Micro Economics for Demand-Side Management

by

Hisao Kibune

MIT-CEPR 91-004WP February 1991

Micro Economics for Demand-Side Management

Hisao Kibune

Visiting Economist,
Center for Energy Policy Research
M.I.T

February, 1991

I thank David O. Wood, Tatsujiro Suzuki and Alan K. Meier for helpful discussion and helpful comments, also appreciate Joanna Caictch for her editing work. I gratefully acknowledge financial support from The Institute of Energy Economics, Japan.

Abstract

This paper aims to interpret Demand-Side Management (DSM) activity and to point out its problems, adopting micro economics as an analytical tool. Two major findings follow. First, the cost-benefit analysis currently in use has the following problems: (i) inconsistency in cost comparison between utility costs on the supply-side and utility costs plus customer costs on the demand-side, (ii) inconsistency in price comparisons among different consumption levels, and (iii) arbitrary pricing after DSM implementation.

Second, DSM programs can be recognized as a conventional economic activity, if we assume "energy service concept" as a definition for demand and also recognize the DSM program as a supply-side option. Concurrently, (i) DSM is justified, since it increases social welfare, and (ii) we are in a position to determine the amount of rebate to be paid. However, (iii) the utility bill of a DSM participant should not be reduced in the name of demand reduction, since the utility continues to provide energy service at the same volume, and must recover the DSM costs in order to avoid double payment to the participant. (iv) We note that the compensation method of DSM cost recovery, which is applied in several states, has a limitation. (v) The interpretation of DSM activity proposed in this paper is also useful in the case of marginal cost supply-side decrease.

Micro Economics for Demand -Side Management

by

Hisao Kibune

1. Introduction

Energy conservation programs financed by the public utilities, which are termed Demand-Side Management (DSM) programs, have been introduced and implemented widely in the United States, although neither the justification nor the validity of their success has been discussed sufficiently in economic or social terms. Consequently, economists, regulators, and utilities officials have no integrated sense of these issues. "Negawatts" and "Sell less and make more" are popular terms indicating these DSM activities.[1]

Regulators are very aggressive in promoting DSM ventures, recommending that power companies treat conservation programs as alternatives to supply-side options.[2] Many power utilities are also active in this ambitious attempt to promote conservation programs as equal to supply-side options. The major reasons for DSM support by utilities are that (1) DSM provides lower cost measures to meet the demand than does the supply option, (2) DSM can reduce the risk of future uncertainties, and (3) DSM can ease the burden on the environment.[3]

As a matter of fact, "there are some 1,300 utility-sponsored energy-efficiency programs operating in the United States right now covering all market sectors," and over

---

1 Lovins, A., (1985)

2 NARUC, (1989)

3 NEES (The New England Electric System Company), (1989) pp. 2-3. Hirst, E. classifies the benefits of DSM as followings; (1) provide low-cost alternatives to construction of new power plants, (2) save money for customers, (3) improve relations with customers by providing additional services, (4) improve relations with state public utility commissions (PUCs), (5) reduce financial risks to utilities, (6) improve environmental quality, and (7) enhance the economic competitiveness of utilities and their customers. Hirst, E., (1990)

$1.3 billion per year is expended on these programs by utilities.[4] More than 16 states have already examined or introduced to utilities some incentive measure to promote DSM programs.[5] However, the regulatory intervention to enhance energy conservation by such programs as DSM has proven very controversial, not only in terms of practical methodologies but also in terms of theoretical value. Advocates of DSM are mainly grounded in market imperfection [6] and externalities.[7] On the other hand, the typical assertion that DSM is not an appropriate measure for the market argues that the program acts as a producer intervening in consumers matters -- that DSM does not match the market and might in fact distort the market.[8]

Additionally, the cost-benefit analysis is solely used for justification of DSM programs and its methodology is widespread in several states throughout the United States.[9] The problems with such usage of cost-benefit analysis are that (1) the relation between existing cost and incremental cost is not explicit, (2) the demand curve is not counted, and (3) only marginal cost is taken into account, although rate making is usually based on average cost.

This paper aims to (1) interpret DSM activities from the view point of micro economics, (2) clarify the mechanisms and conditions of DSM program justification, and (3) set forth enigma's extraction of the practical measures as an important object. The methodology for the analysis undertaken here is dependent upon comparative statics.

The paper is divided into five sections including this introduction. The following section examines the compensation issue of DSM costs which are actually taken on, considering both marginal cost and average cost. The third section analyzes actual DSM

---

4 Speech by William B. Ellis, chairman of Northeast Utilities, at Edison Electric Institute-Unipede meeting. Quoted from Electrical World, October, 1990, p.39

5 Reid, M. and Chamberin, J., (1990) p. 5

6 See for example, Fisher, A. C. and Rothkopf, (1989). And Bates, R., (1990) is well organized on this issue.

7 See, for example, Haites, E. E., (1990)

8 Joskow, P.L., (1988)

9 The standard methodology of cost-benefit analysis on DSM program is California Public Utility Commission and California Energy Commission (1987).

activities by average prices and then abstracts the justification and conditions of DSM programs. The fourth section examines a specific example of DSM and takes up the restriction of DSM options. The fifth and final section is both a conclusion and a reference to future works.

2. Marginal Cost, Average Cost, and DSM

Initially we need to comprehend the situation in which DSM is said to be economically justified and review why and how DSM programs are implemented practically. In order to do this, we take a simple model of the current electricity market showing demand supply equilibrium.

Figure 1. simplifies the electricity market, illustrating its demand and supply curves. We assume that the current equilibrium stays at the right side of point (*), which is the intersection with long-run marginal cost (LRMC) and long-run average cost (LRAC). And the price of electricity is determined by the average cost. Suppose the current demand curve is D1-D1, consumption is q1, and price is p1.

When the marginal cost is larger than the average cost, it is quite obvious that average cost pricing produces the social welfare losses.[10] This shows triangle A, C, E on the chart. Therefore, the current equilibrium on the chart (price is p1 and consumption is q1) does not reflect an optimal market situation. Based on this social welfare loss, we have a policy recommendation that marginal cost pricing creates an efficient market. But marginal cost pricing produces another practical problem.[11]

10 See, Joskow, P.L., (1988)

11 Although marginal cost pricing on retail market is a key for creating efficient market, there are several practical problems. Time and Use rate might be one of preliminary approach to the marginal cost pricing. But actual marginal cost is changing to time by time. If we try to reflect this capricious cost on rate, we need huge amounts of investments on the networks and meters. Each residential customers has to equip instruments showing time by time price and metering its consumption. Of course it's not impossible, and we might have such an era in future. AEP (American Electric Power) has experimented

2.1 Market of DSM

We assume future demand is projected by D2-D2. The power company has to deal with the incremental demand (q2-q1) , by increasing supply capacity or decreasing the demand intentionally. The former is a supply-side option, the latter a demand-side option, DSM. Here, we assume the demand volume reduced by DSM options is as much as the expected incremental demand (q2-q1). It means that demand curve D1-D1 remains at the same position after DSM implementation. We don't pay attention here to the issue of whether it is correct or not in an economic sense that the producer makes a demand curve shift to the left because of his investment, despite its curious and uncommon occurrence in the market. The above frameworks are the fundamental tools for this analysis.

Now we adapt the tests based on cost-benefit analysis, which usually examine the economy of DSM programs, to fit the above framework. Generally, the conditions which justify DSM programs in an economic sense are the following: (1) the total cost of the DSM option is smaller than the avoided cost of the supply side: Total Resources Cost Test (TRC test). (2) The impact on the power rate of adopting DSM options is smaller than that of supply side: Rate Impact Test (RIM test or "no loser principal") means the power price with DSM options is cheaper than that with supply-side options, and (3) the DSM program is attractive to customers: Participant Test (P test).[12]

We can show these tests on Figure 1. (1) The condition of TRC tests illustrates that the marginal cost of DSM options should be lower than the point F. The cost is p3, which is the intersection of LRMC and consumption volume q2. (2) In that case, if the power rate

---

this kind of system named AEM (Advance Energy-Management System). However, time is to early to implement thorough marginal cost pricing currently. As for AEP's experimentation, see Electric World April 1990, pp. 47-49

12 Usually, we have four kinds of tests for DSM economy; reflecting each economic subject's benefit. Beyond three tests mentioned, we have U Tests (Utility Test). See, an example, California Public Utility Commission and California Energy Commission (1987). U Test is involved in TRC Test, and also RIM Test is counted in TRC Test, without consideration of issue of benefit allocation. See, Berman, J. S. and Logan, D. L. (1990)

with DSM options is determined under the price p2, which is indicated as point B (intersection of LRAC and q2) then the DSM programs pass the RIM test and "no loser principal." Actual consumption in this case is not q2 but q1. And the power rate is p4, which is determined by D, the point of intersection of long-run average cost with DSM options (LRAC+DSM) and q1. (3) P test is the comparison of the area O, q2, B, p2 minus the area O, q1, D, p4, which means reducing rate payment and incentives given by utilities, with the cost paid by customers, (which is not illustrated in the chart.)

2.3 Problems of Cost-Benefit Analysis on DSM

We can point out several important problems that arise in the cost-benefit analysis of DSM programs, using the above tools.

First, the TRC test compares the area q1, q2, F, C (or marginal cost q3) to the DSM cost burdens on both utility and customers, although the LRMC is only for the utility's cost function. If we want to make this comparison consistent, we must include customer costs in the utility's supply-side LRMC from the initial stage. Therefore, the comparison which is done in the name of cost-benefit analysis is not based on the same standard.

Second, the power rate goes up to p4 from p1, caused by DSM costs, although the supply volume is not changed after DSM programs are implemented. "No loser principle" tells us p4 doesn't have any loser because p4 is cheaper than p2. But p4 is not determined by the same condition as p2. Under the p2, a utility could supply volume q2. The comparison of price levels which have different supply volumes is illogical. Additionally, if we watch only consumers' surplus, it is presumed that consumers' satisfaction on the demand curve D2-D2 is greater than that of D1-D1.

Third, we have assumed the power rate with DSM programs; p4 reflects the costs of DSM and it is necessary to be below p2. Certainly this is correct. But there is still a wide range for p4. That is, the revenue required in order to recover the DSM costs is only the area O, q1, D, p4, and it is possible for the utility to increase revenue up to the maximum level of the area p1, q1, G, p2. This can allow regulators to approve the spending of money for incentives to boost DSM to utilities, incentives such as shared conservation bonuses and higher rates of return on DSM investments. In other words, we have the possibility with DSM programs that regulators can have the power to set utility rates and incentives arbitrarily, as long as they remain under the ceiling price. Such a possibility means that the consistency of pricing might break down.

2.4 Limitation of DSM on Existing Facilities

All of the above discussion is based upon a situation in which we need additional supply sources to meet increasing demand - in other words, based on long-term future marginal costs. Can we adopt DSM programs when we already have enough existing capacity to supply electricity? If so, under what conditions? This situation is similar to the current equilibrium with a D1-D1 curve. Let's consider this case from the view point of the price comparison.

Here, we can have 3 equations explaining the relations among costs, demand, and price at the initial stage, without DSM implementation.

$$TC = FC + VC \tag{1}$$

$$VC = a x + b(X-x) \tag{2}$$

$$\begin{aligned} p0 &= TC / X \\ &= EC/X + \{ a x + b(X-x) \} / X \end{aligned} \tag{3}$$

TC is the total costs of the utility, composed of fixed cost (FC) and variable cost (VC), X is current demand level, and x is the volume which is expected to be reduced by DSM programs. Variable cost per unit (cents per kwh) is "b", when the supply volume is less than X-x, or "a" when the supply volume is more than X-x. Here, "a" is larger than "b." The main item of the variable costs is fuel cost, and we can expect this variable cost per kwh is increasing in proportion to supply volume, since we must operate older and less efficient generators to meet the demand expansion. This means the marginal cost is increasing. The price level under the demand X is p0.

$$p^* = \{ FC + b(X - x) + FC_{dsm} \} / (X - x) \qquad (4)$$

FC_{dsm} is the cost of DSM programs, the volume of demand reduced by the programs is expected x, and the price after DSM has been implemented is p*. The condition in which DSM activities cause the power rate to sink lower than that without DSM programs is written as follows.

$$p^* \leq p0 \qquad (5)$$

$$FC_{dsm} \geq x / X * \{ (X - x) * (a-b) - FC \} \qquad (6)$$

Extend formula (5) and then we arrive at (6). Formula (6) explains that the validity of DSM programs ($FC_{dsm} \geq 0$) depends on the size of the fixed cost (-FC), the speed of the marginal cost increase (a-b), and the demand level after DSM programs have been implemented.

If the variable cost per kwh is stable (a = b), the DSM program makes power sales decrease and the fixed cost per kwh increase. In that case, the utility must raise the price in order to recover the cost already invested. Therefore, DSM programs in this situation should not be considered valid.

3. Micro Economics for DSM

As mentioned before, there are several problems in the current cost-benefit analysis which is put into operation. We must improve these issues. And, it is difficult to adapt DSM activities to the contexts of the conventional economic theory, since the theoretical phenomenon under the name of DSM programs means that a demand curve for electricity is made shifted to left side, not by demand side, but by supply side's activity and investment. Figure 2 shows this phenomenon. The demand curve projected in the future without DSM is h shown as D-D. And if we do take DSM projects, D-D would be changed to D'-D'. Such theory, which justifies this DSM activity by suppliers, is not popular and is never seen in text books.

How can we interpret DSM programs as an activity consistent with traditional economic theory? In the next chapter, we will discuss this issue.

3.1 "Energy Service" Concept

First of all, we interpret DSM programs by applying a standard different from the one used in the previous chapter. To do so, we need to be inventive with the two key concepts; demand and supply. If we add a little metaphoric pepper, to spice up the concepts of demand curve and supply curve, then DSM activities become consistent with conventional economic theory.

As for the demand curve, the pepper we add here is the concept of "energy service". That means we should consider "energy service" as the demand curve of electricity, which reflects the utility function of rate payers such as satisfaction of lighting, power and cooling by consuming electricity, instead of physical kwh or kw.[13] Originally and generally, a demand curve in theory depends not on a numerical term, but on the utility gained by consuming goods or services. And the purpose of electricity use is to take the utility of light, power and cooling associated with electric consumption by appliances.

Here, we think the position of the demand curve based on "energy service" is not changed even after DSM is implemented, although the demand curve in physical terms is shifted to the left side of its initial position . For example, we can regain the original brightness after replacing an inefficient bulb in an efficient fluorescent lamp. Similarly a bottle of beer when placed in a low energy use refrigerator, that has been substituted for an inefficient one, becomes as cold as it was previously. We presume that the demand curve of "energy service" stays at D-D, as shown on the Figure 2.

3.2 Supply Curve for DSM

The next problem is the choice of technology (measure) in the supply side to meet the demand. Here, we will recognize a DSM program as one of supply-side options. This recognition is precisely the same as a basic idea adopted in a Least Cost Planning (LCP), which tries to compare demand-side options with supply-side ones at the same level to achieve least cost purpose.

The curve S-S on Figure 2 indicates the short-term average cost curve for supply side. The options include construction of new power plants and purchase of the power in the wholesale market. Along with the short-term cost function, we can gain the long-term average cost curve, which is shown as LRAC in the chart.[14] On the other hand, the cost curve of DSM programs is drawn as S_{DSM}-S_{DSM} and its long-term average cost curve is

13 The adoption of "energy service" concept is not new. In the works by Sant(1984), Lovins(1985), and Cicchetti and Hogan(1990) they use it.

14 In this part, we don't focus on the pricing issue. It is very obvious that social welfare is lost when marginal cost is higher than the average cost under the average cost pricing. In that case, marginal pricing is one of the policy recommendation. See Joskow P. L. (1988)

gained as $LRAC_{DSM}$, indicated by the dotted line.

This figure displays the supply curve with DSM programs ($LRAC_{DSM}$) bent at q1 and with its position below the other one (LRAC). Thus, if a DSM program is more costly than an option of supply side, that program is not chosen as a means to meet demand. As for the equilibrium prices on the chart, if we adopt the DSM option to meet the demand the price is set at p1, although in the case of supply-side adjustment p2 is the choice.

The above framework is a basic and simple tool for this analysis. (1) Measuring demand by this "energy service" concept and (2) recognizing a DSM program as one of supply options, peppering with those two key concepts makes explanation of DSM programs possible by conventional economic theory.

3.3 Equilibrium of DSM

The above charts, analyzing DSM programs in terms of micro economics, provide us with useful information about DSM activities. Following are the five fine messages gained from these charts.

First, social welfare increases through DSM programs more than otherwise would occur.

Here, we assume the demand curve D1-D1 is the current (initial) one and D2-D2 is the projected future one; both are in terms of physical electricity demand. And point A on Figure 3 is the equilibrium point between future demand and supply of electricity in physical terms. On the other hand, point C indicates the equilibrium point between demand and supply with DSM programs in "energy service" term, and q2 shows the equilibrium volume. In the latter case, in which the means of meeting demand is adoption of DSM programs, the position of the demand curve in physical term is considered to be stationary at D1-D1 as before.

If DSM programs keep the service level at the same point as the supply option would provide, DSM options make social welfare (consumers' surplus plus producers' surplus) increase as much as the area of the triangle A,C,D on the Chart, compared to the supply options. The length q1-q2 indicates the volume of conservation of electric demand projected.

Second, this model solves the problem of how much power utilities should pay to DSM programs as rebates or investment. The area of the square q1,q2, C,A indicates that amount. This area is recognized as the cost for de-coupling the level of "energy service" demand with the level of electric demand in physical term. In other words, this amount is the cost of increased efficiency. Therefore, the cost of DSM programs in term of rebates or investments should be equal to the cost of "pure" efficiency increases.

Third, the chart presents the answer to the question of how much the rate payer should pay after DSM programs have been implemented. It is not necessary to say that the revenue required is equal to the total customers' bill, and the amount is gained by multiplying price per kwh by volume of consumption. Here, we have determined that the demand curve is based on the "energy service" concept and is maintained at the same level of D2-D2, meaning the level of energy service doesn't decrease after DSM implementation. That is , we should not reduce the customers' bills in association with the level of the electric demand in physical term.[15]

If we misunderstand that the demand level is still q1, price is p1 and the revenue required is the area of the square O, q1, A, p1, after DSM programs implementation, then the cost of DSM programs (the square q1, q2, C, A) would not be recovered. Of course, the total bill in the case of a DSM option is smaller than that in a supply option, but we have to keep in mind that satisfaction or utility by consuming electricity is the same level in both options, therefore demand levels are not different. In the case of a decreased total bill, that decrease should be caused not by demand level change, but by price reduction (p2 -p1).

Fourth, we notice the critical difference between a theoretical method and a practical one in figuring how to compensate the cost of DSM programs . The biggest problem on

15 This conclusion is same as Ciccetti and Hogan(1990).

the model is how to measure the level of "energy service," how to distinguish the actual and physical volume of electric demand measured by meter from "efficiency increased," and how electric power companies send the bill, combined with physical demand and increased efficiency, to the rate payer. We regret that we can not offer a solution to these practical problems.

However, we can describe what power companies or regulators are doing to handle these cost compensation issues in practice. The demand level in physical term being maintained at q1, power utilities would let the price rise up to the point p3, which is at random but cheaper than p2, in order to recover DSM costs. Revenue would increase through this rising price. If this increment revenue (that is the area of square p1, A, E, p3) is equal to or greater than the DSM (the area of square q1, q2, C, A), then electric power companies can recover their costs on DSM. Price level such as p3 should be determined by this view point. At the same time, the demand curve in physical term should remain not at D1-D1, but at D3-D3.

Since p3 is lower than the supply side avoided cost (p2), power companies can justify their DSM options. Using this compensation method, they employ consumption volume which is actually measured by meter as billing data directly. Additionally, incentive systems of DSM investments to share holders, which are examined and some appointed by several PUCs -- such as ERAM, with the bonus based on shared conservation merit and so on -- are also manipulated by the same mechanism; the costs of those incentives come from the price increase.

Fifth, we can generalize from the above model. So far, we take up the issue under conditions in which the marginal cost of the supply option is higher than the average cost, meaning that both marginal cost and average cost are increasing. We can embrace the above model's framework, except for the interpretation of a price rise to compensate DSM cost in practice, on the condition that the marginal cost is decreasing. The important considerations are (1) adopting the "energy service" concept as demand curve, and (2) recognizing a DSM option as one of the supply side options. These two key peppering agents could be used similarly even under the condition of decreasing marginal cost and whether an economy of scale exists or not.

4. Concrete Instance of Above Model

Here, we will consider an example in order to grasp a concrete image of the above model.

4.1 Concrete Instance

Suppose that the current revenue required of a power company is $80, including fixed costs and variable cost, and the total demand of electricity is 1000 kwh, then the price is $.08 per kwh. Here we'll have a new increment demand of 100 kwh, and an incremental cost to meet that is $10. On the other hand, the DSM optional cost is $8 to reduce 100 kwh in physical term. The marginal costs of both options are $.10 per kwh and $.08 per kwh, respectively. The DSM option is clearly less costly. That is, if the cost of DSM programs, which provide the same service level as supply-side options, is equal to or lower than supply-side costs, then we conclude that the DSM program is cost effective.

When we take a stand of long-run average cost, we will recognize that DSM programs demonstrate the following characteristics. The level of "energy service " provided by DSM programs is equal to that of supply side options, although the demand of electricity in physical term in the two cases is different. Therefore, the unit price per "energy service" kwh in the case of the DSM option will not change, but will maintain the initial price of $.08 per kwh. The bill is calculated based on this "energy service" kwh. Compared to this calculation, the unit price in the case of the supply side option will change to $.0818 per kwh. The key factor in the above calculation is that the sales volume, which is adopted as the denominator to gain the price, is based not on the physical electric demand but on the "energy service" concept.

Are there any cases in which the long-run average price with the DSM option is lower than that with the supply side option even in the calculation based on demand in physical term? Yes, there are, and those cases might be very acceptable to rate payers, in general. We 'll describe such an instance.

4.2 Long-Run Average Cost in Physical Term

The condition in which the long-run average cost with DSM options is lower than that with supply side options calculated by physical demand of electricity (not using the "energy service" concept here) is represented as follows.

$$(A + Cs) / (X + x) \geq (A + Cdsm) / X \tag{7}$$

Here, A is the existing cost, Cs is the increment cost by supply side option, and Cdsm is the increment cost by DSM option, respectively. And X is the demand level in the initial stage and x is additional demand.

If the value of the right side is smaller than that of the left side, then the long-run average cost with DSM option is lower than that with the supply side option, even though we adopt physical demand level as the denominator to calculate the price. And the value of the right side means the price level to compensate the DSM costs recovery (that level which is price p3 on the chart shown before) is lower than the left side value (which means p2 on the chart), so the price should be readily accepted, giving power companies and regulators justification for DSM programs.

The above formula is expanded as follows.

$$x / X \leq (Cs - Cdsm) / (A + Cdsm) \tag{8}$$

$$Cdsm \leq (Cs\,X - A\,x) / (X + x) \qquad (9)$$

The formula (8) shows the DSM option has advantages when the growth rate of demand is smaller than that of cost deferential between supply side and DSM options to total cost with DSM option. In other words, the advantages of DSM options depend on both the projected demand growth and the supply side cost.

The formula (9) indicates ceiling amount to DSM investment practically, compared to supply side options. If we refer to the above example, Cdsm should be less than $1.82. This amount is equal to the that long-run average price is $.0818 per kwh under the calculating conditions which we adopt, and demand is determined by physical term after implemented DSM options. If the cost of DSM options is lower than this figure, we can afford to price hike to compensate DSM cost recover.

4.3 The condition of Cost Compensation

However, we should notice the restriction of compensation using the above mechanism; boosting price compensation. Here the fundamental condition for DSM program implementation is that Cdsm must be a positive number.

$$Cdsm \geq 0$$

$$1 \leq (Cs / A) \;/\; (x / X) \qquad (10)$$

The right side of the formula (10) demonstrates the slope of marginal cost of supply side options. The value should be greater than 1.0. That means that marginal cost is increasing. Therefore, the compensation method for recovering DSM costs -- which measures demand in physical term and boosts the price to compensate DSM costs --, a method widely adopted in the states, is only valid under the increasing marginal cost of supply side options. In other words, if the marginal cost of supply side options is decreasing, this compensation method does not work and DSM options are not justified. Consequently, power companies and regulators should pay attention to this important restriction of their cost compensation method.

5. Conclusion

Using micro economics as an analytical tool, this paper surveys DSM activity and its problems, as summarized below.

(1) The cost-benefit analysis currently in operation has the following problems; (a) inconsistency of cost comparison between costs of utility in supply-side and costs of utility plus customers in demand-side, (b) inconsistency of price comparison among different consumption levels, and (c) arbitrary pricing after DSM implementation.

(2) DSM programs can be recognized as a conventional economic activity, if we adopt "energy service concept" for demand and if we recognize a DSM program as one of the supply-side options. Along with this recognition, (a) DSM is justified, since it increases social welfare, and (b) we can answer the question of how much rebate should be paid. However, (c) the bill of a DSM participant should not be reduced in the name of demand reduction, since the utility continues to provide energy service in the same volume, and the utility needs to recover the DSM costs and avoid double payment to the participant. (d) We should notice that the compensation method to recover the DSM costs, which is applied in several states, has a limitation. (e) The interpretation of DSM activity presented by this paper is also useful even in the case of marginal cost in supply-side decrease.

We have two important future works. One is to develop the index or unit to measure the "energy service concept." "Energy service concept" is a useful tool to understand the DSM activity in theory, however we have a practical difficulty in measuring it.

The other prospective work is a precise study based on actual proof about the cost structure of power companies. Basically, the validity of DSM programs depends on whether a utility's cost structure is under the marginal cost increase or not. What is the actual situation? Although many distinguished authorities have attempted to clarify this issue, it is very difficult to draw conclusions.

Fig. 1. Marginal Cost, Average Cost, and DSM

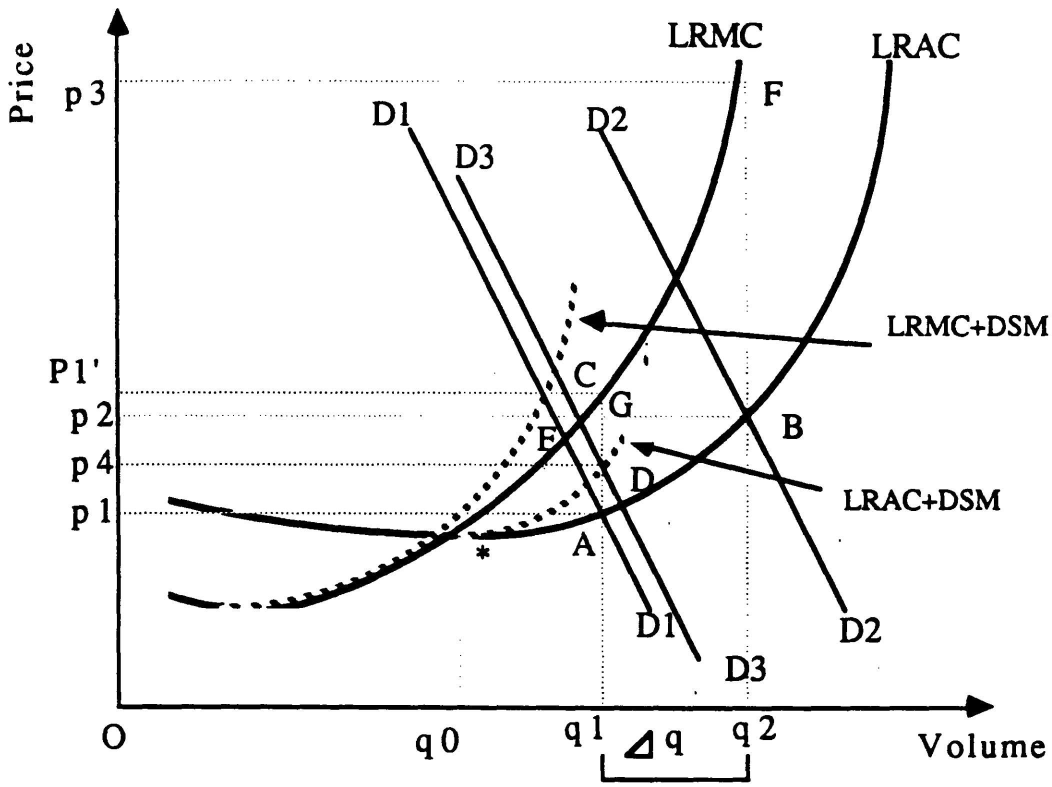

Fig. 2. Long-Run Average Cost and DSM

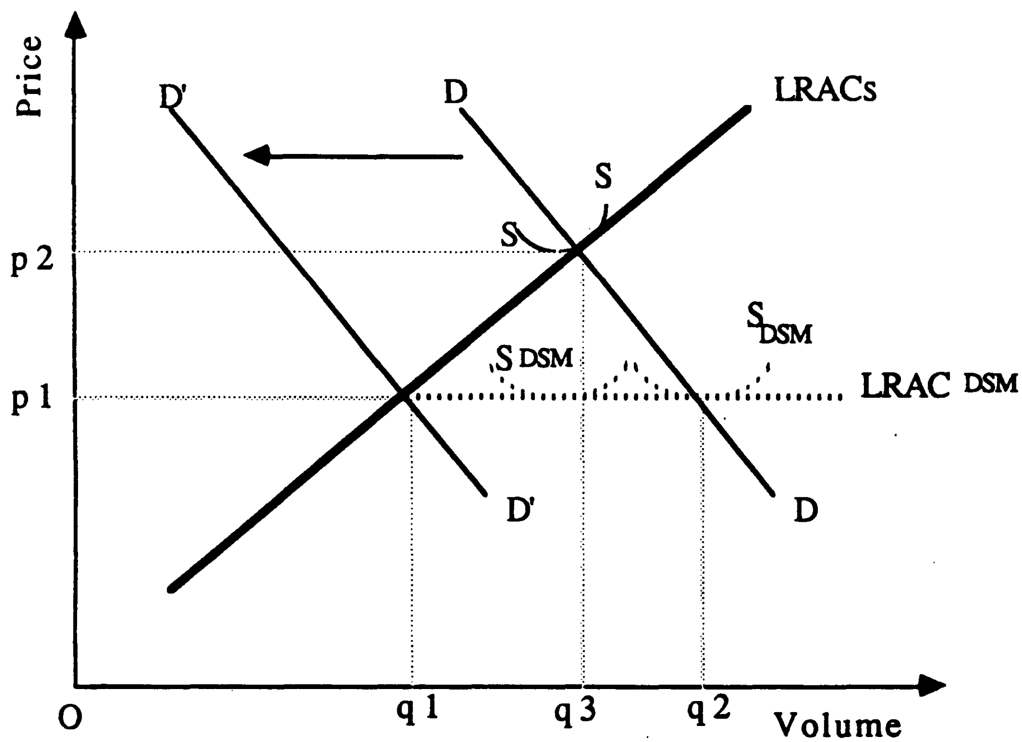

Fig. 3. Equilibrium of DSM

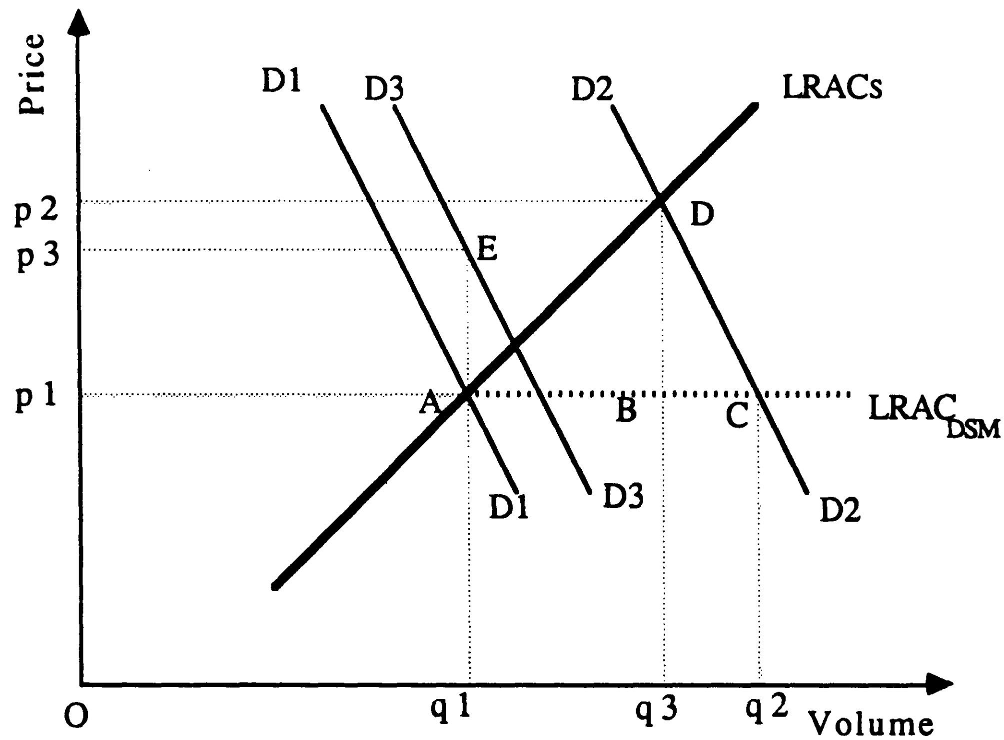

Table 1. Example of DSM Effects

		Current Status	Future Option	
			Supply	DSM
Increment Cost ($)		- -	10.00	8.00
Total Cost ($)		80.00	90.00	88.00
Demand	kwh in Energy Service Concept	1,000	1,100	1,100
	kwh in Physical Term	1,000	1,100	1,000
Price	cents / kwh in Energy Service Concept	8.00	8.18	8.00
	cents / kwh in Physical Term	8.00	8.18	8.80
Mrgnl Cost	cents / kwh in Energy Service Concept	- -	9.00	8.00
	cents / kwh in Physical Term	- -	9.00	∞

Reference

Bates, R., "Commercial Energy Conservation and Public Policy in Developing Countries," draft paper, July 1990

Berman, J. S. and Logan, D. L., "A Comprehensive Cost-Effectiveness Methodology For Integrated Least-Cost Planning," presented at Innovation is Pricing & Planning Conference, Milwaukee, May 1990

California Public Utilities Commission and California Energy Commission, Economic Analysis of Demand-Side Management Programs, Dec., 1987

Cicchetti, C. S. and Hogan, W., "Including Unbundled Demand-side Options in Electric Utility Bidding Program," Public Utilities Fortnightly, June 8, 1990, pp. 9-20

Fisher, A. C. and Rothkopf, M. H. ,"Market Failure and Energy Policy," Energy Policy, August 1989

Hirst, E., "Encouraging Electric-Utility Energy-Efficiency and Load Management Programs," proceedings of Energy and Environment Symposium, held by M.I.T. March 1990, pp. DIV26-42

Haites, E. E, "Environmental Externalities & DSM Cost Effectiveness," proceeding of the meeting of ADSMP meeting, Dec. 1990

Joskow, P.L., "Testimony Before The Subcommittee in Energy and Power House Committee on Energy and Commerce Congress of the United States," M.I.T. Center for the Energy Policy Research, March,1988

Joskow, P.L., "Understanding the "Unbundled" Utility Conservation Bidding Proposal," Public Utilities Fortnightly, January 4, 1990, pp.

Kahn, E., Electric Utility Planning & Regulation, American Council for an Energy Efficient Economy, 1988

Lovins, A., "Saving Gigabuck with Negawatts," Public Utilities Fortnightly, March 21, 1985, pp.19-27

NARUC (National Association of Regulatory Utility Commissioners), Conservation Committee, "LCP DSM Promotion," Press Release, March 1989

NEES (The New England Electric System Company) and The Conservation Law Foundation of New England, Power by Design, September 1989

Reid, M. and Chamberin, J., "Incentive Designed to Accelerate DSM," Strategies, ADSMP, Summer 1990, pp 1-5

Ruff, L. E., "Least-Cost Planning and Demand-Side management: Six Common Fallacies and One Simple Truth," Public Utilities Fortnightly, April 28, 1988, pp.19-26

Sant, R. W., Bakke, D. W., & Naill, R. F., Creating Abundance: America's Least-Cost Energy Strategy, New York, MacGraw Hill Book Company, 1984