ECONOMIC PRINCIPLES AND THE STRUCTURE OF ELECTRIC RATES:
COST OF SERVICE, ALLOCATION OF COSTS, AND RATE DESIGN

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PREFACE

During June and July 1975, the Board of Commissioners of the Los Angeles Department of Water and Power held a series of special public meetings before its Electric Rate Structure Committee in order to inform itself and the public about both traditional and recently proposed methods of determining the structure of electricity rates. Commissioner Michael Glazer, Chairman of the Committee, invited Rand researchers to participate in the meetings and to present information on the costs of producing electricity and the role of rate structures from the perspective of economics. Our input was chiefly to explain what economists could contribute to the discussion and, in particular, to discuss some of the issues and implications involved in basing rates on the marginal costs of production and distribution of electricity. This paper is an edited version of our presentation and discussion at three of the public meetings.

The hearings focused on one major topic in each of four sessions. This paper presents the testimony and discussion on the topics of Cost of Service (June 5, 1975), Allocation of Costs to Class of Customer (June 19, 1975), and Design and Form of Rates (June 26, 1975). The participation of Jan Acton and Bridger Mitchell in these hearings grew out of their research on the distributional impact of price changes and other policies on the demand for energy. That study, The Distributional Impact of Price Changes and Other Policies on the Demand for Different Energy Types in the Residential Sector, is supported by the National Science Foundation under grant number SIA 74-18987.

Other works prepared for this project include: Selected Econometric Studies of the Demand for Electricity: Review and Discussion, by Bridger M. Mitchell, with the assistance of Jan Paul Acton and Ragnhild Mowill, P-5544.
In addition to Michael Glazer, member of the Board of Commissioners of the Department of Water and Power, and Chairman of this special committee, Commissioner Patricia Nagel participated in all the meetings. Other persons whose comments are included in the transcript are: Lloyd Adams, Engineer of Financial Planning, Department of Water and Power; Mark Braly, now the Mayor's Energy Coordinator; and Harrison Call, Jr., consultant to the Department of Water and Power.
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I. COST OF SERVICE

TESTIMONY

CALL: Dr. Mitchell will now cover the area that involves proposals for changes from the historic concept of cost of service that have been discussed so far.

DR. MITCHELL: Well, I am going to try to bring to you tonight the perspective of the economists and during the course of this talk, you may have occasion to be reminded of that now rather ancient remark by a sister science that economics is the dismal science. Some of the more recent events in the history of this economy may reinforce that view.

Let me encourage people to ask questions of clarification as I go along, since many of the terms may come to you as either new or different usage, but I think the Chairman would like to refer general discussion to later.

We might begin by clarifying the economists penchant for distinguishing prices from costs. In our common-day usage when we ask what something costs, we refer really to a price, the rate at which we can go out and purchase that goods or service. Conceptually these are two quite different ideas and I will remind you of that at several points as we go through.

The economists like to point out that prices really act as signals, as carriers of information from different agents in society--producers who buy input from other firms and from consumers for what they're willing to pay for different goods and services, and they convey particular information about value, what people are willing to pay, what they have spent on resources. And the role of rate structure--one role of rate structure is to give signals both to consumers as to what resources have been used up in the production of electric power, in this case, or natural gas, or whatever the commodity may be, and also to signal to the producer what consumers are willing to pay for those services. And when these signals are worked out, in more or less desirable or optimal ways, then the information that is transmitted is going to be useful both to consumers and the producers and at least under certain conditions, were going to get level of production and methods of production which make highly desirable use of society's resources.
(Contd.)

DR. MITCHELL: The costs then, in the economists view, do, or ought to, provide a measure of what resources are worth, what they can actually do for us as consumers, what can be produced from them. And we can usually find that under competition, where it works vigorously and effectively, what some producers, in moments when they're suffering under it, might call cut-throat competition, but in any case under competition, prices generally get set at or near the level of the costs of the resources that go into production. And you will recall, from recent examples of the type of economic history we have had recently, that these costs change and they may change rather rapidly. Now, the price and the costs which are being equated here are current costs and they're rather distinct from the type that Mr. Call was talking about, the costs we inherit from history over a period of time that a utility has been in operation or a firm has been producing. They're the cost that would be incurred today in producing that goods and service.

The best example I can think of is the supermarket inventory which, when you go to the store, you occasionally find these days that the label has been marked up even while the goods has been sitting there on the shelf. And this indicates that prices reflecting the current cost of putting that goods out for sale, the cost may have actually changed in the matter of days or weeks under very high rates of inflation. These are not historical costs then, they are not necessarily the costs that were incurred at the time that can of soup was run through the plant but the cost of today replacing that particular can of soup.

Well, an issue I think will be addressed throughout these meetings then is how and to what extent it is desirable that prices of electricity be set to reflect the actual cost of producing electricity. And its the case that under monopoly, which a regulating utility certainly is, prices need not be equal to costs. They may be greater than cost for some services, less than cost for other services. They need not reflect the current cost of producing power but may only reflect the past costs. In trends up or down they have an important bearing on that. The one regulatory job for a public board, or for a public utility commission in regulating price of private utilities is to determine what its policy will be with regard to what extent prices and costs should be brought into equality or if they are to deviate, on what basis they should deviate.

Okay, let me just recall for you the classic problem as seen by the economists or certainly one of the fundamental problems is how to make best use of resources we have. There are two ways to state this problem, they're really the same, we can try to get the most output for a given expenditure or given resources or whatever resources we may have. Or we can turn the problem around and we can say we have a target we want to produce a given amount of electricity, or loaves of bread or whatever it may be, we want to do that at minimum cost. This is the problem of economizing or optimizing or being efficient, and that's what we pay managers of utilities for and that's what we reward managers of any firm for, solving the problem as best can be done.
(Contd.)

DR. MITCHELL: There's a second-level problem, it's a more general problem, really, for society and that's to determine how much of the output of one good is to be produced as compared with how much of some other good. And here some more careful thinking leads to the conclusion that we want to increase output of one good until its value--its value of the last unit, if you will, is just equal to the value of the resources you have to use to produce that unit. And we'll come back to this again, but it's really a comparison if you added a little more output of electricity you're going to have to use up more resources. What are those resources worth to you or to society in general, and are they worth as much as the last unit of electricity. If they are, fine, one ought to produce more and one ought have to keep producing more until those two valuations are brought together. If, on the other hand, that last unit of electricity is worth less than what you could do with that labor, and capital and other resources, it would be better to divert those resources into some other type of production and cut back. And here you can begin to see how prices may signal how much is going in fact get produced by the firm and what consumers on the other hand really are willing to pay for it, what value they assign to the output.

Now, we sometimes use another name for these costs just to emphasize this comparison and that's the term "opportunity cost". Economists have to remind you again and again, a part of this dismal business, that there is no free lunch. At any moment in time we have a limited financed quantity of resources to manpower, capital, hydroelectric resources, fuel and so forth and they can be used in zillions of ways but there is a limit on what can be done. And to have more of one good necessarily means giving up something someplace else in the economy to the extent that we have been efficient in our initial use of our resources. Of course if they are slack, it's always desirable to get rid of it to squeeze out as much output as possible. But when you've done that, you then have the problem of choosing more of one good being less than others. And the cost measure that comes out of this is then to ask what opportunities are you giving up in order to have more electricity. What resources, what good could you have produced, if you had not produced more electricity. And as a simple, and I think not numerically carefully accurate example, but I suggest that perhaps a hundred kilowatt hours might require giving up four loaves of bread in exchange, something of that order of magnitude. We use all society's resources as best we can, at the end we have to decide between more bread and more electricity, or more guns and more butter, we can't have more of both. We convert the value of bread output into dollars by using the prices of bread, you might say that hopefully two dollars worth of bread, as exchanging for this additional amount of electricity.

Now another way to put opportunity costs, really the same idea emphasized in a slightly different fashion, is to measure the increment of output, increase output a little bit and find out what you have to give up. So that opportunity costs then is the value of additional resources that are needed to add some small amount of additional output. And we can ask our managers to calculate this at least in principal. We hope
DR. MITCHELL: \(\text{they have done a good job of minimizing the costs at the current level of production, and they can tell us what that is. We then turn to them and say now suppose instead we ask for another hundred kilowatt-hours of electricity, go back to the drawing board, redesign your system, and tell us what the additional costs would be. How much bread do I have to give up to get that additional output? Or rather, how much labor and capital and so forth do I have to give up; if I value those inputs at the prices at which I can buy them how much bread would that buy. Okay, the difference between those two calculations then will be what we call the marginal costs, extra costs of extra output.}\)

And now we come back to the roll of prices. If we set the price of electricity equal to that cost per kilowatt-hour then we will have signaled to the purchasers of electricity the resources that get used to produce the additional amount of output. And this will--it turns out, is not certainly obvious the first time you see it, that this will solve the problems of the firm as to how to produce the output at a minimum cost, or to produce the most output at a given cost; it's an economizing problem. It also solves society's problem of choosing between electricity and bread, guns and butter because prices now convey the information as to how much resources are used up in producing the goods at which price they represent. When consumers face 50 cents a loaf of bread versus 2 cents a kilowatt-hour of electricity and is able to balance how much of each she wants. And those balances are done then on what the input actually will be able to produce if shifted from one area of production to another. I am sure it is clear to you that this is certainly somewhat of a conceptual exercise, it is certainly one that cannot be done overnight (you can't turn guns into butter or bread into electricity just by a flick of a switch); but if we think of alternative levels of electricity consumption, or gourmet standards of dining, whatever, we can imagine choosing as a society having more electricity and less consumption of other goods. And these measures will tell us what we have to give up and in what quantities we have to give them up in order to have more of one at the cost of something else. In essence they are so called long-run calculations.

Now, Mr. Call has already indicated three rather different types of costs that occur in this particular type of good, production of electricity. And, I just want to go back over them and indicate which ones do vary with the level of consumption which we can neglect in terms of marginal costs, increments to costs. Customer-related costs for a given number of customers, are really independent of the amount of electricity taken, they're the costs of the meter, the lines that run to the house, transformers, the billing that is required, all of these things are given whether or not the consumers consume electricity or whether he consumes more this month than last month. So, they are not properly marginal costs, but we might call them fixed costs or customer-related costs. They would now come in the calculation of adding additional expenditure that would be required to increase electricity. The running costs clearly do vary, and they vary directly with the amount of electricity produced. There can be some differences even there, according to the time of day or the season, and certainly different as among utilities as to what those costs may be,
(Contd.)

DR. MITCHELL: but they will definitely be marginal costs.

Now capacity costs would come in two forms. If we are talking about times at which the system is not straining its capacity--there are additional generating units available for additional power--then an increase in kilowatt-hours requires an increase in its output--will require no additional plant expenditures or no additional construction be undertaken. And so there is no opportunity that is foregone by adding kilowatt-hours--let's say in the middle of the night. The plant stands ready to serve, it can produce additional output, and we really don't incur any additional costs. There may be some additional maintenance and so forth, but the plant itself stands there with idle capacity.

At the peak hours when capacity is being pushed to its maximum, we have the opposite situation. And there there is an opportunity cost if we're going to have additional production, higher levels of output then we have to give up resources from society someplace else in order to add to generating capacity and make this additional power actually available to consumers.

AUDIENCE: What about costs that aren't readily accounted for in terms of dollars?

DR. MITCHELL: What type of cost do you have in mind?

AUDIENCE: The environmental wealth, say value (unintelligible)—for instance.

DR. MITCHELL: Well, let's take it—would smoke pollution be an example?

AUDIENCE: Yes

DR. MITCHELL: Yes. Okay. There may be, in this case, output of the production process, byproducts of generation, which don't get sold or for which the utility does not pay, but putting smoke into the air. In that case they would be costs and it would be associated directly with running costs. So they would add to the marginal cost of a kilowatt hour. From the economists point of view, the problem there is that there is no one around buying that output—or if you put it the other way, there is no one charging utility for creating that product. You can think of it as a negative cost.

AUDIENCE: You keep talking about costs, and you haven't included what is profit. Profit is one of the main escalating costs to the consumer, and it doesn't make any difference. Now you're talking about some kind of a vague little monster by the name of cost. Now when everybody adds their profit to every particular item, every particular resource, or every particular service, that is not a true cost, that is cost plus profit, cost plus profit, cost plus profit all the way up the line until it gets
(Contd.)

AUDIENCE: to the consumer. And you seem to be painting the picture that the consumer has a choice; he can either turn off the electricity and eat bread--

GLAZER: Do you have a question? I mean if you would like to make some statements, why don't we let him finish and at the end we'll have public input, if you don't mind.

AUDIENCE: Well, I would like to find cost on the bare cost, not adding all the costs up the escalating line with the profit.
What is the cost of material taken from the ground before it is converted into use? How many profit margins--how many profit percentages are tacked on to the original cost?

NAGLE: Mr. Mulman, I think that is a point that we should consider, but I think perhaps it would be best to let Dr. Mitchell finish his presentation and have the presentations finished and then go into these other thoughts.

GLAZER: Let me ask you one question. If you think you can respond quickly to that because that's--

DR. MITCHELL: Let me try to make a short response and reserve a more detailed discussion perhaps for later. All the costs I am talking about include the opportunity that we give up of producing something else. Now, to the extent of those production opportunities also require capital investment, and returns are required by individuals to make savings available, then there will be profits, or returns to capital, however you wish to measure these, also included in these costs. This is a fairly deep subject and I don't want to indicate that there is a simple answer necessarily; but returns to capital, profits, interests dividends are necessarily included here as they are in any type of production in economy, whether it be bread, guns, butter or electricity.

GLAZER: So that for the purposes of your discussion, you're including as costs some factor for profit.

DR. MITCHELL: Yes, I am.

GLAZER: Thank you.

AUDIENCE: (Unintelligible) Before, you mentioned the can of peas as current price. Is marginal cost taken in concept of charging for today's can of peas, what it's going to cost 5 years from now?

GLAZER: Perhaps, for the record why don't you repeat that because we can't pick that up on the transcript.
DR. MITCHELL: If I got the question, it referred to the supermarket example of the chart for a can of peas or whatever, and the question was whether the price today reflects the cost five years in the future, is that correct?

AUDIENCE: Well, I know the price today reflects today's cost, but when you talk about marginal costs and costs to society, do you want a price for electricity or a can of peas, and what it's going to cost five years from now or what it costs today?

DR. MITCHELL: Let me separate the question. The price in which a can of peas will sell today is close to what it would cost (unintelligible) a can of peas today, and its competition in the pea canning market which guarantees that result. If it could be produced at significantly less, the firm will step in and make a profit by doing so. Now whether one wants the price to do that, or to reflect alternatively some future cost, is a question really for social judgment and economists have particular views on that subject, and what they would like to point out is that prices that reflect current costs are useful because they help consumers choose as to which goods uses up more resources than its current production and how much resources go into peas and how much go into electricity. But if you are the czar of the electricity board or the central planner of an economy which doesn't rely on competitive markets, you can set prices to be whatever you want. There'll be consequences of setting prices that depart from marginal costs, and my purpose only was to illustrate that the extent we have competitively produced goods, competitively supplied input, such as labor and capital, their prices will tend to reflect rather closely the cost of resources of the value of the resources that goes into their production. We don't have--you're not guaranteed that's the result under a monopoly because there is the problem of setting prices. There's no market that pushes you to that result. But if we can set prices at that level, we will accomplish the signalling or indicator functions as to what the alternative use of those resources would be able to do for us.

GLAZER: Why don't you proceed with the rest, then we'll get back to questions afterwards, if that's all right?

DR. MITCHELL: But, my last comments here really are very brief. There have been some recent proposals in this industry and other regulated industries that go under the general heading of long-run incremental costs. And, they are in some peoples' minds an attempt to approximate, or provide a practical way of calculating marginal costs. But there are some significant differences from the concept of marginal or opportunity costs, as I indicated a moment ago, in this particular proposal of long-run incremental costs.

The way people propose to calculate this LRIC is to look at the planned growth of the utility over the next five or ten years and ask what the average cost is of additional output, the average cost of additional kilowatt hour, given the expansion plans that the utility has programmed. And that will, of course, vary from one utility to another according to its particular investment plan, it will also vary according to what's
(Contd.)

DR. MITCHELL: expected to happen over this time period in terms of improvements in technology, changes in fuel prices and capital costs and other types of input, and perhaps increasing requirements for environmental standards. But this is a future-looking cost and it is one which is in effect anticipated by the utility. It does not provide a kind of measure we were talking about earlier, which is to say, what would happen today if instead of current levels of output, we asked for another one percent or another hundred megawatts, whatever the unit is, how much more would it cost today in today's cost with today's technology to have a higher level of output? Well, you can turn the question around, you say how much would it cost--how much would we save by reducing consumption by some increment? So this really is not the economist's view of what a marginal cost is, it is an instructive number, it tells us what we can expect in the way of additional expenditure per kilowatt-hour as the system grows. But it doesn't indicate the resources we now give up by adding to consumption for the resources we save by curtailing consumption. And it's that concept which is the true marginal cost.

Okay, I think that's where I would like to stop.

AUDIENCE: May I ask a question?

GLAZER: Yes, go ahead.

AUDIENCE: How do you differentiate between opportunity costs and capacity cost (unintelligible)?

DR. MITCHELL: Well, an opportunity cost occurs anytime we have to use up resources from some other output, producing some other good, in order to get more electricity. Let's stick to that example. If we are talking about the capacity of the capital expenditures of the utility, we have some idle capacity at the time we want more output, then we don't have to give up anything. There's no opportunity cost in the middle of the night of adding some electricity demand. We will add some fuel costs, and those are resources taken away from something else, but we don't add any capacity costs.

AUDIENCE: It is true then that opportunity costs follows after capacity costs? You know, after you use the full capacity then (unintelligible).

DR. MITCHELL: That's right. When you are asking for all the output that your capacity can produce, you then have an opportunity cost of either building more plants or cutting back some functions.

GLAZER: Thank you Mr. Mitchell.
PRICE VS. COST

EVERYDAY USAGE

PRICES ARE SIGNALS

COST: MEASURES VALUE OF RESOURCES USED

UNDER COMPETITION: PRICE = COST

RATE STRUCTURE ISSUE: HOW TO SET PRICES = COSTS

Figure 1
THE ECONOMIC PROBLEM

Optimize the use of resources

Maximize output for a given cost

or

Minimize cost for a given output

Optimize the level of resources

Adjust quantity produced until value of output

= value of alternative use of resources

Figure 2
OPPORTUNITY COSTS

LIMITED RESOURCES
To entire economy
To a firm

To produce more electricity
Reduce resources for other uses
Forego output they would produce

Opportunity Cost
Value of resources in best alternative use
E.g.: 100 kWh costs 4 loaves of bread

Evaluate using prices of resources
E.g.: $2.00 worth of bread

Figure 3
MARGINAL COST

DEFINITION:

THE OPPORTUNITY COST OF A SMALL INCREASE IN OUTPUT
= THE VALUE OF EXTRA RESOURCES REQUIRED TO EXPAND OUTPUT
= THE AMOUNT OF OTHER OUTPUTS THAT MUST BE FOREGONE

CALCULATION:

FIND MINIMUM COST OF CURRENT PRODUCTION
RECALCULATE ASSUMING INCREASED CURRENT OUTPUT
   (LONG RUN VS. SHORT RUN)
THE DIFFERENCE IS MARGINAL COST

WHEN PRICE = MARGINAL COST, OPTIMUM SOLUTION RESULTS

FOR THE FIRM: ADJUST OUTPUT UNTIL PRICE = MARGINAL COST
FOR SOCIETY: PRICE OF EXTRA CONSUMPTION = COST OF EXTRA RESOURCES
              CONSUMERS PURCHASE OUTPUT UNTIL ITS VALUE TO THEM = VALUE OF THE OUTPUTS FOREGONE

Figure 4
LONG RUN INCREMENTAL COST

CALCULATED FOR FUTURE GROWTH IN OUTPUT

AVERAGE UNIT COST OF PLANNED INCREMENT IN CAPACITY

INCLUDES EXPECTED CHANGES IN

TECHNOLOGY

FACTOR PRICES

ENVIRONMENTAL STANDARDS

DOES NOT MEASURE OPPORTUNITY COST OF INCREASED CURRENT OUTPUT

Figure 5
Types of Electricity Costs

Customer-Related Costs

Independent of usage

Not marginal costs

Running Costs

Vary directly with output (J4H)

Can differ by season, time of day

Capacity Costs

Off-peak: Independent of output

Peak: Opportunity cost of expanding capacity

Figure 6
RECENT COST TRENDS

RISING FACTOR PRICES

GENERAL INFLATION

RELATIVE PRICE INCREASES

FUEL

COST OF CAPITAL

CONSTRUCTION

TECHNOLOGICAL CHANGE

THERMAL GENERATION

POSTWAR IMPROVEMENTS

NUCLEAR GENERATION

ENVIRONMENTAL AND SAFETY REQUIREMENTS

ECONOMIES OF SCALE

Figure 7
DISCUSSION

GLAZER: Okay. So, what you're telling me is that, if I can try and rephrase it again, is that the economists have come up with a definition of costs which they think would provide a better system in terms of resource allocation than either the average costs that we now use or the historical costs that others may use or the mixture that may be used in utilities, but how to apply that, is it still unclear?

CALL: How to apply it and get the utility the amount of revenue they need, that is, enough revenue to pay the bills, so to speak, and not too much revenue in the--to the extent that they have money left over which they've taken from their customers and they don't need.

GLAZER: But I gather the basic gut impetus behind this is the fact that the costs are going up as you look out into the future, and that the argument is that if you don't use the long-run cost, if you don't look at what is going to cost you to build that next plant 15 years out and don't charge a customer today a higher price because he's going to make you build that plant, that somehow you're misusing the concept, or am I mixing up apples, oranges and all kinds of things here?

CALL: You're not mixing it up first. It was mixed up before. The 15 years--

GLAZER: Let me ask a very simple question. Why all the fuss about this?

CALL: Let me back off and ask Bridger to answer that question.

DR. MITCHELL: Well, that's dangerous since I contributed a few of those 3/4 of a million words in Case 9804. I don't think the operational distinction or the important distinction is the time, that is, future, present or past. All that affects the outcome. To illustrate that, let's suppose for a moment, that prices were expected to remain stable over the next fifty years. Fuel costs, inflation and so forth, were all going to be the same. We would still face the question of what a desirable charge for additional electricity is today. And the answer to that question would depend on whether we're basing our results on historical allocations of cost or what it would cost to expand the system that we now have.
GLAZER: In your example, they wouldn't be any different at all.

DR. MITCHELL: Well, it would because the treatment of capacity costs versus running costs varies according to these calculations, and a marginal cost approach or an incremental cost approach looks at the cost of additional usage at different times of day very differently than does traditional embedded or historical costs. The implications really are for the structure of rates much more than they are for the level of rates. That's what I wanted to emphasize here.

... 

GLAZER: So what you're telling me is that a number of utility commissions have decided that there may be an economically more accurate way to determine what costs it is you're trying to recover, but they haven't yet exactly figured out how to turn the academics into reality. Is that too harsh?

CALL: I'm going to answer that question yes, and I'll let Bridger disagree if he wants to.

GLAZER: I'm just trying to understand; I didn't mean that as a loaded question.

DR. MITCHELL: No. That's right. American utilities are just beginning to approach this problem, and its practical aspects. There is some experience in Europe with this type of pricing that's existed since the end of the Second World War. But this is new material and I think it's fair to say we have not developed methods certainly down to a workbook level.

GLAZER: It is theoretically possible by, though, using a long-run cost you may--and deciding these are the costs you want to recover that you may in fact be producing revenues which are more than you would have produced by using the more traditional concepts.

DR. MITCHELL: Or possibly less. It would depend on the circumstances.

GLAZER: Or possibly less. But I gather there's been some concern about simply recognizing that there are these costs that you want to recover but nonetheless those figures being high enough that you somehow be generating more revenues than you would otherwise--
CALL: Or less depending on the situation and the results will differ between utilities depending exactly on what their generation expansion path looks like, which is a problem that's being addressed. When a cost-of-service study is done today, you go down to the Accounting Department and get the books and you look in the books and find the numbers. To get into these long-run incremental costs, we're involved in running computer simulations of system operation out into the 1980s and equally complicated other techniques.

As far as this utility is concerned, those studies are going on, because there are certainly alternatives that have to be considered.

GLAZER: And my understanding is that you're going to attempt to make a cut at what those would look like some time in the reasonably near future, so that we can compare in some real numbers the differences.

ADAMS: I think for most utilities the costs are increasing into the future so that in most cases, although it does not necessarily hold for the Department, long-run incremental costs will produce more revenue than you need. Now herein lies one of the problems of implementation. We have, as you know, quite a time getting the revenue we need down to the dollar and we ask for more--

GLAZER: On an economic theory?

ADAMS: --even though we intend to refund it, we have an uphill battle.

GLAZER: That may be one of the difficult lines between the economists and dealing in a more political atmosphere.

DR. MITCHELL: One interesting observation that might be made. While generally it is now assumed that long-run incremental costs will be higher than our current costs or historical costs, interesting to note in the case of this utility, that it might quite possibly be just the opposite because we have our current costs or cost loads that are involved in the low-fire generation and we're looking now to new generation that will be--which will be able to produce energy at a lesser cost than either a nuclear plant or a coal-fired plant. It's quite possible that the long-run incremental costs of this utility may actually be lower than are those of other utilities.

GLAZER: Are you suggesting that if we move to a long-run incremental costs system our rates might go down?

DR. MITCHELL: No. I didn't say that. I'm just making an observation.
CALL: But if you followed—that points up the problem in the other direction, if you followed, without solving the problem, that exists in long-run incremental cost pricing, you could not have enough revenue to pay the bills, so to speak, if you pursued that. I might add with regard to the studies that this utility is doing, the Department's doing, I think it's fairly generally recognized that Dr. Ralph Turvey is probably as experienced and knowledgeable in this area as anybody and he is assisting in developing these studies, so the utility's serious about developing them.

GLAZER: It would be invaluable to see some numerical examples whenever we can see it.

CALL: I would hope within the next month or six weeks they'll be available.

KRALWASSER: Yes, my name is Harold Kralwasser. I just had a question I think probably goes to Dr. Mitchell. When you talk about long-run incremental cost, we haven't really gotten into the around to stating sort of the theoretical underpinnings for them. I guess I was sitting here trying to understand whether—or the reasons to go to the long-run incremental cost system. Specifically, I was wondering whether the impetus behind long-run incremental cost pricing is that we've now decided that there is increasing scarcity and the historical cost did not tend to try to incorporate the concept of increasing scarcity of various goods, services and materials used and, too, there are variable rates of increasing scarcity, which again would not necessarily be reflected in the use of a historical-cost concept.

I guess what I'm saying is part of premise for long-run incremental cost pricing, a recognition on the part of certain economists, or its proponents anyway, that what they are trying to do is anticipate the increasing scarcities and the variable rates of increasing scarcities and in some way make the consumers' choice in terms of his opportunity costs, anticipate those increasing scarcities and the variable rates of the increasing scarcities today so that effectively you avoid putting pressure on those things which will have the highest and fastest rate of an increasing scarcity some time in the future. Is that the purpose of this or have I restated something which is not related to the purpose of the concept?
DR. MITCHELL: No, I think the question's very well stated. Part of it, however, goes to the motivation of some people who have proposed this particular form of cost measurement, or cost-allocation. Now, this is a personal judgment, but I think from reading some of the literature of the groups who have espoused this position that's a fair reading, that they do want to reflect increasing scarcity and are looking for a method using a price system that will approximate that. I don't believe you'll get a very wide consensus among economists that that's a desirable thing to do. We don't, for example, price gasoline at $5 a gallon because of some time in the future it will become so increasingly scarce that that's the price at which you'd have to produce it. But we don't argue that that ought to be the price today. The motivation for pricing resources, or pricing goods, at the cost of actually producing them in the current situation is precisely to reflect the kind of exchanges and tradeoffs that the consumer has to face day after day. Should he buy a big car and consume a lot of gasoline or should he economize and buy something else? Should he buy a refrigerator which is well insulated and conserves electricity or should he spend that extra income on some alternative commodity? Or should he buy a gas stove? Should he use some other form of energy?

(Contd.)

DR. MITCHELL: The marginal cost proposal or approach, and I distinguish that from the long-run incremental cost, would attempt to base that as nearly as possible on what resources are required to produce the additional energy or the additional insulation or whatever the commodity is in current terms. Note that even if there were no increasing scarcity, this proposal would be just as valid. You would still want to make choices among different goods, based on the resources you have to give up.

KRALWASSER: Although, correct me if I'm wrong, but if there were no increasing scarcities of any sort, the average historical cost, at least in dollar terms in the year in which it was incurred, should probably approximate the future cost in the same real dollars. I mean--What I'm trying to say is, if we want to adopt a system, is the primary motivation for adopting the system, or is the primary benefit that we hope to generate out of adopting the system, the idea that we are going to be able to factor into our pricing system some anticipation of scarcities which you don't get by using a historical base, which among other things also does not assume one way or the other increasing scarcities or increasing abundance of a given item, but only takes it as a slice on the day that the opportunity cost choice has to be made. I guess what I'm saying is that if you go to the system, it's the whole purpose of the exercise to try to substitute for your old assumption of looking at things only on the day you make your choice and try to anticipate either an abundance or scarcity downstream by imposing a cost today, effectively forcing people to plan on the basis of cash flow where they would only plan now on the basis of some kind of long-run downstream cost, which you don't get many consumers to do. Is that what we're really talking about? I'm just trying to understand it. If you go through the exercise, is that the output that you're looking at the end of the tunnel?
GLAZER: I guess what he's suggested--That's basically what you said the first time and what he suggested is some people would say "yes" and some people would say "no" and that depends on their motivations.

DR. MITCHELL: Well, let me answer the earlier question there. Even if we did not anticipate any increase in fuel costs or construction budgets or any increase in capital cost over the next 50 years, the future would like it has in the past. There could still be improvements in technology, we could have break-throughs in reactors that would lower costs, we could have increases in environmental costs, rates, cost of electricity. History is not necessarily a good guide to the cost of additional consumption today.

KRALWASSER: That's right, and I don't mean to--

DR. MITCHELL: And even without trying to anticipate trends in the future, basing prices on additional or reduced output, in today's terms, is a better reflection in the use of those resources than their historical cost.

CRAVEN: My name is Howard Craven. I have a question for clarification on the difference between marginal cost and the long-run incremental cost. Put behind us all the historical cost, because this Department of Water and Power isn't using that. Suppose that we were pricing--that this utility were pricing its product exactly equal to current marginal costs reflecting current opportunity costs, what would be the case for long-run incremental costs? And then we pose another question which sort of leads to the--it's the same question in another way. Suppose that long-run incremental costs would be higher than current marginal costs, and we were priced today at current marginal costs, why shouldn't the people who are using the electricity services today pay the marginal costs for today, and if and when we ever reach that point where capacity is strained and we have to expand capacity, then why shouldn't the people who then use electricity pay for those additional costs?

GLAZER: Dr. Mitchell? Mr. Call? Straining at the bit there, go ahead Mr. Call.

CALL: No, no, you want me to?

DR. MITCHELL: Why don't you start.
CALL: I think the gentleman's question is whether it deals with short-run marginal cost pricing. You agree, Bridger? Okay.

A problem inherent in declining cost industries and the utility, in the short run, today at least, is a declining cost industry, I submit; that is, as output increases, given fixed plant cost on the average decline. There would be a question as to whether pricing at a short-run marginal cost would provide sufficient revenues, and I'll let Bridger expand on that a bit.

DR. MITCHELL: Maybe if I could back up just a moment. If I've got the thrust of your question, the problem comes that the utility can't add capacity in very small little chunks just as demand is growing, but it has to bring on a multi-hundred megawatt unit if it's going to be able to invest efficiently and obtain as low-cost power as it can produce. So that when it brings on a new generating unit there's a large increase in capacity and then for some time you have excess capacity reserves until demand over time grows and again starts straining against that and then another chunk of investment is necessary.

Now, during that period of growth, it's true that, for a year or some shorter period of time, additional output can be produced without requiring any more capacity at all. It's already in place and part of it is idle or it's being used less than fully. But, given the expected growth and population and rate of usage of electricity the time will come when you do push against that and then some further investment is required.

Now, the longer-run view is an attempt to apportion or average those large chunks of investment over all the consumers who are going to share in the increased amount of output, and to divide it year by year into approximately the same amount of price or additional revenue requirement.
II. ALLOCATION OF COST OF SERVICE TO CLASS OF CUSTOMER

TESTIMONY

ACTON: My purpose, as Mr. Cali indicated at the beginning, is to continue the theme that was started by my colleague, Bridger Mitchell, a couple of weeks ago, talking about some of the alternative proposals that are being made for the pricing of electricity; chiefly, one under the title of marginal cost pricing. And since tonight's topic is on the allocation of costs, I'd like to chiefly indicate what the implications for the allocation of the costs of service are for different groups of customers, if you follow the principles of marginal-cost pricing.

First, let me review very briefly what I think a couple of the main points were that he made last session. (Figure 8). First is that the pricing system serves as a signalling mechanism; that is, that it sends the signals to the customers of what it costs to produce the services. At least that is the role we hope it will fill, and that is the principle that marginal-cost pricing attempts to fulfill. Now, signals are a two-way motion; that is, the system when it is following the principles of marginal-cost pricing is telling its customers what it will cost if they demand some more of some less electricity. At the same time the customer is sending the signal back to him--back to the system that is--that if I consume it at those prices, it is worth it to me, you should continue doing it. Therefore, it is important that we make sure that these prices that we set reflect the true costs that are within the system. They provide the incentives for consumption; they also provide the incentives back to the system to change its generation system over the long period of time, to supply electricity in a different manner, or at different times of the day.

Now, the basic principle underlying marginal-cost pricing is that you should reflect in those rates, as much as possible, both the short-run and the long-run marginal costs. The reason it's important to distinguish both the short-run and the long-run and to talk about marginal-cost pricing in the first place, is that it doesn't cost the same to produce electricity under all conditions. You notice the sets of load curves that both Mr. Cali and Mr. Adams used indicated that the amount of electricity generated varies both by the season of the year and by the time of the day. In fact, there is a more significant swing over a 24-hour cycle, whether it is winter or summer, than there is between the winter and summer altogether. Also, costs vary as a function of the number of kilowatt-hours the system is called upon to produce. The first few kilowatt-hours that the system can produce, it will take out a relatively inexpensive hydroelectric power; the more and more it has to produce over an annual cycle, the more it has to get into its less efficient means of production.
REV

PRICES SERVE AS SIGNALS

PRICES SHOULD REFLECT MARGINAL COSTS --
BOTH SR & LR

COSTS DIFFER BY

TIME OF DAY & SEASON
SYSTEM LOAD CURVE
KWH
KW
VOLTAGE

Figure 8
Another important variation in costs has to do with the kilowatt and the voltage at which the electricity is supplied. In both of the diagrams showing the hypothetical grid system, as you go further through the system, you are reducing the voltage so that it is usable for the types of appliances that different customers have. These have implications for the costs. Because of the nature of individual demand curves, the way those customers group together have important implications for how big of a distribution system you have to make, how many customers you can tie in to a given transformer, and so forth.

The basic idea with marginal-cost pricing is to try to start with the so-called electrical facts—or at least starting with an engineering point of view and it's asking basically, "What does it cost the system to produce under these different circumstances?" From that it moves to the design of a tariff, without conciously allocating costs to any particular class of customers. You don't arbitrarily define one class of customer, except for voltage and these characteristics that I've described. For instance, you don't arbitrarily distinguish blond customers from brunette customers. You instead look at the implications of their demand curves on your system costs, and you let the people, by the nature of their demand for the services, allocate the costs to themselves.

To oversimplify this approach—what I am describing as the electrical facts approach to things—we can ask a couple of questions when the customer comes on and demands some electric power. First we ask, "Must the system generate some more power in order to meet that?" The answer is almost always "yes". And then we ask the question, "Okay, what does it cost to supply that extra power?" The second major question you ask is, "Must the system be larger in order to meet the nature of that electricity that he is demanding?" And if the answer is "yes", "Where must it be larger?" "Must it be larger at the distribution station?" Must it be larger back at the generation source?" "What is the cost of those different places?"

Well, the costs that will follow from this depend on the time at which the customer demands his electricity, the quantity of electricity he demands, and the state of the nature of the system load curve, of the kind Mr. Call and Mr. Adams used; and, importantly—because this will vary from one utility to another—the nature of that utility generation mix.

If I could substitute Mr. Adams curve (Figure 9) Let's work real quickly through this.

From the point of view of costs, "What must a system do when it has a daily load curve that looks something like this?" What is showing really—that solid white line—is showing the instantaneous rate at which electricity is being consumed, but if you add up, under the curve through the full 24-hour cycle you get the total amount of electricity that was produced over a 24-hour cycle. The first thing you must note about this, is that you have to cover your total costs or you have costs implications for having supplied
Department of Water and Power

Typical Daily Load Curves

Aug. 1, 1974

Dec. 11, 1973

Figure 9
(Contd.)

**ACTON:** that much energy that would shade in this whole area. The second thing is that your system has to be at least this large; it has to be large enough to be able to curve 3.5 or almost 3.6 million kilowatts of power at the maximum of rate of consumption; that is, the amount of installed generation and transmission capacity has to be that large.

Now, let's ask what happens when our hypothetical customer comes on line. Well, the first important question we have is, "What time of the day is he coming on line?" If that customer is coming in at 2 or 3 in the morning, like this, what does it cost the system to supply a few kilowatt-hours to him? We know it is not going to cause them to build any larger system, because they had to build the system large enough for 3.5 million kilowatts and we are way down here under 2 million kilowatts. So, basically, the additional costs the customer poses coming on at 2 or 3 in the morning are the so-called variable costs or energy-related costs that have to do with burning a little more fossil fuel to turn out a few kilowatt hours of power. What on the other hand happens if the guy comes on right where we've got this dotted line, that is at the system peak. Well, we not only have to do the same thing we did at 2 am, we have to burn enough fossil fuel to supply him with 2, 3 or 4 kilowatt-hours of added power; but we--also if we had built the system to be exactly this large, if he wants to stay on that peak, we have to build a slightly larger system. That in some sense is the signal the customer is sending to the system--I need a larger system. Now, he is not really saying it that way, all he is interested in is electricity, he don't really--may not care one way or another whether the system is any larger, but from the Department's point of view, if it had only built the system large enough to meet that one largest annual demand, and then all of a sudden you had a permanent customer which came on and wanted a little bit more electricity, you'd need a slightly larger system. So he causes the system to incur not only an energy cost but a capital cost.

Now, of course, it is not really the last guy that comes onto the system that causes it to be 3.5 million kilowatts, because everybody who is demanding electricity, at about 3 pm in this example, is contributing to that total of 3.5 million kilowatts being delivered. And any one of them, who cut back on his consumption a little bit, would obviate the need to make a slightly larger system. So, if the pricing system sets up the signal to customer: "It's a little more expensive to us or maybe a lot more expensive, because we are now going to have to go through a little more capital expansion." Some of those customers say, "Wait a minute, I'd just as soon consume what I used to be consuming at 3 pm; I am perfectly willing to consume it a little later in the afternoon; come to think of it I get home at 8 o'clock at night and I could run my laundry perfectly well at that hour rather than doing it just before I go to work."

Any of a number of things can happen and those are the elements of an important study right there. But the point is we set up
(Contd.)

ACTON: a two-way communication system between both the customers and the system, saying, "Is it worth enough to you consuming your electricity at three in the afternoon to pay not only the energy-related charges but also some present discounted value of what it cost us to start a little bit of plant expansion now?"

There are a couple of important things I would like to just mention in passing, and these aren't rigorously developed obviously. One of the things is that it really doesn't depend on who the customer is for the purposes of this generation and transmission system, (which is really all that load curve refers to right now). As far as the costs that are imposed back of the generation and transmission system, it doesn't matter really whether that is a large customer or a small customer that is adding to the 3.5 million kilowatts. It doesn't matter if it is a customer that has consumed a lot during the night period or only comes on at 3 in the afternoon for a few hours. As far as the system is concerned, it's being called upon to produce more electricity and that will cost it something. Therefore, I would like to suggest that there are a couple of principles that follow from marginal-cost pricing. (Figure 10)

First, the pricing system that results from marginal-cost pricing should be forward looking if the signals are to work back and forth. When a customer must decide whether or not to consume more electricity, we have to tell him what it will cost now to supply his demand, not what it cost in some historic year.

Second, the things that are happening are coincident with the system curve at that time; that is, that it matters at the time when he is coming on, and that in general means at the transmission and generation stage, that you have to worry about coincident demand not non-coincident demand. The fact that he has an individual peak at 2 am didn't have anything to do with the fact that you needed 3.5 million kilowatts at the maximum. That's true at the transmission and generation stage. However, the closer you get to the individual customer, the more his nature of demand will influence the distribution system you need -- the size of the transformers, the frequency with which you have to spread transformers around through the system, and the way you size lines coming into his house, or his place of consumption.

I'd like to borrow a little bit of nomenclature from the French who have been practicing marginal-cost pricing for a period of about 15 or 20 years now; they started, following World War II, (Fig. 11) They found themselves constrained both in capacity and in energy, and they realized that they had to organize their electricity production and distribution system more coherently than it was. They were the first country, in a big way, to get into the business of marginal-cost pricing. And the way they build the exercise up is to start back at the generation stage and follow through the system and see what costs a person imposes on the system. This is similar in spirit to the
PRINCIPLES OF PRICING

- SHOULD BE FORWARD-LOOKING
- SHOULD REFLECT COINCIDENT DEMAND--NOT NON-COINCIDENT DEMAND
- RELATIVE TO GENERATION
- RELATIVE TO DISTRIBUTION
BUILDING UP COSTS

- ENERGY COSTS - DEPEND ON KWH AND SYSTEM LOAD CURVE

CAPITAL COSTS

- COLLECTIVE SYSTEM DEPENDS ON CONSUMPTION AT SYSTEM PEAK

- SEMI-INDIVIDUALISED SYSTEM, SIZE DEPENDS CONSIDERABLY ON FLUCTUATIONS IN EACH USER'S CONSUMPTION

- INDIVIDUAL INSERTION, SCALE DIRECTLY DETERMINED BY CLIENT'S OWN PEAK

Figure 11
(Contd.)

ACTON: outline that both Mr. Adams and Mr. Call indicated
As you go through the system basic difference
is that you're talking about marginal costs that are associated at
each one of those stages. But when we are talking about the energy
costs--that is the cost of supplying some more electricity at any
point in the load curve--they depend basically on the load curve.

If you know all the time that the demand that comes to
you comes when you are running well below the maximum capacity, it
is, loosely speaking, less expensive to produce that per kilowatt-hour.
As you get closer and closer to the system peak, that is as you have a
system load curve that fluctuates more, the more costs are imposed
on the system per kilowatt-hour generated to get onto the system peak.
So, the energy costs themselves are chiefly a function of the nature of
your system load curve and whether or not you, as an individual customer,
are consuming on the system peak or not.

The capital costs, on the other hand, have to be broken
down in several stages, as Mr. Adams indicated. First the collective
system, that is something that everybody uses, is basically the gener-
ation and the high-voltage transmission. Now those, again, depend on
the nature of the system load curve; that is the maximum size you had
to install was dependent on that 3.5 million kilowatts that
that you were called upon to supply in the hottest summer day. As you
get out into your medium system, half way through the grid in effect,
you know, midway in the grid there, the characteristics of an individual
customer's demand go a longer way to determining how big the size of
the system must be. If you have a single customer who comes on with a
big very high level of demand, you may have to install a larger transformer
strictly for him or even, when you are talking about smaller customers,
the more extreme their individual load curves are, and especially if they
are identical, then you just can't hook as many of them into a given size
 transformer. And finally, as you get down to the level of a single
individual, his specific nature of demand determines entirely the final
connection you must bring into him.

Now, I would like to touch briefly a point that I noticed,
in reading the transcript, came up late in last session's discussion,
and that is if you go to the principles of marginal-cost pricing, might
you be generating more revenue or less revenue than the total cost that
you must raise. The total cost, by the way, the notion of servicing
debt and hiring employees who will be employed, whether you read meters
at high levels or low levels, and a number of things like this, these
will be costs that are ongoing under any case and you can determine a
number of those costs to begin with, then the marginal costs will be
covering the variable costs associated with more or less energy. But,
it is still true that if you use marginal-costs pricing that generally you
can't count on total revenue being precisely equal to total cost. What
happens at that point?

Well, the principles of marginal-cost pricing don't ignore
this need to balance the books, and they have a couple of observations
about what you may want to do in reallocating this difference--this
(Contd.)

potential difference between total revenue and total costs.

**ACTION:**  (Figure 12) In the first place, if you followed the principles of
marginal-cost pricing, you went to some effort to assure that the people
who were asking for more electricity were willing to pay the full cost
of it, the people who were not asking for electricity, at a certain
time, at a certain voltage, relative to the system load curve, if they
are not demanding it at that time, they don't have to pay the costs
that are uniquely associated with that kind of service. So, they had
an important role in determining resource allocations, and to the extent
that we have to reallocate a surplus or make up the deficit, as much
as possible we don't want to distort this resource allocation that we
have just achieved. In particular we don't want to distort the decision,
of the quantity of electricity they are consuming and the time at which
they are consuming, unnecessarily. And that's what you would like to
do, keep the relative prices--let's say, for instance, of peak and
off-peak electricity as close as possible to the marginal cost in the
last block, or where the customer is receiving the price signal. If he
is consuming a little bit more, you want to make sure it tells him
how much more that's costing; if he consumes a little bit less, you
want to let him realize the full saving of that consuming a little bit
less. See, you'd like to keep the last price signal that goes out
to the customer as close as possible to marginal costs.

What alternatives are available to us if you want to
stay within the principles of marginal-cost pricing? (Fig. 13) Principally
they are the three approximations I indicate here. First that you
can have proportional adjustment of rates; that is that if you need
to scale them up 5% or down 5% you'll keep the ratio of peak to off-
peak charges the same. Another thing you can do, if you don't want
to affect this resource allocation that you have just achieved is to
reallocate these extra costs or extra savings to customers who basically
don't respond to prices in a significant way. That means they won't
change the nature of their demand on the system, you won't affect
your total system cost, and you'll just redistribute the costs or
savings to the customers without affecting the total resource allocation.
Or third, you can take all customers, or a large proportion of your
customers, and attempt to find a section of their rate structure where
they are basically not affected by the price. And the example that
Ralph Turvey suggests, and there are a few comments by Ralph Turvey
that will follow me, have to do with, for instance, putting it into the
first block of the rate structure. If you know for instance that
99 or 99-1/2% of your customers all consume above a certain level
at say 50 or 100 kilowatt-hours per billing period, then changing
that up or down a little bit won't affect the price at the margin;
that is, the price that he is paying out where he is actually consuming
electricity. If he consumes a little bit more, he is still facing the
full marginal costs, if he consumes a little bit less, he reduces his
bill by that marginal cost.

Hopefully, the questioning period will bring out some
of the points that I've hit over in abstract terms and quite rapidly.
I hope also that Mr. Turvey's comments will help fill in a little bit on
ALLOCATING ANY DIFFERENCE BETWEEN TOTAL REVENUE AND TOTAL COSTS

PRINCIPLES

- DON'T DISTORT RESOURCE ALLOCATION
- MINIMIZE IMPACT ON PURCHASE DECISION
- THUS, KEEP RELATIVE PRICES AT MARGIN AS CLOSE TO MC AS POSSIBLE

Figure 12
ALTERNATIVES

- PROPORTIONAL ADJUSTMENTS OF RATES
- REALLOCATE TO CUSTOMERS WHO ARE NOT RESPONSIVE TO PRICES
- REALLOCATE IN A PART OF THE RATE STRUCTURE WHERE CONSUMPTION IS NOT AFFECTED

Figure 13
(Contd.)

ACTON: this last point about the reallocation of potential surpluses or deficits. And I look forward to your questions here.

Well the French system is different in a number of ways than U.S. utilities in general. For instance, they have very little need for air conditioning. Air conditioning is an important characteristic of your demand here. They have a different stock of generating plants, they have a higher proportion of hydro, I believe, at that time than you have now. The point that I wished to make was not that you would want to imitate the rates that the French, or the British, or the Swedes or any of a number of other people have come up with in applying the principle of marginal-cost pricing, instead the point is that, what they found desirable in terms of resource allocation, in terms of sending price signals to their customers, I think are the same sorts of desirable principles for U.S. customers and U.S. utilities. Now, you won't expect, in general, to get identical price structures or price levels in different utilities, because the nature of the system load curve for each utility is important in determining those costs. Furthermore, the nature of the individual demands will be important in determining the total revenue that results. You may have, hypothetically, under some circumstances where you find customers who are quite anxious to shift their usage off-peak when they are charged more for electricity, and therefore, your system load curve will flatten out considerably over a period of, say, 5 to 10 years as it comes into effect. You may have other cases where people are quite unwilling to change their pattern of consumption and therefore, the price differential will stay rather large; people are happy with it; they send the signal back to the system that's the one I want, let's keep it going.

I passed over very briefly mentioning that which you do by not deliberately defining a class of customer that
(Contd.)

ACTON: you call blondes or brunettes or residential or small commercial arbitrarily, is, you permit the customer, by the nature of his demand, to determine what his bill will be. Therefore, he allocates to himself the cost that he actually imposes on the system. If you have a customer who sees the relative price of electricity from daytime to nighttime, being arbitrarily a factor let's say 2 to 1, and that's strictly for illustrative purposes. If he says, "I would rather do most of my electricity consumption at night," then he can avoid the periods of time when you are imposing a greater cost on the system. Other customers say to themselves, "I value that service at the time that I am consuming it; it's perfectly worth it to me to pay twice as much during some periods as in other periods," just automatically allocate it to themselves, too. What you do is you permit a greater flexibility that's not permitted in this average-cost pricing, which is necessarily averaging over a large class of customers the cost that they collectively impose on the system, you instead give a greater degree of freedom for the person determining his own pattern of consumption.

GLAZER: That is strictly tied with being able to measure how much he is using when.

ACTON: You're right. If you are, for instance, in a time-related tariff that you want to charge more at some periods of time than others, then you must necessarily know how much you consumed in those two periods of time.

GLAZER: That's necessarily required in terms of the marginal-cost concept that you are talking about.

ACTON: Absolutely. Now, there can be some exceptions to this. I shouldn't say there can be—it's not that it is an exception to the principle of marginal-cost pricing—it may still be true that even though you know what would be the ideal way, for instance, the cost of administration and the cost of metering may be larger than the system's savings, and you may do an approximation that is short of knowing what he consumes at day and at night. One approximation that is used in some other utilities, (and this is leaping ahead a little bit to next week's topic) but you may, for some classes of customers, just have them subscribe to a capacity. For instance, they may subscribe to three volts of power coming into their house or six volts. Remember, as we got wave out the distribution system, the maximum level of an individual's demand had to do with how many transformers you had to supply in the neighborhood and things like that. Well, if you allow them to just subscribe in terms of volts like that, you can recover most of the variation in that charge without knowing whether he actually did it at 6 p.m. or not.
ADAMS: Isn't it true, Jan, that this test that we plan to take together, the purpose of this is to determine what response we can expect from this sort of pricing from our customers, to see if it will be effective or not here?

ACTON: Yeah, you're referring to the test that we submitted as a proposal to FEA. Yes, --the exact area of uncertainty, or large area of uncertainty, involves how much people will respond to the sorts of price differentials that are indicated by these principles of marginal-cost pricing. Because, if people don't change at all in their pattern of consumption, it may be simpler just to avoid the metering costs altogether, if they don't show any responsiveness at all to differential pricing. On the other hand, if you do observe that people change their pattern of consumption around enough to recover those metering costs, you've given them a degree of flexibility, you have assured that the system is viable financially, and both parties should gain.

GLAZER: Is it an incredible over simplification, or am I completely wrong to say that this evening's discussion was about the defining classes of services and then trying to allocate costs among them, and, essentially, what you would say is that under the economic concepts that you were talking about--even talking about classes of service is misleading--what you are really talking about is slots of time during the day, for instance, rather than the traditional groups of users that acted the same way.

ACTON: It is especially slots of time when you are talking about the energy charge and when you are talking about the common costs that are common to everybody. Now the farther you go out the distribution system, the more depends on an individual's characteristic of demand. Therefore, it depends on things like his voltage, his peak rate of consumption, and how that compares to the people who are in his little node of the distribution system.

GLAZER: But with respect to the capacity costs.

ACTON: But with respect to the overall common costs, it really depends on what time of day that he does it.

GLAZER: So the distinction is really--you are really talking about classes in two very different ways.

ACTON: That's right, these classes are determined by characteristics of his consumption of electricity, as opposed to some other characteristic that he might have.

NAGLE: And this would hold true for the commercial and industrial...
GLAZER: I think you would say those are irrelevant distinctions in some sense, right?

ACTON: They are irrelevant to the strictly common costs; they are important, as Mr. Adams had indicated, because they don't share in, let's say, the medium voltage transmission and the low voltage transmission. They don't require that you run miles and miles of wires all over the place because they come out fairly close to the main transmission system. So, it's only in the central costs of energy and the--then the core capital costs of generation and high-voltage transmission.

GLAZER: That the really significant differences are going to take place between the two concepts.

ACTON: That's right.

NAGLE: I have a question. Mr. Call, is there anyone of Professor Turvey's stature, who disagrees with some of the answers that Professor Turvey gave you in your interview with regard, for example, to the lifeline--

CALL: He came across very hard on lifeline--

NAGLE: Yes he did.

CALL: --and I don't think that was his intention. He was speaking as an economist worrying about pricing. He was not speaking as an economist, or as a sociologist or as a human being worried about how well people are off and how badly they are being hurt by this thing.

Purely from the view of pricing, I think most economists would agree with him Jan, please jump in. There are economists though who strongly support the lifeline proposals from a social standpoint and looking at it from the consumers' side and not the pure question of pricing.

ACTON: I think that the important point to stress is that when you talk about something like the lifeline rate, you are really talking about a social judgment about who should be given a break either in terms of income or in terms of what it cost him to get the things by which he lives. And those are issues about which economists can predict outcomes. They can describe different ways of achieving the outcomes for given costs; they can perhaps identify more efficient ways of doing it and less efficient ways of doing it; but they are not specially endowed with any right to judge one social distribution of income better than another. That is fundamentally a matter of public morality, if you will, and it is something that you normally expect to be determined in the broadly construed political context.
GLAZER: And the pros and cons of that particular judgment, I think, is what we want to get into in the fourth session.

CALL: You know, Mrs. Nagle, whenever you ask a question like this (if any of you saw "Give 'em Hell Harry" when it was across the street) I think Harry Truman said at one time, "If you had 50 economists and laid them out in a row, they'd point in 50 directions".

NAGLE: So then yes—the answer is then yes that there are economists who take divergent views of all of these aspects contained in the interview with Professor Turvey.

CALL: I think Professor Turvey, from the view of pricing, generally reflected the consensus of the discipline. Would you agree Jan?

ACTON: Yes, I concur that in his description of what it takes to implement marginal-cost pricing, the basic principles that he describes, I think you'd find very wide agreement among the economic community. I think also, if I may add parenthetically, you'd find large agreement in his descriptive statement that the lifeline is an attempt at redistributing purchasing power and there may be more efficient ways to do it. I think you would find a large segment of the economic profession which would agree with that without--you know--without prejudging whether or not they would say go ahead and do it anyway. They would just say, as an efficiency measure, it's not necessarily the most efficient way to do it because it's a coarse sieve you know, you pick up a lot of people you didn't intend and you miss a lot of people you might have intended by it. And I think that's the point he was trying to make; and I think you'd find a lot of agreement on that issue.

GLAZER: With respect to the economic concepts we've been talking about, in a very practical sense, I still keep coming back to my wondering that American public utilities seem to be spending a lot of time thrashing about with respect to concepts that I'm not sure anybody really understands. That is, in the first session, we talked about how you define the cost and we explained how it's always been done and we explained the concept called long-run incremental costs that nobody was exactly sure what it was, but that's what we're all talking about these days. Second session is how you define the classes of customers that are going to bear those costs; and we've now decided we understand how it's been done in the past, we understand some general theoretical concepts about how it might be done now, except nobody's really done it now either. Is that an unfair description?

I am trying to assess where we are and why this is significant to this utility, if at all.
ACTON: Okay, I'd like to take major exception to leaving the impression that marginal-cost pricing is merely a hypothetical concept and that it has not been applied. It's true that in the United States' context we have not made substantial attempts to implement marginal-cost pricing until quite recently. However, you have over a 20-year history of full-blown marginal-cost pricing in France. You have in excess of 10 years' experience in the United Kingdom. These are not hypothetical examples; these are prices that are set for an entire nation's production, distribution and retail of electricity. They are dealing with systems that are considerably larger than the Department of Water and Power's system; they exceed the size of any single utility in the United States, and they balance their books at the end of the year.

Furthermore, the type of principles have been extended in a number of other countries. Dr. Turvey, himself for instance, recently engaged in a study that was done for the country of Thailand, under the auspices of the World Bank, in which they developed a pricing system that was appropriate for both rural and residential areas. And that's a forthcoming study, I believe, co-authored with Dennis Anderson.

In the United States, the Madison Gas and Electric case contained testimony that provided the basis for a marginal-cost pricing algorithm, exactly conformable, or in exactly the same sort of detail that you get for a conventional cost allocation. If you ever read the transcripts of conventional rate review, you find some disagreement about whether they ought to use 5.8 or 5.9% discount rate; you find disagreement about whether there ought to be double-declining balance depreciation,
(Contd.)

ACTON: or whether there ought to be straight-line depreciation.

I don't think you should lose track of whether—when the
principle has been accepted and adopted and there may have been disagreement
on some of the fine details, or when there has been substantial disagree-
ment on the major concept. And the major concept of marginal-cost pricing
has been shown to be valid and has been shown to be implementable and
has been shown to be something you can adjust to over the years.

GLAZER: Any essential thrust of the argument for it is that
it's simply a better economic indicating system, in
some gross sense; that is, it allows people to respond to the true
cost of the service thrust they are demanding.

ACTON: That's exactly right. What you want the major thrust
of why the proponents of marginal-cost pricing find it
attractive is, that as energy becomes an increasingly scarce good,
it is increasingly important that you send a precise message. In
periods of substantial energy surplus, and substantially flat or
perhaps even declining long-run marginal costs, it was not important
that you send an extremely, finely tuned price signal to your customers
or even the largest of your customers, because you were going to do
well. You might have a surplus at the end of the year; you can either make
that up by undercharging a little bit the next year or use it for
system expansion.

When we are in a position where we see fuel costs rising
substantially, when we see capital costs at a very high rate, when you
see the constraints on capital expansion as severe as they are now, it
becomes very important that you think about all the tools that you have
for bringing your system demand into line with your ability to supply
that electricity.

NAGLE: May I bring up another point? Dr. Turvey is pretty
strong in his statement that rate structures based on
marginal-cost structures are very very different depending on the
utility and, therefore, the customers that they serve; and, therefore,
this Department cannot really look to any one particular area. As an
example, unless that particular area fits exactly the prototype of our
customers.

ACTON: Your observation is very good Commissioner Nagle,
especially if you're pointing to the fact that the
precise levels of the rates for the Department of Water and Power might
be substantially different than the precise levels of the rates that
you observe in another utility. However, there are certain types of
lessons that I think you can draw some comfort from in other utilities;
for instance, the administrative feasibility of it. Whether it's a peak-
load pricing system where you charge 3 cents and 2 cents on your
(Contd.)

ACTON: peak and off-peak, or whether it’s a system where you charge 4 and 1 is not of a great deal of difference. The question is can you put the meters out, can you get the message to the customers, can you process the bills, can you adjust to it as your costs adjust? And those are the lessons that I think are more generally transferable. The lessons that are less transferable have to do with what your precise cost picture is, and that will depend on your generation mix, which in general is not identical to other peoples. It will depend on the nature of your customer mix, which in general varies rather substantially. DWP has 50% commercial customers, and that’s in excess of the nation average and in excess of the Cal--

NAGLE: What is the nation average?

ACTON: It’s more like 38%

CALL: Yeah, in that order.

ACTON: It is one of the reasons that--that the commercial sector was called upon and did bear a major role in the curtailment ordinance a couple of years ago. One of the reasons it was successful is that they found ways to conserve, and they constitute a large proportion of your system.

The other thing that will vary is not only your generation mix, and therefore your cost picture, not only your mix of customers, but the ability or the willingness of customers to vary their pattern of consumption may differ substantially from one utility to another. You may find customers, for instance, in a hot climate very dependent upon their air conditioning, and, therefore, relatively inflexible in their use of air conditioning on peak, which is not to say all uses on peak but air conditioning on peak. And you may find other places where customers are quite willing to shuffle their demand around and change loads rather substantially.
DISCUSSION

BRALY: Mark Braly, I am Councilman Marvin Braude's deputy.
I wondered--I know that the two people from Rand have
done previously some studies that involved the Department, so I wondered
if you have any feeling for how easy or how tough it would be for the
various classes of customers to switch their consumption from the system peak to
the other times.

ACTON: I think that one of the lessons of the curtailment period
that followed the Arab oil embargo (getting close to two
years ago now) was that the citizens of Los Angeles (residential,
commercial and industrial) all showed themselves willing to pay attention
to the needs that the Department faced, when it faced increasing resource
constraints, they were willing to adjust their consumption. I think the
pattern was not indicated--I mean this was a degree of adjustment that
exceeded anything that we observed anywhere else in the country. It
suggests to me a couple of things. That the citizens of Los Angeles are
prepared to be more responsive in their energy use. And, they're also
prepared to be responsive in a direction that promotes overall system
efficiency.

I think another important lesson which Mayor Bradley
mentioned in his letter, that was read at the beginning of this session,
was that it was not merely an adjustment during the ordinance period.
There has been a permanent reduction by a certain amount in the historic
pattern of energy consumption that indicates that to me (among other
things) there has been some of this re-education, there has been some
of this change in life-style that Commissioner Nagle asked about, and,
I think an increasing, or a continuing awareness, of the importance of
energy conservation.

I studied the commercial sector in some detail, but a
relatively small number of customers, following the curtailment period,
and one of the things that we found in interviewing commercial establish-
ments of all kinds, (from the ma-and-pa grocery stores up to rather large
supermarkets and department stores) we found that the people were
maintaining several of the conservation measures that they had adopted
during the curtailment period after the ordinance had been suspended
and one of the reasons--the prominent reason that they gave was that
they were aware of the higher energy prices. So it strikes me that the
L.A. citizens are already aware and, in some sense, prime candidates for
making good use of a more sophisticated pricing system.

GLAZER: My first reaction when you started off was, "Gee, isn't
it naive to think the citizens of Los Angeles are any
more, you know, generous about these things than anywhere else in the
country." But what you're saying is that we had a bigger shock about it
at the start, and so perhaps we really are.
ACTON: We had a shock financially, and we had a shock propagand-wise.

GLAZER: Yes. Propaganda.

ACTON: I mean the people learned a lot during that period of time.

NAGLE: Dr. Acton, did you conduct any studies with industrial or residential customers?

ACTON: No, our--well, the answer is both yes and no. The individual interviews to which I referred were confined to the commercial sector.

NAGLE: I see.

ACTON: So I can only talk in detail about the kind of conservation measures of the commercial sector. However, we studied the aggregate consumption, or the sales, by all three classes of customers, and as you well know, all three classes of customers dropped their consumption significantly during the period of the ordinance and all three classes of customers have maintained--post suspension of that ordinance, maintained a reduction.
RATE DESIGN

TESTIMONY

ACTON: First, I'd like to preface my remarks this evening by an important qualification, or at least important from my point of view, and that is that what I'm talking about tonight doesn't constitute a recommendation or a disrecommendation on any particular tariff form. I'd like to discuss a number of alternatives that I think exist, and one of the reasons that I think it would be premature to concentrate on a single tariff form at a single rate level perhaps, will be first that the necessary studies I think to design such rates are in progress at the Department, but they're not, they're not at the stage where I think we could discuss the types of numbers that come out of them. And the second thing is that I'd like to stress that I believe there are several options involved when you consider the implementation of what, on a broadly marginal-cost pricing. And, so rather than squelch the notion that there's more than one way to do it, I'd like to instead try to indicate a bit of that variation because there are important judgmental factors that go into a decision to adopt one particular solution rather than another.

If I could try to distill very quickly what I think my colleague, Bridger Mitchell, and I have been arguing so far about

(Contd.)

ACTON: marginal-cost pricing, that is that we want to set up a pricing, a communication between the system and the customer that sort of signals the true system cost of consuming a little more or a little less electricity at any given point in time. That implies to us a number of principles that lie behind basic tariff design. (Figure 14)
PRINCIPLES FOR TARIFF DESIGN

- SIMILAR SYSTEM COSTS SHOULD BE PRICED THE SAME
- DIFFERENT SYSTEM COSTS SHOULD BE PRICED DIFFERENTLY -- BUT ONLY TO THE EXTENT OF COST DIFFERENCES

IMPLEMENTATION:

SIMPLICITY
UNDERSTANDABLE
STABLE
CONSIDER COSTS AND ADMINISTRATION

Figure 14
ACTON: (contd)

The first is that similar costs of the system ought to be priced the same. Now, we have to watch what we mean about similar costs of the system because we're recognizing throughout all these discussions that voltage differs, and with different levels of voltage, you're talking about different costs. We also recognize some things that because of the variation in the system load curve, you get to use more efficient generating units at some times, and less efficient generating units at other times. And, therefore, over the day, or perhaps over the week, or perhaps over the year, the marginal costs that are faced by the system may vary.

Conversely, that is, it follows that different system costs should be priced differently, but only to the extent of those price differentials. This is what's falling out of the so-called, or what I will characterize as the pure marginal-cost pricing. Now, the actual implementation, of course, won't necessarily follow the extremes of a simplistic statement like I just made. In the first place, theoretically, marginal costs are changing continuously. More than every hour, they may be changing within every hour for the 8,000+ hours that you have per year. Well, that's far too complex to implement as a tariff, so you have to make some compromises for the sake of simplicity.

In the second place, you have to make some compromises so the people can understand what's going on. As a heuristic, you might be pricing usage during daylight hours differently than nighttime hours, or you may be pricing weekdays different than weekends, or you might be pricing hot days different than not-hot days, or if you were in a different sort of system, very cold days, different from moderately cold days.

The third important characteristic is where you draw back from the extremes of the simplistic statements that I made is that rates must be fairly stable. Stable enough for people to make sensible plans. After all, if you're setting up a communication in the pricing system that's trying to signal to people what it costs the system to deliver different types of electricity at different times of the day, and they go out and they buy an electric water heater because they expect it to mainly charge up at night, and then they coast on the hot water during the day, and then you flip the rate around on them, you've really done them a disservice.

So, you have to have enough stability for people to make the sensible sorts of adjustments that you would like in terms of long-run equilibrium.

And fourth, just to note it, that at all times you've got to talk about the cost of implementation and administration. In particular some of the tariffs that we talked--will talk about later involve different kinds of meters than you use now. And, therefore, you've got to balance off the costs of these meters with the expected savings in net to the system. But the implications of these principles that I've suggested under the two green dots at the top, I think are several.
(Contd.)

ACTON: One, it means that once you’ve defined a homogeneous type of demand, that is a similar demand on the system at a given voltage perhaps with a given amount of distribution system, at a given time of the day, you should charge a flat rate per kilowatt-hour. That is, any given customer who uses one more kilowatt-hour or one less kilowatt-hour does the same thing to the system. It’s irrelevant whether he has previously consumed 1,000 kilowatt-hours or whether he’s only consumed 3 and he’s thinking about consuming 4. He’s imposing the same costs on the system, so that first principle of similar cost implies similar price, suggests that within homogeneous periods you’re talking about a flat tariff. It follows that they’re not discounts, it also follows they’re not surcharges obviously. It—the fact that the person has consumed 1,000 at this point, doesn’t all of a sudden make it more costly to serve him 1,001. Given that his voltage and his transmission system and everything getting down to him are similar to other people like him.’

Second, it doesn’t, from the point of view of this marginal-cost pricing theory, make any difference what his final use is. There aren’t meritorious and nonmeritorious uses as far as the system’s concerned. A kilowatt-hour back at Hoover Dam or a kilowatt-hour down at one of your fossil plants is still a kilowatt-hour of energy produced and it doesn’t really make any difference whether it ends up shaving somebody’s beard off, or whether it ends up air conditioning his house, or whether it ends up driving a machine a little bit.

And finally, from the point of view of this marginal-cost pricing, it doesn’t make any difference whether you’re talking about a master-metered or an individually-metered customer. Although it may make some differences in the amount that you invest in meters per se. As far as generating more or less electricity, this notion of a little more and a little less, that’s irrelevant. Basically you’re trying to set a price for the costs that are imposed on the system.

Now, to focus this discussion --I think add considerable concreteness to this discussion-- I’d like to focus on a couple of foreign examples, where people—or the utilities involved—have been pricing according to some of the principles of marginal-cost pricing for a couple of decades in the case of the French and a little under two decades in the case of the British. I think that this will give you an indication of one country’s approach to the problem—it gives you some feel of the types of compromises with these actual implementation criteria I suggested, and perhaps will help focus further discussions about whether or to what extent those sorts of things would or would not be useful ideas here in a system which has a number of obvious differences. Remember, these are basically for illustrative purposes because one of the points I made last week in costing was that the marginal cost that you get out of looking at any particular system will depend upon the generators it has, the amount of distribution system it needs to get out to its customers, the number of customers, the proportion of them that consume daytime-nighttime, whether they consume with a very sharply peak demand on the system, or a reasonably flat, rolling sort of a cost imposed on the system. So, take these numbers as being chiefly illustrative, but illustrative of something that has been worked, modified and implemented over a number of years.
(Contd.)

ACTON: The first thing that we talked about on the notion of costs is that there were really just two type of costs in a marginal-cost sense that are imposed upon the system. First, is those costs that are associated with the number of kilowatt-hours that are produced—you can call them variable costs or something like that if you like. The others are the types of costs that are associated with just getting the system in place and ready. And those can be called capacity costs or capital costs—or a number of things like this. Remember though when I talk about costs, I'm talking basically in the notion of a forward-looking concept, although we're talking about the same basic parts of the system, that when it comes to calculating this actual cost, we're talking about what does it do to the system to do a little more or a little less, which is intrinsically a look-forward or an opportunity cost, or a marginal-cost concept.

I take a stylized version of the electricity system here (Fig. 15) For argument's sake we can say that there are three parts shown respectively in blue, green, and red. There's a generation system and it produces very high-voltage electricity. And some customers in France and not quite in the Department's system, but some customers in France take their voltage straight off the high-voltage system at 220 kilovolts. In the Department's case, you would have a transformer before anybody takes anything out, and this blue set of the system is really used by everybody. Second, you then get a reduction in voltage and, therefore, an increase in cost because you do something to the electricity, you lose some of it by transforming it and you lose some of it by sort of shipping a little farther out the system. And you get down to a medium-voltage level. Now there may be more than one medium voltage. And you have some customers that come out at that point in green. And third, you do further reductions in voltage and, therefore, incur some more costs and ship the electricity on out to your final consumers at low voltage. Those would be all the residential and some of those small commercial customers in the case of both systems we're talking about.

Let me concentrate for a moment on the notion of these costs that vary with the number of kilowatt-hours consumed and for the moment pretend that it doesn't make any difference whether I'm producing them during the day or during the night. But just sort of concentrate on this sort of a grid that distributes the electricity throughout the system. Well then the costs of serving anybody who comes off as a final customer either at high voltage or medium voltage or low voltage are associated with the number of kilowatt-hours he consumed and the voltage which is consumed. And the Electricité de France or the French National Utility system which produces themselves all the electricity in France, they have average costs associated with these three levels, approximately indicated as follows.

Now they define their high voltage, I mean they break them into two categories, there's very high voltage and there's high voltage. For our purposes those all can be thought of as high voltage, there's sort of a technical difference what the two are. But the set of costs per kilowatt-hour that they calculate in a marginal-cost sense of getting kilowatts out to these very high-voltage customers are 1.25¢ per kilowatt-hour, or if you reduce the voltage somewhat for them, then 1.5. They're chiefly reflecting the line losses and transformation losses that are encountered in just getting the electricity out.
Figure 15

AVERAGE PRICE

Very High 1.25¢/KWH
High 1.5¢/KWH
Med. 2.5¢/KWH
Low 5.0¢/KWH
The next group of customers and the way they build up their marginal costing, their marginal cost for purposes of charging per kilowatt-hour—it takes the marginal cost that you calculate at the last up above, in this case 1.5¢, finds out what your line losses and transmission losses are in getting down to the next level, and they find that the costs are about 2.5¢ per kilowatt-hour produced or delivered, really in this sense, because at this point, you have to get it to the guy's meter for it to count for this purpose.

Now, we'll take the number 2.5¢ and ask ourselves how many, what sort of additional marginal costs do we incur in getting out to those final customers, and their answer is 5¢ per kilowatt-hour.

Now these are average notions, of course, and one of the points that we were discussing in some detail last week is that what it costs per kilowatt-hour depends on what time of the day or, really more precisely, what the state of the system is when you try to do it. And we have this useful way of summarizing the information in a system load curve. (Fig. 16) Now system load curve I have running across the bottom of this 24 hours, that's midnight starting there up through 6:00, 12 noon, 1800 or 6:00 and midnight again. And on the vertical graph here I have, I've normalized that 3,000, what was it—3,600 and some kilowatts which was the Department's curve that we were using last week that shows an instantaneous rate of production, and I've just normalized it so that on the average it's 1. But this is the rate of production of electricity at any given moment in time. So, for instance, at this given rate if we did it for an hour we'd have in these units, something like about .7 kilowatt-hours or something times whatever would normalize this—readjust this whole curve, and up at this point we'd have something like 1.18 up at the maximum.

Now, remember when we're operating in the valleys as we described them last week, the system has a little bit of flexibility available to it. That is that it can select among its most efficient plants, this is heuristically speaking, not in a dispatcher's sense of the word. But in terms of the costs that are imposed on the system, the system can choose its most efficient plants and, therefore, essentially has lower costs per kilowatt-hour generated than when it's up near full capacity as you get way up in the tops of both of these shaded areas. And when it's up nearer capacity it has to use all the resources that are available to it and these impose a higher average cost per kilowatt-hour generated.

And so the first step they did was to define one area of the curve of this sort of system load curve as the one in which they were starting to strain the system a little bit, and they defined those as high consumption. Or I translated it as high consumption—it's not quite the word they used. And in the nonshaded area they define as off-peak or slack hours and the hours that they use when they set this system up, back about, in about 1958, were from 10 P.M. or 2200 hours, through midnight all the way to 6 a.m. Those were slack and they defined them as the hours in which an additional—a customer who decided to consume a few more kilowatt-hours of electricity during those periods of time made no difference in the amount of capacity they had. They didn't
have to install any more generation or high-voltage transmission or anything like that for them. It just didn't do anything to the size of the system; they need it. And in the rest of the hours, with increasing probability, imposed some of those additional costs on the system.

Now, they have a system which peaks more in the winter than in the summer. They heat with electricity as opposed to cool with electricity as we do out here. The winter they define as being November through April—arbitrarily they call it winter, you could call it the high season or almost anything else. And the summer they define as those other six months. It doesn't really come out that way in France—if you've been in their weather, but that's what they call it. In addition to that, however, the months of December, and January, and February and March, where they have a lot or air cond—a lot of electric heating loads, they have a real sharp peak during some of these early morning hours, and some of those late afternoon hours. And so they define an additional peak period, which I translated as the peak or the area I shaded in red, and then I defined the rest of that shaded area now as high usage and then the unshaded area as being slack hours.

Okay, now what are the implications once you've decided that? I beg your pardon. One more qualification that was—I guess I said it, there's only four months that they count the red area—the rest of it they just call winter peak or winter slack and in the summer they call it either winter, I'm sorry, winter high or winter slack, and then in the summer they call it, summer high or summer slack in that unshaded area.

Well, what, what sort of implications does this have and again thinking only in the energy component, or only in that variable-cost sense of the word, what kind of tariffs did they come out once they start recognizing those different system costs, and how the grid system of the kind I indicated with those average charges that I put up there. Let's take the medium-voltage customer which does not up the transmission and not coming directly out of the transmission level, but a little farther down. He had to go through one transformer step, and then he had some customers coming out on this medium-voltage step. And here is an example of a tariff that they used to implement these concepts. (Figure 17) Ignoring the left-hand column for a minute, remember in the winter, we've got three periods that we have to talk about—peak, high and slack, and in the summer we only have to talk about high and slack. And if we get cents per kilowatt-hour, this is the sort of charges they have. For those hours 7 to 9 in the morning, and 6 to 8 at night, I believe it was—I'm sorry it was 1700 to 1900—it was 5 to 7 at night—they're charging 6.24¢ per kilowatt-hour consumed. And they have meters that record what those customers are consuming each hour of the day. For those other daylight hours, or those other shaded hours, they were charging 3.25¢ per kilowatt-hour, and then in that slack period, where all the costs they figure you're imposing on the system are only the running costs of the—strictly variable costs of generating one more kilowatt-hour at 2 a.m., or one less kilowatt-hour at 2 a.m. I think that's about 1.15¢.
**PRINCIPAL MEDIUM VOLTAGE TARIFF**

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<thead>
<tr>
<th>FIXED PREMIUM BASE RATE $/KW/YR.</th>
<th>PRICE PER KILOWATT HOUR (IN CENTS)</th>
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<tr>
<td></td>
<td><strong>WINTER</strong></td>
<td><strong>SUMMER</strong></td>
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<td>PEAK</td>
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<td>27.35</td>
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*Figure 17*
Similarly in the summer, they have a much lower high or daytime rate and then a slack rate that's just about 1¢.

They, for practical purposes have these two slack rates, both the winter and the summer slack rate are reasonably, are quite close to one another and you can argue in one sense that they should be identical because if you're planning your system over a whole year, so they're averaging those strictly off-peak prices as running costs, and if you schedule correctly, you know, and sort of smooth in your hydraulic and everything like that, then, you know, it's running slightly over 1¢ per kilowatt-hour to get it down to that voltage.

Now, at this point, all I've done is talked about the energy costs that are associated with, in other words, the strictly variable costs that are associated with consuming electricity. But, of course, there are those capital costs that are out there, and the other half of the story last week is that marginal-cost pricing says that certain types of consumption are sending the signal back to the system, you need to be a larger signal—you need to be a larger system. That is, if somebody is coming onto the system at the point where you are already reasonably near full capacity, in other words, already up at one of these fairly high levels, and he keeps, you know, demanding more and more electricity at that time, it's going to cause you to build a bigger system eventually. And so that's a cost of the system, and so the system wants to send a signal back. No, wait a minute, that's going to cost me something. You sure you want it? So, you've got to get some variation in the price that reflects that sort of thing.

But the way the French choose to handle the fact that consuming a lot of electricity at some times of the day is different, or recover the capital costs, is that they let people subscribe to capacity in advance, and you have to sign a contract, and it's a contract you can't back out of. And again, I'm talking about the high-voltage and the very high-voltage customers at the moment. And, so, instead of that single, general tariff that I just showed you for these medium-voltage customers, which had 6.24 and 3.25, and so forth, cents per kilowatt-hour, we then have to look at what they charge per kilowatt per year. And this is the way, as I said, they choose to recover their capital costs. And as soon as you do that, you have to look at something like—some of the characteristics of the customer's demand; the way he imposes costs on the system. Well, for your average customer who is sort of an average, medium, or low-voltage customer with his varying time pattern on the system, they figure out that averages something like $27 per kilowatt per year of subscribed capacity. And so we're going to record the fact that, how many you consume, and as long as you don't go over $27 times how many you signed up for, that's fine, if you go over, we're going to charge you a surcharge for not having contracted for enough in advance.

But other customers may have a somewhat different load pattern, for instance, they may be the kinds of customers Mr. Call was describing who run their plant at virtually constant rate throughout a 24-hour cycle. And that's going to essentially impose all sorts of costs on the system. In the first place, you've got to make sure you've got transformers and things like that that are sized to him. Because, there's no question that he's ever going to consume less and you can sort of
average him in with other people--he's already up there at a very high-load factor. Furthermore, it's absolutely certain that if he's consuming over a 24-hour cycle, that you basically have to build as many kilowatts back at the generating station as he is consuming. But there's a nice thing about it--if you know he's got that sort of a pattern of demand, you can build your most efficient type plant, because you know you get to run it on a 24-hour cycle. So, you've got a higher charge per kilowatt-hour, per kilowatt of subscribed capacity because he is imposing, for certain, some additional capacity constraints on the system. But, he is really allowing him to produce the less expensive sort of electricity, so for what they call a make-up tariff, the charge per kilowatt-hour consumed is somewhat lower reflecting those costs and all costs in each one of the time periods we're talking about. Now much of the difference you notice when we're in the slack, slack period, and this makes very good intuitive sense. Remember, we defined the slack period as being the one in which no customer really was imposing any capacity constraints on the system, well, there shouldn't be much difference from the average customer than this guy who's got a 24-hour load pattern, and so in the truly off period, we find them being charged virtually the same thing per kilowatt-hour, although you're charging them a different amount of the fixed subscription basis.

ADAMS: Jan, what type of kilowatts are these? Is that the customer's maximum demand, or is it his demand during a specified period?

ACTON: No, it's the maximum rate at which he will consume during the entire year. In other words, it's an individual, noncoincident peak concept.

ADAMS: Without regard to one of the currents.

ACTON: That's right. You're forcing me to draw one of my important conclusions about the French system and that was that in drawing this compromise between the pure theory of marginal-cost pricing and something that is implementable, they chose at the medium voltage, or medium tension they call it, to make it a noncoincident peak-type charge, as far as this capacity notion is. So they departed from the pure notion of marginal-cost pricing in that sense. Or let me make the sense very clear. Some of these guys--let's go back to our general customer here--might care to consume more electricity say at midnight; they can fiddle around with their production process, or they could put storage electric heating in, or a whole variety of things like that, and from the system's point of view, we decided that having another kilowatt-hour consumed at midnight doesn't impose any capital constraints on it. But, if by considering enough at midnight, he goes over his subscribed rate, he all of a sudden starts paying $27.35 for every one of those kilowatts that he goes over, well, that's a disjunction between the system and the individual at this point; they're not truly reflecting the total cost back and forth to them. And so, they have available to all customers, but the only ones for whom it's financially worth doing it are the very--the 600 largest who take electricity off of their system at
220 kilovolts or 150 kilovolts, which is extraordinarily high voltage. Those people subscribe to capacity in each of these five time periods we’re talking about. And what you find is that people doing exactly what you would expect good sensible businessmen to do; they subscribe—they figure out what is the absolute minimum they can get away with on peak, and they only subscribe to enough of that. They subscribe to somewhat more on the average in this high period and they subscribe to noticeably more in the slack period, both summer and winter, and the average figures for the system, you’ll see, just go up as you get into these less expensive periods because they charge, you know, the tariff for these 600 largest, or the 600 largest who take advantage of it, charges less for capacity on peak than capacity that is intermediate and/or strictly off peak.

Now, of course, the high-load factor is only one part of the picture. There are other—there’s the average guy we called on the general rate and there’s people on the high-load-factor tariff, but there are other people who come on the system just in short bursts. (Fig. 18) Now, they do different things to your system than either of these two that we’ve talked about so far. The guys that come onto the system in short bursts, if you have enough of them to average out, don’t—only sort of in an expected value sense put a little more demand on the system that you need; in other words, more capacity that you need out there, because you can average some of these short-utilization guys together with maybe a mild winter day and a whole variety of things like that. So, the capacity costs, or the capital expansion costs that they impose on the system are somewhat less. On the other hand, when they come on, you’ve all of a sudden got to look around for your next most efficient plant, but the one you’re not using, so you know it’s higher—it’s more expensive than average. So, you charge him that per average—per kilowatt-hour he consumes. So your short-utilization customer gets away with a lower capital cost, but he pays for it on a per kilowatt-hour basis more, and again we’re reflecting some marginal-cost differences here, and reflected throughout the system—throughout the rate schedule, except again as you notice, if it’s a short-utilization customer in the middle of the night, you know, why charge him very much? And they don’t.

And we have, finally, emergency tariffs which is just sort of a somewhat more extreme version of the short-utilization tariffs. I didn’t get a precise description from them of who all is on this. My impression is that people who essentially generate their own electricity, and the people who generate their own electricity are only going to call upon the French system for electricity when their equipment breaks down. In general, the law of averages says, “That’s going to be one at one of your most expensive times to generate electricity”. So we impose a somewhat higher capital cost on them, and this same much higher charge per kilowatt-hour.

Now, so far they didn’t—I want to discuss both what is and is not sort of a very conscious and a very close following of the major principles of marginal-cost pricing as we’ve indicated them so far. In the first place, they’ve got flat charges during what they define as homogeneous periods of demand. It really doesn’t make any difference whether this guy’s consuming a few hundred kilowatt-hours per month or
### Optional Medium Voltage Tariffs

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Figure 18
whether he's consuming thousands per month. From their point of view as long you paid that capacity to serve you, this is your charge per additional kilowatt-hour and that's what it saves you if you cut back a little bit. This sort of fills some of the gap that Mr. Call was talking about where customers can't understand if they cut back, they're paying higher on the average. If you cut back here, you can see very clearly what the saving is.

The straight two-way communication between the customer and the system -- if I cut back on my utilization, you give me back on my bill what you saved in energy costs. Obviously, it didn't save you anything in capacity costs because I subscribed to it in advance and you had to make sure it was there. On the other hand, I did save you all your energy costs, and therefore I want it back. So they're true in that sense of flat rates and on the marginal cost and also since one of the other components of cost were these voltage-related costs and the system-expansion costs, they charge on a per-unit basis as they can calculate them as being true marginal cost for different types of consumption and at different voltages, we have the very high, or the high, and the very high-voltage tariffs and we have, you know, the lower-voltage tariffs which have characteristics in general similar to what I've indicated here.

But, they weren't fully paid for, and Mr. Adams put his finger right on it. By not taking account strictly of the fact that in some sense of the word, and even in the sense of the word in which they use it many times, these guys out in slack consumption aren't really imposing much in the way at all of additional capital burden on the system. They still are making it an individual demand-related tariff or a noncoincident demand in the language that American utility rate structures are described.

CALL: Jan, can I ask you a question? Are the marginal costs you speak of the French have used, do they fall into what you call the long or are they--

ACTON: Yes. They revised their tariff--again, if you think about the comments before implementation criteria that I indicated at the beginning, they strive for stability in tariffs; they strive for them to be understandable to their customers, and so they don't revise them super-frequently. But, and to my knowledge, they have basically averaged about once every 10 years on their revision so far except that they have had a sufficient shakeup in their cost structure with the oil embargo which came just after a major revision, that they're going to have to do it again right away. What they were doing was trying to plan a basic structure of tariff that they could post, so it would be good for about a 10-year period. Now, they knew their energy charges were going to go up somewhat each year, so they knew these were going to go up, but the basic nature of them are predictable and the basic nature of these capital charges were predictable. And the way they actually implemented it was to do some cost forecasting halfway through the system, that is five years into the implementation period if they plan to have this basic tariff in effect for a ten-year period. And they tried to
ACTON: estimate marginal costs five years forward, and then folded those into the current rate structure, discounted a little bit for inflation, so that you could move smoothly up through that five-year predicted point, and about ten years later be sufficiently out of whack that you had to do it again.

ADAMS: We had a demonstration from General Electric Company a few days ago on metering, and it seems that they now have available a meter which will measure not only the kilowatt-hours in a specified time of day, but the maximum demand that occurs in that period also. For two or three different period---designated periods throughout the day. In other words---

ACTON: I see, so this essentially amounts to being a means; I guess it's a measuring kilowatts in different time segments during the day---maximum kilowatts.

ADAMS: And, that's right, and they cost $180 apiece right now.

ACTON: How much?

ADAMS: $180 apiece.

ACTON: The fourth point in implementation is always to remember the cost of implementation, but at the same time as you say cost, remember the savings that are associated with it. That's where the calculation comes in.

Now, let me get down to the residential tariff and just describe it very quickly in verbal terms. It turned out that the medium-voltage tension was, or medium-voltage service was the richest to describe in terms of showing variation both in patterns of demand and flat rates and so forth. They build up the marginal cost on the average for these residential customers exactly as I indicated in that stylized version of a utility, and then they offer a residential customer the option of either paying on a flat per kilowatt-hour basis or having a peak/off-peak differential. He pays a little more per month if he has the peak/off-peak meter because it costs a little bit more. I'm sorry I can't tell you precisely because I couldn't find it in any of my notes, but I believe the daytime charge is the same, no matter which tariff you're on.

Basically what that two-part tariff gets you is an off-peak discount for the residential sector. That's not, again, strictly faithful to the notion that we've described but you know, it's a compromise of complexity and metering costs and a variety of other things that they've decided. They also recover these costs that are imposed on the system for more generating capacity and distribution system, they recover them by the same basic principle that we see here in the notion of a contracted maximum kw's that the customer will draw on the system.
The way they implement it is an extremely simple inexpensive way to do it. They just essentially let you buy circuit breakers at different rated capacities. You want to buy a 3--I'm not an engineer, so I won't get the units right--3 amp circuit breaker, you pay so many francs per month, and if you want to buy 6 amps you buy a bigger one. It makes no difference in your cost per kilowatt-hour; you have just subscribed to a larger capacity, and if you exceed 6 amps, or whatever, it does exactly what your circuit breaker does now, it stops you. You have to go out and you have to reset it--turn one of your appliances off because you've exceeded 6 amps.

Let me describe very quickly, again in verbal terms what the United Kingdom does because that's the other European country that's done the most with implementing these types of marginal-cost pricing principles that we've described so far.

Basically, in a broad stroke that the British might stiffen their lip at, they do the same sorts of things that the French do. That is, that they've got time variation in their tariffs, people subscribe, and they attempt to calculate marginal cost at the highest voltage and the next lower-voltage levels, and at the level of residences, they make it optional whether you have a flat per kilowatt-hour charge or whether you have a peak/off-peak kilowatt-hour charge.

The interesting variation that the British implemented for some of their largest customers is the so-called "yellow" tariff, and the yellow tariff fills one of these gaps that we had in the discussion of the French tariff that I didn't really call your attention to. And that is that we defined area--or times of the day and times of the year that we called, sort of high season and low season, or you know, high or peak hours and non-peak hours. And that means that on the average, it comes in those hours, or you better define these days of the winter as being high-risk days or you're going to miss the winter peak. But, from the system's point of view, some days are high-demand days and some are not. You have a mild weather day even if it's in the summer and you don't turn on that much air conditioning in Los Angeles and the system really doesn't go up to a high level of generation, but, some of the hot Santa Ana-type days, and you really are up there.

And so one of the notions if you can implement what will be a more complex tariff is to try to charge only that very highest rate on the days when it really costs you the very most to generate your electricity, or on those days when you really are pushing right against your total physical plant capacity. And they do this by offering an optional tariff to their largest industrial customers of the following kinds. You have some tariffs that faces you under most circumstances; however, we know when we get the 5 p.m. weather forecast that sometimes the next day is going to be one of those cold ones--again in Britain--when people are really going to be heating and everybody's going to be lighting their business establishments and a whole variety of things like that, and we're going to be right up against capacity sometime tomorrow. And, therefore, on very short notice tomorrow, I'm going to turn on a light at your factory. You can go right ahead and continue consuming electricity if you want, but you're going to pay one bloody lot more for
(Contd.)

ACTON: your electricity if you keep doing it. However, if we advise you as soon as the light comes on, then people do it, to start dropping a lot of your individual load, then you're at a reasonably low charge per kilowatt-hour. Now, this won't last for more than 2 hours at any one time; I may do it more than once in a given day though, if you're really at capacity all day. I won't do it to you more than 50 times for a year. And, as a result, you know they get a different tariff, and I don't know all the details of what the monthly charges are, and what the cost per kilowatt-hour.

But the point is, they pay a substantial economic penalty for every kilowatt-hour they consume during the period of time, that figuratively speaking, the yellow light's on, and they have about 50 customers who have signed up for this. And the system works well enough, relies upon that good old reliable U.S. telephone, or that United Kingdom telephone. It works well enough that by placing 50 of those phone calls, the night before when they need to they can drop 2-1/2 percent off their entire system load by just calling 50 people or flipping their yellow light on. And that's a significant savings at those few times when you really are right up in what I have indicated here is the dark red area. When you're getting right up near your peak of your system, you either physically don't have it or you're going to have to generate your electricity with your clunkiest old unit that's most expensive to generate by. And the alternative is to have those customers just drop some of their load for a little while.

ADAMS: But, there are certain production processes, the electrochemical, and the air-reduction, that they just can't interrupt the process in this way without disaster.

ACTON: Well, nobody forces them to take this. It's an entirely voluntary tariff. There are a number of production processes that seem to take enormous advantage of it. For instance, your big electric heaters that are associated with iron smelting, maybe. You don't suffer much at all by just turning off the electricity for them, and the thing cools down very slowly; and within a couple of hours, they can flip it back on or really charge up like mad overnight.

It turns out, I'm informed by Ralph Turvey, that one of the most enthusiastic implementers of it though is the British equivalent of Linde Gas, who has what we think is a continuous process, and can't turn the machines off. But they are enthusiastic implementers of the yellow tariff in Britain. If anybody here is from Linde Gas, and they want to add a demurrer.
ACTON: Alright, I can go ahead and deliver the punchline that I should have given at the end of the French description in the first place. (Figure 19) If we go back to 1952, which was prior to the implementation of the--their time-related tariff, and plot our now-familiar system load curve, where we go from midnight through 6 a.m., mid--noon, 6 p.m. and midnight again, and normalize again our system load curve, so that one equals the average number of kilowatts produced over a 24-hour cycle, and this means that roughly at 3 in the morning they were producing something like half of the average and at about 9 in the morning they were producing close to 1.4 times the average. We see the 24-hour cycle plotted here in green and, as I said, it indicates more than a two-to-one difference between their slack or their valley and their system peak which at that time was occurring between seven and nine o'clock. That's why they set up those to be the peak hours. If we go to 1975, what the system's like today, and I'll just assert that the intervening points lie between them and they do--I just want to keep this uncluttered--we find that the system moved to a much flatter load curve; that is, that it's able to use a greater proportion of base-type plants, which are the more efficient per kilowatt-hour to generate and so instead of being six-tenths of the average consumption at night, we're more like eight-tenths of the average consumption at night and the peak value that we observe is a little over, well, it's about 13 percent above the average as opposed to 35 percent above the average that was previously observed. These are the sorts of things that as the system evolves through time let's you--lets you substitute the more efficient plans for your less efficient cycling or peaking-type plans.

GLAZER: As you're going toward that, perhaps you can answer another question as to what extent you can identify the rate structure as a determinate of that flattening as opposed to some other kind of social change like everybody--for some completely extraneous reason, deciding that getting television sets between 1975 and 52 and turning them on in the late evening--

ACTON: The late hours would help them with the load--

GLAZER: Yes.

ACTON: That's a very good question and the answer to it is that I can't--I haven't gone through enough of their data. I've seen some of their--well, one very gross piece of evidence that says that it's certainly the tariff that's doing it rather than anything else is that if you saw a sharp break in 1958 when they introduced it. The other piece of evidence which is perhaps another one of the least controversial pieces of evidence of the effect of the tariff has to do when they switched from the summer rate to the winter rate. Remember we have these price differentials. I should have brought all my slides up. We have these price differentials so that as soon as you go to what they call the winter season during that shaded period in the center, we now charge more, and literally on November 1, you can see--the first Monday in November, you can see a sharp drop from what it is on Octo--
Let's make November 1 a Thursday. Thursday, November 1, just looks different than Wednesday, October 31st, and to the tune of about 750 megawatts on a 20,000 megawatt system. If I did those num--If I remember my numbers was that--that implied something like 20 percent--20 percent drop in the peak the day--the day you go into the winter rate. Now, they certainly didn't change their viewing habits that month. Now, let me go to Mr. Call's request which was to try to overlay these things and I don't know whether I've succeeded--that's getting a little--As you can tell, I put my colors on different--

Call: Now I can make my point that I thought I could make.
ACTON: Okay. If you take--if you take the heaviest black line--that is, the heaviest black line is January, the red line is the--well, it's an average month of January. Now we have--what we have is the peak hours. The shaded area is the high hours and then the unshaded area is the totally off-peak hours.

CALL: One of the--one of the things that--again, I'd like to make a disclaimer Dr. Acton made and that is what I say doesn't reflect anything that I believe necessarily--in this--in this place anyway. One of the things you worry about--is you start to work with putting together the studies that we're putting together on peak-load pricing--is the possibility that if you assign a high cost to a peak period, that high cost will in fact influence people to move off that peak period. If I'm not misreading the graph, and remembering that Dr. Acton said that the French change their tariffs about every ten years, that high cost relates to the peak in terms of the green on the chart which is the old peak, and the new peak is outside--the new morning peak is outside of the high-cost period as is the new evening peak.

ACTON: Yes. You're absolutely right.

CALL: So, you've created new peaks and in defining our peak hours that we're working with, we're worrying about this and making sure we define them across a range that is not only the peak that is actually now occurring but the period in which the peak could shift to.

ACTON: Mr. Call's point is extraordinarily well taken. Now, the point that didn't--I didn't get across because I forgot to put the slide up in the first place. As you can see, they define the peak exactly on that green thing, and one of the features of their system is that they implement a time-of-day tariff (and note that you can implement more than one way) but they choose to implement many of their--the tariffs--many of their customers with an internal time clock. Now, that means that it switches so that it accumulates in the high register at these hours during those months, and so forth, and it requires a manual resetting of thousands and hundreds of thousands of meters that they want to move over in price at what is the new peak and that--that causes them to be sluggish and not as flexible and not as adaptable as they would be if they wanted to truly track system cost. Now, it's certainly true--I think it's certainly true that if you eliminated this as a peak period, just went back and called this--this all-high with no peak charges, I think you'd probably go back to seeing a peak coming earlier in the day. This is strictly responding to exactly the hours seven to nine that they call higher rate. It's one of the important considerations, I think, if the Department thinks about going into one of these types of tariffs that they build into the system flexibility at the beginning, and I don't know whether you want to do it tonight or next week or never to talk about a few of the technical means of implementation, but one comment I'll make right now is that instead of internal time clock, you can have meters switched to different accumulators, in a sense, different registers by remote signal. It can be either radio
(Contd.)

ACTON: or it can be over the line. In other words, the system provides the clock instead of an internal unit providing the clock; gets over the problem of having any system outages which just might cause a clock to go out and also lets you move over the years with your tariff system very inexpensively. It's more expensive to put in at the beginning.

ADAMS: Jan, can I comment on that a minute? The green curve is a terrible load curve. They had a lot of room for improvement there. Now our present curve is better than the one you have there finally. If you were to imagine a curve that was absolutely flat from 6 p.m. till 10 p.m., what else can you do to encourage people to use energy at 2 o'clock in the morning? In other words, you reach a point of no return of economics where you can't get back what you put into it.

ACTON: Well I—you know the data better than I do, but one of the things I thought I remembered from the early load curves that we had up for the Department showed the difference between the valley and the peak was a factor of about 2 to 1. That's something like what the ratio of the valley to the peak used to be in EDF, but it's not what it is now.

ADAMS: Our present load curve—I'd say—I would consider—I think it's probably a better load factor than the red one you have there, and there is some room for improvement, naturally, but I say you do come to a point to where you have to consider what you put into the cost benefit—the relationship there.

ACTON: Let me stop that discussion at this point and open it up to a general set of questions, which I think have been accumulating for all three speakers. But, the point I wish to emphasize in all of this is that you make practical compromises in going from the strict notion of changing the margin, or having the marginal cost change minute by minute, to having some reasonably sensible, understandable stable tariff. But, this has been done, it's been found acceptable to customers, and it's been found administratively feasible and adaptable over a number of years of experience in a number of major European countries, not just France and Britain.

And, the specific form of the tariff, the number of customers who will choose to go on one or another of optional tariffs and the overall system costs, of course, depends heavily on the system you're talking about. But the principle, at least, seems to be a feasible one where it's been tried.
DISCUSSION

SHAPIRO: My name is Jerry Shapiro. It seems to me that an important distinction of principle is maybe neglected—being neglected in the discussion we've been having in the past few minutes that I'd like to point out in that there are fixed charges and variable charges. One of the questions really being addressed is, "How should the--" at least the way I see it is "How should the fixed charges be allocated?" And, time-of-day pricing relates those fixed charges to what people actually use and the purpose of the time-of-day metering is to see what they use at a certain time. And the principle, thus, is to charge them base—charge the fixed prices, in that case, actually the total price based on what they use and when they used it.

There's another alternative principle which I think is very—in what Dr. Acton—like some of the examples Dr. Acton gave of France and EDF, and that is where people are charged with relation to their fixed charges based on what they contract to use. And that, I think, is an important distinction because the utility, essentially when we hook up to a utility, we have some kind of a demand principle there, the utility says it will give us what the capacity of our system has at any time we choose to flick the switches; and, therefore, there's an implicit contract, I think, to deliver independent of time of day and so on. And, therefore, I think we should spend less time and less effort, especially using the simplicity in cost of administration in charging for what's actually used as compared to charging for what the utility must be prepared to deliver to a given customer. And in that regard, I wonder whether in France where you described, Dr. Acton, those circuit breakers for the residential customers, whether their fixed charges depend—included the total assigned fixed charges of the system; in other words, not only the customer charges, but assignable capital costs of the system and so on and then whether the variable charges included only the variable charges—costs of the system, and therefore, they would not even have—they would have—it seems to me, if that were so, a very simple rate structure. Namely, they'd pay a fixed cost depending on a fixed charge depending on the fixed costs and a constant energy charge depending on the variable cost. Is that something—
ACTON: That's the essence of what they tried to do. They tried in building up the energy costs merely to go through that sort of grid, the way I indicated, to keep adding up marginal cost. And when they got to this average cost of five cents a kilowatt-hour for the residential sector, that was just the energy-related costs and the costs that are associated with the generator back at the beginning that everybody shares, and then essentially the additional capacity that's involved in the distribution system and the transformation system getting both is essentially related to that subscription that they pay for their circuit breakers. So, they essentially try to break into a two-part tariff exactly as you indicate. I should put one slight qualification in this, however; many utilities, and France is one of them, don't for reasons I don't fully understand, don't decide to charge the person the full amount regardless--even the person who draws zero kilowatt-hours per month--and so they have a very high rate per kilowatt-hour for the first few kilowatts, first few kilowatt-hours, so that it amounts to basically a two-part tariff--I'll skip the graph right now--so that the first few kilowatt-hours per month per customer you pay in addition--heuristically about half of the cost of the circuit breaker as a lump sum, and half of the circuit breaker averaged over those first few kilowatt-hours. It is designed and it works so that something like 98% of the people are always consuming above the point where you switch over to strictly five cents per kilowatt-hour which reflects nothing but energy costs; so that for essentially a very high proportion of the system they're facing exactly that marginal cost that is only energy.