THE MOVE TOWARDS MARGINAL COST PRICING IN ELECTRICITY

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It comes as no surprise to observers and participants in the American electricity scene that a lot of things have changed recently. But what is emerging more slowly is the relationship between some of these recent changes and the need to reform the basic manner by which we set the price of electricity. My purpose today is to try to draw together some of the principal factors behind the movement towards rate reform and to discuss some of the facts needed to judge whether the suggestions are useful for a particular utility.

My remarks are organized into three main areas.

- o First, What has changed in American electricity that causes us to reexamine the pricing of electricity?
- o Second, Why is marginal cost pricing considered the most attractive alternative to present rate structures?
- o Third, What do you need to know before deciding to implement marginal cost pricing in a particular utility?

I. WHAT HAS CHANGED?

Generally speaking, the basic form of rate structures used by electrical utilities in the United States were decided in the early part of this century. Almost without exception, electricity is sold in a manner that charges less per unit as the customer consumes more electricity. In the residential and small commercial sectors, this results in the so-call declining block rate tariff (illustrated in Fig. 1) where the charge in cents per kwh declines as the customer moves to higher levels of consumption. For larger commercial and industrial customers, there is usually a declining block rate structure for the total number of kilowatt hours consumed similar in form to Fig. 1. In addition, these larger customers usually pay a so-called demand charge for the maximum <u>rate</u> of electricity consumption observed in a

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LOS ANGELES DEPARTMENT OF WATER AND POWER

Tariff Schedules as of June 1975
(incl. fuel adj. charge)

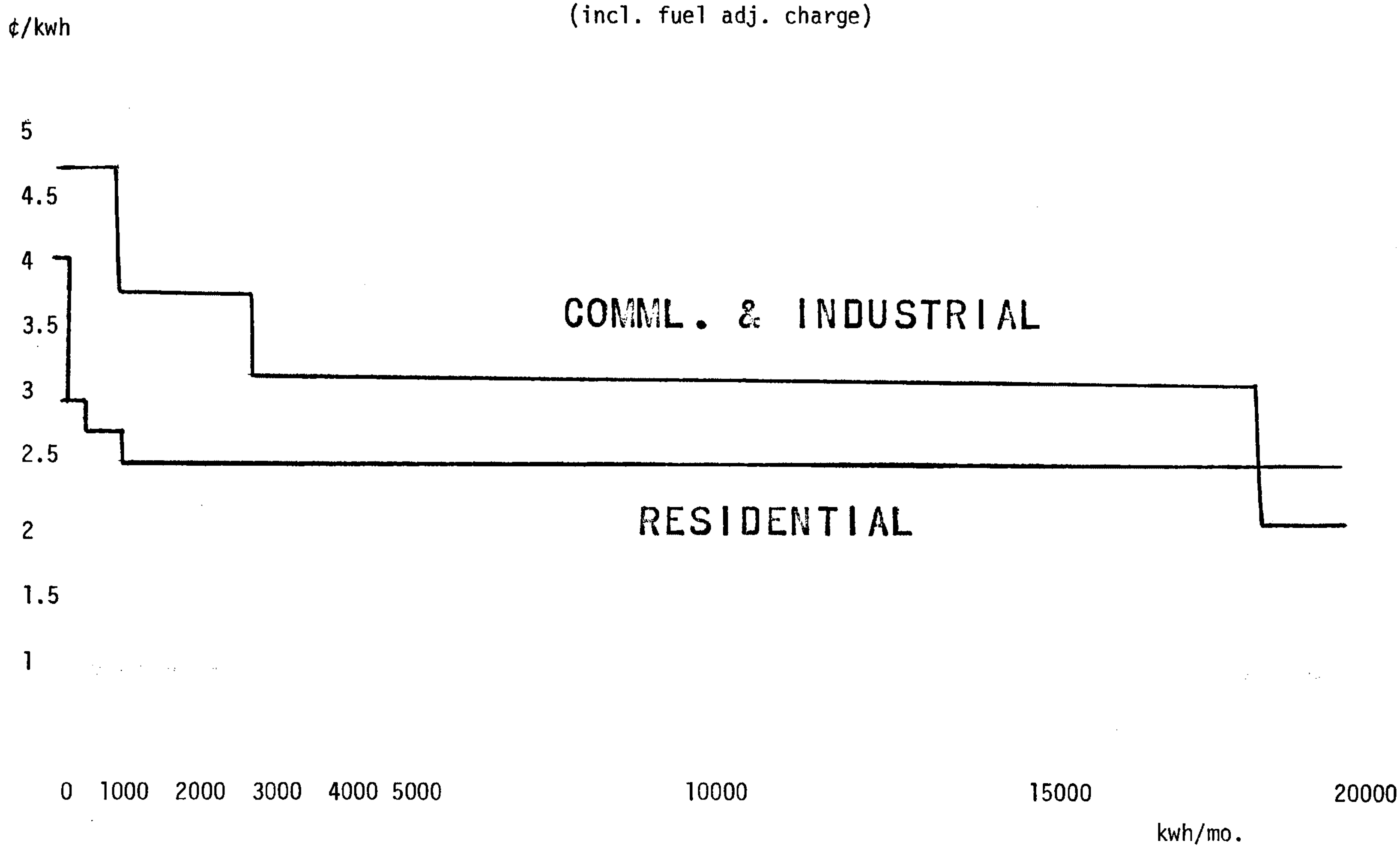

Fig. 1

short period of time (expressed in kw). In general, both types of rates also have a fixed monthly charge that does not depend on the amount of electricity consumed.

In any case, the pricing message reflected to the customer is basically the same: "The more electricity you use, the less it costs you per unit."

A number of factors have changed since this basic pattern of electricity rates was established over 50 years ago. These can be grouped under four principal headings.

- o Changes in level and pattern of electricity use.
- o Reversal in cost factors facing utilities.
- o The practical experience and example of foreign utility systems.
- o Environmental and general conservation concerns.

A. CHANGES IN LEVEL AND PATTERN OF ELECTRICITY USE

First, the amount of electricity consumed has grown dramatically. For instance, in 1926, the average consumption of electricity per household was 407 kwh per year. In 1973 it was almost 8000 kwh per year--a 20-fold increase! Since 1950, the increase was about 4-fold. Similarly, commercial and industrial use per customer grew about 15-fold between 1926 and 1973 and more than tripled between 1950 and 1973.

Second, the mix of appliances and equipment to use electricity has also changed significantly. In the early part of the century, most households had little more than electrical lighting. Some had refrigerators, and a few had electrical heating or water heating. Today, refrigerators are found almost universally, air conditioning, dishwashers, clothes washers and dryers, and a host of small appliances are found in great numbers of households. Similar major shifts are found in commercial and industrial customers where many types of electrical equipment are commonplace, that did not exist 50, and sometimes even 20, years ago. For instance, air conditioning is now almost universal in modern commercial buildings and is used at least 9 months of the year to dissipate the heat buildup from internal lighting--even in cities such as New York, Boston, and Minneapolis.

These changes in electrical equipment served not only to increase dramatically the amount of electricity consumed per customer, but also to change the daily and seasonal pattern of use. Most utilities find the fastest growth in their load curve occurring during the daylight hours leading to a significant proportion of their load shifting from the nighttime to daytime and from winter to summer.

B. REVERSAL IN HISTORIC DECLINES IN LONG RUN PRODUCTION COSTS.

The second major change for the electricity industry from the period in which rates were first designed lies with production technology and costs. For several decades the average cost of producing a kilowatt hour of electricity was decreasing for most utilities. This permitted utilities to make few requests for rate changes--and in many cases the actual level of rates fell. For instance, in LA, from 1927 to 1970, the Department of Water and Power had 14 rate decreases and only two rate increases. In the nation as a whole, the average price of electricity fell from the 1920's until 1950 and remained fairly constant in nominal terms until about 1970. Of course, in real (constant dollar) terms, the price continued to fall even until the early 1970's. With costs in this favorable trend no one worried too much about the exact details of electricity pricing.

This happy state of affairs came to a halt for most utilities somewhere between 1965 and 1970--as they exhausted the advantages of growth in the size of generation and transmission facilities and also started to encounter significant increases in capital and operating expenses. The 1973 Arab Oil Embargo was an abrupt reminder that things had changed, but the message was clear a few years before that we were in for some hard rethinking about electricity rate levels and structures.

In my opinion, the fundamental changes in pattern of electricity use and revised cost picture alone are sufficient to call forth a major reanalysis of electricity pricing. There are, however, two other important factors that contribute to the current interest in rate reform--the example of other utility systems and environmental and general conservation concerns.

C. EXAMPLES FROM FOREIGN UTILITY SYSTEMS.

Historically, most other countries have not found energy as plentiful and cheap as has been the case in the United States. Consequently, they have had to face some time ago the need to examine closely electricity pricing policy. European electric utilities in particular have been active and successful in adopting, devising, and implementing electric rate structures to reflect more accurately the costs of producing and supplying electricity to various customers. For more than four decades the Scandinavians have had inexpensive reliable devices in households to charge for kw as well as kwh consumed. More than two decades ago, the French required time of day pricing for their biggest customers and it is now available on an optional basis for all customers. Over a decade ago the British also introduced time of day tariffs for larger customers and have made them optional for residences since the late 1960's.

The importance of their experience is to demonstrate that a number of means of pricing electricity exist as practical alternatives to declining block rate tariffs. They are not merely theoretical ideas incapable of implementation. These utility systems have addressed successfully a number of theoretical and technical issues, devised the appropriate administrative procedures, and their customers have learned how to make good use of the pricing structures.

D. ENVIRONMENTAL AND GENERAL CONSERVATION CONCERNS.

Finally, as a country we have become aware that the manner in which we produce and consume energy has important implications for the environment and for the future availability of resources. We can not afford to fail to reexamine any pricing or use of energy resources that gives even the appearance of having a promotional aspect.

The concerns--highlighted by these four areas of change--are manifested in a variety of public ways. In a number of states we have seen Public Utility Commissions hold generic rate cases and reexamine some of the fundamental principles by which rates are set. Second, we encounter considerable public interest--both in specific rate cases and in written forms. Third, we are beginning to see specific rate cases being decided by both governing bodies of publically-owned utilities and by Public Utilities Commissions ordering new rate structures for some or all groups of customers.

I think we can safely predict that this is not a brief fad which will pass quickly. Instead we face an altered set of circumstances that force reexamination of electricity rates. Let us move, then, to a brief description of the type of pricing principle that is likely to receive the most discussion--marginal cost pricing--and then discuss some of the kinds of information that would be needed in order to decide if it is a good idea for a particular utility system.

II. WHY MARGINAL COST PRICING?

Economists have long held that marginal costs provide the correct basis for pricing in both regulated industries--such as electricity--and unregulated industries. The argument is not merely one of theoretical appeal or convenience. It is based on fundamental observations about the way prices signal customers whether to consume more or less of a good, the empirical realization that prices do matter, and that correctly set prices lead to the most efficient use of society's scarce resources.

A. PRICES SERVE AS SIGNALS

Prices serve more than one role for a utility. On the one hand, they provide the basis for collecting revenue--certainly an important function. From the point of view of the customer, however, they serve another function which is especially important in a period of reexamination. Prices serve as signals to customers about how much it is worth--in dollars--for him to consume less or more electricity. In the short-run, the customer can vary the intensity with which he consumes electricity and see the changes reflected in his bill. In the longer run, he can adjust his capital investments--his holdings of appliances and energy-using equipment, the type of building he occupies, and so forth--as well as the scheduling and intensity of utilization of electricity. He can compare the purchase and operating cost of, say, gas appliances with the purchase and operating cost of electrical appliances. Thus, customers are induced to adjust their consumption of electricity up or down by the price of electricity relative to the prices of other uses of their money.

The objective of the economist is merely to help assure that electricity rates signal to customers the true social cost of supplying electricity under various conditions of time of day, day of the week, or season of the year.* In advocating marginal cost pricing, it is not the objective of the economist to encourage or discourage the use of electricity or any other form of energy. As long as the prices reflect the true cost to society of providing electricity--including environmental and any other costs if these are not already borne by the utility--the economist is neutral with regard to the amount consumed. Consumption of electricity, in itself, is neither good nor bad and therefore is neither to be encouraged nor discouraged willy nilly.

As a pragmatic rule of thumb, one can start by saying that electricity should never be sold for a price less than it costs to produce it at a given time of the day, of the week, or of the year.

B. AS AN EMPIRICAL FACT, PRICES MATTER

A substantial, and growing, body of empirical studies is demonstrating that the price of electricity has a significant effect of the amount of electricity consumed. That is, it is not merely a theoretical proposition that prices have an important signaling role, there is evidence from both national and regional studies to support the relationship. Although the precise magnitude may be known with varying degrees of precision--depending on factors such as type of customer and geographic location--the evidence of price responsiveness is

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*There are of course other elements of cost which must be taken into account--most notable, the fixed costs associated with keeping the customer on the system and the voltage level at which electricity is supplied.

overwhelming. For instance, studies of residential demand for electricity indicate, in general, that a 10 per cent increase in price will produce something like a 10 per cent reduction in electricity use in the long run. In a recent study we conducted on energy use in Los Angeles County, we concluded that the short-run response to a 10 per cent price rise was probably in the order of a 5 per cent reduction in use.* The evidence for industrial and commercial use is not as systematic, but it appears that these customers may have an even greater responsiveness to price changes.**

These empirical studies are all based on existing American electricity tariffs which do not charge different prices by time of day. Consequently, they do not tell us how responsive customers would be to a change in the price of electricity at different hours of the day or days of the week. However, I think most observers would agree that customers would exhibit a price response in the peak period <u>at least as great</u> if a time element were introduced. That is, if we already see a substantial reaction to price in total electricity consumption, then we can expect an even greater responsiveness if customers have the option of <u>shifting</u> their use to a different time rather than going without electricity.

If we agree that prices are important in signaling to customers the true cost of energy and, furthermore, that as an empirical matter customers respond to the price signals they receive, then the important question for electricity utilities is: How shall we set the prices we charge customers?

C. RATES BASED ON MARGINAL COST PROMOTE EFFICIENT USE OF ENERGY

In their role as signals to consumers, electricity rate structures let the customer know the added cost of increasing his consumption or

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*Acton, J. P., B. M. Mitchell, and R. S. Mowill, "Residential Demand for Electricity in Los Angeles: An Econometric Study of Disaggregated Data," R-1899, The Rand Corporation, forthcoming.

**See Taylor, L. D., "The Demand for Electricity: A Survey," BELL JOURNAL OF ECONOMICS, Vol. 6, No. 1, Spring 1975, and

Taylor, L. D., "The Demand for Energy: A Survey of Price and Income Elasticities", study prepared for the National Academy of Sciences, mimeographed, Univ. of Arizona, April, 1976, for a review of much of this evidence.

conversely his savings if he reduces the consumption by some amount. In order to promote efficiency in the producing and supplying of electricity, the prices facing the consumer must in detail reflect the marginal cost to the utility of producing more or less electricity. In this manner, customers who increase their consumption during time periods that are expensive to the utility will see that cost reflected in their bills. Correspondingly, if the customer reduces his consumption during those expensive time periods he can see his savings to this system reflected in his own bill. This is what we mean by marginal cost pricing--customers should face a rate schedule that charges them the cost of producing additional electricity at the time at which they consume it. If such additional consumption of electricity also causes the system to add generating, transmission, or distribution capacity, then the customer should also pay part of the cost of adding capacity to the system.

The first important observation about a utility's cost structure is that there is substantial variation in cost by time of day, day of week, or season of the year. The cost of supplying an additional kilowatt hour at the time of the daily peak is significantly greater than the cost off-peak. This cost variation is based both on the operating efficiency of the generation plant as well as the cost of adding additional capacity to the system. See Figure 2 for a possible indication of peak and off-peak time periods using LA's system load curve. In order to supply electricity on peak the utility must use its less efficient means of generation. Therefore, the cost both in fuel and in other operating expenses are greater at this time period than at off-peak hours when most efficient plants are used. In addition, customers who wish to consume added kilowatt hours at the time of the system peak cause the utility to build more generating and transmission capacity than it would otherwise need. Customers consuming in the off-peak period on the other hand, generally only impose operating costs on the system and do not cause the system to add additional capacity.

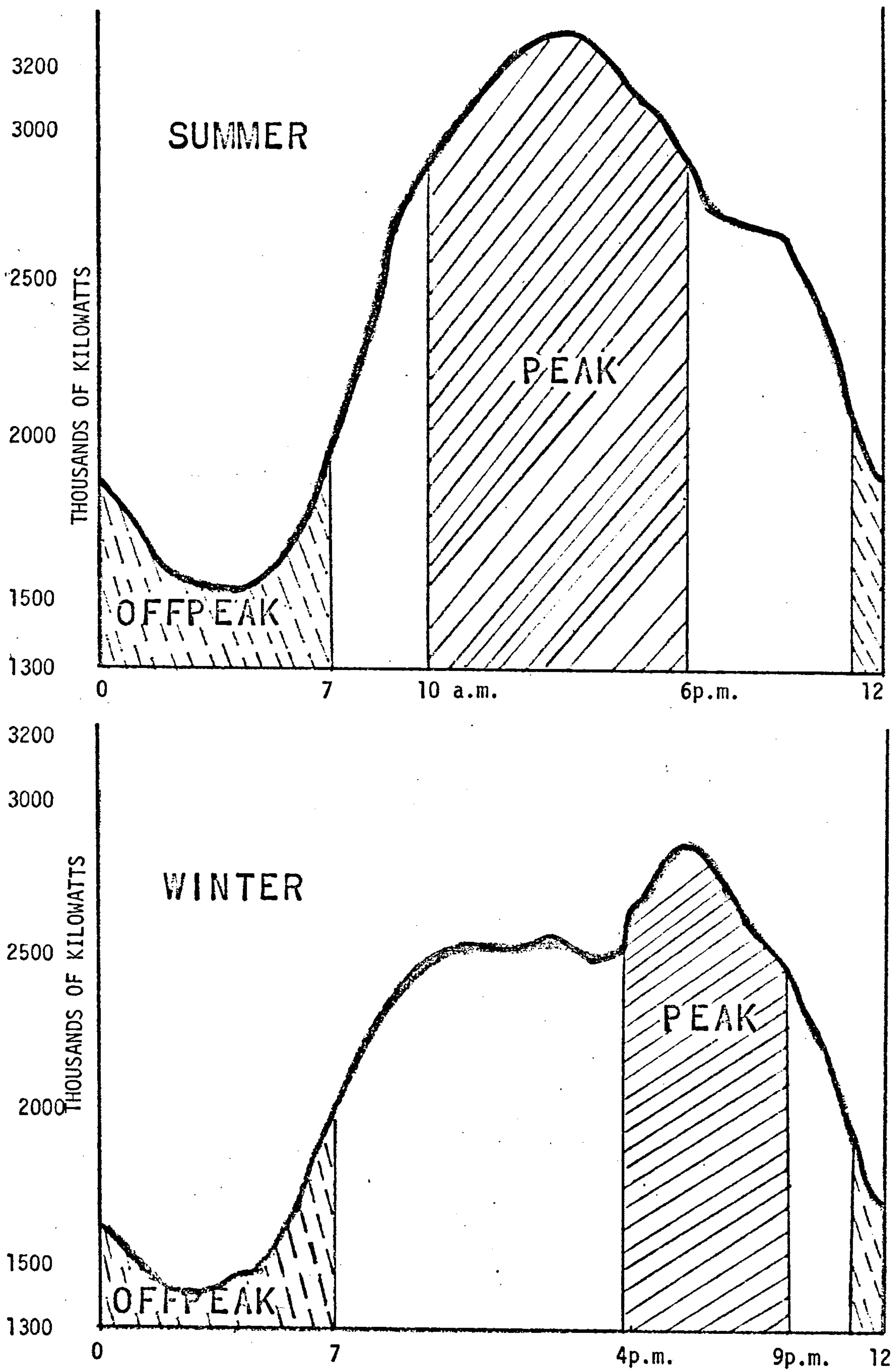
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Fig. 2

If rates are to be based on marginal cost, we will then observe different costs being borne by different customers--depending upon the time at which they consume electricity. Furthermore, the same customers will pay different amounts for electricity depending on the time of actual consumption. Thus, electricity rates based on marginal cost will necessarily charge different amounts when the costs of production vary.

What are the benefits to the utility then of moving to marginal cost price? If we observe customers responding to prices that vary by time of day or day of the week, then we will see a change in the systems load curve. Less consumption will take place on peak and possibly greater consumption will take place on the off-peak period. For instance, some summer use of electricity might be reduced at the time of the system peak as shown in Fig. 3 and perhaps some of it will shift to off-peak periods. This will permit the utility to operate more efficiently by using its most efficient plants at higher rates of production. In addition, movements of consumption away from the peak period will lessen the need for plant expansion to meet a growing system peak. Furthermore, the generation facilities that are built in the future can be more efficient units because they will be used to help meet a more steady rate of demand.

If, on the other hand, there is little shifting in electricity consumption from the peak to off-peak period of time, then there will be less gain in terms of operating efficiency to the utility. Marginal cost pricing will instead result in a better allocation of its cost. That is, only those customers who consume electricity at the time of the system peak will bear higher than average costs. Those customers who consume the majority of their electricity in off-peak periods will enjoy lower than average costs because they impose fewer costs on the electricity system.

In any case, a move towards marginal cost pricing improves efficiency in the sense that no one is paying less for electricity than it costs to supply that electricity. And those who impose the greater cost on the system bear a higher charge.

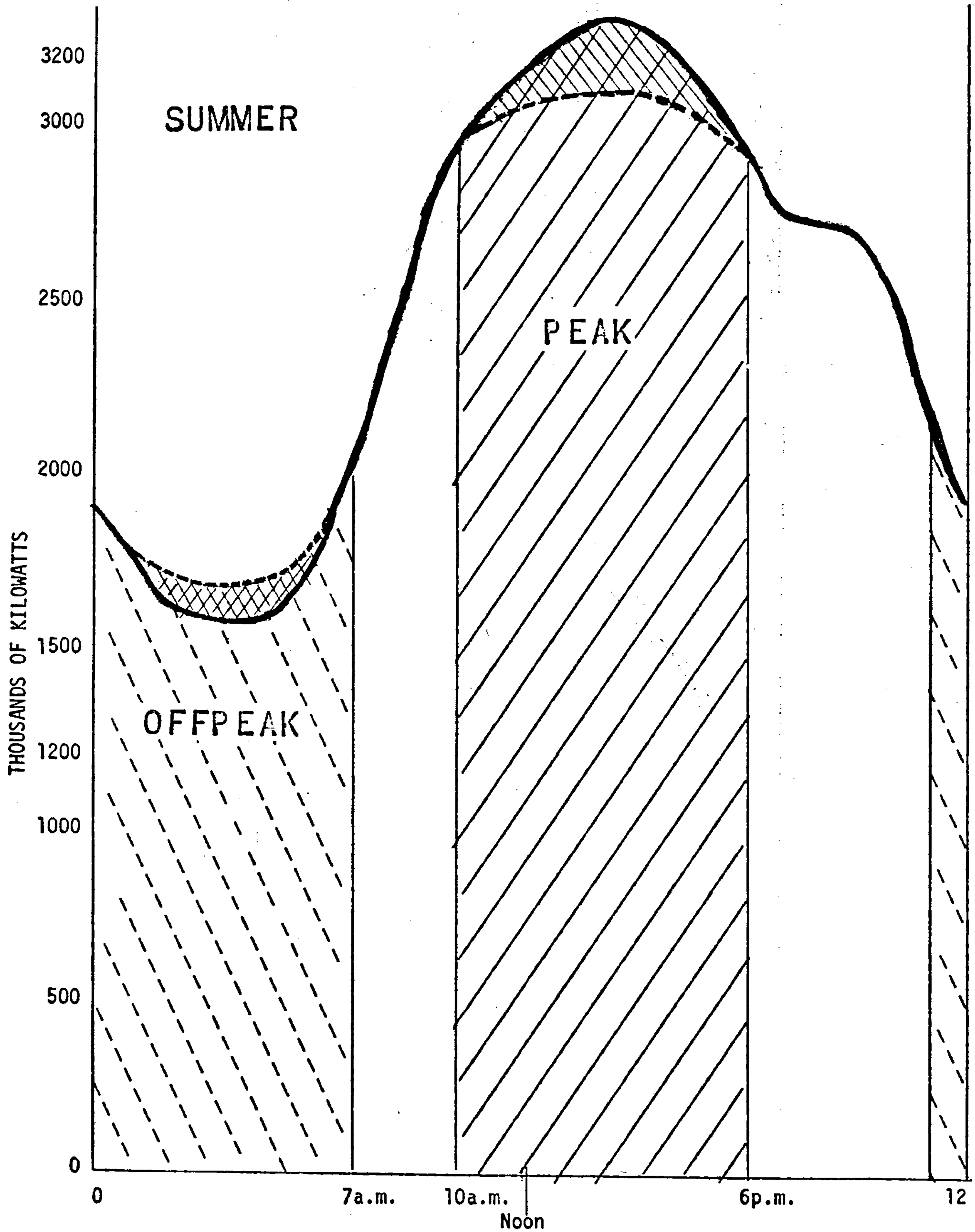

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Fig. 3

III. WHAT DO WE NEED TO KNOW IN ORDER TO JUDGE THE DESIRABILITY OF MARGINAL COST PRICING?

The decision for any particular utility to adopt marginal cost pricing depends on a number of specific facts about that utility system. Basically one must compare the benefits--measured in terms of systems cost savings--with the cost of administering and metering a more complex electricity tariff. If there were no cost of metering and administering the new tariff, then the system as a whole would be no worse off with marginal cost tariffs than with conventional tariffs and in general would find itself in an improved operating position. We know, of course, that no suggested change is cost free. These more complicated rates generally require more sophisticated meters than are currently in place and they require at least the one time administrative cost of converting to a new system. Furthermore--and this may be particularly important to members of governing bodies--some individual customers in fact will find their bills going up while others find their bills going down if we shift to a different method of pricing. This last point grows directly out of the fact that by charging customers the average price of supplying them electricity we are necessarily under-charging those whose cost patterns are more expensive to the system and necessarily over-charging other customers whose consumption occurs substantially off-peak. That is, current rates necessarily involve some customers being subsidized by others. This latter observation is not sufficient to rule out the desirability of marginal cost pricing, it is merely to recognize from the outset that any change from the status-quo will cause some people to feel that they have been hurt while others gain.

The specific facts we need in order to judge whether the benefits to the system as a whole exceeds the cost of metering and administering can be broken into two parts. First, there are the savings on the supply side, measured by marginal cost. Second, there is the degree of price responsiveness that is observed among customers if they face a time of day or other marginal cost-based tariff.

A. THE MARGINAL COSTS OF SUPPLY

The gains and losses of the electricity system are measured by comparing operating and capital costs under their current load curve with the operating and capital costs that would exist with a new load curve. In Fig. 3, it would be the change in costs associated with the original load curve (indicated by the solid line) changing to the dotted line. These changes in costs are marginal, or incremental, costs associated with producing a bit more or a bit less electricity at various points in the system load curve. As a first approximation, marginal costs will be calculated in order to set the trial electricity tariff. Through time, of course, if customers' responsiveness exceeds or falls short of original projects, the system may, in fact, realize greater or less savings in operating and capital costs associated with particular times of the day. This will require some adjustment of the marginal cost tariffs, but type of adjustment would be no different in principle from the adjustments utilities must currently have as the system grows through time.

B. CUSTOMER RESPONSIVENESS TO MARGINAL COST TARIFFS

The degree of customer reaction, measured in kilowatt hours consumed at different time of the day, of the week, or of the year, will determine the amount of change that is actually observed in the system's load curve. That is, the shaded area in Fig. 3. The direct evidence available for measuring the precise magnitude of change is limited by the almost total lack of United States experience with time-differentiated electricity rates. Basically, there are two sources of information available to us to estimate customers response.

First, we can look to European countries for their experience with mandatory or optional time of day rates. In both England and France there now exists considerable experience to suggest that customers can grow to understand the details of time of day rates and in turn to adjust their patterns of consumption in a manner that produces significant operating and capital savings. While most observers of the

American electricity scene find this example useful in indicating the feasibility of time of day rates and the basic qualitative nature of customer response, they are more reluctant to transfer the precise degree of response to the American scene. Responsiveness of American customers could easily be greater or less than their European counterparts due to difference in habits of energy use, types of equipment currently available or in place, or differences in climate and other important factors influencing patterns of demand.

The second major source of information about customers responsiveness lies with direct trials with American customers. A number of utility systems are beginning to experiment with time of day or peak-load pricing--whether under the direction of a Public Utility Commission order or in response to their own desire to gain information about the nature of their customers reactions. Some of these experiments are being partially supported by the Federal Energy Administration or with the encouragement and interest of the National Association of Regulatory Utility Commissioners and the Electricity Power Research Institute. The Los Angeles Department of Water and Power, along with The Rand Corporation, is currently conducting one such trial with its residential customers and I would like to briefly outline that project in order to indicate some of the types of information that may be important to governing bodies as they consider the desirability of new rate structures for their customers.

The Los Angeles residential rate experiment extends to approximately 2,000 households who will pay for electricity under a different rate structure for a 30-month period starting this summer.* This will permit us to observe utilization over a period of 3 summers and 2 winters. The types of rates included in this experiment will be seasonal rates, time of day rates, and time of day rates with weekend exemptions. In order to have the greatest confidence possible that our results will apply for some time in the future, we are deliberately providing some customers with extreme levels of rates either on the high side or the low side to reflect optimistic and pessimistic conditions that may apply

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*An overview of the statistical design and some of the principle objectives of the study is found in *Design Of The Los Angeles Peak-Load Pricing Experiment For Electricity*, R-1955.

in the next 5 years. In all, there are 41 different rates under trial. As an illustration, some seasonal customers are paying 5¢ per kilowatt hour during the summer peak months of June through September and 2¢ kilowatt in the other 8 months of the year. This compares with the current rate of a little over 3¢ for kilowatt on the average to residential customers. The time of day rates experiment with charging people different peak and off-peak rates at different hours of the day and for different amounts of time. For instance, some customers pay a rather extreme amount of 13¢ per kilowatt hour between the hours of 3PM and 6PM and only 2¢ per kilowatt hour for the remaining hours. Other customers may pay 5¢ per kilowatt hour between 6PM and 9PM and 2¢ at all other hours. Still a third group of customers may face a charge of 9¢ per kilowatt hour from 9AM to 9PM and 1¢ at other times.

The reasons for this great variety of experimental plans and rate levels lies both in the need to assure statistically significant results as well as a desire to produce results that will stand up under a variety of individual circumstances. Since such experiments are expensive to conduct and are unlikely to be repeated frequently, we need to gain the maximum possible information consistent with the available budget. First, we feel it is necessary to measure statistical relationships between time of day price levels and the quantity of electricity consumed. This means we cannot merely test one or two rates versus conventional rates, but instead must design a trial that will allow us to infer a statistical demand curve in the economist's sense. By having a valid statistical relationship between price and quantity, we can then synthesize the effect of a number of different specific tariffs that may be appropriate to different individual utility circumstances. For instance, we may not know in advance whether the appropriate time period for peak charges is Noon to 6PM or 3PM to 8PM, therefore we must be able to judge the effects of both length of peak charge as well as time of peak charge.

Similarly, we may not know with certainty at the outset the appropriate peak rate--because of uncertainties about future costs or availability of fuels, availability of certain generating equipment, and so forth. Consequently we must be certain that the rate levels employed during the trial cover the likely range of future peak and off-peak charges.

An added benefit of this more general approach that is being taken by Los Angeles Department of Water and Power is that the results of its experiment will be of greater interest and value to other utility systems. That is, we are not merely testing some rates that are potentially useful to LA, but we are also measuring some more fundamental characteristics of customer response to time of day and seasonal tariffs.

Customer reaction to these experimental rates will be measured through statistical demand curves as well as by a number of other indicators. Some of the important measures of consumer responsiveness include changes in total number of kilowatt hours consumed, changes in consumption during selected time period--say peak and off-peak--and the impact of these electricity rates on the consumption of natural gas and other aspects of energy consumption.

Given the constraints of time, I will hold additional detail about this experiment for the question period or for discussion with individual members of the audience.

CONCLUSION.

In conclusion I think three points should be made. First, the facts facing electricity utility industry have changed dramatically since the early twentieth century when the form of electricity rates was established for most utilities. This means we must urgently reexamine the underlying rationale for rates.

Second, there is overwhelming evidence that the price structure can play an important role in helping meet these revised circumstances. Furthermore, rates based on marginal cost are both theoretically appropriate and have been shown to be administratively feasible where they have been employed.

Third, the important question for a particular U.S. utility is: Will the savings from moving to marginal cost pricing justify the administrative and metering costs in a particular utility system? As a practical matter this usually boils down to a question of how far and how fast should we proceed.

The preliminary conclusions most regulators and utilities have drawn are the following:

- o It is almost certainly worth it to go over to marginal cost or time of day pricing for the largest customers right away. They have meters in place that would permit a more complicated tariff, and electricity is sufficiently important that even minute changes will result in sufficient system savings.
- o Consideration should be given to extending marginal cost rates to intermediate size customers on a mandatory or optional basis. This decision will depend in part on the success observed with the largest customers.
- o The value of extending more complicated rates to the smallest residential and commercial customers is less certain. The best course at the moment seems to be some systematic trials or experimentation with a number of alternative rate forms along the lines of the Department of Water and Power Experiment just discussed.

Finally, I would like to direct your attention to a comment by Richard Cudahy--recently-retired chairman of the Wisconsin Public Service Commission--in which he looked back at his experience in the two years it took to write the pioneering Madison Gas and Electric decision.* Mr. Cudahy regards as the most significant quality of this decision that it took an unequivocal position on the issue of <u>how</u> rates would be set--what should be the underlying principles. "The case stood for marginal-cost pricing; it stood for flattened rates; it stood for peak-load pricing;..." he says.

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*Cudahy, R. D., "Rate Design Today: The Aftermath of <u>Madison Gas</u>," <u>Public Utilities Fortnightly</u>, pp. 15-19, May 20, 1976.

It did not end by saying that some ideas look good in theory, but we cannot implement them fully at this moment and therefore we should continue with a rate base that is admittedly inappropriate.

The crucial importance of a commitment to a clear set of principles is that it lets everyone--utilities, customers, and governing bodies--know which way you are heading. Everyone can plan the transition with an idea of ultimate purpose, and solve some of the detailed matters of implementation as rates evolve over the years. Finally, says Mr. Cudahy, he came away from the Madison Case with the conclusion that not only were the principles correct, "but that the theory could be applied relatively simply."

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Acton