	0	MCF	
Industrial electric consumption	3,021,366	MWh	
Industrial gas consumption	0	MCF	
Total electric consumption	11,551,046	MWh	
Total gas consumption	0	MCF	
Total peak electric demand	2,718	MW	
Revenue from residential electric sales	525,478,190	$	
Revenue from residential gas sales	0	$	
Revenue from commercial electric sales	127,794,835	$	
Revenue from commercial gas sales	0	$	
Revenue from industrial electric sales	153,815,862	$	
Revenue from industrial gas sales	0	$	
Total revenue from electric and gas sales	807,088,887	$	
Planned electric generation investments	Type of unit, (eg CT or DSM)	Year	Capacity in MW
Spurlock 4	coal--CFB	2009	278
Smith 1	coal--CFB	2010	278
Smith CT8	CT	2008	100
Smith CT9	CT	2008	100
Smith CT10	CT	2009	100
Smith CT11	CT	2009	100
Smith CT12	CT	2009	100

Data provided by EKPC to the Utility Working Group (aka the Kentucky Energy Efficiency Working Group)

Workpaper for 2e.

Electricity sales to industrial customers by EKPC (directly)

	MWh/year
Inland Container	220,486
AGC	146,387
Gallatin	1,034,356
TGP	155,726
Inland Steam	277,091
Total	1,834,046

3,021,366 − 1,834,046 = 1,187,320

Source: Application, Exhibit I, pp. 4 and 5 of 7

Workpaper date: 8/2/07 G.M.Y.

DATA REQUEST RESPONSES BY THE SIERRA CLUB

PSC CASE NO. 2006-00472

PSC STAFF'S FIRST DATA REQUEST DATED JULY 25, 2007

RESPONSIBLE PERSON: Geoffrey M. Young

Request 3.

Refer to the Young Testimony, pages 15 and 16 of 41. Mr. Young states that because DSM is generally a much cheaper energy resource than building new power plants, it may be concluded "with certainty" that plans by East Kentucky Power Cooperative, Inc. ("EKPC") to build plant cannot be the lowest-cost plan for its customers or society as a whole.

Request 3a.

Describe the analyses or studies Mr. Young has conducted that support this conclusion concerning EKPC. Provide printed copies of the analyses or studies.

Response 3a.

There are two ways to approach this topic: from the bottom up and from the top down. I will first cite an analysis I conducted in Case No. 2000-044, "A Review Pursuant to 807 KAR 5:058 of the 2000 Integrated Resource Plan of East Kentucky Power Cooperative, Inc.," while I was employed at the Kentucky Division of Energy. The following paragraphs are reprinted from the Division's comments submitted near the conclusion of that case. They address one of the elements that should be included in an analysis of the technical potential for cost-effective energy savings in EKPC's service territory:

> Savings of a similar magnitude are obtainable in the residential sector. The U.S. Department of Energy's *Building America* program is apply-

ing whole-building principles to new home construction and reducing energy use by approximately 50%, at little or no additional cost to production builders in a range of climate zones. See the program's web site at http://www.eren.doe.gov/buildings/building_america/system.shtml

The Rocky Mountain Institute describes a case study of what can be done in the residential sector by a utility company that is seriously interested in exploring the potential energy savings resulting from whole-system design. The Pacific Gas and Electric Company, as part of its Advanced Customer Technology Test (ACT^2) program, hired the Davis Energy Group to improve an initial design for a house that already met California's strict Title 24 energy code, which is supposed to include all efficiency measures that are worth buying from a societal perspective. The first step was to eliminate unnecessary corners that had added 23 feet (11%) of length to the outside walls. The designers then put the windows in the right places, used window frames that would transmit less heat, and invented an engineered wall that saved about 74% of the wood, reduced construction costs, and nearly doubled the insulation. A number of small improvements to the building envelope, windows, lights, major appliances, and hot-water system raised the total energy saving to 60% and increased the cost by approximately $1,900. At the same time, however, the thicker insulation and better windows eliminated any need for the $2,050 furnace and its associated ducts and equipment. Instead, on the coldest nights, a small amount of hot water from the 94%-efficient gas-fired water heater could be run through a radiant coil cast into the floor-slab. Finally, the designers eliminated the air conditioner by adding several more efficiency measures that had not previously appeared to have been cost-effective based on a conventional (measure-by-measure) analysis. The report concludes as follows:

> "Factoring out small electrical appliances (one-third of initial electricity usage), which offered many savings opportunities but would be brought along by the buyer rather than installed by the builder, the resulting final design would save about 80% of total energy or 79% for electricity alone: 78% for space heating, 79% for water heating, 80% for refrigeration, 66% for lighting, 100% for space cooling, and 92% for space cooling plus ventilation. If such construction techniques became generally practiced – so-called "mature-market cost" – then those savings would make the house, in a mature market, cost about $1,800 less to build and $1,600 less to maintain.
>
> "The measured savings, adjusted for some last-minute design changes requested by the homebuyer, agreed well with these

> predictions. The house proved very comfortable even in a severe hot spell. Since by law the Title 24 code is supposed to include all cost-effective measures, the Davis house may mean that this influential state standard has to be rewritten from scratch." [Rocky Mountain Institute, "Designing For Zero Cooling Equipment in a Hot Climate," 1999, www.naturalcapitalism.org/sitepages/pid27.asp]

> If EKPC were interested in applying this approach in Kentucky, it should be possible to develop, or to contract with expert consultants to develop, marketable house designs that replace the central furnace by a water-heater based system – as home builder Perry Bigelow has done in the Chicago area – and downsize or eliminate the conventional air conditioning system. [Kentucky Division of Energy's Comments Related to the 2000 Resource Plan of East Kentucky Power Cooperative, Inc., pp.10-11.]

Ideas such as the foregoing that are based on whole-system design need to be incorporated into EKPC's existing Touchstone Energy Home and Touchstone Energy Manufactured Home programs. The design of these programs, as currently displayed in Tariff Sections DSM-1 and DSM-2, frankly, leaves much to be desired. They need to be made more ambitious in view of the concept of "tunneling through the cost barrier" that Amory Lovins discussed in the article reproduced above in response to Request 2a. ["Energy Efficiency, Taxonomic Overview," pages 17-18 of 31.]

Vast potential efficiency gains are possible in the commercial sector as well. The same set of KDOE comments on EKPC's 2000 plan contained the following analysis:

> Focusing on the present-day reality in one large sector of the economy (buildings), a Strategic Issues Paper produced by E Source concludes that "Well over half of the energy used to cool and ventilate buildings in countries like the United States can be saved by improvements that typically repay their cost within a few years." Other analyses have found comparable potential savings in lighting, drivepower, office equipment and other end-uses. The report continues, "To a theoretical economist, these are astounding statements: it is inconceivable that in a market economy, such large and profitable savings would remain untapped. But to a practitioner who knows how buildings are created and run, it is not only conceivable but obvious." Energy-Efficient

Buildings: Institutional Barriers and Opportunities, E Source, Inc., 1992, Boulder, Colorado, p.6. The rest of the report provides a detailed examination of the process by which commercial buildings are designed, built and operated, and how inefficiencies are introduced at every stage through practices which are typical of the construction market. Most of the market barriers to energy efficiency result from split incentives, perverse incentives, lack of information, and lack of communication between the numerous parties involved. Although each market participant may be behaving rationally within his or her narrow area of responsibility, the overall result is a system that chronically undervalues energy efficiency.

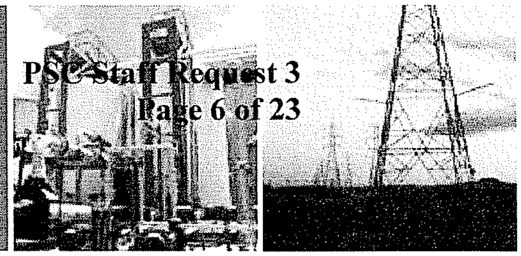
Given the large number of market barriers in the new commercial construction market cited in the E Source Strategic Issues Paper, it should not be surprising when analysts reach the conclusion that huge gains in energy efficiency are technically feasible at very reasonable cost. The Environmental Energy Technologies Division of the Lawrence Berkeley National Laboratory estimates that "If only tune-ups and performance monitoring of existing buildings were performed, average energy use could be reduced by about 20%. If proven efficiency measures were applied when a building is retrofitted (usually about every 15 years), about 50% reduction could be attained. The full range of efficiency measures that can be designed and incorporated into new buildings could bring about an energy reduction of as much as 75%." Lawrence Berkeley National Laboratory, "Creating High-Performance Commercial Buildings," *EETD News*, Fall 1999, pp. 1-2. Other estimates (for example, by E Source) are even higher. The fact that a long list of market barriers exists does not mean that they could not be overcome through carefully designed programs and policies, with active cooperation from the utility company.

Indirect but very real economic benefits resulting from improved daylighting designs such as increased retail sales or improvement in the performance of students or workers can make Total Resource Cost (TRC) benefit/cost ratios extremely high. Heschong Mahone Group, "Skylighting and Retail Sales," submitted to Pacific Gas and Electric Company on behalf of the California Board for Energy Efficiency Third Party Program, 1999; Romm, Joseph J. and William D. Browning, "Greening the Building and the Bottom Line: Increasing Productivity Through Energy-Efficient Design," Rocky Mountain Institute, Boulder, Colorado, 1994, p. 11; Heschong Mahone Group, "Daylighting in Schools: An Investigation into the Relationship Between Daylighting and Human Performance," submitted to Pacific Gas and Electric Company on behalf of the California Board for Energy Efficiency Third Party Program, 1999. While the energy savings generated by the daylight-oriented whole-building design of

> Lockheed's 600,000 square foot office building in Sunnyvale, California paid back the initial extra costs in four years, absenteeism among a known population of workers dropped by 15%, which represents annual cost savings equal to the entire incremental cost of the improved design. To this could be added productivity gains estimated at another 15%, bringing the simple payback period down to a matter of weeks. Romm and Browning, op. cit., pp. 8-9.

Approaching the same question from a large-scale perspective, I would cite the excellent analysis performed in 2006 by the Leadership Group of the National Action Plan for Energy Efficiency, a comprehensive effort co-chaired by Jim Rogers, the President and CEO of Duke Energy, and Diane Munns, the President of the National Association of Regulatory Utility Commissioners (NARUC). The entire report is available at http://www.epa.gov/solar/pdf/napee/napee_report.pdf. Chapter 6 of the document describes energy efficiency program best practices. The first seven pages of this chapter are reprinted below. One of the key findings, based on a national survey of utility-sponsored DSM programs, is that "Energy efficiency resources are being acquired on average at about one-half the cost of the typical new power sources, and about one-third the cost of natural gas supply in many cases – and contribute to an overall lower cost energy system for ratepayers." [National Action Plan, page 6-5]

The next finding is that "Many energy efficiency programs are being delivered at a total program cost of about $.02 to $.03 per lifetime kWh saved and $0.30 to $2.00 per lifetime MMBtu saved. These costs are less than the avoided costs seen in most regions of the country. Funding for the majority of programs reviewed ranges from about 1 to 3 percent of electric utility revenue and 0.5 to 1 percent of gas utility revenue." Further, even such sub-optimal levels of investment are enabling utilities to eliminate 20 to 50 percent of their expected load growth. [Ibid.]



6: Energy Efficiency Program Best Practices

Energy efficiency programs have been operating successfully in some parts of the country since the late 1980s. From the experience of these successful programs, a number of best practice strategies have evolved for making energy efficiency a resource, developing a cost-effective portfolio of energy efficiency programs for all customer classes, designing and delivering energy efficiency programs that optimize budgets, and ensuring that programs deliver results.

Overview

Cost-effective energy efficiency programs have been delivered by large and small utilities and third-party program administrators in some parts of the country since the late 1980s. The rationale for utility investment in efficiency programming is that within certain existing markets for energy-efficient products and services, there are barriers that can be overcome to ensure that customers from all sectors of the economy choose more energy-efficient products and practices. Successful programs have developed strategies to overcome these barriers, in many cases partnering with industry and voluntary national and regional programs so that efficiency program spending is used not only to acquire demand-side resources, but also to accelerate market-based purchases by consumers.

Leadership Group Recommendations Applicable to Energy Efficiency Program Best Practices

- Recognize energy efficiency as a high priority energy resource.
- Make a strong, long-term commitment to cost-effective energy efficiency as a resource.
- Broadly communicate the benefits of, and opportunities for, energy efficiency.
- Provide sufficient and stable program funding to deliver energy efficiency where cost-effective.

A list of options for promoting best practice energy efficiency programs is provided at the end of this chapter.

Challenges that limit greater utility investment in energy efficiency include the following:

- The majority of utilities recover fixed operating costs and earn profits based on the volume of energy they sell. *Strategies for overcoming this throughput disincentive to greater investment in energy efficiency are discussed in Chapter 2: Utility Ratemaking & Revenue Requirements.*
- Lack of standard approaches on how to quantify and incorporate the benefits of energy efficiency into resource planning efforts, and institutional barriers at many utilities that stem from the historical business model of acquiring generation assets and building transmission and distribution systems. *Strategies for overcoming these challenges are addressed in Chapter 3: Incorporating Energy Efficiency in Resource Planning.*
- Rate designs that are counterproductive to energy efficiency might limit greater efficiency investment by large customer groups, where many of the most cost-effective opportunities for efficiency programming exist. *Strategies for encouraging rate designs that are compatible with energy efficiency are discussed in Chapter 5: Rate Design.*
- Efficiency programs need to address multiple customer needs and stakeholder perspectives while simultaneously addressing multiple system needs, in many cases while competing for internal resources. *This chapter focuses on strategies for making energy efficiency a resource, developing a cost-effective portfolio of energy efficiency programs for all customer classes, designing and delivering efficiency programs that optimize budgets, and ensuring that those programs deliver results are the focus of this chapter.*

Programs that have been operating over the past decade, and longer, have a history of proven savings in megawatts (MW), megawatt-hours (MWh), and therms, as well as on customer bills. These programs show that energy efficiency can compare very favorably to supply-side options.

This chapter summarizes key findings from a portfolio-level[1] review of many of the energy efficiency programs that have been operating successfully for a number of years. It provides an overview of best practices in the following areas:

- Political and human factors that have led to increased reliance on energy efficiency as a resource.
- Key considerations used in identifying target measures[2] for energy efficiency programming in the near- and long-term.
- Program design and delivery strategies that can maximize program impacts and increase cost-effectiveness.
- The role of monitoring and evaluation in ensuring that program dollars are optimized and that energy efficiency investments deliver results.

Background

Best practice strategies for program planning, design and implementation, and evaluation were derived from a review of energy efficiency programs at the portfolio level across a range of policy models (e.g., public benefit charge administration, integrated resource planning). The box on page 6-3 describes the policy models and Table 6-1 provides additional details and examples of programs operating under various policy models. This chapter is not intended as a comprehensive review of the energy efficiency programs operating around the country, but does highlight key factors that can help improve and accelerate energy efficiency program success. Organizations reviewed for this effort have a sustained history of successful energy efficiency program implementation (See Tables 6-2 and 6-3 for summaries of these programs) and share the following characteristics:

- Significant investment in energy efficiency as a resource within their policy context.
- Development of cost-effective programs that deliver results.
- Incorporation of program design strategies that work to remove near- and long-term market barriers to investment in energy efficiency.
- Willingness to devote the necessary resources to make programs successful.

Most of the organizations reviewed also have conducted full-scale impact evaluations of their portfolio of energy efficiency investments within the last few years.

The best practices gleaned from a review of these organizations can assist utilities, their commissions, state energy offices, and other stakeholders in overcoming barriers to significant energy efficiency programming, and begin tapping into energy efficiency as a valuable and clean resource to effectively meet future supply needs.

1 For the purpose of this chapter, *portfolio* refers to the collective set of energy efficiency programs offered by a utility or third-party energy efficiency program administrator

2 *Measures* refer to the specific technologies (e.g., efficient lighting fixture) and practices (e.g., duct sealing) that are used to achieve energy savings

Energy Efficiency Programs Are Delivered Within Many Policy Models

Systems Benefits Charge (SBC) Model

In this model, funding for programs comes from an SBC that is either determined by legislation or a regulatory process. The charge is usually a fixed amount per kilowatt-hour (kWh) or million British thermal units (MMBtu) and is set for a number of years. Once funds are collected by the distribution or integrated utility, programs can be administered by the utility, a state agency, or a third party. If the utility implements the programs, it usually receives current cost recovery and a shareholder incentive. Regardless of administrative structure, there is usually an opportunity for stakeholder input.

This model provides stable program design. In some cases, funding has become vulnerable to raids by state agencies. In areas aggressively pursuing energy efficiency as a resource, limits to additional funding have created a ceiling on the resource. While predominantly used in the electric sector, this model can, and is, being used to fund gas programs.

Integrated Resource Plan (IRP) Model

In this model, energy efficiency is part of the utility's IRP. Energy efficiency, along with other demand-side options, is treated on an equivalent basis with supply. Cost recovery can either be in base rates or through a separate charge. The utility might receive a shareholder incentive, recovery of lost revenue (from reduced sales volume), or both. Programs are driven more by the resource need than in the SBC models. This generally is an electric-only model. The regional planning model used by the Pacific Northwest is a variation on this model.

Request For Proposal (RFP) Model

In this case, a utility or an independent system operator (ISO) puts out a competitive solicitation RFP to acquire energy efficiency from a third-party provider to meet demand, particularly in areas where there are transmission and distribution bottlenecks or a generation need. Most examples of this model to date have been electric only. The focus of this type of program is typically on saving peak demand.

Portfolio Standard

In this model, the program adminstrator is subject to a portfolio standard expressed in terms of percentage of overall energy or demand. This model can include gas as well as electric, and can be used independently or in conjunction with an SBC or IRP requirement.

Municipal Utility/Electric Cooperative Model

In this model, programs are administered by a municipal utility or electric cooperative. If the utility/cooperative owns or is responsible for generation, the energy efficiency resource can be part of an IRP. Cost recovery is most likely in base rates. This model can include gas as well as electric.

Table 6-1. Overview of Energy Efficiency Programs

Policy Model/ Examples	Funding Type	Shareholder Incentive[1]	Lead Administrator	Role in Resource Acquisition	Scope of Programs	Political Context
SBC with utility implementation: • California • Rhode Island • Connecticut • Massachusetts	Separate charge	Usually	Utility	Depends on whether utility owns generation	Programs for all customer classes	Most programs of this type came out of a restructuring settlement in states where there was an existing infrastructure at the utilities
SBC with state or third-party implementation: • New York • Vermont • Wisconsin	Separate charge	No	State agency Third party	None or limited	Programs for all customer classes	Most programs of this type came out of a restructuring settlement
IRP or gas planning model: • Nevada • Arizona • Minnesota • Bonneville Power Administration (BPA) (regional planning model as well) • Vermont Gas • Keyspan	Varies: in rates, capitalized, or separate charge	In some cases	Utility	Integrated	Program type dictated by resource need	Part of IRP requirement; may be combined with other models
RFP model for full-scale programs and congestion relief	Varies	No	Utility buys from third party	Integrated – can be T&D only	Program type dictated by resource need	Connecticut and Con Edison going out to bid to reduce congestion
Portfolio standard model (can be combined with SBC or IRP): • Nevada • California • Connecticut • Texas	Varies	Varies	Utility may implement programs or buy to meet standard	Standard portfolio	Programs for all customer classes	Generally used in states with existing programs to increase program activity
Municipal utility & electric cooperative: • Sacramento Municipal Utility District (CA) • City of Austin (TX) • Great River Energy (MN)	In rates	No	Utility	Depends on whether utility owns generation	Programs for all customer classes	Based on customer and resource needs; can be similar to IRP model

1 A shareholder incentive is a financial incentive to a utility (above those that would normally be recovered in a rate case) for achieving set goals for energy efficiency program performance.

Key Findings

Overviews of the energy efficiency programs reviewed for this chapter are provided in Table 6-2 and 6-3. Key findings drawn from these programs include:

- Energy efficiency resources are being acquired on average at about one-half the cost of the typical new power sources, and about one-third of the cost of natural gas supply in many cases—and contribute to an overall lower cost energy system for rate-payers (EIA, 2006).

- Many energy efficiency programs are being delivered at a total program cost of about $0.02 to $0.03 per lifetime kilowatt-hour (kWh) saved and $0.30 to $2.00 per lifetime million British thermal units (MMBtu) saved. These costs are less than the avoided costs seen in most regions of the country. Funding for the majority of programs reviewed ranges from about 1 to 3 percent of electric utility revenue and 0.5 to 1 percent of gas utility revenue.

- Even low energy cost states, such as those in the Pacific Northwest, have reason to invest in energy efficiency, as energy efficiency provides a low-cost, reliable resource that reduces customer utility bills. Energy efficiency also costs less than constructing new generation, and provides a hedge against market, fuel, and environmental risks (Northwest Power and Conservation Council, 2005).

- Well-designed programs provide opportunities for customers of all types to adopt energy savings measures and reduce their energy bills. These programs can help customers make sound energy use decisions, increase control over their energy bills, and empower them to manage their energy usage. Customers can experience significant savings depending on their own habits and the program offered.

- Consistently funded, well-designed efficiency programs are cutting electricity and natural gas load—providing annual savings for a given program year of 0.15 to 1 percent of energy sales. These savings typically will accrue at this level for 10 to 15 years. These programs are helping to offset 20 to 50 percent of expected energy growth in some regions without compromising end-user activity or economic well being.

- Research and development enables a continuing source of new technologies and methods for improving energy efficiency and helping customers control their energy bills.

- Many state and regional studies have found that pursuing economically attractive, but as yet untapped energy efficiency could yield more than 20 percent savings in total electricity demand nationwide by 2025. These savings could help cut load growth by half or more, compared to current forecasts. Savings in direct use of natural gas could similarly provide a 50 percent or greater reduction in natural gas demand growth. Potential varies by customer segment, but there are cost-effective opportunities for all customer classes.

- Energy efficiency programs are being operated successfully across many different contexts: regulated and unregulated markets; utility, state, or third-party administration; investor-owned, public, and cooperatives; and gas and electric utilities.

- Energy efficiency resources are being acquired through a variety of mechanisms including system benefits charges (SBCs), energy efficiency portfolio standards (EEPSs), and resource planning (or cost of service) efforts.

- Cost-effective energy efficiency programs for electricity and natural gas can be specifically targeted to reduce peak load.

- Effective models are available for delivering gas and electric energy efficiency programs to all customer classes. Models may vary based on whether a utility is in the initial stages of energy efficiency programming, or has been implementing programs for a number of years.

Table 6-2. Efficiency Measures of Natural Gas Savings Programs

Program Administrator	Keyspan (MA)	Vermont Gas (VT)	SoCal Gas (CA)
Policy Model	Gas	Gas	Gas
Period	2004	2004	2004
Program Funding			
Average Annual Budget ($MM)	12	1.1	21
% of Gas Revenue	1.00%	1.60%	0.53%
Benefits			
Annual MMBtu Saved [1] (000s MMBtu)	500	60	1,200
Lifetime MMBtu Saved [2] (000s MMBtu)	6,000	700	15,200
Cost-Effectiveness			
Cost of Energy Efficiency ($/lifetime MMBtu)	2	2	1
Retail Gas Prices ($/thousand cubic feet [Mcf])	11	9	8
Cost of Energy Efficiency (% Avoided Energy Cost)	19%	18%	18%
Total Avoided Cost (2005 $/MMBtu) [3]	12	11	7

[1] SWEEP, 2006; Southern California Gas Company, 2004

[2] Lifetime MMBtu calculated as 12 times annual MMBtu saved where not reported (not reported for Keyspan or Vermont Gas).

[3] VT and MA avoided cost (therms) represents all residential (not wholesale) cost considerations (ICF Consulting, 2005).

- Energy efficiency programs, projects, and policies benefit from established and stable regulations, clear goals, and comprehensive evaluation.
- Energy efficiency programs benefit from committed program administrators and oversight authorities, as well as strong stakeholder support.
- Most large-scale programs have improved productivity, enabling job growth in the commercial and industrial sectors.
- Large-scale energy efficiency programs can reduce wholesale market prices.

Lessons learned from the energy efficiency programs operated since inception of utility programs in the late 1980s are presented as follows, and cover key aspects of energy efficiency program planning, design, implementation, and evaluation.

Summary of Best Practices

In this chapter, best practice strategies are organized and explained under four major groupings:

- Making Energy Efficiency a Resource
- Developing an Energy Efficiency Plan
- Designing and Delivering Energy Efficiency Programs
- Ensuring Energy Efficiency Investments Deliver Results

For the most part, the best practices are independent of the policy model in which the programs operate. Where policy context is important, it is discussed in relevant sections of this chapter.

Making Energy Efficiency a Resource

Energy efficiency is a resource that can be acquired to help utilities meet current and future energy demand. To realize this potential requires leadership at multiple levels, organizational alignment, and an understanding of the nature and extent of the energy efficiency resource.

- *Leadership* at multiple levels is needed to establish the business case for energy efficiency, educate key stakeholders, and enact policy changes that increase investment in energy efficiency as a resource. Sustained leadership is needed from:

— Key individuals in upper management at the utility who understand that energy efficiency is a resource alternative that can help manage risk, minimize long-term costs, and satisfy customers.

— State agencies, regulatory commissions, local governments and associated legislative bodies, and/or consumer advocates that expect to see energy efficiency considered as part of comprehensive utility management.

— Businesses that value energy efficiency as a way to improve operations, manage energy costs, and contribute to long-term energy price stability and availability, as well as trade associations and businesses, such as Energy Service Companies (ESCOs), that help members and customers achieve improved energy performance.

— Public interest groups that understand that in order to achieve energy efficiency and environmental objectives, they must help educate key stakeholders and find workable solutions to some of the financial challenges that limit acceptance and investment in energy efficiency by utilities.[3]

- *Organizational alignment.* With policies in place to support energy efficiency programming, organizations need to institutionalize policies to ensure that energy efficiency goals are realized. Factors contributing to success include:

— Strong support from upper management and one or more internal champions.

— A framework appropriate to the organization that supports large-scale implementation of energy efficiency programs.

— Clear, well-communicated program goals that are tied to organizational goals and possibly compensation.

— Adequate staff resources to get the job done.

— A commitment to continually improve business processes.

- *Understanding of the efficiency resource* is necessary to create a credible business case for energy efficiency. Best practices include the following:

— Conduct a "potential study" prior to starting programs to inform and shape program and portfolio design.

— Outline what can be accomplished at what costs.

— Review measures for all customer classes including those appropriate for hard-to-reach customers, such as low income and very small business customers.

Developing an Energy Efficiency Plan

An energy efficiency plan should reflect a long-term perspective that accounts for customer needs, program cost-effectiveness, the interaction of programs with other policies that increase energy efficiency, the opportunities for new technology, and the importance of addressing multiple system needs including peak load reduction and congestion relief. Best practices include the following:

- Offer programs for all key customer classes.

- Align goals with funding.

3 Public interest groups include environmental organizations such as the National Resources Defense Council (NRDC), Alliance to Save Energy (ASE), and American Council for an Energy Efficient Economy (ACEEE) and regional market transformation entities such as the Northeast Energy Efficiency Partnerships (NEEP), Southwest Energy Efficiency Project (SWEEP), and Midwest Energy Efficiency Alliance (MEEA).

It should be noted that these total program costs of 2 to 3 cents per lifetime kWh saved are typical of certain existing utility DSM programs, and that if Amory Lovins' cost estimates are realistic, the total costs of improving energy efficiency would be substantially lower and the net benefits to customers and society substantially higher. Please refer to Lovins' estimate of the technical potential for energy efficiency provided in the article, "Energy Efficiency, Taxonomic Overview," reproduced above in response to Request 2a. Lovins claims that his "analyses in the late 1980s found, from measured cost and performance data for more than 1000 electricity-saving end-use technologies, that their full practical retrofit could save about three-fourths of U.S. electricity at an average CSE [cost of saved energy] of approximately 0.6 cents/kWh (1986 dollars) – roughly consistent with a 1990 Electric Power Research Institute analysis in which the differences were mainly methodological rather than substantive." [Response to Request 2a, page 12 of 31.] Although I am not saying that Lovins' dramatic claims should be accepted uncritically by EKPC, the Commission or any other party, I believe that his record of technical accuracy over the last three decades suggests that his arguments and ideas merit serious consideration, investigation and study by anyone interested in pursuing least-cost strategies in the energy sector. I am aware that on many occasions when Lovins' technical claims have been challenged by serious researchers, he has been able to document and defend his position convincingly. The potential economic and societal benefits are too large for any party to dismiss his analyses out of hand simply because his conclusions seem too good to be true.

A relatively recent example of a debate between Lovins and another energy researcher is posted on the web site of the Rocky Mountain Institute. Titled, "Exchanges between Mark Mills and Amory Lovins about the electricity used by the Internet," it is a posting of a series of communications during 1999 about the topic of how much energy the internet uses and saves. It illustrates Lovins' attention to detail, the high value he apparently places on technical accuracy, and his willingness to invest time and effort to make sure the numbers he cites are correct. The web site is http://www.rmi.org/images/PDFs/Energy/E99-18_MMABLInternet.pdf

EKPC's cost for fuel and purchased power alone is well over 3 cents/kWh. This means that EKPC could have been saving energy via increased investment in DSM for less than its average short-term variable cost. EKPC's existing resource expansion plan, which envisions ongoing fuel purchases as well as massive investment in new power plants, which will add significantly to EKPC's fixed costs and will lead to substantial increases in electric rates in the next few years, must therefore be a higher-cost plan than one that would have reduced or eliminated EKPC's load growth through improved energy efficiency. This would be the case whether we use the CSE figure of 2 to 3 cents/kWh from the "National Action Plan for Energy Efficiency," Lovins' CSE estimate of 0.6 cents/kWh, or any estimate in between.

Request 3b.

Assume EKPC determines it has a resource need for 300 MW annually. How many residential and commercial customers at the 16 member coops would have to participate in cost-effective DSM programs to meet the 300 MW need? Include all workpapers, calculations, assumptions, and sources of information utilized in the response.

Response 3b.

Because this request was expressed in terms of demand, the analysis shown on the attached workpaper uses the units of MW, although it could have been expressed equally well in terms of energy use in MWh per year.

Assumptions:

1. The figure of 300 MW in the information request refers to demand during EKPC's coincident peak.

2. EKPC has developed and implemented a set of DSM programs that would enable virtually any residential or commercial customer to participate if they wish. Program elements would include residential retrofit of building shell, heating and cooling system, and lighting; residential new construction (stick-built, manufactured homes and modular homes); residential solar hot water; commercial/institutional (C/I) retrofit of building shell, HVAC, lighting, and motor/drive systems; C/I building design, new construction and major renovation; C/I solar hot water; C/I air preheating using solar transpired air collectors; and C/I real-time pricing to encourage customers to shift load away from peak periods.

3. The typical residential customer purchases 14,721 kWh/year and the typical commercial customer 56,634 kWh/year. [Data source: 2005 data provided by EKPC to the Utility Working Group and reprinted above in response to information request 2e, page 30 of 31]

4. The coincident peak load of a typical residential customer is 10 kW, and of a typical commercial customer 25 kW. [Data source: Spreadsheet analysis performed by Susan M. Zinga on EKPC's existing, planned, and potentially expanded DSM programs; six pages of that analysis are included below.] Ms. Zinga performed a detailed analysis of EKPC's existing and planned DSM and marketing programs, as described in its most recent integrated resource plan (IRP; Case No. 2006-00471). The Sierra Club included the results of her analysis in our public comments submitted in Case No. 2006-00564, "An Investigation into East Kentucky Power Cooperative, Inc.'s Continued Need for Certificated Generation," April 10, 2007, pages 9-12.

5. The set of residential and C/I DSM programs outlined above is capable of reducing the coincident peak demand of the average participating residential customer by 50% (i.e., 5 kW) and the average participating C/I customer by 40% (i.e., 10 kW). [Data sources are the same ones cited above in response to information request 3a.]

The attached workpaper indicates that if approximately 20% of the commercial customers and approximately 10% of the residential customers were to participate in the DSM programs outlined above, EKPC's peak demand could be reduced by 300 MW.

Energy Efficiency Programs filed in East Kentucky Power Coop IRP

DSM Programs	Program Description	Non-participant Customer Usage (kWh)	Pre-program Customer *Summer* Coincident Demand Impact (kW)	Pre-program Customer *Winter* Coincident Demand Impact (kW)	Annual Program Participant Usage (kWh)	Program Participant *Summer* Coincident Demand Impact (kW)	Program Participant *Winter* Coincident Demand Impact (kW)
Existing							
Electric Thermal Storage Propane	Supplement/replace propane furnaces with electric thermal storage heating system	0	0	0	11,159	0.00	0.11
Electric Thermal Storage Furnace	Supplement/replace electric space heating with electric thermal storage heating system	12,675	0	9.62	13,307	0.00	2.83
Electric Water Heater New Construction	Installation of a high-efficiency electric water heater in new residences where a standard electric water heater would have been installed.	4,821	0	1.12	4,433	0.00	1.03
Electric Water Heater Retrofit	Replace natural gas water heaters with high efficiency electric water heaters	0	0	0	4,433	0.00	1.03
Geothermal Heat Pump New Construction	Geothermal heat pump & high-efficiency water heater would be installed instead of a SEER 13 air-source heat pump in new residences.	13,458	0	9.38	10,796	0.00	4.66
Air Source Heat Pump New Construction	Installation of a SEER 15 air-source heat pump instead of a SEER 13 air-source heat pump and some penetration into the market for natural gas space heating in new residences.	6,275	0	6.09	6,865	0.00	8.12
Air Source Heat Pump Retrofit	Installation of a SEER 15 air-source heat pump instead of a SEER 13 air-source heat pump and some penetration into the market for natural gas space heating in existing residences.	5,996	0	5.69	6,865	0.00	8.12
Tune-up HVAC Maintenance	Certified contractors perform maintenance on heat pump and electric space heating equipment to improve efficiency in existing residences.	11,286	0	8.96	9,932	0.00	7.89
Button-up Weatherization	The use of insulation and other weatherization materials to improve energy efficiency for existing residences with electric primary space heating.	11,286	0	8.96	8,882	0.00	7.05
Single Participant Net Existing Program Portfolio Impact		**65,797**	**0**	**50**	**76,672**	**0**	**41**
Total Annual Impacts of Existing Program Portfolio		**20,264,880**	**0**	**14,778**	**20,173,780**	**0**	**13,409**
Cumulative Existing Program Portfolio Impacts		**202,648,800**	**0**	**147,776**	**201,737,800**	**0**	**134,093**

Energy Efficiency Programs filed in East Kentucky Power Coop IRP

DSM Programs	Participant *Summer* Net Demand Impact (kW)	Participant *Winter* Net Demand Impact (kW)	Participant Net Annual Energy Impact (kWH)	Program Type	Annual Anticipated Program Participants	Program Life	Total Program Participants	Comments
Existing								
Electric Thermal Storage Propane	0.00	0.11	11,159	Peak & Energy Load Building	130	10	1,300	127 participants in 2005
Electric Thermal Storage Furnace	0.00	-6.79	632	Winter Peak Reduction; Energy Building	120	10	1,200	117 participants in 2005
Electric Water Heater New Construction	0.00	-0.09	-388	Winter Peak Reduction and Energy Savings	640	10	6,400	2004 & 2005 average participation = 638
Electric Water Heater Retrofit	0.00	1.03	4,433	Peak & Energy Load Building	50	10	500	2004 & 2005 average participation = 44
Geothermal Heat Pump New Construction	0.00	-4.72	-2,662	Winter Peak Reduction and Energy Savings	150	10	1,500	2004 & 2005 average participation = 151
Air Source Heat Pump New Construction	0.00	2.03	590	Peak & Energy Load Building	320	10	3,200	2004 & 2005 average participation = 322
Air Source Heat Pump Retrofit	0.00	2.43	869	Peak & Energy Load Building	340	10	3,400	2004 & 2005 average participation = 344
Tune-up HVAC Maintenance	0.00	-1.07	-1,354	Winter Peak Reduction and Energy Savings	350	10	3,500	Average participation 2002-2005 is 338 per year.
Button-up Weatherization	0.00	-1.91	-2,404	Winter Peak Reduction and Energy Savings	500	10	5,000	Average participation over 8 years has been 509 per year.
Single Participant Net Existing Program Portfolio Impact	0	-9	10,875		2,600			
Total Annual Impacts of Existing Program Portfolio	0	-1,368	-91,100		2,600			
Cumulative Existing Program Portfolio Impacts	0	-13,683	-911,000				26,000	

Energy Efficiency Programs filed in East Kentucky Power Coop IRP

DSM Programs	Program Description	Non-participant Customer Usage (kWh)	Pre-program Customer *Summer* Coincident Demand Impact (kW)	Pre-program Customer *Winter* Coincident Demand Impact (kW)	Annual Program Participant Usage (kWh)	Program Participant *Summer* Coincident Demand Impact (kW)	Program Participant *Winter* Coincident Demand Impact (kW)
New							
Compact Fluorescent Lighting	Replacement of incandescent bulbs with fluorscent bulbs in existing residences.	130	0.00	0.02	30	0	0.005
Touchstone Energy Geothermal Heat Pump Home	Install a geothermal heat pump instead of a 13 SEER air-source heat pump and an electric water heater with a desuperheater instead of a standard electric water heater in addition to other energy efficient building envelope measures in new residences.	15,378	0.00	12.17	9,772	0	4.05
Touchstone Energy Air Source Heat Pump Home	Install a 15 SEER air-source heat pump instead of a 13 SEER air-source heat pump and an electric water heater with a desuperheater instead of a standard electric water heater in addition to other energy efficient building envelope measures in new residences.	12,490	0.00	9.11	10,308	0	7.82
Touchstone Energy Manufactured Home	Provide incentives for new all-electric manufactured homes built to ENERGY STAR specifications.	17,194	3.11	9.73	12,036	2.18	6.81
Direct Load Control for Air Conditioners & Water Heaters	Perform direct load control on residential central air conditioners and water heaters.	6,702	2.70	1.03	6,688	1.3	0
ENERGY STAR Clothes Washers	Provide incentives for the purchase of ENERGY STAR clothes washers that save on energy needed for electric water heating and electric clothes drying.	5,450	0.47	1.29	5,100	0.44	1.2
ENERGY STAR Room Air Conditioner	Provide rebate for the purchase of an ENERGY STAR room air conditioner instead of a standard efficiency room air conditioner.	1,100	1.80	0	1,000	1.64	0
ENERGY STAR Refrigerator	Provide rebate for the purchase of an ENERGY STAR refrigerator instead of a standard efficiency refrigerator	600	0.87	0.57	500	0.72	0.47
Programmable Thermostat with Electric Furnace Retrofit	Provide rebate for a programmable thermostat in existing homes with electric furnace and central air conditioner with standard efficiencies.	14,936	2.05	9.62	14,187	1.95	9.62
Dual Fuel Air Source Heat Pump	Replaces propane furnace with air-source heat pump and backup propane fuel.	0	0.00	0	4,003	0	0
Commercial Lighting	Installs high-efficiency lighting in commercial buildings	21,000	4.19	2.24	16,275	3.25	1.73
C&I Demand Response	Request load reductions from commercial/industrial customers for rate reductions.	10,500	35.00	35	0	0	0

Energy Efficiency Programs filed in East Kentucky Power Coop IRP

DSM Programs	Participant *Summer* Net Demand Impact (kW)	Participant *Winter* Net Demand Impact (kW)	Participant Net Annual Energy Impact (kWH)	Program Type	Annual Anticipated Program Participants	Program Life	Total Program Participants	Comments
–								
New								
Compact Fluorescent Lighting	0.00	-0.02	-100	Winter Peak Reduction and Energy Savings	37,000	10	370,000	
Touchstone Energy Geothermal Heat Pump Home	0.00	-8.12	-5,606	Winter Peak Reduction and Energy Savings	40	10	400	
Touchstone Energy Air Source Heat Pump Home	0.00	-1.29	-2,182	Winter Peak Reduction and Energy Savings	100	10	1,000	Actual participation in 2005 was 92.
Touchstone Energy Manufactured Home	-0.93	-2.92	-5,158	Winter & Summer Peak Reduction and Energy Savings	10	10	100	2004 & 2005 average participation = 7
Direct Load Control for Air Conditioners & Water Heaters	-1.40	-1.03	-14	Winter & Summer Peak Reduction with very minimal Energy Savings	5,000	10	50,000	Assumes 20% penetration rate for 50% eligible population in 8 coops.
ENERGY STAR Clothes Washers	-0.03	-0.09	-350	Winter & Summer Peak Reduction and Energy Savings	500	10	5,000	Share increase of 7% in target market
ENERGY STAR Room Air Conditioner	-0.16	0.00	-100	Summer Peak Reduction and Energy Savings	600	10	6,000	Targets 10% of the new room air conditioner purchases each year.
ENERGY STAR Refrigerator	-0.15	-0.10	-100	Winter & Summer Peak Reduction and Energy Savings	900	10	9,000	Assumes 4% penetration of annual purchases for new refrigerators.
Programmable Thermostat with Electric Furnace Retrofit	-0.10	0.00	-749	Summer Peak Reduction and Energy Savings	650	10	6,500	Achieves 10% increase in penetration of programmable thermostats in existing homes with electric furnace and central air conditioning.
Dual Fuel Air Source Heat Pump	0.00	0.00	4,003	Energy Load Building	100	10	1,000	
Commercial Lighting	-0.94	-0.51	-4,725	Winter & Summer Peak Reduction and Energy Savings	570	10	5,700	Achieves cumulative participation of 20% of customers over 10 years.
C&I Demand Response	-35.00	-35.00	-10,500	Winter & Summer Peak Reduction and Energy Savings	167	3	500	Assumes 10% of eligible customers.

Energy Efficiency Programs filed in East Kentucky Power Coop IRP

DSM Programs	Program Description	Non-participant Customer Usage (kWh)	Pre-program Customer *Summer* Coincident Demand Impact (kW)	Pre-program Customer *Winter* Coincident Demand Impact (kW)	Annual Program Participant Usage (kWh)	Program Participant *Summer* Coincident Demand Impact (kW)	Program Participant *Winter* Coincident Demand Impact (kW)
Commercial Efficient HVAC	Incents commercial customers to replace SEER 13 heat pumps with SEER 15 heat pumps.	11,875	3.52	1.87	10,482	3.05	1.73
Commercial Building Performance	Provide incentive for commercial customers to implement energy efficient building envelope measures.	13,875	3.07	2.77	10,800	2.39	2.16
Commercial New Construction	Provide incentives to install heat pumps in new commercial construction instead of standard efficiency electric speace & water heating	100,000	27.00	13.57	90,000	24.3	12.21
Commercial Efficient Refrigeration	Install high efficiency refrigeration.	40,000	5.98	4.02	28,000	4.81	2.81
Industrial Premium Motors	Provide rebates for installation of high efficiency motors.	500,000	98.70	54.3	487,600	96.3	53
Industrial Variable Speed Drives	Provide incentives for variable speed drives when applicable.	240,000	47.40	26.1	141,600	28	15.4

Single Participant Net New Program Portfolio Impact	1,011,230	236	183	848,381	170	119
Total Annual Impacts of New Program Portfolio	115,069,210	35,300	27,607	99,838,940	20,337	14,415
Cumulative New Program Portfolio Impacts	1,138,407,100	312,052	235,122	998,389,400	203,367	144,149

Energy Efficiency Programs filed in East Kentucky Power Coop IRP

DSM Programs	Participant *Summer* Net Demand Impact (kW)	Participant *Winter* Net Demand Impact (kW)	Participant Net Annual Energy Impact (kWH)	Program Type	Annual Anticipated Program Participants	Program Life	Total Program Participants	Comments
Commercial Efficient HVAC	-0.47	-0.14	-1,393	Winter & Summer Peak Reduction and Energy Savings	150	10	1,500	Targets 10% of HVAC replacement market
Commercial Building Performance	-0.68	-0.61	-3,075	Winter & Summer Peak Reduction and Energy Savings	200	10	2,000	Achieves 10% penetration of applicable market in 10 years.
Commercial New Construction	-2.70	-1.36	-10,000	Winter & Summer Peak Reduction and Energy Savings	80	10	800	Targets 20% penetration of forecasted new commercial construction.
Commercial Efficient Refrigeration	-1.17	-1.21	-12,000	Winter & Summer Peak Reduction and Energy Savings	35	10	350	Achieves 20% market penetration in 10 years.
Industrial Premium Motors	-2.40	-1.30	-12,400	Winter & Summer Peak Reduction and Energy Savings	50	10	500	Achieves 25% share of motor purchase market
Industrial Variable Speed Drives	-19.40	-10.70	-98,400	Winter & Summer Peak Reduction and Energy Savings	35	10	350	Achieves 25% share of motor purchase market
Single Participant Net New Program Portfolio Impact	**-66**	**-64**	**-162,849**					
Total Annual Impacts of New Program Portfolio	**-14,964**	**-13,192**	**-15,230,270**		**46,187**			
Cumulative New Program Portfolio Impacts	**-108,686**	**-90,974**	**-140,017,700**				**460,700**	

Workpaper for 3b.

Avg. energy usage per customer

Residential: 6,796,291 MWh / 461,679 = 14,721 kWh/customer
Peak load = 10 kW. Potential reduction = 5 kW.

Commercial: 1,733,389 MWh / 30,607 = 56,634 kWh/cust.
Peak load = 25 kW (better load factor)

Potential reduction = 10 kW.

Approx. 20 % of commercial customers = 6,000
@ 10 kW = 60 MW

Approx. 10 % of residential customers = 48,000

@ 5 kW = 240 MW

Total peak reduction = 300 MW

G.M.Y. 8/3/07

DATA REQUEST RESPONSES BY THE SIERRA CLUB

PSC CASE NO. 2006-00472

PSC STAFF'S FIRST DATA REQUEST DATED JULY 25, 2007

RESPONSIBLE PERSON: Geoffrey M. Young

Request 4.

Refer to the Young Testimony, pages 16 through 19 of 41. Mr. Young states that Louisville Gas and Electric Company ("LG&E), Kentucky Utilities Company ("KU"), and The Union Light, Heat and Power Company ("ULH&P) had pilot decoupling programs in the past.

Request 4a.

The Commission authorized the pilot decoupling program for LG&E in Case No. 1993-00150 [footnote 1: Case No. 1993-00150, A Joint Application for the Approval of Demand-Side Management Programs, A DSM Cost Recovery Mechanism, and a Continuing Collaborative Process on DSM for Louisville Gas and Electric Company, final Order dated November 12,1993] and for ULH&P in Case No. 1995-00312 [footnote 2: Case No. 1995-00312, The Joint Application Pursuant to 1994 House Bill No. 501 for the Approval of the Principles of Agreement, Demand Side Management, The Union Light, Heat and Power Company, and for Authority for The Union Light, Heat and Power Company to Implement Various Tariffs to Recover Costs, Lost Revenues and Receive Incentives Associated with Demand Side Management Programs, final Order dated December 1, 1995]. Was Mr. Young aware that the Commission never authorized a pilot decoupling program for KU?