RESIDENTIAL DEMAND FOR ELECTRICITY AND PRICING POLICY IMPLICATIONS IN A DEVELOPING ECONOMY : THE CASE OF THE PHILIPPINES*

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Abstract

A simple model is used to estimate the short-run and long-run elasticities of demand for electricity by residential consumers in the Manila Electric Company franchise area in the Philippines. Residential demand for electricity is found to be responsive to its own price, the price of electricity consuming equipment, environmental variables and to a certain extent income. Marginal, inframarginal and average prices comprise the own price variables. A finding of positive marginal price elasticity is explained in terms of consumers' response to signals given by a structure of subsidized prices. Some pricing policy implications are derived.

I. Introduction and Organization

This paper uses a simple model to estimate both the short-run and long-run elasticities of demand for electricity in a developing economy and derives some implications for electricity pricing policy reforms. The specific characteristics of electricity as a commodity, the price at which it is sold and the way it is utilized are considered in the analysis. The demand model is tested using data from the Philippines, more specifically, the data on residential consumers of the Manila Electric Company (MERALCO), a utility which distributes electricity in the Luzon grid.[1]

The remaining portion of this paper is organized as follows. Section II describes briefly the specific features of electricity as a consumer good, the price structure at which it is usually sold and the way it is utilized. A simple diagrammatic illustration of the dynamics of demand for electricity showing short-run and long-run demand behavior is presented. A model of demand for electricity is specified taking into account the development in the literature and the nature of the data available. In Section III, the data, the empirical specification of the

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1 There are seven power grids in the Philippines and the Luzon grid accounts for approximately 80% of total electricity production and consumption. Total electricity consumption in the MERALCO franchise area accounts for approximately 60% of the total country-wide use of electricity.

demand model, and the estimates of the parameters are presented. As a form of validation, Section IV explains the results and derives some pricing policy implications. Section V summarizes the study.

II. Features of Electricity and the Demand Model

A. Supply, Demand and Price

Electricity, as it is being utilized, has two related components, power and energy, which are usually expressed in kilowatts(kw) and kilowatt-hours(kwh) respectively.[2] The quantity of power supplied is limited by the power generating capacity available and the necessary transmission and distribution facilities. The quantity of energy supplied depends on the length of time power is made available. Since electricity cannot be stored economically, it must be continually supplied to meet demand which is usually time dependent.

The demand for electricity, aside from being time dependent, is a derived demand. The use of electricity only provides utility or satisfaction via an electricity consuming equipment. In the short-run, wherein it is assumed that the stock of electricity consuming equipment is fixed, the level of demand for electricity depends on the rate of utilization of the existing stock. In the long-run, wherein the stock of electricity consuming equipment is not fixed, the demand for electricity depends on both the rate of utilization as well as the stock level.

Most electric utilities sell electricity at different prices for different levels of consumption. These consumption levels are in blocks of kw or kwh and the prices are referred to as "demand" and "energy" charges respectively. Unlike that of the commercial and industrial users, the price schedule for residential consumers usually contains only the energy charge since their power requirements are relatively small as contrasted with those of the industrial and commercial users.

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2 Technically, this characterization differentiates between power and work. From the economic viewpoint, each component corresponds to a particular type of cost, capacity and energy costs respectively.

B. A Diagrammatic Illustration of Electricity Demand

Following Taylor(1975), Figure 1 provides a diagrammatic illustration of the dynamics of electricity demand using indifference curve analysis. The horizontal axis refers to the quantity of electricity demanded per unit of time while the vertical axis refers to the bundle of all the other goods, the price of which has been conveniently assumed equal to unity. If the prices of electricity during a time period t are p_{1t}, p_{2t}, and p_{3t} for consumption levels $q_t \geq q_{1t}$, $q_{1t} < q_t \leq q_{2t}$ and $q_t > q_{2t}$ respectively, where $p_{1t} > p_{2t} > p_{3t}$, i.e., a block decreasing price schedule, then the resulting budget constraint for a given income level is shown by ABCD. The consumer's equilibrium demand is q_{*t} as indicated by his indifference curve IC^1 tangent at point T on the segment BC of his budget constraint.

Suppose q_{2t} is the maximum amount of energy which could be consumed at the existing stock level of the electricity consuming equipment.[3] In the short-run, the quantity demanded could only fall within the range 0 to q_{2t} with the corresponding range of the rate of stock utilization 0 to 1. At equilibrium demand q_{*t}, the rate of utilization of existing stock is equal to q_{*t}/q_{2t}.

In the long-run, however, the stock of electricity consuming equipment could change. Suppose, the consumer's income level increases. Assuming that relative prices do not change, this increase in income is illustrated by a shift of the budget constraint to A'B'C'D'. The new equilibrium demand is at q^*_{*L}, where L is some time periods after t. The consumer must have purchased additional stock to be able to reach this new equilinrium level of demand.

Suppose the new stock level is q_{3L}. Here, his rate of stock utilization is q^*_{*L}/q_{3L}. This implies that changes over time L in relative prices, income and other explanatory variables which determine demand could result in relatively larger changes in quantity

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3 The stock level is usually measured in power rating of kw, say s_t during period t. If t is equal to one month, then the maximum quantity of energy which could be used by the given stock approaches $730s_t$ kwh. This means that q_t is proportional to s_t assuming out non-linearities at higher rate of utilization. This simplifies the representation of the concept of rate of utilization of the stock of electricity consuming equipment.

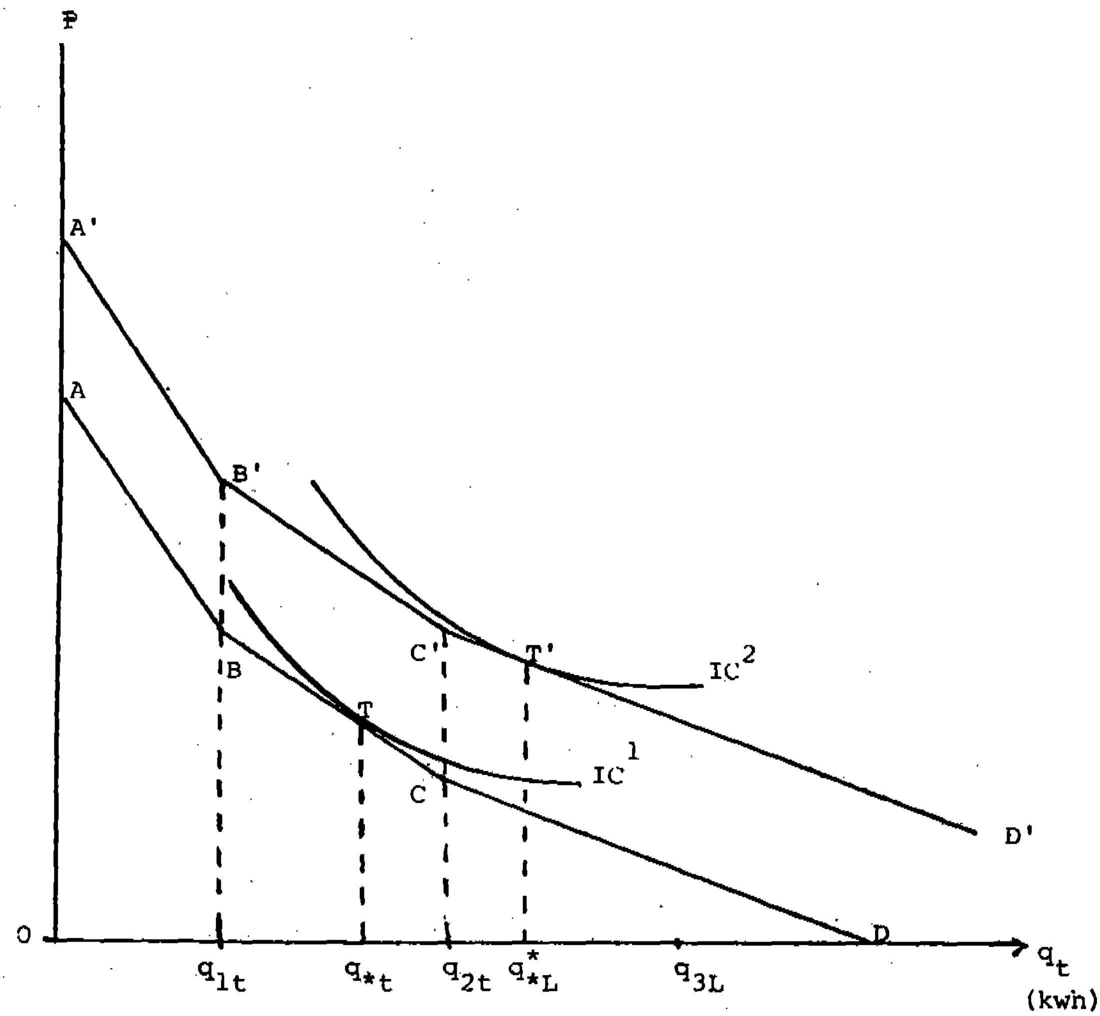

Figure 1

Indifference Curve Analysis of
Consumer Demand for Electricity

demanded than over time t. This is true because aside from $q^*_{*L} > q_{*t}$, both the direct and indirect effects of these changes in prices, income and other explanatory variables could have been realized over a longer period L. Thus, on the average, it is expected that long-run price and income elasticities are larger in magnitude than short-run elasticities.

Now, suppose that an increase in income results in the shift of the budget constraint to A'B'C'D' but the consumer stock level allows him only to consume q_{2t} kwh of electricity, i.e., he did not make any addition to his stock of electricity consuming equipment. Then, he may have to spend a part of that income to purchase additional electrical appliances and he will be at a lower utility level. Thus, it is evident that the price of electricity consuming equipment enters into the consumer's demand function for electricity.

Moreover, the rate of utilization of the stock of electricity consuming equipment is affected by environmental variables such as temperature and humidity. For instance, in tropical and warm regions, rising temperature increases the use of refrigerators, airconditioners, electric fans and other equipment for ventilation by residential consumers. This increases the demand for electricity. Thus, environmental variables are expected to affect consumer demand for electricity and are, therefore, also included as explanatory variables.[4]

C. The Electricity Demand Model

Based on the foregoing discussion, the following demand model for electricity is postulated.

$$q_t = q_t(P_t, B_t, A_t, Z_t, Y_t) \qquad (1)$$

where,

P_t is a vector of prices of electricity at period t,

B_t is a vector of prices of substitutes for electricity,

A_t is a vector of prices of electricity consuming equipment,

Z_t is a vector of environmental variables, and

Y_t is the income variable.

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4 For some recent U.S. studies which explicitly include environmental variables, see for instance, Lilliard and Aigner(1984), Dubin(1985) and Engle, et. al.(1986).

The price vector P_t consists of the marginal and inframarginal prices of electricity. Figure 2 shows a block decreasing price schedule. Suppose the consumer is at consumption level q_*. Then, p_2, which is the price for quantity $q_1 < q \leq q_2$, is the price which is marginal to the consumer, p_1 is inframarginal and p_3 "superfluous". Changes in the inframarginal price results in an income effect, changes in the marginal price induces both income and substitution effects, while changes in the superfluous price has no effect on demand, hence the name.[5]

Taylor(1975) suggests that the inframarginal price could be represented by p_1, the price up to but not including the marginal block, or the total payment OCDI. Nordin(1976) argues that the price should instead be $(p_1 - p_2)$ or the total payment BCDE which will enable the consumer to purchase the desired quantity at the marginal price p_2. If the price schedule is instead block increasing, as shown in Figure 3, Taylor's inframarginal price could be represented by payment OAIH, while that of Nordin could be represented by $(p_3 - p_2)$ or payment ABJI which are negative quantities implying a net subsidy.

Nordin's definition is theoretically more appealing and his specification of the inframarginal price is used in this study.[6]

The vector B_t may include prices of firewood, liquified petroleum gas (LPG) and others which may serve as possible substitutes for electricity.

A_t is a vector of prices of electricity consuming equipment. Based on Figure 1, these equipment are a part of the bundle of other goods. Electrical appliances such as refrigerator, cooking range and television are some of the electricity consuming equipment.

Y_t represents the consumer's income. Usually, the personal disposable income is used to measure this. However, in its absence, other

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5 For added details on these observations, see Taylor(1975, 1977) and Murray, et.al.(1978).

6 Francisco(1986) made two sets of parameter estimates using Taylor's and Nordin's definitions. The results indicate that the latter's specification of the inframarginal price yields better results.

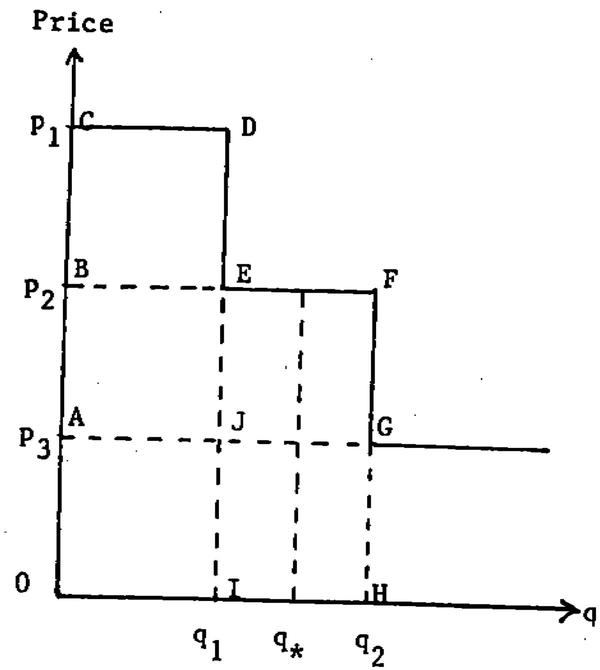

Figure 2
Block Decreasing Price Schedule

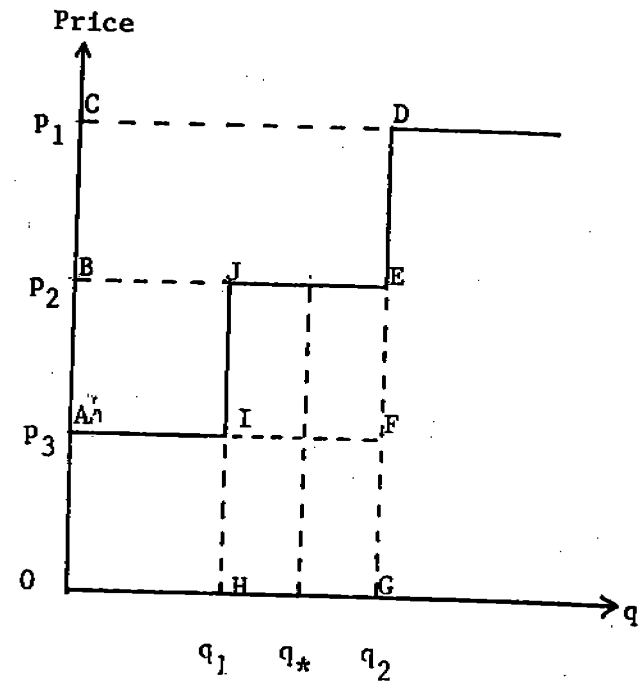

Figure 3
Block Increasing Price Schedule

income surrogates such as employment level or the gross national product (GNP) are used.

Z_t could be represented by factors such as temperature and relative humidity. The choice of which factor to use is most often dictated by data limitations, as it is the case for many of the above-described variables.

III. Data, Empirical Specification and Results

A. Data

MERALCO provided monthly data from January 1971 to December 1984 on the total number of residential customers, the total monthly kwh consumption and the total monthly revenues. Adjustments were made on monthly revenues taking into account fuel cost and other changes in the monthly bills. The rate schedules over the same period were also provided by MERALCO. Based on these rate schedules, the monthly marginal and inframarginal prices were calculated. The monthly average per capita kwh consumption, which is computed from the total number of customers and total kwh data, is used to determine which price on the price schedule is marginal. The inframarginal prices were computed based on Nordin's (1976) definition.

Monthly data on the index price of LPG, firewood, flat iron and refrigerator are taken from the National Census and Statistics Office (NCSO). LPG and firewood are used to represent the possible substitutes for electricity. Flat iron and refrigerator represent the electricity consuming equipment.

No comparable monthly data are available on per capita personal disposable income. Instead, the level of employment is used as income surrogate. Quarterly employment data from NCSO were interpolated to get the corresponding monthly employment levels.

Monthly maximum temperature and relative humidity data were provided by the Philippine Atmospheric, Geophysical and Astronomical Administration (PAGASA). These represent the environmental variables.

The dependent variable is in per capita kwh per month. The price of electricity is deflated using the price index for fuel, light and water with 1978 as the base year.[7] The price indices of substitutes for electricity and electricity consuming equipment have the same base year.

B. Empirical Specification

Assume that (1) takes a double logarithmic functional form. More specifically,

$$\ln q_t = a + b_i \sum_i \ln P_{it} + c_j \sum_j \ln B_{jt} + d_k \sum_k \ln A_{kt} + e_m \sum_m \ln Z_{mt} + f \ln Y_t + u_t \quad (2)$$

where a, b_i, c_j, d_k, e_m and f are the parameters to be estimated and u_t is the error term which is assumed to represent identically distributed independent random variables for all t with mean 0 and variance σ_u^2.

The problem of simultaneity and identification, as recognized by Halvorsen(1975) and Taylor(1975), arising from the price being a function of quantity, could be minimized if the price is based on the rate schedule which is exogeneously determined by the utility which is in turn usually under a strong regulatory environment. Moreover, the price schedules are both block decreasing and block increasing with significant number of blocks having practically the same price. This further reduces the possible effects of this potential problem.

Equation (2) does not explicitly consider consumers' stock adjustment behavior. However, as stated earlier, the price of electricity consuming equipment is included to help overcome this deficiency. Besides, there is no data available on stock of electricity consuming equipment. It is possible, however, to overcome this data limitation by using lagged dependent variable. However, this usually leads to autocorrelation and other econometric problems.[8]

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7 The price index for fuel, light and water closely approximates the Consumer Price Index (CPI) except for the last few years of the sample period. The former is used to be able to make more meaningful comparison in a related study (Francisco, 1986) of residential demand responses with that of commercial and industrial consumers. However, using the CPI as deflator yields similar test results.

8 For a discussion of the various demand specifications for electricity and the associated econometric problems, see Bohi(1981, chapter 2 and 3).

Equation (2) could be used to estimate both short-run and long-run demand elasticities by making the necessary assumption on the time period t. Suppose t is one month. For residential consumers, it is reasonable to assume that one month is too short a period for consumers to adjust their stock of electricity consuming equipment, i.e., the stock level is fixed within a one-month period. On the other hand, suppose t is one year. It is possible that within one year, consumers can fully adjust to their desired stock levels and the indirect effects of changes in the other variables could have been fully realized. Thus, using monthly and annual data could perhaps provide adequate estimates of short-run and long-run demand elasticities respectively.[9] With data available for 168 months, this procedure can be implemented.

C. Results

1. Short-Run Elasticities: Monthly Data(January 1971 to November 1984)

The estimated residential demand model based on (2) using monthly data is shown below. The coefficients of the explanatory variables serve as estimates of their short-run elasticities of demand.

$$
\begin{aligned}
\ln q_t = \underset{(0.7822)}{3.0326} &+ \underset{(4.7027)}{0.0893} \ln P_1 - \underset{(-0.6364)}{0.0385} \ln P_2 \\
&+ \underset{(1.1104)}{0.0939} \ln B_1 - \underset{(-0.1442)}{0.0073} \ln B_2 \\
&- \underset{(-0.8943)}{0.0640} \ln A_1 - \underset{(-1.8495)}{0.2272} \ln A_2 \\
&+ \underset{(3.1278)}{0.3900} \ln Z_1 + \underset{(1.9488)}{0.1893} \ln Z_2 \\
&+ \underset{(0.6011)}{0.1930} \ln Y, \qquad (3)
\end{aligned}
$$

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9 This implicitly assumes that the time period captured by the data coincides with the timing of consumers' decisions on stock adjustments which is not observable. Moreover, some consumers might be able to adjust their stock levels in a period of one month while others may not be able to adjust in a period of one year. This could have effects on the magnitudes of the parameter estimates. For further discussion on this, see Francisco(1986, chapter 6) where a dynamic reformulation of (2) is used to interpret the results. Suffice it is to say here that the characterization of one month and one year as short-run and long-run respectively is only an approximation of an underlying unobservable phenomenon.

$R^2 = 0.6620$, $\bar{R}^2 = 0.6425$, S.E.E. = 0.0603, D.W. = 1.8289.

The figures in the parenthesis are the t ratios and where,

P_1 and P_2 are the marginal and inframarginal prices respectively,

B_1 and B_2 are the prices of LPG and firewood,

A_1 and A_2 are the prices of flat iron and refrigerator,

Z_1 and Z_2 are the average monthly maximum temperature and relative humidity, and

Y is the income variable represented by employment level as an income surrogate.[10]

The price elasticity of P_1 is positive and significantly different from zero while that of P_2 is insignificant but with the correct sign. Both possible substitutes for electricity are insignificant but with positive and negative signs for B_1 and B_2 respectively. The signs of A_1 and A_2 match a priori expectations but only the price of refrigerator (A_2) is significant. The coefficients of Z_1 and Z_2 are with the expected sign and both are significant. Employment level has the correct sign but insignificant. [11]

The finding of a positive marginal price elasticity requires verification. The ex post average price is therefore introduced as an additional price variable. Since the price schedules over the sample period are both block decreasing and block increasing as well as relatively flat for some block levels, the problems of simultaneity and identification, as pointed out earlier, could be minimal. Also, the ex post average price has the advantage of being independent of the marginal and inframarginal prices. Moreover, the recent study of Jeong-Shik Shin(1985) indicates that residential electricity consumers may take into account in their demand behavior the cost-benefit considerations of getting additional information based on the published price schedules. Otherwise, if the cost of additional information does not justify the benefits, their demand behavior could be based on a

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10 To be able to use (2) in the test, the origin is shifted for the computed data series of inframarginal prices which for some periods are negative for a block increasing price based on Nordin's(1976) definition. This introduces a specification bias on the intercept but not on the explanatory variables as long as the orthogonality conditions among these variables are met. Care should therefore be taken in looking at the estimated values of the intercept. However, our primary concern here are the parameter estimates of the explanatory variables. Estimates using Taylor's(1975) definition, which do not require this procedure, are comparable with the results here except for the values of the intercept and the coefficient of the inframarginal price.

11 The level of statistical significance used is at least 10% using a two-tailed t test.

notion of an average price. The ex post average price could serve as an adequate measure of this consumer's notion of the average price.

Also, the significant finding on the environmental variables provide the clue to include the price of electricity consuming equipment used for cooling and ventilation such as airconditioner and electric fans. Since an airconditioner consumes relatively more electricity than an electric fan, the former is used. The results are presented below.

$$\begin{aligned}\ln q_t = {} & \underset{(0.9293)}{3.3913} + \underset{(5.1075)}{0.0989} \ln P_1 - \underset{(-1.4948)}{0.0852} \ln P_2 + \underset{(1.5524)}{0.0881} \ln P_3 \\ & + \underset{(1.5508)}{0.1217} \ln B_1 + \underset{(0.6960)}{0.0349} \ln B_2 \\ & - \underset{(-0.9291)}{0.0646} \ln A_1 - \underset{(-1.9087)}{0.2264} \ln A_2 - \underset{(-3.3046)}{0.2974} \ln A_3 \\ & + \underset{(3.0850)}{0.3771} \ln Z_1 + \underset{(1.9173)}{0.1821} \ln Z_2 + \underset{(1.3288)}{0.4034} \ln Y, \qquad (4)\end{aligned}$$

$$R^2 = 0.6870,\ \bar{R}^2 = 0.6647,\ \text{S.E.E.} = 0.0584,\ \text{D.W.} = 1.8441,$$

where P_3 is the ex post average price of electricity and A_3 is the price of airconditioner.

For the price variables, the results are similar to those of the previous test results except that the t ratio of P_2 increased in magnitude but still insignificant. P_3, the ex post average price variable, has a coefficient with positive sign and insignificant but with a t ratio of 1.5524. This provides some level of confirmation for the positive elasticity of demand for P_1. Further explanation for this perverse result is necessary. This will be done in the next section.

The coefficients of B_1 and B_2 are still insignificant but now both have positive sign. The coefficient of the price of airconditioner is negative and significant as expected while the signs and magnitudes of A_1 and A_2 did not change from previous estimated values. Also, the results for Z_1 and Z_2 are the same as before. The income variable Y is still insignificant but the t ratio increased.

2. Long-Run Elasticities: Annual Data (1971-1984)

Using annual data, the estimated residential demand model is shown below. Due to the number of degrees of freedom consideration in the statistical analysis, only one variable each for B_t, A_t and Z_t is included. These are B_1, A_3 and Z_1 respectively.

$$\ln q_t = \underset{(-0.7967)}{-5.6962} + \underset{(2.0724)}{0.1990} \ln P_1 - \underset{(-1.4829)}{0.0592} \ln P_2 - \underset{(-3.7049)}{0.4646} \ln P_3$$

$$+ \underset{(0.9302)}{0.1855} \ln B_1$$

$$+ \underset{(0.6325)}{0.0749} \ln A_3$$

$$+ \underset{(0.4940)}{0.2526} \ln Z_1$$

$$+ \underset{(1.4460)}{0.6568} \ln Y$$

$$R^2 = 0.9111,\ \bar{R}^2 = 0.8070,\ \text{S.E.E.} = 0.0321,\ \text{D.W.} = 2.8622.$$

The signs of the estimated coefficients of P_1 and P_2 are the same with those using monthly data. The magnitude of the coefficient of P_1 is twice as much as that of the estimate using monthly data and is still significant. The income variable Y is still insignificant but the value of the coefficient increased by 70% and the t ratio also increased. P_3 is significant and with the correct sign and the magnitude of the coefficient dramatically increased. The price of LPG (B_1) and airconditioner (A_3) as well as maximum temperature (Z_1) are all insignificant using annual data.

IV. Explaining the Results: Some Pricing Policy Implications

This section provides interpretation and explanation of the preceding results especially on the finding of positive marginal price elasticities for both tests using monthly and annual data. The attempt to explain this perverse result looks into the evolution of the structure of the rate schedules and the responses of residential demand for electricity given the nature of the price signals. The implications for pricing policy are thereafter presented.

A. The Evolution of the MERALCO Rate Schedule

Over the 15-year period covered by the data, there were five basic rate schedule changes made by MERALCO. Table 1 summarizes these rate schedules at various block levels. These basic rate schedules exclude price adjustments due to exchange rate fluctuations, changes in fuel and steam costs and other adjustments. The average price adjustments, though observed to be minimal, have been included in the calculation of the *ex post* average prices. The minimum payment for consumption at the initial block (usually the first 10 kwh) is converted to the corresponding average price by dividing the minimum monthly bill by the block length. Table 1 also shows the indexed price where the price of the first block is set equal to unity. This shows the relative price of electricity at various block levels and also indicates whether the price schedule is block decreasing, block increasing, flat or a combination of all types. Figure 4 graphically shows the evolution of the MERALCO residential basic rate schedules.[12]

Three sets of related observations are evident from Figure 4. First, the basic structure of the rate schedules is both block decreasing and block increasing exhibiting a "V-type" form where the base of the V occurs somewhere at the 100-120 kwh block. This is particularly evident for the rate schedules of May 1970, October 1972 and September 1974. Second, the rate schedules evolved from a basically block decreasing to a block increasing structure with the price of the 0 to 200 kwh block becoming practically "flat" over the years. Finally, the real price of electricity has been declining over the last 15 years especially for blocks of consumption up to 200 kwh per month.

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[12] It is noted that the data used is only up to November 1984. This is to preclude the possible effects of outlayers which could arise from the December 1984 rate schedule change.

Table 1

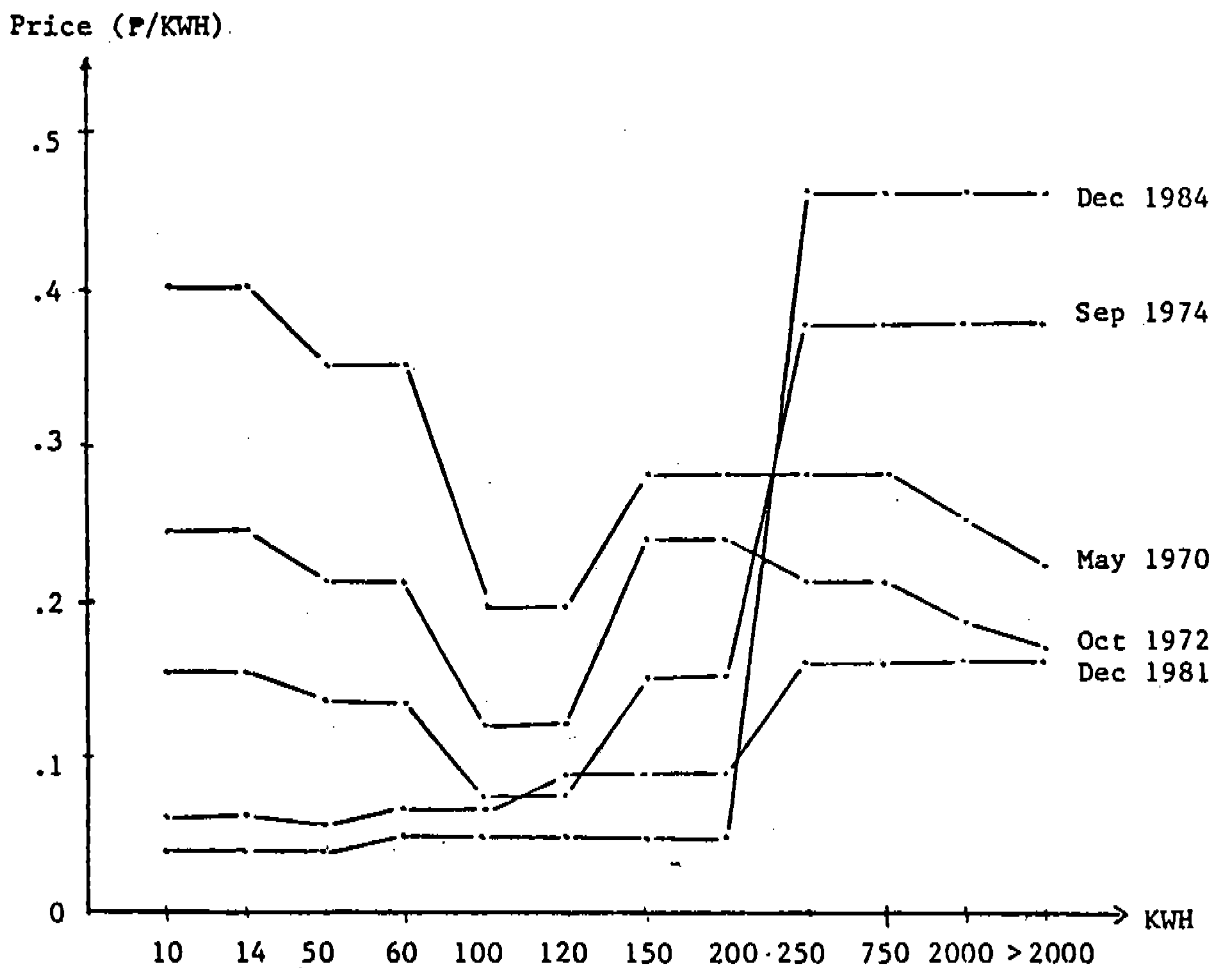
AVERAGE PRICES - MERALCO[a]
RESIDENTIAL - DEFLATED
(BASE YEAR: 1978)

KWH BLOCKS	MAY 1970 PRICE	MAY 1970 DEFLATED AP[b]	MAY 1970 INDEXED DEFLATED AP	OCT 1972 PRICE	OCT 1972 DEFLATED AP	OCT 1972 INDEXED DEFLATED AP	SEPT 1974 PRICE	SEPT 1974 DEFLATED AP	SEPT 1974 INDEXED DEFLATED AP
0-10	.1429	.4025	1	.1429	.2459	1	.1429	.1548	1
11-14	.1429	.4025	1	.1429	.2456	1	.1429	.1548	1
15-50	.125	.3522	.875	.125	.2149	875	.125	.1354	.875
51-60	.125	.3522	.875	.125	.2149	.875	.125	.1354	.875
61-100	.07	.1972	.49	.07	.1203	.49	.07	.0758	.49
101-120	.07	.1972	.49	.07	.1203	.49	.07	.0758	.49
121-150	.1	.2818	.7	.14	.2407	98	.14	.1517	.98
151-200	.1	.2818	7	.14	2407	.98	.14	.1517	.98
201-250	.1	.2818	.7	.125	.2149	875	.35	.3792	2.45
251-750	.1	.2818	.7	.125	.2149	.875	.35	.3792	2.45
751-2000	.09	.2536	.63	.11	.1891	.77	.35	.3792	2.45
>2000	.08	.2254	.56	.1	.1719	.7	.35	.3792	2.45

KWH BLOCKS	DEC 1981 PRICE	DEC 1981 DEFLATED AP	DEC 1981 INDEXED DEFLATED AP	DEC 1984 PRICE	DEC 1984 DEFLATED AP	DEC 1984 INDEXED DEFLATED AP	1970-1984 AVERAGED DEFLATED AP	1970-1984 INDEXED AVERAGED DEFLATED AP
0-10	.1429	.0639	1	.2	.0392	1	.1812	
11-14	.1429	.0639	1	.2	.0392	1	.1812	
15-50	.125	.0559	.875	.2	.0392	1	.1595	.880
51-60	.15	.0671	1.05	.25	.049	1.25	.1637	.903
61-100	.15	.0671	1.05	.25	.049	1.25	.1019	.562
101-120	.2	.0894	1.4	.25	.049	1.25	.1064	.58
121-150	.2	.0894	1.4	.25	.049	1.25	1625	.896
151-200	.2	.0894	1.4	.25	.. 49	1.25	.1625	.896
201-250	.365	.1632	2.5549	2.36	.4623	11.8	.3003	1.657
251-750	.365	.1632	2.5549	2.36	.4623	11.8	.3003	1.657
751-2000	.365	.1632	2.5549	2.36	.4623	11.8	.2895	1.597
>2000	.365	.1632	2.5549	2.36	.4623	11.8	.2804	1.547

[a] Prices are in Pesos (₱) per kilowatt-hour.

[b] "AP" means average price.



MERALCO Price Schedule By Blocks (Deflated)
Residential, May 1970-Dec 1984 (1978=100)

Figure 4

B. Consumers Demand Responses to Changes in Rate Structure

Table 2 shows the percentage breakdown by kwh blocks of the number of customers, the kwh consumption and the revenues for May 1971, May 1975, April 1980 and June 1984 based on bill frequencies of MERALCO for these period. Figure 5 shows a graph of the percentage share of kwh consumption based on Table 2. Three patterns can be discerned from Figure 5. The first is one in which there is no appreciable change in the percentage share of kwh consumption over the 15-year period. This "stable" pattern is exhibited by blocks 81-120 and 351-650 kwh. The second is a pattern of decreasing percentage share exhibited by blocks 0-10 to 51-80, 651-1050 and greater than 1050 kwh. The third pattern is an increasing percentage share of kwh consumption exhibited by blocks 121-150 and 201-350 kwh.

The pattern for the percentage shares of the number of customers closely follows the pattern for the percentage shares of the kwh consumption. These observations are summarized in Figure 6.

Frequency distributions were estimated and plotted for the percentage shares of kwh consumption, number of customers and revenues. Those for kwh consumption and the number of customers are shown in Figures 7 and 8 respectively. These figures show the structural shifts in demand.

C. Explanation for the Positive Marginal Price Elasticities

Table 3 summarizes the estimates of the weighted means of the kwh consumption, number of customers and revenue distributions. It is evident that the mean kwh of the percentage share of the number of customers, kwh consumption and revenues had been declining over the period under study. Similarly, the estimates of the standard deviations declined. The last row in Table 3, which shows the ratio of the mean kwh of the percentage share of kwh consumption and that of the number of customers, indicate that the ratio is declining. This means that the per capita kwh consumption in fact had been decreasing since the ratio fell from 3.241 to 1.832.

Since the dependent variable q_t is in per capita kwh consumption and the marginal price P_1 is shown to have been declining over the sample

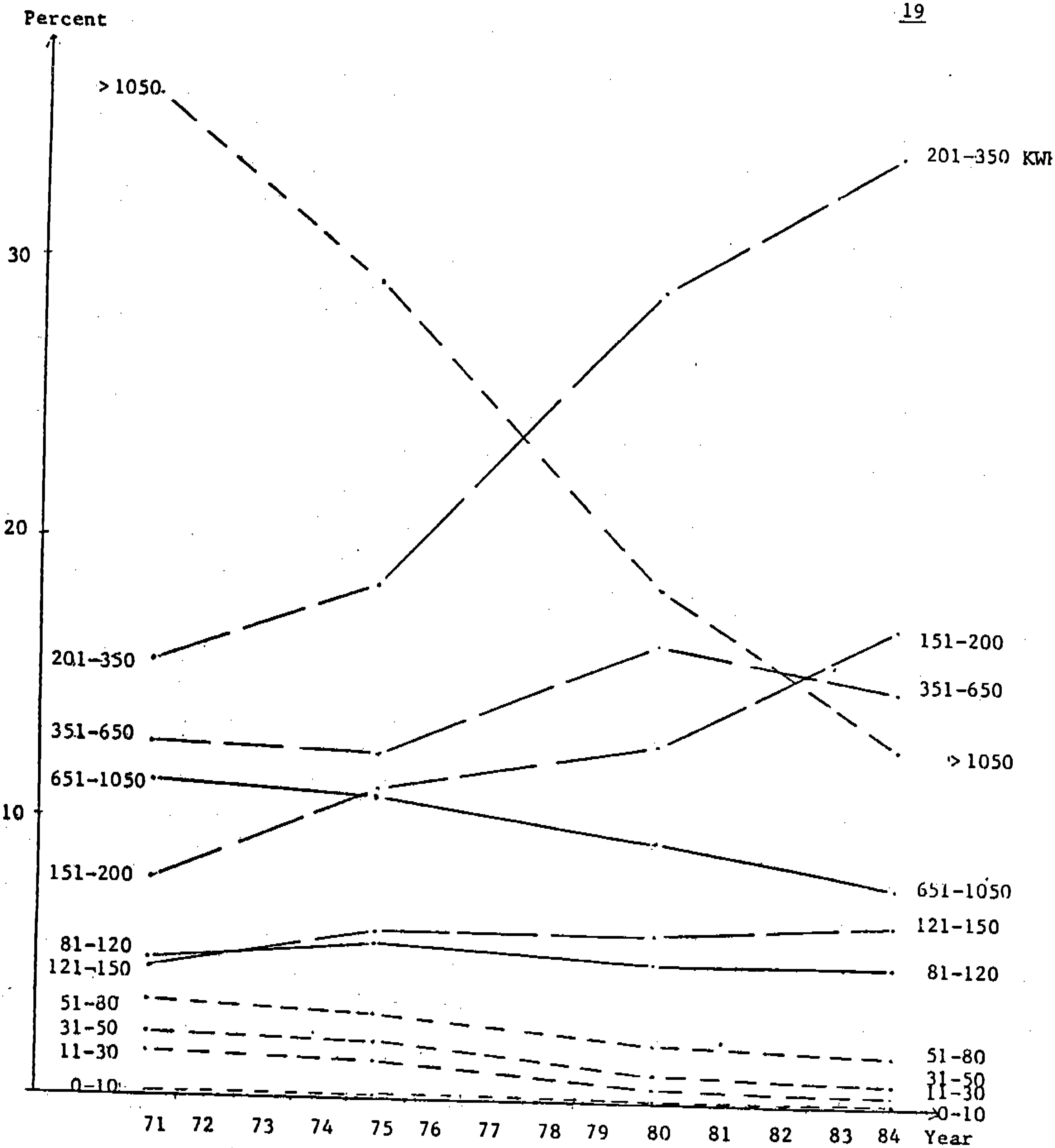
Table 2

MERALCO Residential Consumers
Percentage Breakdown By KWH Blocks[a]
(1971, 1975, 1980, 1984)

	1971			1975		
KWH Blocks	No. of Customers	KWH Consumption	Revenue	No. of Customers	KWH Consumption	Revenue
0-10	3.9	0.100	0.349	2.7	0.074	0.116
11-30	16.8	1.591	2.210	13.1	1.284	0.797
31-50	12.6	2.266	2.997	10.9	2.047	1.211
51-80	11.8	3.429	4.266	11.1	3.329	1.851
81-120	11.1	4.972	5.280	11.9	5.581	2.646
121-150	7.6	4.601	4.620	9.5	5.962	2.806
151-200	10.0	7.809	7.848	13.6	11.058	5.596
201-350	13.4	15.576	15.668	15.6	18.319	13.691
351-650	6.0	12.619	12.705	5.6	12.333	13.921
651-1050	3.1	11.332	11.289	2.9	10.839	14.316
1050-above	3.7	35.705	32.768	3.1	29.173	43.048

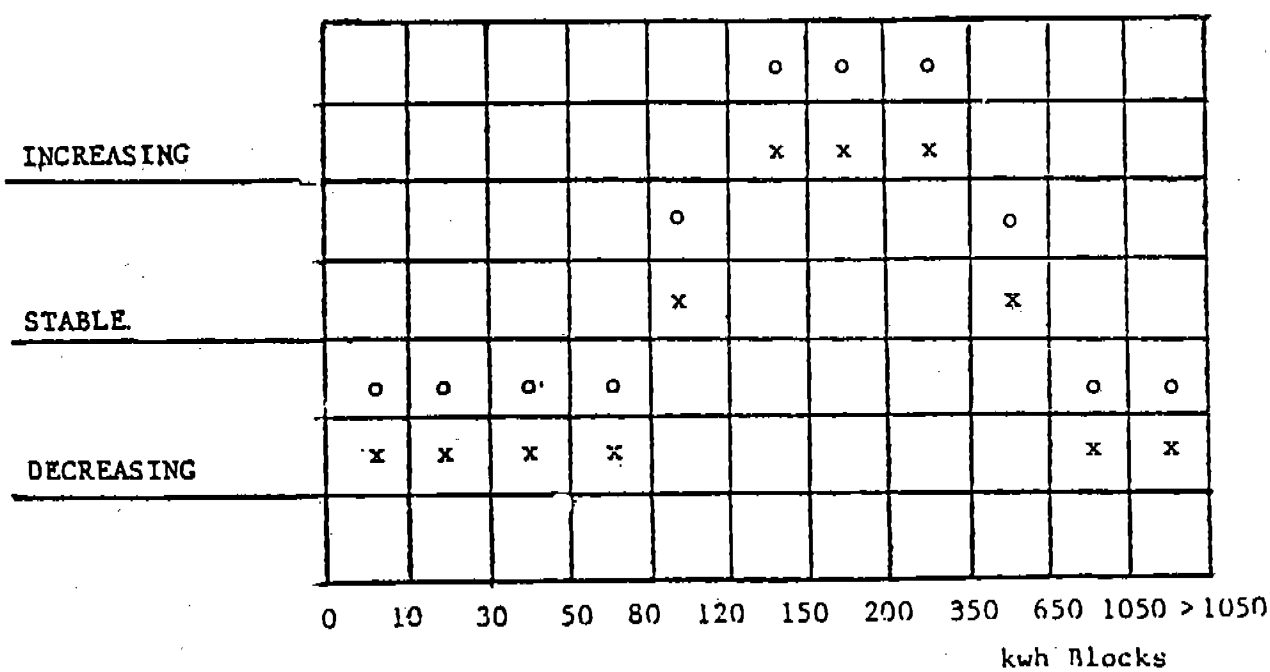
	1980			1984		
KWH Blocks	No. of Customers	KWH Consumption	Revenue	No. of Customers	KWH Consumption	Revenue
0-10	1.8	0.028	0.075	2.1	0.030	0.100
11-30	5.0	0.454	0.302	3.5	0.326	0.328
31-50	5.7	0.983	0.625	3.8	0.681	0.640
51-80	7.8	2.128	1.267	6.1	1.787	1.273
81-120	11.4	4.864	2.473	10.8	4.855	3.362
121-150	10.4	5.903	2.988	10.6	6.402	4.540
151-200	17.4	12.784	6.967	21.8	16.959	12.359
201-350	26.9	28.871	23.525	30.2	33.741	30.635
351-650	8.5	16.273	19.515	7.3	14.731	17.622
651-1050	2.8	9.336	13.238	2.2	7.751	10.515
1050-above	2.3	18.376	29.024	1.6	12.737	18.725

[a]Source of data: MERALCO. Computed from the bill frequencies for May 1971, 1975, April 1980 and June 1984.



MERALCO RESIDENTIAL CONSUMERS
Percent Distribution of KWH Consumption By KWH Blocks
May 1971 to June 1984

Figure 5



o – Percentage of Number of Customers

x – Percentage of kwh Consumption

Figure 6

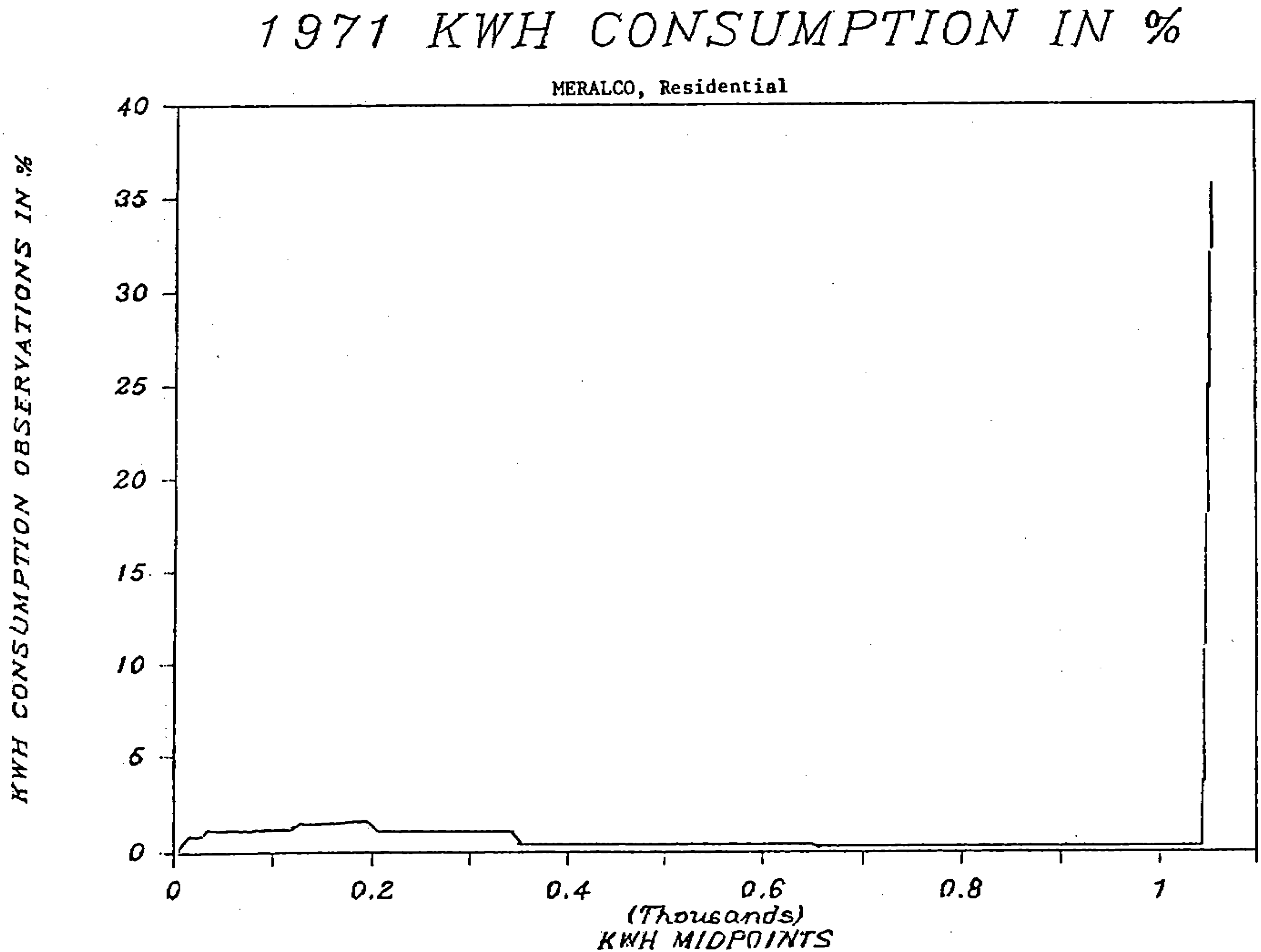

1971 KWH CONSUMPTION IN %
MERALCO, Residential
KWH CONSUMPTION OBSERVATIONS IN %
40
35
30
25
20
15
10
6
0
0
0.2
0.4
0.6
0.8
1
(Thousands)
KWH MIDPOINTS

Figure 7a

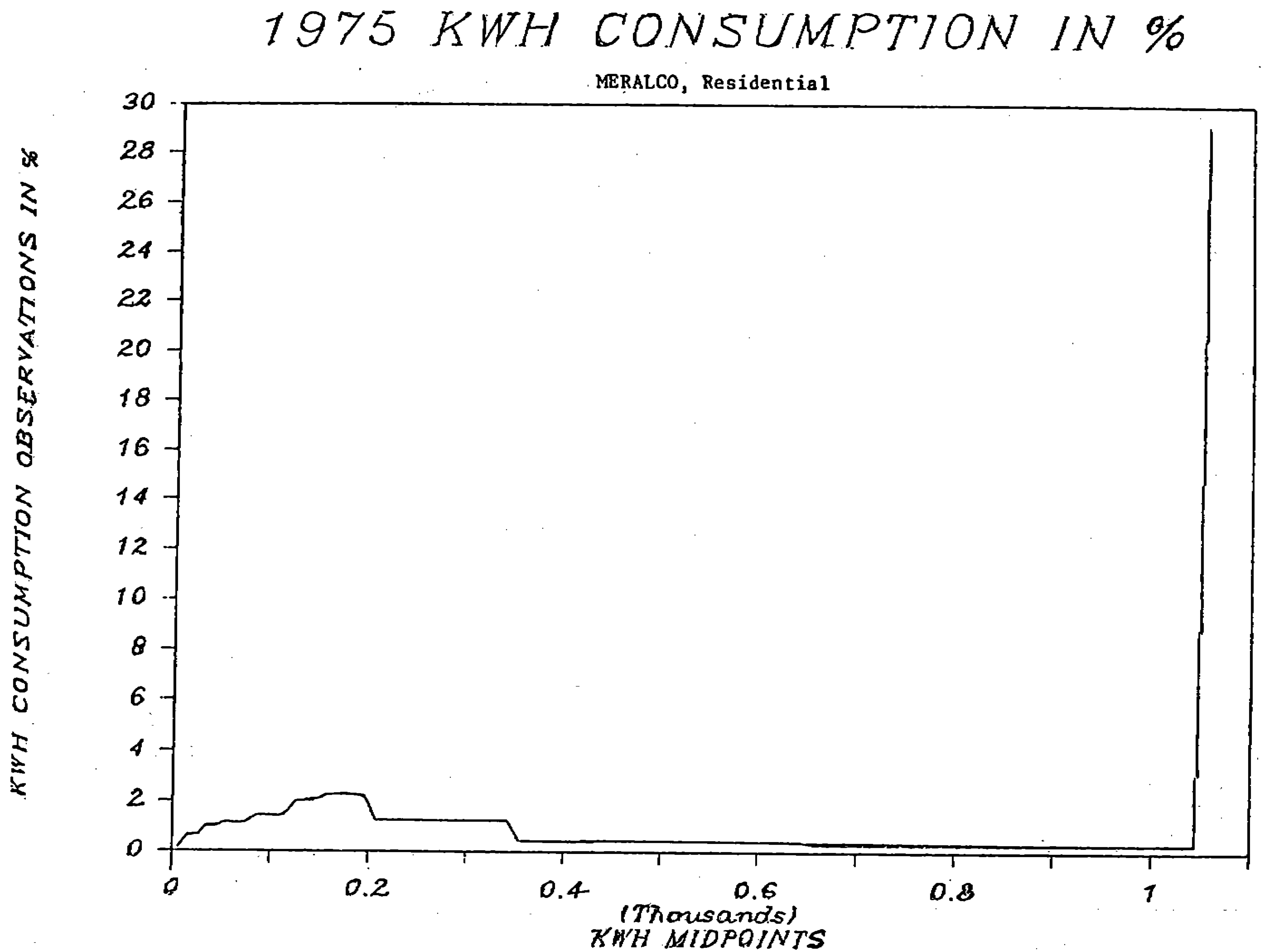

1975 KWH CONSUMPTION IN %
MERALCO, Residential
KWH CONSUMPTION OBSERVATIONS IN %
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
(Thousands)
KWH MIDPOINTS

Figure 7b

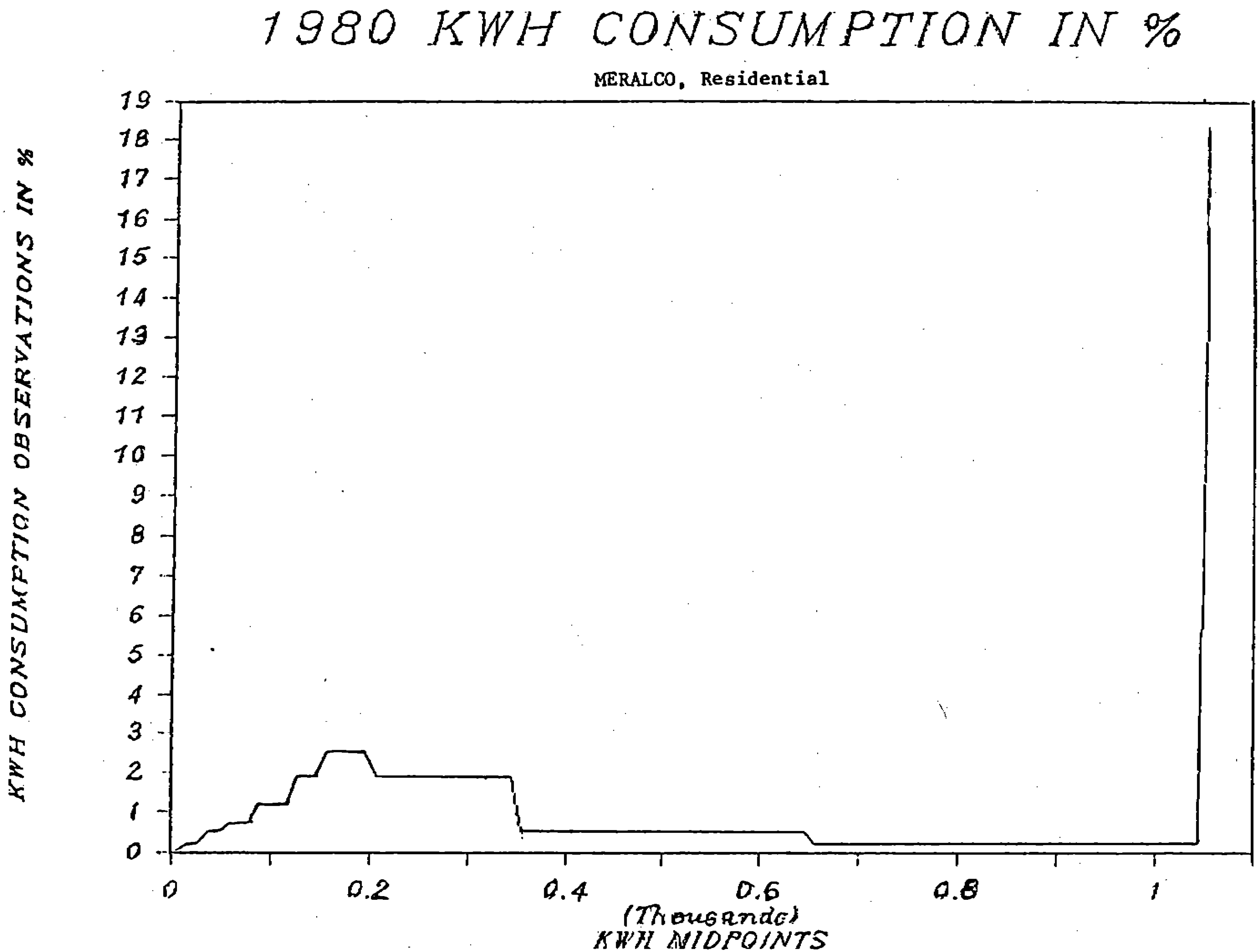

1980 KWH CONSUMPTION IN %
MERALCO, Residential
KWH CONSUMPTION OBSERVATIONS IN %
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
0.2
0.4
0.6
0.8
1
(Thousands)
KWH MIDPOINTS

Figure 7c

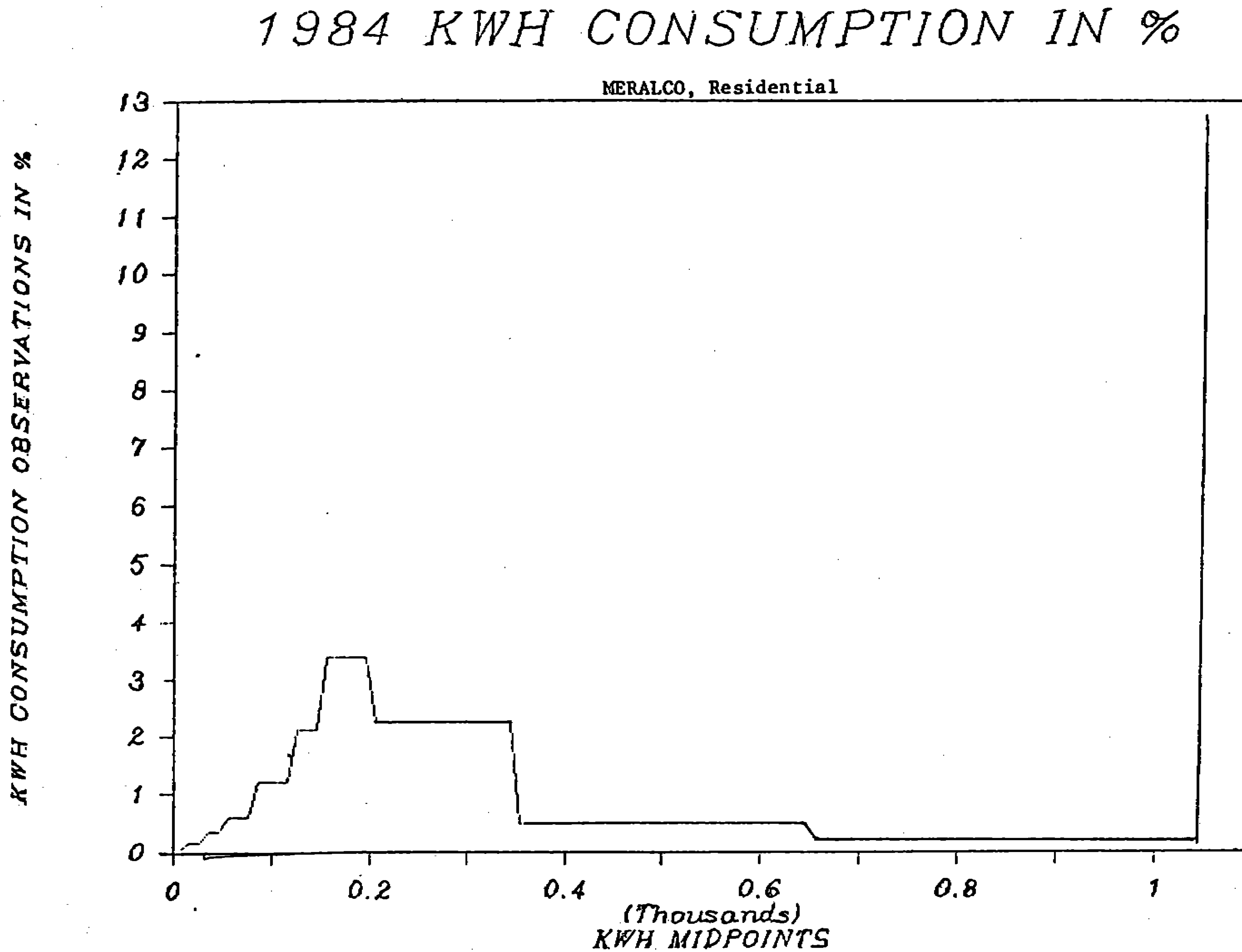

1984 KWH CONSUMPTION IN %
MERALCO, Residential
KWH CONSUMPTION OBSERVATIONS IN %
0
1
2
3
4
5
6
7
8
9
10
11
12
13
0
0.2
0.4
0.6
0.8
1
(Thousands)
KWH MIDPOINTS

Figure 7d

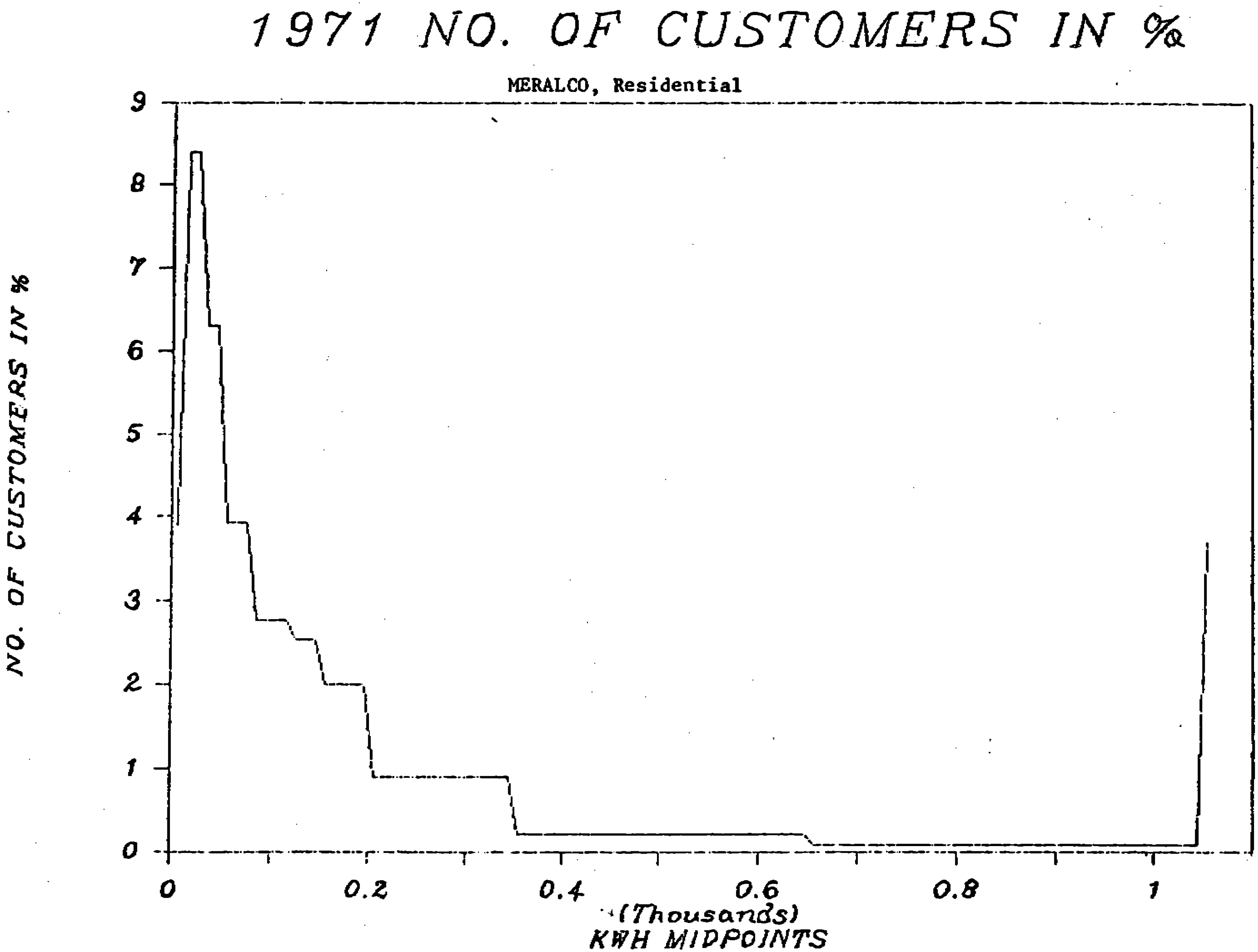

1971 NO. OF CUSTOMERS IN %
MERALCO, Residential
NO. OF CUSTOMERS IN %
0
1
2
3
4
5
6
7
8
9
0
0.2
0.4
0.6
0.8
1
(Thousands)
KWH MIDPOINTS

Figure 8a

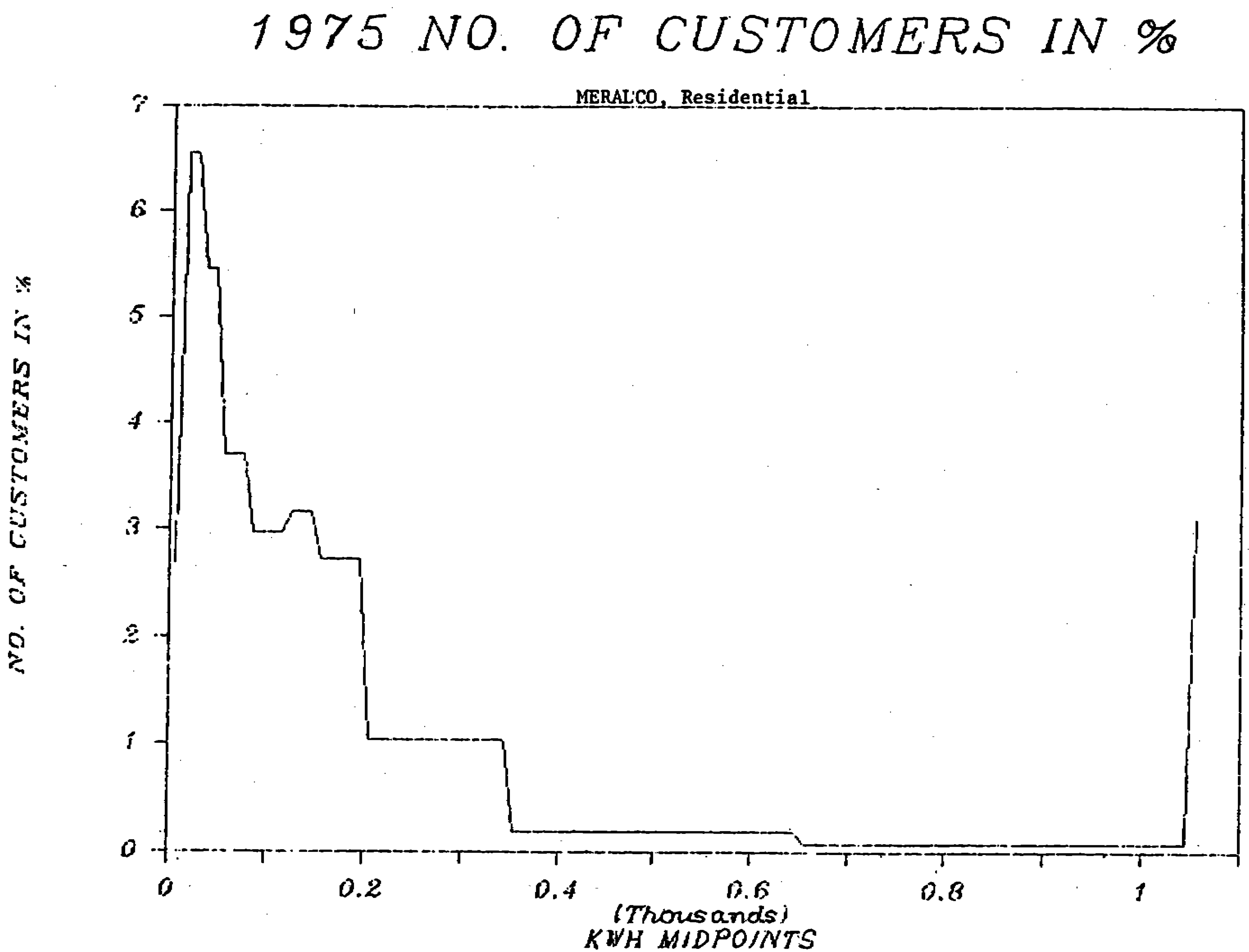

1975 NO. OF CUSTOMERS IN %
MERALCO, Residential
NO. OF CUSTOMERS IN %
7
6
5
4
3
2
1
0
0
0.2
0.4
0.6
0.8
1
(Thousands)
KWH MIDPOINTS

Figure 8b

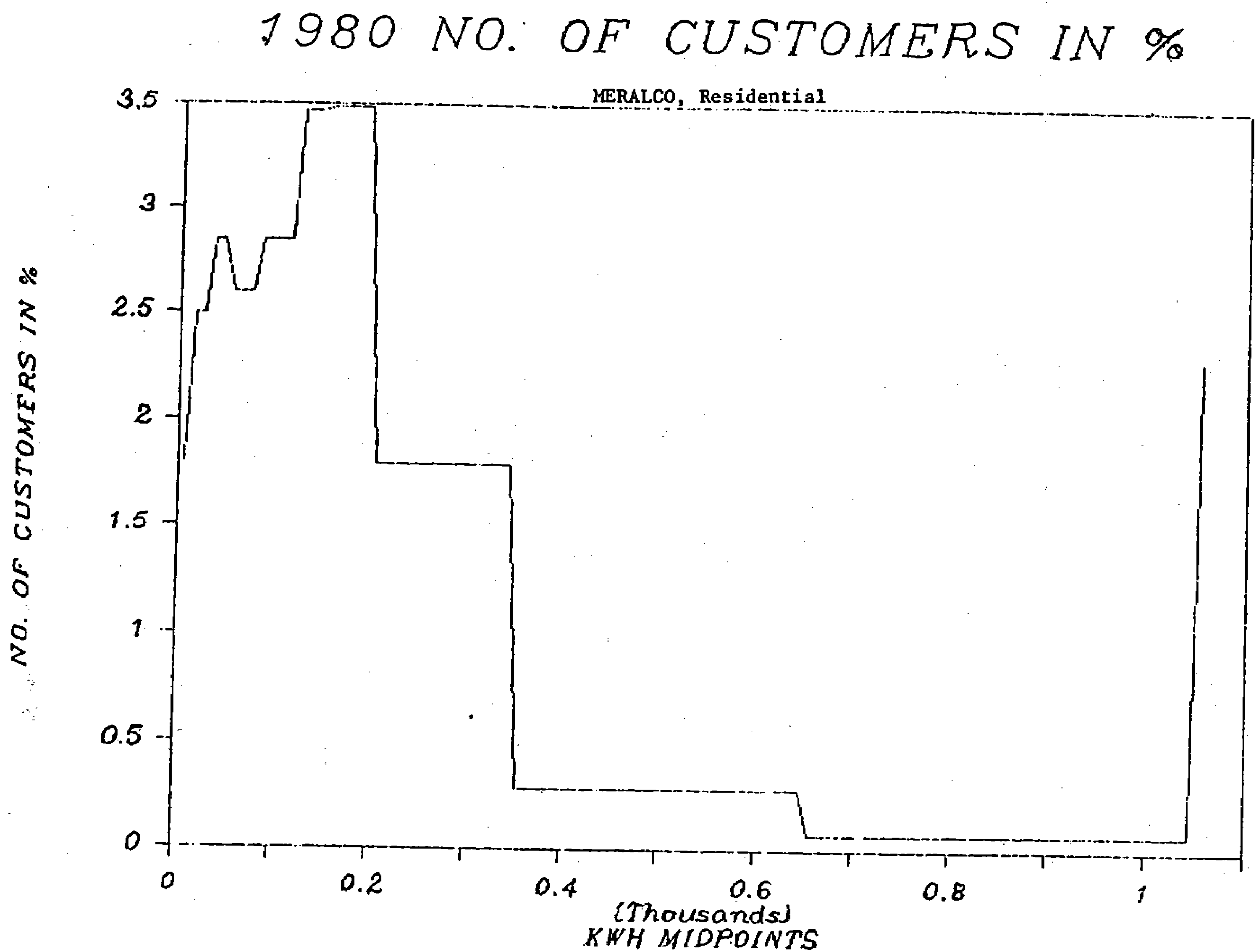

1980 NO. OF CUSTOMERS IN %
MERALCO, Residential
NO. OF CUSTOMERS IN %
3.5
3
2.5
2
1.5
1
0.5
0
0
0.2
0.4
0.6
0.8
1
(Thousands)
KWH MIDPOINTS

Figure 8c

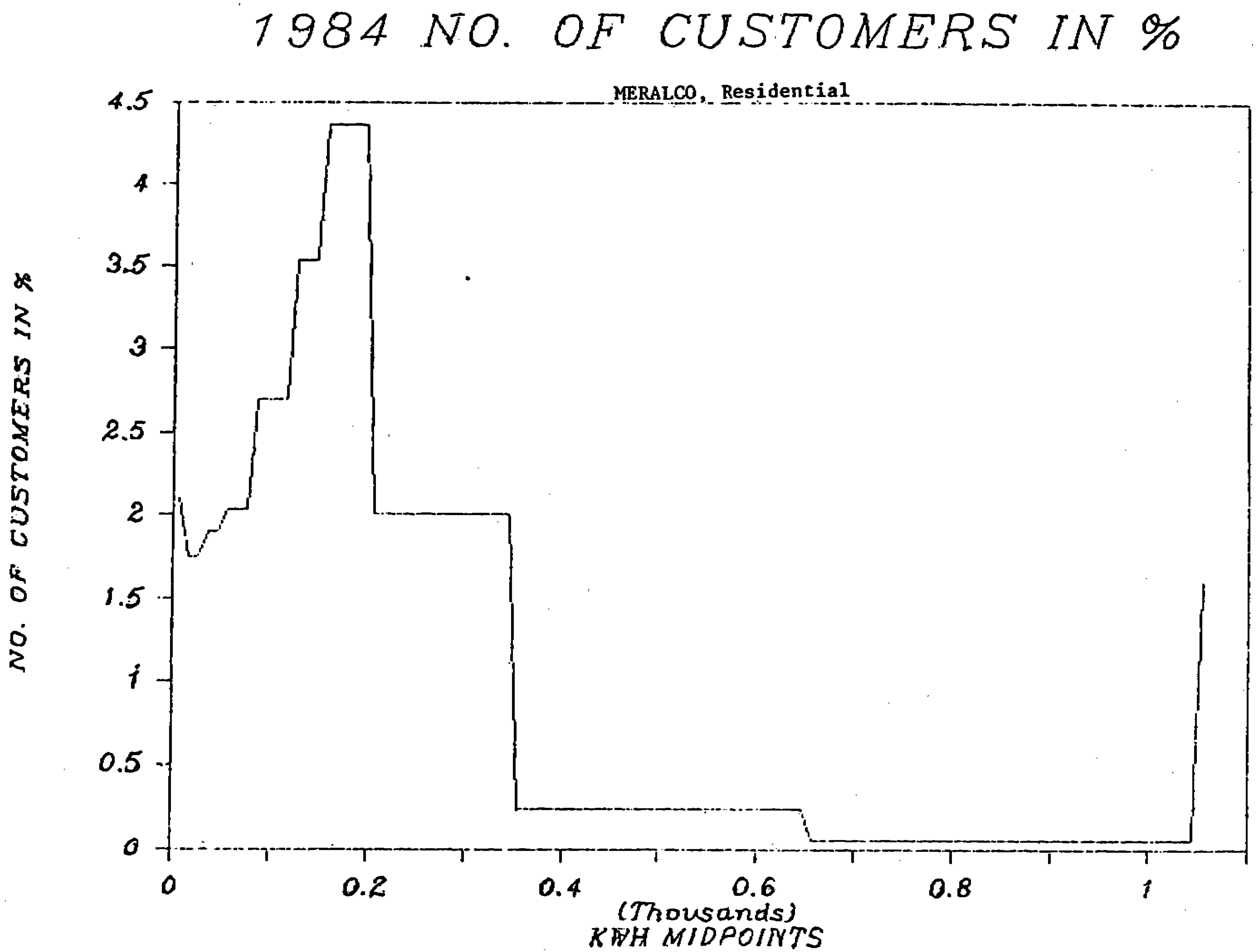

1984 NO. OF CUSTOMERS IN %
MERALCO, Residential
NO. OF CUSTOMERS IN %
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.2
0.4
0.6
0.8
1
(Thousands)
KWH MIDPOINTS

Figure 8d

Table 3

Estimates of Mean KWH and Standard Deviations[a]
Consumer, Consumption and Revenue Distribution
MERALCO Residential Consumers (1971, 1975, 1980, 1984)

			1971	1975	1980	1984
Number of Customers:	(1)	Mean:	187.358	191.161	228.808	224.614
		Std. Dev:	247.189	231.687	213.123	189.224
Kwh Consumption :	(2)	Mean:	607.241	548.183	471.006	411.452
		Std. Dev:	400.688	393.904	348.204	317.219
Revenue :	(3)	Mean:	577.943	701.171	600.830	296.810
		Std. Dev:	403.303	376.690	361.879	257.677
Kwh Consumption (2) : No. of Customers (1)			3.241	2.868	2.059	1.832

[a]Weighted values based on frequency distributions taking into account the kwh block lengths.

period, the estimates of the marginal price elasticities using both monthly and annual data could be positive since both dependent and explanatory variables are moving in the same direction.

Regarding the ex post average price P_3, the estimated elasticity is significant and with the correct sign. The annual average price is computed by dividing total annual residential revenues by total annual kwh consumption. Also, the annual per capita kwh consumption is computed by dividing total annual kwh consumption by the annual average number of customers. Since this procedure will not reveal the structural shifts in kwh consumption, number of customers and revenues at various block levels, the results indicate that on the whole residential consumers overall demand behavior is rational and in accordance with standard consumer demand theory. In the process, however, there are gainers and losers.

At the micro level, however, it might be necessary to further look into the consumers' demand behavior in response to price signals as they maximize utility. This will be further discussed below.

D. Implications for Pricing Policy

1. The Structure of Price Schedules

Figures 9 and 10 show the budget constraints for two income levels for a block increasing and block decreasing price schedules respectively. The equilibrium levels of demand are indicated by the tangency points of the indifference curves at T and T'.

In Figure 9, which the case of a block decreasing price schedule, the consumer is expected to increase his rate of utilization of his stock of electricity consuming equipment. This is indicated by the direction of his consumption path traced by TT' which moves more towards q rather than the bundle of other goods P. Since residential consumers are known to have relatively low load factor, this improvement in the rate of utilization will increase efficiency in the use of electricity and hence improve the load factor.

In Figure 10 which is the case of a block increasing price schedule, the consumption path traced by TT' moves away from the direction of q in

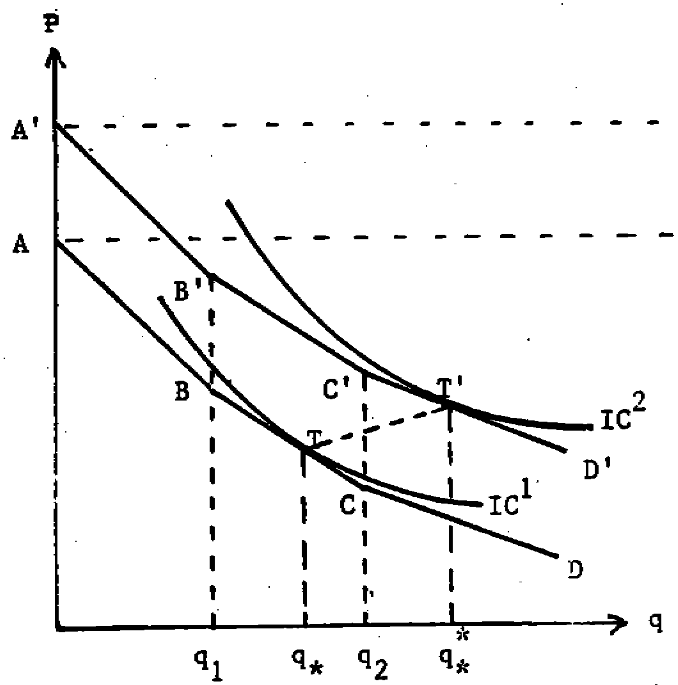


Figure 9

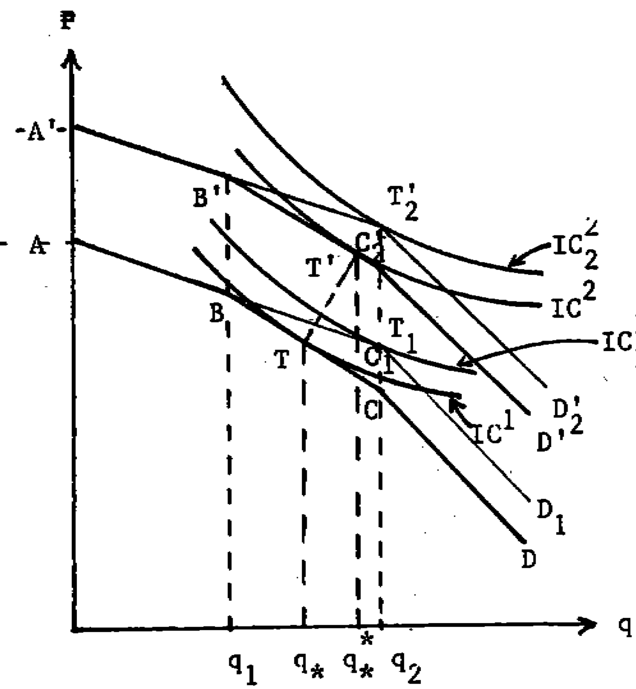


Figure 10

contrast with that in Figure 9. This implies that, given his stock of electricity consuming equipment, the consumer is not given incentive to increase his rate of utilization. This could worsen the low load factor.[13]

Suppose that the block increasing price schedule in Figure 3 is such that the prices are p_3 for $0 \leq q \leq q_2$ and p_1 for $q > q_2$, where $q_2 \approx 200$ kwh per month. This case represents the MERALCO price subsidy for residential consumers which was started in September 1974 but the price signal became more evident in December 1981 and December 1984 as previously shown in Figure 4.[14] Correspondingly, the lower budget constraint in Figure 10 becomes ABC_1D_1 and the higher budget constraint becomes $A'B'C_2'D_2'$. The consumer improves his utilty level to IC_1^1 and IC_2^2 for the lower and higher budget constraint respectively at tangency points T_1 and T_2'. This is due to a positive income effect. The negative coefficient of the inframarginal price P_2, although insignificant, confirms this.

This has three sets of implications. First, at a given income level, the binding constraint may not necessarily be the stock of electricity consuming equipment but the administratively determined quantity q_2 which has been set equal to 200 kwh per month by the subsidy program. This is true for all consumers since the schedule applies for all residential consumers regardless of income levels. Consuming beyond q_2 lowers the consumer's utility such that he is expected to remain at consumption level q_2. This is indicated by the tangency points T_1 and T_2' which are somewhere at the corner points.[15] If the consumer's consumption level is

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13 Statistical estimates of the load factor for the period from January 1971 to November 1984 are 0.22 for residential, 0.30 to 0.45 for three types of commercial and 0.46 to 0.74 for four types of industrial consumers (Francisco, 1986, Table 6.8).

14 Table 1 shows that by the end of 1984, the price beyond the 200 kwh block is 9 to 12 times more than the price at the 0 to 200 kwh block.

15 It may not be a coincidence, therefore, that the average per capita kwh consumption from 1970 to 1984 is 216 kwh per month with standard deviation of 22 kwh. It is recalled that prior to 1974, the price schedule is a V-type with the base of the V at the 100-120 kwh block.

at q_2, then he is able to take advantage of the net subsidy payment given by area ACDF in Figure 3. However, if the consumer has in fact a stock level which enables him to consume beyond q_2, which is quite plausible, then he may apply for another electric meter which records a separate block of 0 to 200 kwh consumption and hence enables him to take advantage of the subsidized price but at a higher overall consumption level and therefore higher utility.[16] This provides an explanation for the emergence during the period of a "market for multiple meters" which effectively increased the number of connections.[17]

The second implication is that this subsidy provided the price signal, to consumers outside but at the fringes of the MERALCO franchise area, as a basis for demanding from government regulators to expand the franchise area of MERALCO such that residential consumers in these areas are able to take advantage of the subsidy. Consequently, in 1984, the government decided to expand the MERALCO franchise area covering a radius of 50 miles from the center of Manila. This also effectively increased the number of residential customers since most of these newly acquired areas are residential.[18]

Finally, this price signal, coupled with the efforts of the government to stabilize the price of primary products and services in Metropolitan Manila, provided inducement for urban in-migration compounding other problems arising from a denser population. Again, this effectively

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16 Overall kwh consumption could increase while per capita kwh consumption could decrease. Estimates of the marginal price elasticities are expected to be positive given the declining real marginal price while the average price elasticities using annual data could be negative confirming previous explanation.

17 The number of customers is based on the number of connections. MERALCO expressly prohibits multiple meters per household. However, the cost of enforcement and administration could be very prohibitive considering that by the end of 1984 there are 1.2 million residential connections.

18 In effect, this expands the MERALCO franchise area to 7,850 square miles from 1,020 square miles in 1974. The subsidy for the newly acquired areas are lesser than the old franchise areas resulting in a three-tiered geographic price structure for residential consumers in the Luzon grid, the highest price being that for consumers outside the MERALCO franchise area who are made to bear the full cost of electricity. For added details on this observation, see Francisco(1984, pp. 190-191).

increased the number of MERALCO residential customers.

The combined effects of all these three sets of demand responses to the price signal resulted in a rapid increase in the number of residential customers. For the periods 1970 to 1974 and 1974 to 1979, the number increased by 5.3% and 5.6% per year respectively. However, from 1979 to 1984, the growth rate was 10.7% per year. In a span of ten years, from 1974 to 1984, the number of MERALCO residential customers almost doubled from 592,902 to 1,163,795.[19]

Since the subsidy burden is borne mostly by industrial and large commercial consumers, and electricity is an important factor input into their cost of production and operations, Philippine industries may have suffered and perhaps could have lost their competitiveness in the world market.[20] While the energy shocks of 1973-74 and 1979 may have resulted to some extent the lesser dependence of GNP growth on primary energy such as oil, this does not necessarily apply to electricity and GNP.[21] Thus, the restructuring of MERALCO residential price schedule and the subsidy program may have had considerable impact on economic growth.

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19 This rapid increase in the number of residential consumers could also result in higher average cost of distribution for MERALCO including technical and non-technical losses.

20 In 1985, a 5-year plan to reduce the subsidized consumption from 200 to 50 kwh per month was implemented. However, the adjustment process appears to be slow. In May 1986, for instance, MERALCO data show that industrial consumers pay ₱ 2.23, while the overall average rate is ₱ 1.78 and the overall subsidized rate is ₱ 0.29 per kwh. The corresponding percentage kwh share of residential and industrial consumers are 36% and 29% respectively, unlike the 1974 shares which are 26% and 40%. A comparison of average industrial power rates in selected Asian countries show that MERALCO has the highest rate followed by Japan. The lowest rate are those of Taiwan, Thailand and South Korea(NEDA, 1986).

21 In the U.S., for instance, Jorgenson(1984,1986) observes that the use of electricity plays an important role in productivity growth. Sioshansi(1986) shows that this so-called "decoupling of energy and GNP" does not necessarily apply to electricity and GNP.

It can be seen that the foregoing three sets of demand responses to the price signals given by the subsidy in a block increasing schedule are not inconsistent with the rational behavior of residential consumers. These demonstrate the need to consider both the technical features of electricity as a commodity and the utility maximizing behavior of consumers in electricity pricing.

Also, the shift from block decreasing to block increasing price schedule is an implicit transfer of income to residential consumers which is evident from the higher indifference curves in Figure 10 compared to those in Figure 9 at the same income levels. This is made more pronounced by the subsidized price structure. This means that policy makers put more weight on redistribution of income rather than on efficiency in resource allocation.[22] The price structure given by the subsidized pricing is therefore antithetical to the efficient allocation of electricity as a scarce resource. Since electricity has strong linkages with the rest of the economy, using electricity pricing as a means for redistributing income could slow down the economic growth process.

2. Substitutes for Electricity

LPG and firewood do not appear to be substitutes for electricity. In fact LPG appears to be a complement of electricity. These results are plausible for two reasons. First, getting a substitute for electricity may not be easy considering its use which requires electricity consuming equipment for specific purposes. Second, the relative and real prices of electricity, especially for the first 200 kwh, have been declining.[23]

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[22] In 1974, MERALCO started the price subsidy for residential consumers as a form of socialized pricing. This is in line with the Price Control Law which expired on June 1973 but subsequently extended. An earlier demand study on residential and industrial consumers (MERALCO, 1973), where price and income elasticities were estimated at various blocks of kwh consumption, was used to evaluate the impact of the 1974 rates on demand as well as the financial viability of the electric utility(Cantoria, 1977, p. 10).

[23] A declining relative price, however, may not be unusual. In the U.S., for instance, Hogan(1985) observes that the relative price of electricity for residential, as well as commercial and industrial consumers, relative to non-electric energy declined from 1960 to 1980 resulting in the interfuel substitution in favor of electricity.

One possible area of substitution is in cooking where LPG and firewood could be used instead of electricity. However, LPG or firewood requires different equipment for cooking. Since the relative price of electricity is low, especially at the first 200 kwh, there is no compelling reason to look for substitutes for electricity. Thus, a residential consumer might use electricity for lighting, ventilation, refrigeration and communication such as radio and television. For most consumers, these activities could be adequately met by 200 kwh per month, but using electricity for cooking could exceed this level. The consumer, therefore, is expected to use electricity for all those electrical appliances and use LPG or firewood for cooking. LPG is also subject to price control. As income increases, more of both electricity and LPG will be used indicating complementarity between electricity and gas and firewood. Thus, the positive coefficient of the price of substitutes, especially in the test using annual data, although insignificant, may not be unexpected.

The implication of this is clear. If the price of electricity does not reflect its true scarcity value, then the use of alternative sources of energy may not be explored and developed.

3. Price of Electricity Consuming Equipment

Using monthly data, all estimates of the coefficients of the price of electricity consuming equipment are with the correct sign and significant, except for flat iron. These results are in accordance with a priori expectations. If the prices of electricity consuming equipment increase, then less of these equipment will be bought. Consequently, there will be lesser stock of electricity consuming equipment and less electricity can be used. This is particularly true for refrigerator and airconditioner. Since flat iron is not used as often as refrigerator or airconditioner and it does not consume as much electricity, the insignificant but correct sign of its coefficient could be expected.

However, using annual data, the price of airconditioner is insignificant. The price of flat iron and refrigerator were not included for reason earlier stated. These insignificant results could perhaps be explained by two reasons. First, monthly variations in both demand and price of airconditioner may have been averaged out in the annualized version of the data used in the test. More specifically, there could be some level of seasonality during dry and rainy seasons in the price of airconditioner and these variations in prices are averaged out over the year thereby giving insignificant results. Second, residential consumers might be able to adjust their desired stock of electricity consuming equipment within a one month period such that changes in prices of these equipment appear not to have long-run effects on demand for electricity. This is quite plausible for airconditioner since those who purchase it usually belong to the middle or higher income bracket. This reason is in consonance with the significant and negative coefficients using monthly data. It also demonstrates a possible limitation of the characterization of one-month period as short-run in contrast with one year as long-run.

In general, however, these results indicate that the price of electricity consuming equipment influence the consumer demand behavior. This confirms a priori expectation considering the derived nature of demand for electricity.

4. Environmental Variables

Monthly average maximum temperature and relative humidity, which were used to represent the environmental variables, have positive and significant effects on demand for electricity for tests using monthly data. This is expected since relatively more electricity is needed for refrigeration, cooling and ventilation during warm hours of the day and warm months of the year. Also, more economic activities are usually being undertaken to take advantage of the dry season. The results indicate that a one percentage point increase in temperature results in approximately 0.4% increase in demand for electricity. The effect of changes in relative humidity is half as much as that of temperature.

This finding has implications for pricing policy and in turn on other economic concerns. Since temperature and relative humidity fluctuate during the day and during months of the year, demand for electricity correspondingly fluctuates. This is evidenced by the typical daily load curve for a given day in a month and the difference in peaks and troughs of typical load curves across months. Since the marginal cost of electricity at higher demand level is higher, the result here on environmental variables provides as empirical basis for using time-of-day pricing or seasonal pricing which will reflect the true scarsity value of electricity.[24]

On the other economic concerns, three areas where beneficial effects of time-of-day and seasonal pricing could be realized are briefly described. The first is on employment. Existing labor laws require overtime or night premium payment for work after 5:00 p.m. or before 8:00 a.m. Since most activities done by labor use structures or equipment which need electricity, and since the existing price of electricity is not time differentiated, the existing policies implicitly tailor the demand for electricity to be concentrated over the traditional office or working hours. This results in higher system peakload, lower load factor and hence inefficient use of electricity. If the price of electricity is time differentiated, the lower eletric bills might offset the overtime and night premium payments and more labor might be employed given a fixed stock of capital and equipment in the economy.[25]

The second, which is related to the first, is on the effects of movements of people to and from places of work. Since the price of electricity is not time differentiated, there is none or little incentive to do work outside of the traditional 8:00 a.m. to 5:00 p.m. work schedule.

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[24] The implementation of seasonal pricing can be easily done. On the other hand, time-of-day pricing requires electric meters capable of recording time-of-day consumption levels. Here, there is a need to compare the cost with the potential benefit of implementation. This, however, is a technological issue which time can resolve, i.e.,eventually, an inexpensive meter which is appropriate for the average residential consumers can be devised.

[25] The positive effect of environmental variables on demand for electricity is not only true for residential but also for industrial and commercial consumers(Francisco, 1986).

As people leave their homes to be on time for work, there are inevitably surges in the arrivals of vehicles. Given the fixed size and capacity of roads, traffic congestion naturally arises. The same phenomenon is observed when people leave work for home. Traffic congestion results in wastes of fuel and more air pollution.

Finally, a time-of-day or seasonal pricing will send the correct signals to economic agents such as architects and engineers, who design and construct houses and buildings, to take into consideration the cost of cooling and ventilation. The relatively low price of electricity, for instance, might have influenced home and building owners to adopt European and Western architecture and designs for pure aesthetic consideration which may not be suited for warm environment.[26]

For the test using annual data, only the temperature variable was included. The result is insignificant. Since monthly temperature data are basically seasonal, these variations have been averaged out such that the insignificant result could be expected.

5. Short-Run and Long-Run Price and Income Elasticities

Based on the result for marginal and average prices, long-run price elasticities appear to be relatively larger in magnitude than short-run elasticities. This is in accordance with theory. Similarly, there is an indication that long-run income elasticity is larger than short-run elasticity. These mean that the immediate effects of changes in price and income on demand are relatively small while their effects on demand over the long-run are relatively larger.[27]

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[26] It is not unusual to see houses and low-ceiling buildings in Metro Manila with walls and roofs covered by bricks reminiscent of London, New York and Boston environment. The heat absorbity coefficient of bricks, especially dark colored, is very high making it ideal for temperate places but may not be suitable for warm environment.

[27] In a review of 25 residential demand studies in the U.S., for instance, Bohi(1981, p.56) observes that..."Overall, there are wide disparities among the estimates reported by different studies. To add to the confusion, some short-run estimates exceed (in absolute value) other long-run estimates. Price elasticities range from -0.03 to -0.54 in the short-run and from -0.45 to -2.20 in the long-run. The overlap is even more confusing among the income elasticities, as both short-run and long-run range from 0 to 2.0. It is little wonder that decision makers are reluctant to place great confidence in any specific values."

Thus, another important pricing policy implication is that the prices of electricity should be made relatively stable and should be free from short-run cost adjustments. A price schedule which is simple and stable provides a clear and consistent signal to consumers for their short-run and long-run consumption decisions.

V. Summary and Concluding Remarks

In sum, this study shows that the residential demand for electricity in the MERALCO franchise area is responsive to its own price, the price of electricity consuming equipment, temperature and relative humidity, and to a certain extent, changes in income levels as approximated by changes in employment levels. The prices of substitutes appear not to be considered by the residential consumers in their electricity demand behavior and there are indications that long-run price and income elasticities are greater in magnitude than short-run elasticities.

Marginal, inframarginal and average prices comprise the own price vector of variables. A finding of positive marginal price elasticity is explained in terms of consumers' responses to signals given by a structure of subsidized prices. Some pricing policy implications are derived.

Due to the various limitations, both in the demand model and the data used, the policy implications derived here, at best, only provide indications of the general and possible directions for policy reforms. Care should therefore be taken in using the estimated parameters, especially for forecasting residential demand for electricity. Nevertheless, the results are explained within the context of standard consumer demand theory considering the specific features of electricity as a commodity.

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