THE IMPACT OF ELECTRICITY PRICE INCREASES ON INCOME GROUPS: WESTERN UNITED STATES AND CALIFORNIA

PREPARED FOR THE CALIFORNIA STATE ASSEMBLY WITH
SUPPORT OF THE NATIONAL SCIENCE FOUNDATION

M. B. BERMAN
M. J. HAMMER
D. P. TIHANSKY

R-1050-NSF/CSA
NOVEMBER 1972

Rand
SANTA MONICA, CA. 90406

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Solar corona photographed at the total eclipse of June 8, 1918, Green River, Wyoming.

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PREFACE

This report is part of the Rand research program on *The Growing Demand for Energy.* The general focus of the program is on the underlying cause of the conflict between energy and the environment—the rapid increase in demand for all forms of energy—and the implications of this conflict for governmental policymaking.

This particular study represents one portion of the research performed for the Committee on Planning and Land Use of the California State Assembly which is summarized in R-1116-NSF/SCA, *California's Electricity Quandary: III. Slowing the Growth Rate,* September 1972. The work was performed under a contract from the State Assembly, augmented by a grant for energy studies from the National Science Foundation.

The report deals with one important aspect of possible future electricity conservation policies in California: the differential effects of increases in the price of electric power on various income groups. It is intended as an aid to policymakers and analysts concerned with energy policy in California.

Other Rand reports related to this study include:

R-990-NSF/CSA, *Electricity Demand and Economic Growth,* by K. P. Anderson (forthcoming).

R-996-NSF/CSA, *On the Desirability of Policies for Energy Conservation: I. The Resource Scarcity Problem,* by R. D. Doctor (forthcoming).

R-1084-NSF/CSRA, *California's Electricity Quandary: I. Estimating Future Demand,* by W. E. Mooz and C. C. Mow, September 1972.

R-1102-NSF/CSA, *The Impact of Electricity Price Increases on Income Groups: A Case Study of Los Angeles,* by M. B. Berman and M. J. Hammer (forthcoming).

R-1115-RF/CSA, *California's Electricity Quandary: II. Planning for Power Plant Siting,* by R. H. Ball and R. G. Salter, September 1972.

R-1132-NSF/CSA, *Slowing the Growth Rate in Electricity Use in California: The Residential Sector,* by R. D. Doctor and S. H. Dole (forthcoming).

Deane N. Morris
Head, Rand Energy Program

SUMMARY

The purposes of this study were to explore the ramifications of increased prices of electricity on residential consumers of different income classes and to estimate how a reduction in the growth rate of consumption of electricity (through increased prices for electricity) might be distributed among the various socioeconomic groups in the residential sector. We first attempted to gain a detailed view of how the residential sector uses electricity. Variables affecting household consumption of electricity include:

- Stock of appliances, which in turn is greatly determined by income.
- Size of household, which also determines the number and intensity of use of appliances.
- Size and volume of the housing unit and the quality of its insulation, which determine the air-conditioning load, amount of lighting needed, and space to install or store various appliances.
- Variance in the outside temperature, which affects air conditioning and space heating.
- Price of fuels.
- Amount of time spent away from the home.

Through the use of data from the Bureau of Labor Statistics, we were able to determine the amount of money the "average" household in various income classes spent on energy and appliances in a 1-year period. Using Federal Power Commission statistics on the prevailing prices of electricity in this 1-year period, we were then able to estimate the consumption of electricity for each income group. Those consumers in the $5000 and over category (60 percent of the population that year) consumed 80 percent of the electricity demanded by the residential sector. Further, consumers earning less than $3000 (17 percent of the population) consumed only 6 percent of the total electricity demanded.

The Bureau of Labor Statistics data were supplemented with more current appliance ownership data by income group for the Los Angeles-Orange County marketing area. These ownership figures were used to predict consumption of electricity for the various income groups. Using this method, the average consumption

for Los Angeles and Orange Counties was 4893 kWh. This figure is fairly close to the weighted average of 4795 kWh for the service areas of the Los Angeles Department of Water and Power and Southern California Edison. We portrayed the impact of various price increases on the different income groups using "drastic" and "reasonable" withdrawals of electrical items from each group. The drastic case consisted of removing as many electrical devices as possible across all income groups, leaving only those necessary for family hygiene and food preparation, adequate space heating, and minimal lighting. The reduction in appliances and lighting loads resulted in a decrease in consumption of electricity ranging from 45 percent (lowest income class, $5000 or less) to 63 percent (highest income class, $15,000 or more) and represents the upper bound on reduction of consumption of electricity by this means. The more reasonable scenario resulted in withdrawal rates of 30 percent (lowest income class) to 54 percent (highest income class). Hence the ability of low income groups to reduce consumption of electricity is much less than has been predicted by previous research using highly aggregated data to predict average reduction. The ability to reduce consumption, then, increases with income. And finally, high income groups would be able to reduce their consumption of electricity by shifting to other sources of energy and increasing the efficiency of their stock of appliances. It can therefore be said that, were it necessary, high income consumers would not suffer loss of the conveniences they enjoy—only reallocations.

The policy implications of this study are quite varied. Should the legislature deem action necessary, a number of options are open that would mitigate undesirable financial effects on low income consumers yet achieve the reduction in demand for electricity that might be required. Such legislative actions as pollution taxes on utilities, stringent pollution standards, power plant license fees, bans on certain types of plant locations and transmission methods, and sales or use tax on residential consumption might be feasible.

Recent rate hearings across the country have provided groups representing the poor an opportunity to urge that low income consumers be exempted from price increases in electricity. In addition, there has been considerable concern that policies for reducing growth rates might prevent the lower income groups from enjoying some of the benefits that come with abundant supplies of electricity. Our analysis indicates that rate schedules can be tailored to exempt the poor and that, to at least a limited extent, low income consumers can increase their use of electricity without seriously disturbing overall consumption.

ACKNOWLEDGMENTS

The authors would like to express their appreciation to the following Rand colleagues: Elizabeth Rolph, Kent Anderson, and Ron Doctor. Their critical reviews were instrumental in the final phase of this study. We also acknowledge the help of Paul McClure in providing information on efficiencies possible in home lighting.

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I. INTRODUCTION

The consumption of electrical energy in California is increasing at an average annual growth rate of 8 to 8.5 percent [1], whereas the population is increasing at a rate of under 2 percent annually. This growth rate in the consumption of electricity is expected to continue through 1980, slowing slightly from that point to the end of the century. Should this rate proceed unabated, it will require a sevenfold increase in power generation facilities by the year 2000.

Each year will bring increasing stress on the environment, and the siting of new power plants will become more difficult as suitable land becomes less available. Further, this growth rate is impinging on the acknowledged fuel supply at an accelerating pace that shortens the time for discovery and exploitation of new, usable resources and technologies. The problems created by the growing demand[1*] for energy have led public groups and governmental bodies to evaluate the national patterns of consumption of energy. This in turn has encouraged much discussion of the efficacy of limiting the growth rate of the demand for electricity. Advocates of decreasing growth rates are escalating their demands for public policies to limit growth. Suggested policies range from strict governmental prohibitions on building new facilities to much milder legislative incentives. Which policies are best, if indeed *any* governmental action is necessary, is a serious question encompassing a complex series of issues. If any governmental policy is required it must follow from a rational appraisal of costs and benefits to the public welfare of all aspects of the economic, social, and environmental issues involved.

This report is a step toward providing the policymaker with information on one aspect of the electrical consumption question—that of the *impact of price increases of electricity on different income classes* of consumers in the residential sector of the economy. This is a relevant examination because many of the policies suggested for reducing electrical energy growth rates involve the price mechanism, e.g., prohibitions, pollution standards, and taxes and license fees for power plants. Should a policy using the price mechanism be considered, to make a rational decision it will be necessary to understand the impact of price changes on all the consuming sectors.

* Small numbers refer to notes to the text; they begin on p. 39. Large numbers in brackets are keyed to the references, which begin on p. 45.

The residential sector in California consumes nearly 30 percent of the electrical energy, and it is therefore an important element in any policy decision. The immediate effect of an increase in the price of electricity would be felt by the consumer through increased home operating expenses; it is this effect that we discuss. Increased costs of goods that use electricity during the course of their manufacture will have a less direct effect on the consumer. An assessment of this indirect effect must await further investigation of the impact of increased prices of electricity in the industrial and commercial sectors of the economy.

Several questions arise when considering price increases in electricity for residential consumption: Do the new prices affect the different consumer classes equally or unequally? How much can we expect residential consumption to change? If the price increase is a result of taxation and other governmental action, how is the burden shared by the consumers? If there is unequal impact, can it be eliminated or reduced? If so, what is gained and what is lost? This report attempts to answer such questions as well as to provide general information on the patterns of residential energy consumption.

II. RESIDENTIAL CONSUMPTION OF FUELS BY INCOME GROUPS

DETERMINANTS OF HOUSEHOLD CONSUMPTION OF ELECTRICITY

Electricity and other fuels are used as an intermediate good in the household. Entertainment is provided by television, radio, and stereo equipment. Food is stored in the refrigerator/freezer and prepared using the stove, cookers, electric frying pans, mixers, toasters, and so forth. The environment is controlled by space heating, air conditioning, fans, and humidity control devices. Household hygiene is made easier through the use of dishwashers, washing machines, water heaters, clothes dryers, and vacuum cleaners. These household devices directly create the demand for fuels.[2] The factors that determine the frequency of use in a household also determine the total fuel consumption. Variables affecting consumption include:

- The stock of energy-consuming devices held by the household, which is determined to a large extent by household income.
- The size of the family determines the intensity of use of major appliances such as stove, washing machine, dryer, water heater, and lighting. It also influences the size and number of many devices.
- The size and volume of the housing unit (and the quality of its insulation) determine the intensity of use of air conditioning and space heating needed to maintain a given temperature. It is also a partial determinant of lighting required and to some extent of the number of appliances (apartment dwellers are less likely to have washing machines and dryers than home owners).
- The variation in the outside temperature affects the intensity of use of air conditioning and space heating.
- The price of fuels influences the quantity of fuels consumed [2,3].*
- The amount of time spent away from the household will have an effect on fuel consumption; this in turn is largely determined by the size of the family and its income.

* See also, R. Halverson, "Residential Electricity: Demand and Supply," unpublished Ph.D. thesis, Harvard University, 1971 (to be published in 1972).

These many determinants of household fuel consumption will be useful as we examine the various data in the following sections relating to income groups. We have chosen to discuss the ramifications in terms of an "average consumer." There is, of course, much variation on either side of the average.

APPLIANCE PURCHASE BY INCOME GROUPS

In the previous subsection we imply that the number and type of appliances held by residential consumers are primarily a function of the income of the consuming units and the size of the family. This is shown in part by an examination of data provided by the Bureau of Labor Statistics (BLS) survey of consumer expenditures,[3] conducted in the Western Region of the United States in 1960-1961. In this study, family spending habits were recorded in specific categories for primary regions and metropolitan areas of the United States. The survey centered on Los Angeles-Long Beach and San Francisco-Oakland, California, as representative of large urban areas in the western United States, and on the smaller cities of Seattle, Washington; Bakersfield and Eureka, California; Denver, Colorado; Honolulu, Hawaii; and Anchorage, Alaska. Surveys are available for single metropolitan areas, such as Los Angeles, but the expenditures were not detailed enough for this report. The total sample was 1770 families.

The relevant expenditure categories are as follows:

cooking stove	washer-dryer combination	ironing machine
refrigerator	air conditioner	electric waxer
home freezer	vacuum cleaner	television
dishwasher	garbage disposal unit	radio
washing machine	dehumidifier	phonograph, tape recorder, etc.
clothes dryer	sewing machine	

With the exception of the recreation or family entertainment items (television, radio, tape recorder), these appliances are generally used in either the kitchen or utility room. Small appliances are lumped into one category.

Household spending patterns are grouped by disposable income, which is defined as gross household income less deductions of personal taxes (federal, state, and local income taxes, poll taxes, and personal property taxes). A household is defined as a consumer unit of people, usually living together, who pool their income and withdraw major expense money from a common fund. Using this definition, the Bureau of Labor Statistics constructs an average household's expenditures (i.e., total amount of money spent divided by total number of households surveyed). The income brackets for which data are reported generally are in increments of $1000 for lower income levels and are in successively larger increments for above-average wages. The following income-after-tax categories are delineated:

Disposable Income Group	Percent of all Urban Families in the Western Region of the U.S.
Under $1000	1.6
$1000-$1999	7.9
$2000-$2999	7.7
$3000-$3999	9.9
$4000-$4999	11.8
$5000-$5999	13.1
$6000-$7499	19.5
$7500-$9999	15.7
$10,000-$14,999	10.3
$15,000 and over	2.6

Figure 1 shows total yearly expenditures on the appliances sampled by BLS by income group. The average urban household[4] spent about $170 for all types of appliances. Expenditures for appliances increase with income. The equation below expresses the statistically significant relationship constructed from the BLS data (see Appendix A):

$$\text{Annual appliance expenditures} = 0.880 \times (\text{disposable income})^{0.677} \times (\text{family size})^{0.288}$$

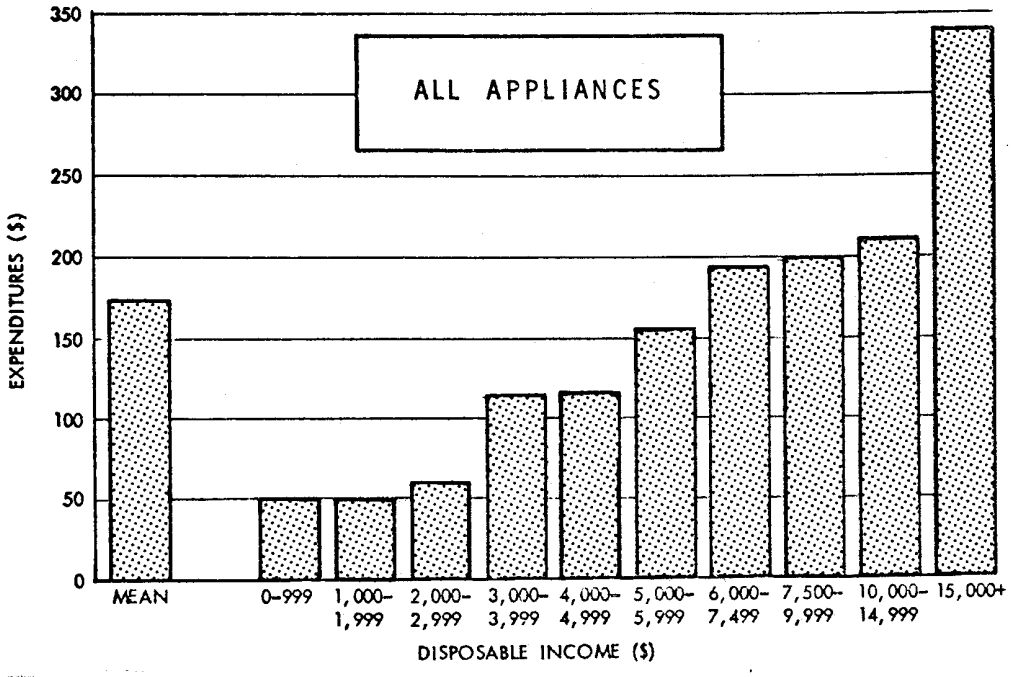


Fig. 1—Appliance expenditures for all urban families and single consumers in the Western United States, 1960 - 1961

This relation demonstrates that appliance expenditures are related to the number of household members in addition to income, as was implied earlier. If we assume that annual appliance expenditures maintain their relative positions every year for each income group, then high incomes should hold the largest stock of appliances and consume more fuels than low income groups of equal number. Thus they should have the highest fuel expenditures.

FUEL EXPENDITURES BY INCOME GROUPS

This BLS expenditures survey was again used to obtain the fuel expenditures for all urban households and single consumers by income group.[5] Figure 2(a) shows the typical annual fuel expenses. As expected, total fuel costs rise with income, ranging from about $60 for the poorest household to almost $300 for the wealthiest. The average household spent over $160 annually. For specific fuels, the average household spends approximately $85, $16, and $65 on electricity, fuel oil, and gas, respectively. Notice that oil represents a very minor portion of total fuel expenditures. In 1970 fuel oil was used in only 0.6 percent of all California households [5]. For this reason we will exclude further comments on fuel oil in this report and treat fuel oil as if it were gas.

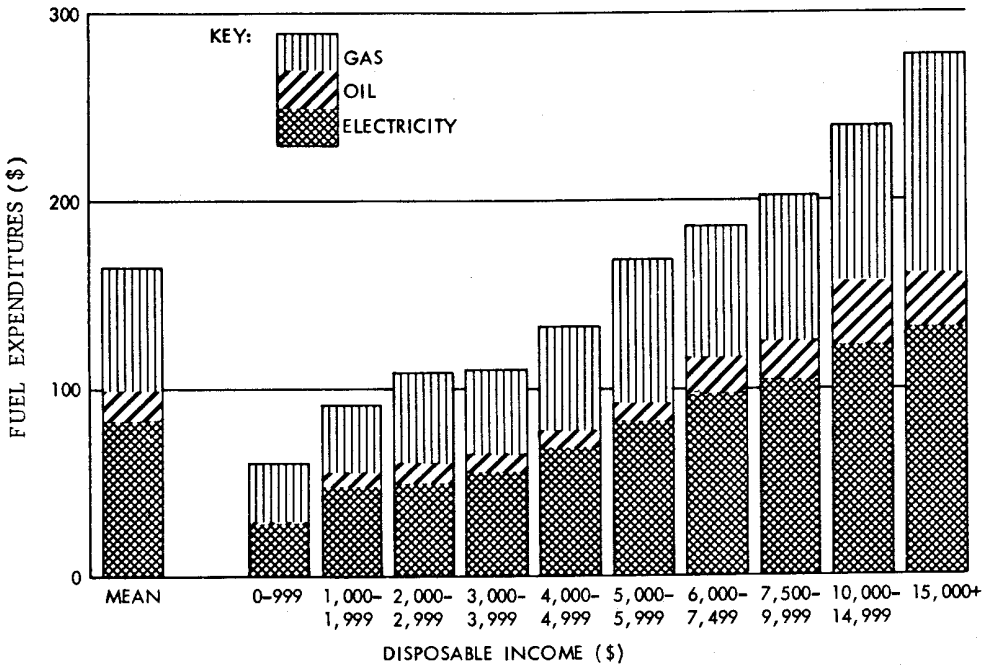
Earlier in this section we hypothesized that income (as reflected in the stock of appliances), the number of people in the household, and the volume of the housing unit are major determinants of fuel consumption. The BLS data add credence to this view. The following statistically significant relation was estimated from the data (see Appendix B):

$$\begin{aligned}\text{Fuel expenditures} = {} & 15.60 + 0.0092 \times (\text{living expenditures}) \\ & + 17.88 \times (\text{number of household members}) \\ & + 0.73 \times (\text{percent home owners})\end{aligned}$$

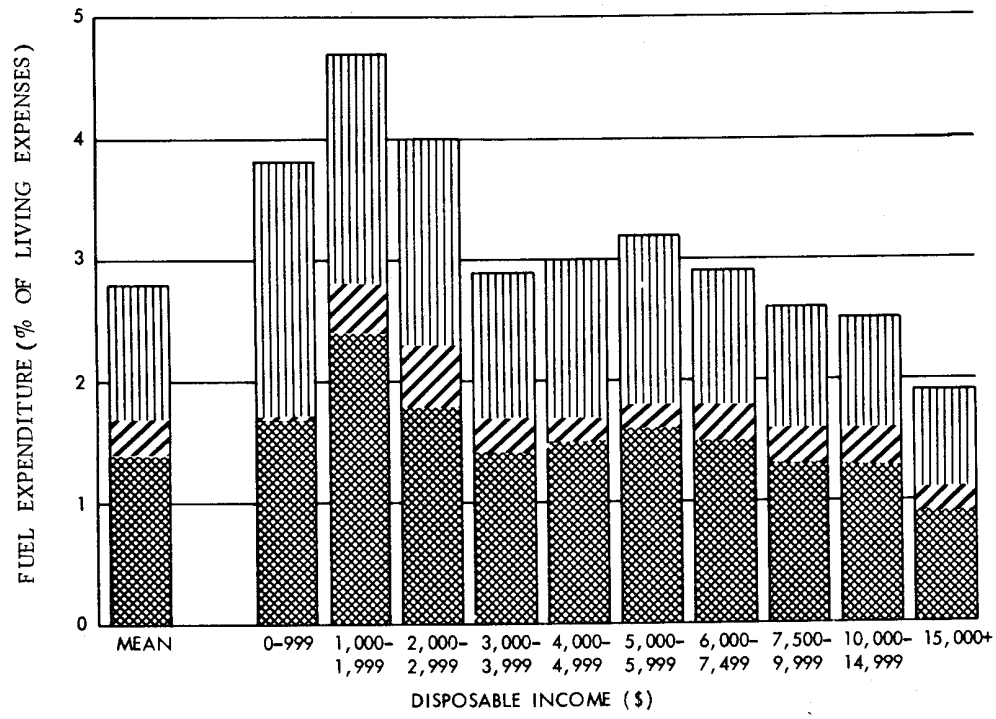
We interpret home ownership in this relation as acting as a proxy for household volume (cubic feet). On balance, home owners tend to have larger living quarters than renters. The relationship portrayed allows the reader to estimate the amount of money the average family spent on fuel in 1960-1961 by using information on the amount of money spent on total living expenses, family size, and home ownership.

Figure 2(b) illustrates the impact on households of these fuel expenditures as a percentage of total living expenses for each income category (see Appendix C). The average household spent about 3 percent of its living expenses on all fuels and approximately 1.4 percent on electricity. Consumers earning less than $3000 spent 4 to 5 percent and those earning more than $7500 spent 2 to 2.5 percent. Thus, low income consumers appear to spend about twice the fraction of their living expenses on fuel as do high income families.

Table 1 uses the electrical energy expenditures reported by income group as well as the prevailing prices of electricity to estimate the consumption of electrical



(a) Dollar cost of fuel for each disposable income group



(b) Percent of living expenses for each disposable income group

Fig. 2 — Fuel expenditures for all urban families and single consumers by income groups, Western United States, 1960 - 1961

Table 1

ESTIMATE OF RESIDENTIAL CONSUMPTION OF ELECTRICITY BY INCOME GROUP--
URBAN AREAS, WESTERN UNITED STATES, 1960-1961

Disposable (Gross) Income Group, $	Percent of All Families	Electrical Expenditure per Family, $	Estimated[a] Avg. Price per kWh, $	Estimated[a] kWh Consumed	Share of Consumption
Under 1000	1.6	27.27	0.050	555	0.003
1000-1999	7.9	47.07	0.041	1148	0.027
2000-2999	7.7	49.08	0.040	1229	0.027
3000-3999	9.9	54.62	0.035	1561	0.046
4000-4999	11.8	68.11	0.032	2128	0.074
5000-5999	13.1	81.06	0.026	3118	0.120
6000-7499	19.5	96.03	0.024	4001	0.230
7500-9999	15.7	103.72	0.023	4510	0.209
10,000-14,999	10.3	121.61	0.018	6756	0.205
15,000 and over	2.6	131.05	0.017	7708	0.059
					1.000
Average				3392[b]	

[a]Estimates were based on data obtained from Ref. 6 for selected cities in BLS sample.

[b]This estimate is close to that of 3290 kWh per customer for California for 1961 [7].

energy for each income group.[6] It should be noted that the average unit price decreases as consumption of electrical energy increases because of the declining block-rate system. In this system, large users receive a quantity discount. Table 1 also shows a very interesting distribution between income and consumption of electricity. Those in the $5000 and over income class (60 percent of the population) consume over 80 percent of residential electricity. Correspondingly, those consumers earning less than $3000 (17 percent of the population) use only 6 percent of total electricity consumed. This suggests that the total impact on both consumption of electricity and revenues would remain relatively unaffected if low income groups were exempted from any proposed increases. This will be discussed further in later sections.

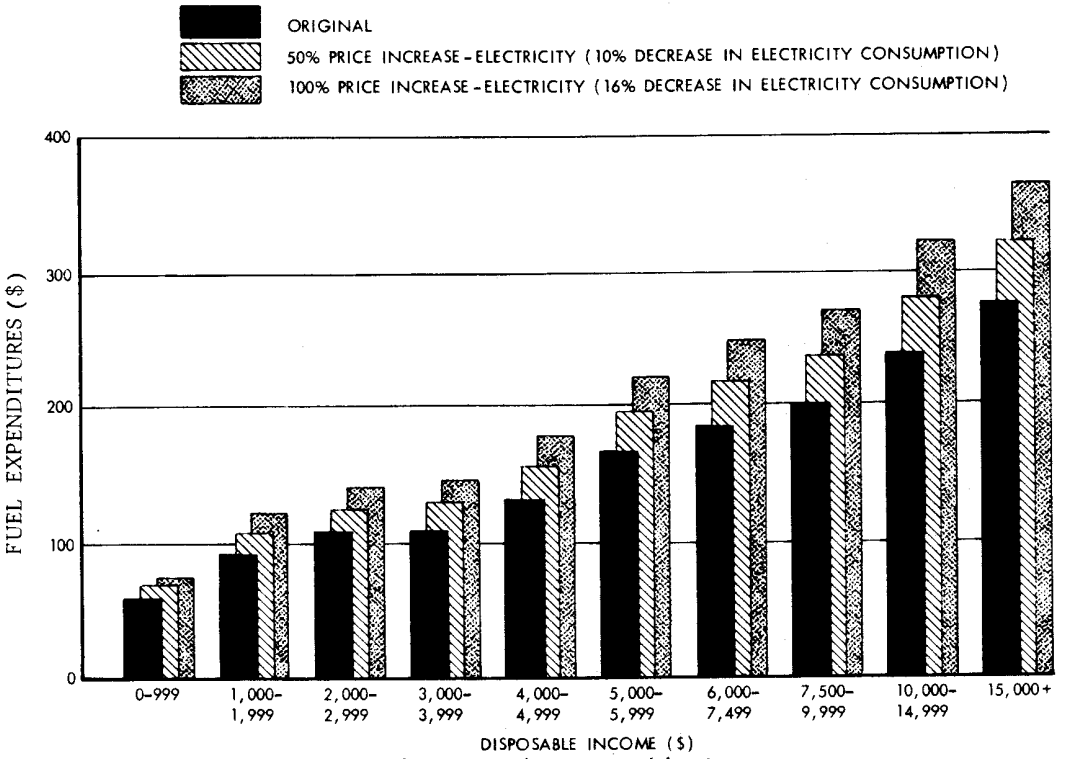
III. IMPACT OF RATE INCREASES

The impact of a price change on the quantity demanded of goods is usually described by the price elasticity of demand. Price elasticity can be viewed as measuring the percentage change in the quantity demanded resulting from a 1-percent change in the price of the good.[7] There are two types of impact for changes in the price of fuels: short term and long term.

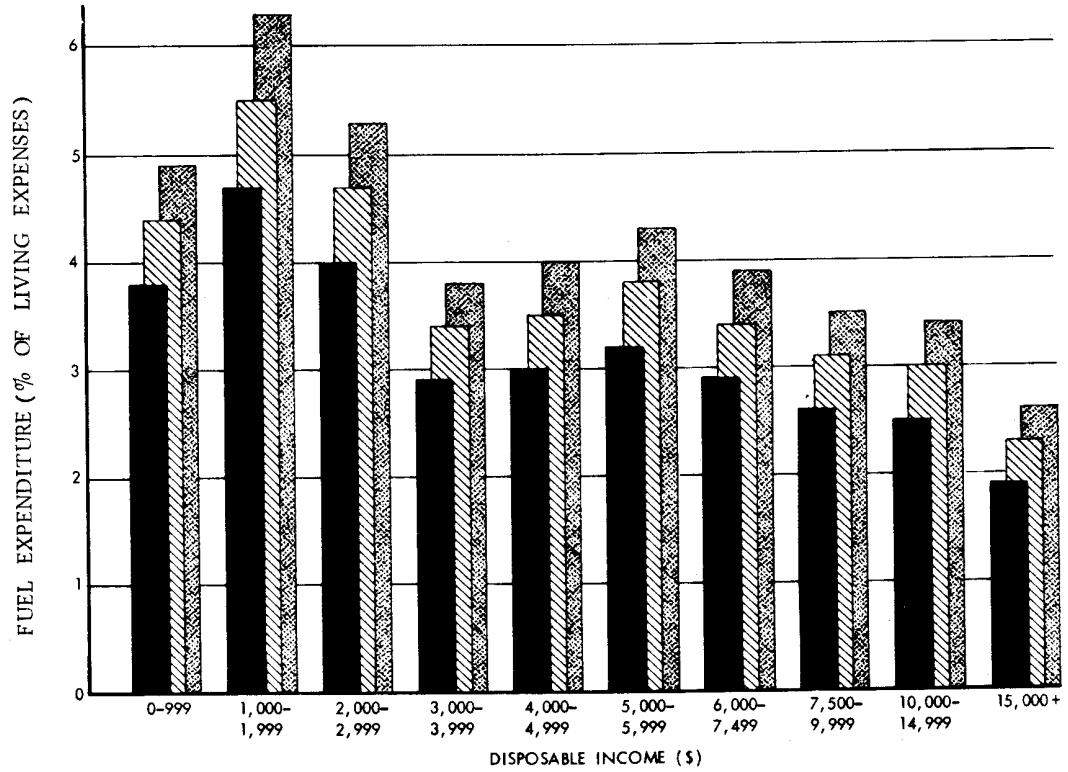
SHORT-TERM IMPACT

The short-term impact on residential consumption of a particular fuel should be very small (inelastic) for even relatively large changes in its price. This is because consumers have a large capital investment in fuel-consuming devices, which militates against abrupt shifts to different equipment (e.g., replacing electric water heaters, stoves, dryers, or space heating with their gas counterparts) or total elimination of the device. The "locked-in" consumer would only be able to react by reducing the intensity of use by, for example, reducing wattage and usage of lighting, careful monitoring of space heating and air conditioners (setting to more moderate temperatures while home and very moderate temperatures while away, closing off unused rooms, adding insulation, etc.), operating washing machines, dryers, and dishwashers with fuller loads and less often, and reducing temperature settings on hot water heaters. Of course, those customers replacing equipment could be influenced in their purchase by major increases in fuel prices. The extent of this influence is discussed in the next subsection.

Detailed estimates were not made of the short-term reduction in consumption in the wake of an abrupt price change for each income group because it will be small for all groups. We estimated that the withdrawal is somewhere between 0 and 15 percent for the average consumer, and therefore used an elasticity of -0.25 (withdrawals of 10 and 16 percent for price increases of 50 and 100 percent, respectively) for all consumers.[8] This should be considered the maximum short-term reduction. Figure 3(a) shows the change in expenditures for each consumer class and Fig. 3(b)



(a) Dollar cost of fuel for each disposable income group



(b) Percent of living expenses for each disposable income group

Fig. 3 — Short-run impact of electricity price increases by income groups. All single consumers and urban families, Western United States, 1960 - 1961

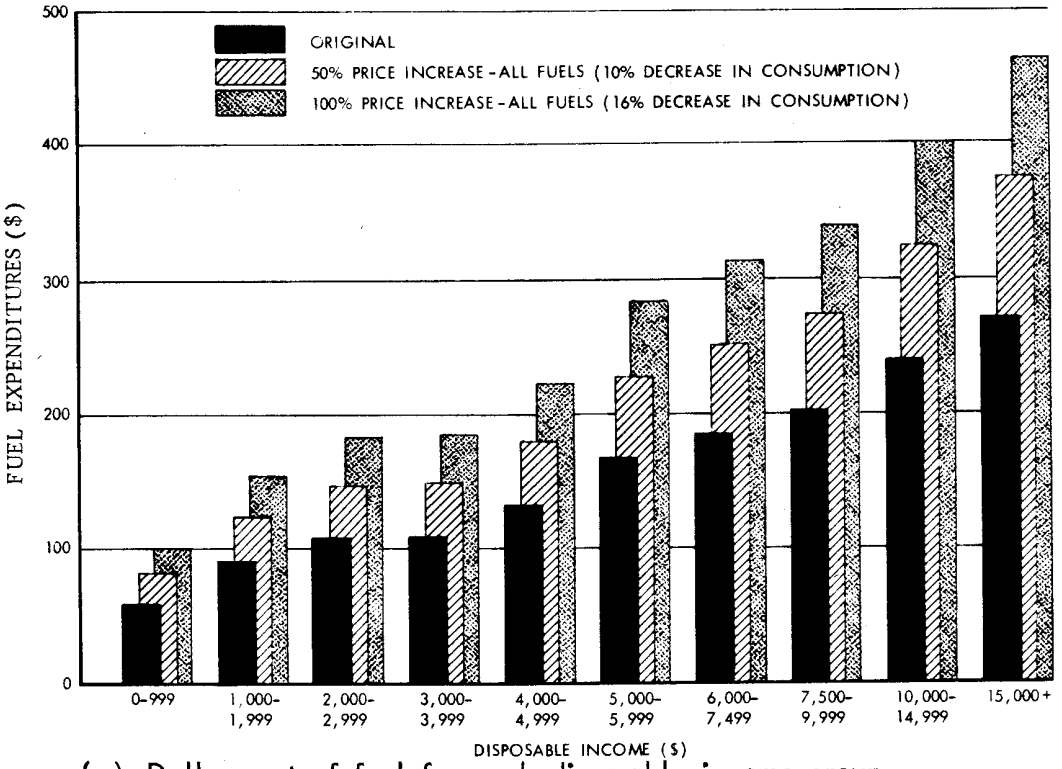
indicates the impact as a percent of each class's living expenses, when only the price of electricity is increased. Figures 4(a) and 4(b) show the effects if all fuels were to increase in price.

LONG-RUN IMPACTS

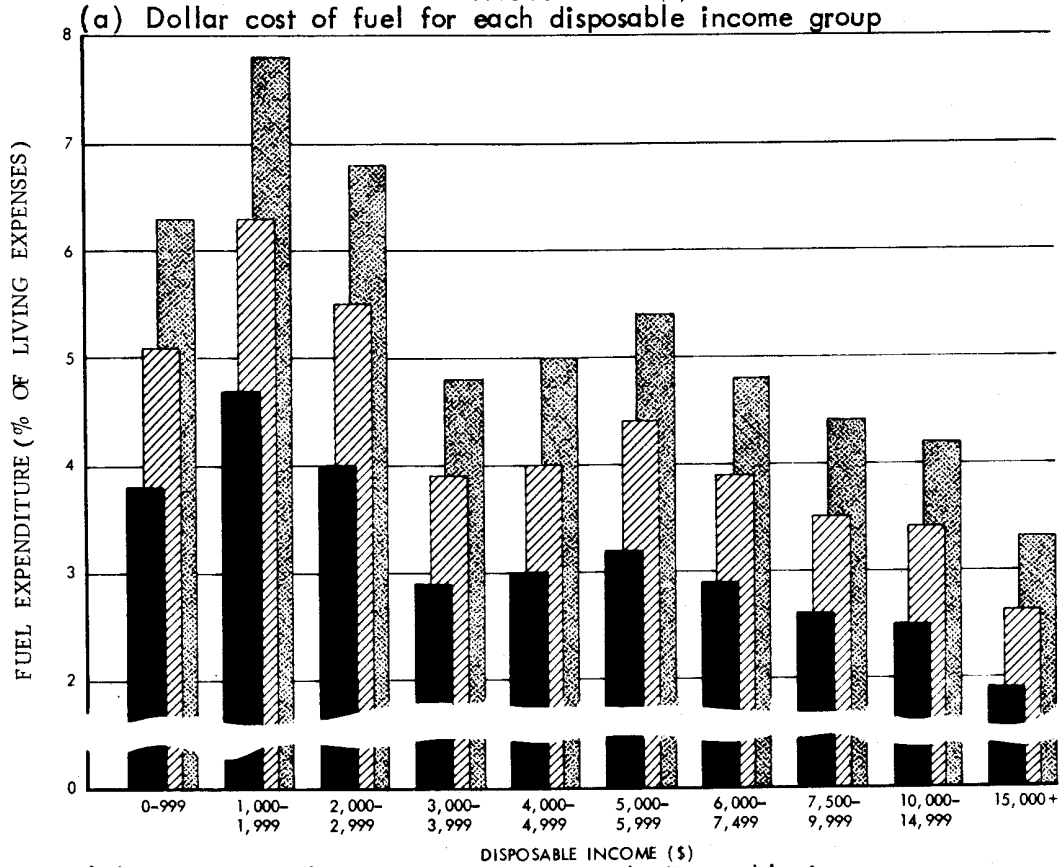
There is considerable evidence that residential demand for electricity is price sensitive [2,3]* when consumers can adapt their consumption over a long period of time. An early work (1962) by Fisher and Kaysen [8] concluded that residential consumption of electricity was inelastic. However, later work (1970) by Wilson [3] shows several defects in the Fisher and Kaysen inquiry. Primary among these defects were emphasis of time series instead of cross-sectional data, use of appliance stock consumption data instead of actual electricity consumption data, use of only a limited number of those appliances in the analysis, and unequal biases in estimates of appliance stocks for different areas of the United States. (See Ref. 3, pp. 210-226, for a more exhaustive treatment of Ref. 8.) Wilson's work is based on a cross-sectional analysis of consumption by urban households in 77 cities across the United States in 1968. His price variable was the typical monthly electric bill for 500 kilowatt hours (kWh) in each city of the sample. The price elasticity of household demand estimated with that variable is -1.33. Wilson also provides estimates on price elasticities for some major household appliances; these are shown in Table 2 along with their implied withdrawals for a price increase of 100 percent. With the exception of the food freezer, these electric appliances all have readily available gas substitutes, which primarily accounts for their high elasticities. The implication of Wilson's work is clear. In the long run, residential demand for electricity would be reduced by increases in the real price[9] of electricity. Much of that decrease results from a shift in the mix of gas and electric household devices.

Anderson [2] has also demonstrated that residential consumption of electricity per household is price sensitive.[10] Anderson's data base was different from Wilson's in that Anderson used average consumption of electricity per household in a cross-sectional analysis of the 50 states in 1969. The price variable used by Anderson was also the cost of 500 kWh; however, he differs from Wilson in that the cost represents the difference between the 1000 kWh cost and the 500 kWh cost, to obtain a better representation of each customer's marginal cost. The comparable price elasticity estimated by Anderson is -0.91. As Anderson points out in comparing his work with Wilson's, "the principal source of this discrepancy is most probably the difference between the two data bases." (Compare Ref. 3 with Ref. 2, p. 16.) Wilson uses data from urban areas where consumers usually have ready availability to utility gas, whereas Anderson's data are from states where gas is not as readily available to those in rural areas. Thus, the opportunity to substitute gas for electricity is not as

* See also R. Halverson, "Residential Electricity: Demand and Supply," unpublished Ph.D. thesis, Harvard University, 1971 (to be published in 1972).



(a) Dollar cost of fuel for each disposable income group



(b) Percent of living expenses for each disposable income group

Fig. 4—Short-run impact of increasing all fuel prices by income groups. All single consumers and urban families, Western United States, 1960-1961

Table 2

PRICE ELASTICITIES AND WITHDRAWALS OF ELECTRIC ITEMS

Item	Elasticity Range (all negative)	Implied Decrease in Ownership for 100% Price Increase
Electric stove	1.6-2.3	0.67-0.80
Electric water heater	2.9-3.9	0.87-0.98
Electric clothes dryer	1.8-2.4	0.71-0.91
Electric food freezer	0.6-0.8	0.34-0.43
Electric heating	5.5-6.5	0.98-0.99

common over entire states as it is in cities. The comparisons in this report are for urban areas, so we should be predisposed to use Wilson's elasticity; however, realizing that both are estimates, we chose the more conservative approach of averaging between the two. This yields an average elasticity of -1.1.

Our purpose is to determine the impact of price changes in electricity on different income classes, and a single value of elasticity is not sufficient. The elasticities estimated by Anderson and Wilson represent aggregate data—averages for whole states and cities, respectively. Although we would expect those values to describe the average household, they are insufficient for individual income groups. Ideally, one should obtain cross-sectional and time series data for households in different income groups and use methods such as those employed by Anderson and Wilson to estimate price elasticities for each group. Such data are only available from records of individual households, and would require a nationwide sampling effort and cooperation of all concerned parties.[11] (It would be similar to the BLS survey of 1960-1961, but on a larger scale to get adequate samples for different fuel prices.) We have employed a less accurate method that at least captures the essence of the differences in elasticities among income groups.

ESTIMATING LONG-RUN IMPACTS OF PRICE INCREASES IN ELECTRICITY BY INCOME GROUPS

The method we employ to estimate the reduction of consumption of electricity is to (1) estimate for a single area (Los Angeles and Orange Counties in California) the saturation of electric and gas consuming devices held by households in different income groups, (2) estimate consumption of electricity by each group, (3) estimate drastic and reasonable withdrawals of electrical items for each group and the corresponding implied elasticities, (4) select elasticities close to the implied values such that the average elasticity is -1.1, and (5) portray the impact on each income group of price hikes of electricity.

1. Estimating Household Energy Device Saturation by Income Group

A home audit survey (1000 households, September to October 1970) sponsored by the *Los Angeles Times* [11] examined the saturation of selected home appliances by income group. Personal interviews were conducted in the Los Angeles/Orange County marketing area (which contains 8,450,000 people and 3,000,000 households) at sample households (both single and multiple dwellings) by an independent marketing research company. The following major and minor appliances are covered in the survey:

range/cooking stove
refrigerator/refrigerator-food freezer combination
toaster
mixer
garbage disposal
coffee maker
can opener/knife sharpener combination
blender
frying pan
waffle grill
carving knife
automatic dishwasher
broiler/rotisserie
food freezer
portable oven
ice crusher
ice cream freezer
meat grinder
vegetable slicer

Saturation levels for each appliance were estimated in terms of household income level. Five income brackets were chosen for cross-comparison, ranging from "under $5000" to "$15,000 and over." The estimates are shown in Table 3. Other major appliances not surveyed by the *L.A. Times* but included in the table are:

black and white television[12]
electric clothes dryer[13]
color television[14]
electric central air conditioner[15]
water heater[16]
vacuum cleaner[17]
room air conditioner[18]
washing machine[19]
space heating[20]

A variety of methods were used to obtain saturation levels for devices not covered in the *L.A. Times* survey. Generally, the average saturation of the device for all income groups was obtained and then that average was distributed across income groups proportionally to data based on other surveys [13,14]. See the notes keyed to each device for a more complete description.

We have separated the table into two classes of devices, necessities and luxuries. This kind of dichotomy is difficult, since a luxury item for one family might be regarded as a necessity by another family. The perception of a necessity depends solely on the personal preference of the owner. For the purposes of this report, identification of a necessity implies that the owner, if making a list of items in order

Table 3

SATURATION OF HOUSEHOLD APPLIANCES BY INCOME GROUP IN THE LOS ANGELES AREA, 1970
(Percent)

Appliance	Average	Under $5000	$5000-$7999	$8000-$9999	$10,000-$14,999	$15,000 and Over
a. Necessities						
Stove	100.0	100.0	100.0	100.0	100.0	100.0
Electric	16.9	7.0	7.1	12.8	23.9	33.6
Gas	83.1	93.0	92.9	87.2	76.1	66.4
Refrigerator	100.0	100.0	100.0	100.0	100.0	100.0
With freezer	70.6	63.4	66.5	75.9	75.6	78.9
Without freezer	33.0	41.4	35.7	27.1	30.0	23.0
Water heater	99.7	98.5	100.0	100.0	100.0	100.0
Electric	6.3	2.2	5.3	7.0	8.5	9.4
Gas	93.4	96.3	94.7	93.0	91.5	90.6
Vacuum cleaner	99.0	99.0	99.0	99.0	99.0	99.0
House heating	98.9	96.5	98.3	100.0	100.0	100.0
Electric	6.6	3.4	5.7	7.4	8.0	8.8
Gas and other	92.3	93.1	92.6	92.6	92.0	91.2
Washing machine	59.0	39.2	59.0	62.9	67.0	70.9
Television	100.0	100.0	100.0	100.0	100.0	100.0
TV (black and white)	69.1	89.0	77.2	65.4	59.4	53.5
TV (color)	46.5	17.5	32.6	49.6	60.2	74.5
b. Luxuries						
Toaster	90.1	89.9	86.3	96.2	94.8	95.4
Mixer	73.9	54.9	67.6	79.7	85.4	89.5
Garbage disposal	65.8	42.9	48.4	65.4	83.6	90.1
Coffee maker	62.5	46.9	55.5	67.7	73.2	76.3
Can opener/knife sharpener	61.4	46.3	49.5	67.7	71.8	79.6
Blender	53.5	33.1	37.9	59.4	73.7	72.4
Fry pan	52.5	45.1	39.6	58.6	67.6	58.6
Waffle grill	43.8	32.6	37.9	43.6	54.0	54.6
Electric knife	31.7	13.7	19.8	34.6	47.9	52.6
Dishwasher	24.2	6.3	9.3	15.8	31.0	63.2
Air conditioning						
Room	21.6	11.3	18.7	23.9	26.1	28.8
Central	6.9	3.6	6.0	7.7	8.4	9.2
Broiler/rotisserie	20.0	10.3	13.7	21.8	26.3	29.6
Clothes dryer	14.5	5.1	12.1	16.2	19.9	21.8
Food freezer	14.0	6.3	7.1	11.3	20.7	26.3
Portable oven	10.8	7.4	9.3	18.0	13.1	9.9
Ice cream freezer	5.3	1.7	2.2	6.8	8.0	9.2
Vegetable slicer	1.7	0.5	1.6	3.0	2.8	1.3
Ice crusher	8.9	2.9	3.3	7.5	13.6	19.1

of their importance, would sooner (on the average) give up the items classed as luxuries rather than those classed as necessities. This does not apply to such tradeoffs as electric stove to gas stove, but to the category of the device in general (e.g., stoves, refrigerators, TVs, etc.).

There are several indications that the division is reasonable. First, the saturation for items classed as necessities is nearly 100 percent for all groups. One exception is washing machines, but in the Los Angeles-Orange County area about 50 percent of the households are held by renters, with the higher density of renters in low income groups.[21] Thus washing machines are very likely in nearly 100 percent of those households that are private homes. Second, the BLS consumer survey 1960-1961 [4] provides information from which we computed the following pattern of purchases, by income class (see p. 4 for a complete list of appliances). All groups spent the majority of their appliance allocation on these five items, with the lowest income groups spending the greatest percentage on these items. This further reinforces the notion that these items would rank quite high on the list of necessities.

Income Group All Urban and Single Consumers, Western U.S., 1960-1961	Money Spent on Stove, Refrigerator, Washing Machine, Radio, and TV as a Percent of All Money Spent on Appliances
Below $3000	72%
$3000-$9999	61%
$10,000 and above	54%

Third, a study based in Houston [16] researched the symbolism various products held for different groups within the population. The items that ranked highest in terms of actual importance to the respondents in the $3000 to $6000 income category were stove, refrigerator, and washing machine, in that order.[22] Further, there is evidence that even between income groups there is greater emphasis on the necessity of television sets for lower income groups than for the higher ones. Low income families spend more time in their dwellings, do not leave the inner city as often as their wealthier counterparts, and are not financially able to find entertainment outside the home on a regular basis. In Lansing, Michigan, low income groups watched TV 5.2 hours daily compared with a general population figure of 2.0 hours. Low income teenagers in Philadelphia averaged 5.45 hours in front of the TV on a typical Sunday compared to 3.7 hours for middle class teenagers [17]. Our expectation is that the reduction of necessities will be more difficult than luxuries when each consumer class is subjected to a price increase. By definition, a necessity is an item that is regarded as highly desirable in day-to-day living. Consumers do not regard necessities as expendable. It is obvious from Table 3 that appliance ownership increases with income (a finding that is consistent with the results of examination of the BLS 1960-1961 data on appliance purchases shown in Appendix A). The table also demonstrates that the ownership of luxury items—dishwashers, clothes dryers, air conditioners, etc.—is particularly sensitive to income level.

2. Estimating Consumption of Electricity by Income Group

The consumption of electricity by income group can be estimated on the basis of the saturation data in Table 3 in conjunction with typical electrical consumption rates per device. In order to provide a rough estimate of kWh used by income class, we have assumed a constant appliance use pattern across the income groups. The expected amount of electricity consumed per year per device is equal to the saturation of the household device times average kWh used annually per device. Table 4 was prepared on this basis. (Exceptions are explained in footnotes, which precede

Table 4

HOUSEHOLD APPLIANCE CONSUMPTION OF ELECTRICITY (kWh) BY INCOME GROUP IN THE LOS ANGELES AREA, 1970

Appliance	Average	Under $5000	$5000-$7999	$8000-$9999	$10,000-$14,999	$15,000 and Over	kWh per Year per Device
a. Necessities							
Lighting[23]	697.0	238.0	340.0	665.0	925.0	1305.0	
Stove	198.6	82.3	83.4	150.4	280.8	384.8	1175
Refrigerator							
With freezer	802.7	720.9	756.1	863.0	859.6	897.1	1137
Without freezer	240.2	299.2	259.9	197.3	218.4	167.4	728
Water heater	265.8	92.8	223.6	295.3	358.6	396.6	4219
Vacuum cleaner	45.5	45.5	45.5	45.5	45.5	45.5	46
House heating							
Electric[24]	462.0	238.0	399.0	518.0	560.0	616.0	7000
Gas (furnace fan)[25]	360.6	219.7	270.8	364.8	432.4	501.6	394
Washing machine	60.8	40.4	60.8	64.8	69.0	73.0	103
Television							
TV (black and white)	250.1	322.2	279.5	236.7	215.0	193.7	362
TV (color)	233.4	87.9	163.7	249.0	302.2	374.0	502
Total	3616.7	2386.9	2902.2	3649.8	4266.5	4954.7	
b. Luxuries							
Toaster	35.1	32.3	33.7	37.5	37.0	37.2	39
Mixer	9.6	7.1	8.8	10.4	11.1	11.6	13
Garbage disposal	19.7	12.9	14.5	19.6	25.1	27.0	30
Coffee maker	66.3	49.7	58.8	71.8	77.6	80.9	106
Can opener/knife sharpener	9.2	6.9	7.4	10.1	10.8	11.9	15
Blender	8.0	5.0	5.7	8.9	11.1	10.9	15
Fry pan	97.7	83.9	73.7	109.0	125.7	108.9	186
Waffle grill	9.7	7.2	8.3	9.6	11.9	12.0	22
Electric knife	2.5	1.1	1.6	2.8	3.8	4.2	8
Dishwasher	87.8	22.9	33.8	57.3	112.5	229.4	363
Air conditioning							
Room[26]	342.0	160.9	272.7	365.2	435.0	520.0	1389
Central[27]	238.9	69.1	153.6	246.4	322.6	412.2	3200
Broiler/rotisserie	20.0	10.3	13.7	21.8	26.3	29.6	100
Clothes dryer	144.0	50.6	120.2	160.9	197.6	216.5	993
Food freezer	167.3	75.3	84.8	135.0	247.4	314.3	1195
Portable oven	22.1	15.2	19.1	36.9	27.1	20.3	205
Ice crusher	1.3	0.4	0.5	1.1	2.1	2.7	15
Ice cream freezer	5.3	1.7	2.2	6.8	8.9	9.2	100
Vegetable slicer	0.2	0.1	0.2	0.3	0.3	0.1	10
Total	1276.7	612.6	913.3	1311.4	1693.9	2058.8	
Grand Total	4893.4	2999.5	3815.6	4961.2	5960.4	7013.5	

the References.) Sources of data on device annual kWh demand are the Edison Electric Institute [18], the Electric Council of New England [19], and All-Electric Homes [20].

Using this method, the average consumption for Los Angeles and Orange Counties is 4893.4 kWh per household annually. This figure is quite close to the weighted average of 4795 kWh for the L.A. Department of Water and Power and Southern California Edison reported for 1970 [20].

The devices that consume the largest amount of electricity in the average household are, in order, refrigerators, space heating (including electric fan in gas units), lighting, air conditioning, television, water heater, stove, food freezer, and clothes dryer; these devices account for 90 percent of the average household's consumption of electricity. The share of total consumption that necessities comprise varies with income. As income increases, the percentage of consumption of electricity devoted to necessities falls from 78 percent (low income) to 67 percent (high income). This drop would seem to indicate that high income consumption might be more elastic than low income consumption.

3. Estimating Price Elasticity of Consumption of Electricity by Income Group

In the face of a large price increase, if given a long enough period of time, there are several ways a household can adjust its consumption: reduction of intensity of use of existing devices, substitution of some devices with their nonelectric counterparts, reduction in saturation of devices, and where no substitute fuel exists, the replacement of existing electric devices with more efficient ones. The mix of these actions can be expected to vary by income class. We have developed several feasible scenarios that might result if the price of electricity were double its current level. Because we are discussing methods of reduction possible today, we have assumed that the real price of electricity has been consistently higher than it actually has in the past 20 to 30 years. The time span employed here would give the consumer adequate time to employ many of the methods suggested in the scenarios.

First, to measure the maximum decrease in consumption, a very drastic case (but consistent for all income groups) is given. This case consists of reducing the lighting for the top three income classes by one-third to "adequate"[23] instead of optimum levels; removing all electric stoves and allowing only one refrigerator (without freezer) and one black and white television to each family; removing all electric water and space heaters (electric fan consumption is appropriately increased); and removing all items classed as luxuries. The reductions in electricity are shown in Table 5 and range from 45 percent for lowest income to 63 percent for highest income group, demonstrating both the larger share of luxuries held by the high income group as well as their greater stock of substitutable devices.

Next, a more reasonable scenario is computed. For the first two income classes, all electric stoves, water heaters, space heating, and clothes dryers are replaced by their gas counterparts. This is basically consistent with the elasticities in Table 2

Table 5

DECREASES IN CONSUMPTION OF ELECTRICITY BY INCOME GROUPS FOR TWO ASSUMED CASES

Gross Income Group, $	Drastic Case, %	Reduction Implied[a] Elasticity	Reasonable Case, %	Reduction Implied[a] Elasticity
Under 5000	45	-0.9	30	-0.5
5000-7999	51	-1.0	40	-0.7
8000-9999	59	-1.3	49	-1.0
10,000-14,999	62	-1.4	52	-1.1
15,000 and over	63	-1.5	54	-1.2

[a]For a doubling in the price of electricity.

obtained by Wilson [3]. Washing machines are reduced by 15 percent, which can be achieved through decreased saturation or reducing the number of loads run per week. A fifty-fifty mix of the two refrigerator types is allowed. All other luxury items are reduced 65 percent. Although this is an arbitrary figure, a similar reduction in consumption can be reached in other ways, such as a 50- to 75-percent reduction in air conditioning through better insulation,[28] a 50-percent reduction in food freezers (see Table 2), a different mix of refrigerator types, and a 10- to 15-percent reduction in other items. The resulting reduction of 30 and 40 percent for the two low income classes is by no means exact, but the scenario does represent a reasonable set of conditions and is less drastic than the first case, which represents considerable deprivation.

The reasonable scenario for the three higher income groups includes substitution of gas for electric stoves, water heaters, electric heaters, and clothes dryers, and is consistent with the appliance price elasticities shown in Table 2. Food freezers[29] are reduced by 50 percent (see Table 2), and 50-percent savings in air conditioning and furnace fans are assumed to result from improved insulation[28] in households with air conditioning. Lighting is reduced by approximately 45, 55, and 60 percent for the middle, high, and highest income classes, respectively. This reflects both decreases in intensity of use and switches to more efficient fluorescent lighting[30] (see Appendix D). A minimal reduction of 15 percent is used for all other electric devices and incorporates both reductions in intensity of use and decreases in saturation. The results are shown in Table 5.

It may be concluded from this subsection that: (1) the maximum ability to reduce consumption of electricity by low income groups is less than that predicted by research using highly aggregated data; (2) the ability to reduce consumption increases with income; and (3) high income groups can reduce consumption of electricity primarily by shifting fuels and increasing efficiencies without being deprived of home equipment.

4. The Impact of Price Increases of Electricity on Income Groups

Using the information in the preceding paragraphs, we estimated a price elasticity of consumption of electricity for each income group in the Western Region of the United States, 1960-1961. Estimates were close to the implied price elasticities in the *reasonable* column of Table 5 and have an overall average of -1.1 The individual values are shown in Table 6.[31] To complete the picture, it is necessary to estimate the increase in gas consumption due to shifts from electric to gas appliances.

Anderson [1] has estimated the residential cross-price elasticity (the effect of a change in the price of electricity on gas consumption) at $+0.08$, based on national cross-sectional data. This suggests that a doubling in the price of electricity would increase the residential consumption of utility gas by 6 percent. The California consumption of gas per average household in 1970 was about 100×10^6 Btus [28]. The electrical equipment that is withdrawn, as discussed in the preceding subsection, would be converted to gas devices using 5.4×10^6 Btus,[32] or an increase of 5.4 percent in the average household's consumption of utility gas. This appears to lend credence to Anderson's estimate. Although we expect this increase to vary with income class, its effect on expenditure changes is so small that we used it uniformly over all groups. Figures 5(a) and 5(b) show the impact on each group's fuel and living expenses. They are summarized in Table 6. The lowest income groups sustain relatively larger effects than do the high income groups. The highest income groups reduce their expenditures on operating costs by proportionally larger switches to lower price fuels (gas costs were approximately \$1.00 per 10^6 Btus and electricity for high users was about \$4.00 per 10^6 Btus) and increasing fixed costs for equipment (improved insulation and installation of fluorescent fixtures).

IMPACT OF INCREASING PRICES OF ALL FUELS

What would occur if the price of all fuels were increased? This could come about through natural increases in the cost of discovering, processing, and transmitting gas, or through legislative restraints to conserve energy.

Anderson [1] estimated, from cross-sectional analysis of data from the 50 states for 1969, a price elasticity of -0.8 for total energy consumption. He converted gas consumption to equivalent kWh and used a weighted sum of the quantities of gas and electricity consumed in each state (i.e., gas and electricity are treated as a single fuel); the price variable was a weighted average of the cost of gas (equivalent kWh) and electricity. If we treat fuel expenditures (Fig. 2) as if they were for a single fuel and prices move simultaneously, we will be approximating the model used by Anderson.

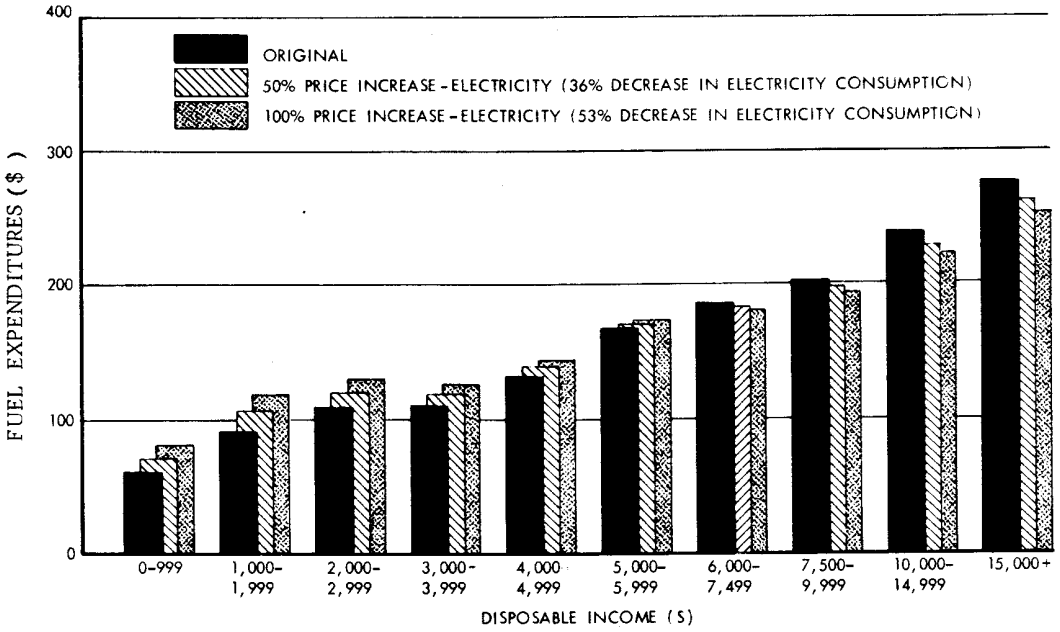
The price elasticity is expected to be lower when all fuel prices increase, since the tendency to switch fuels would be somewhat reduced. Accordingly, we have reduced each income group's price elasticity roughly proportionately to the reduc-

Table 6

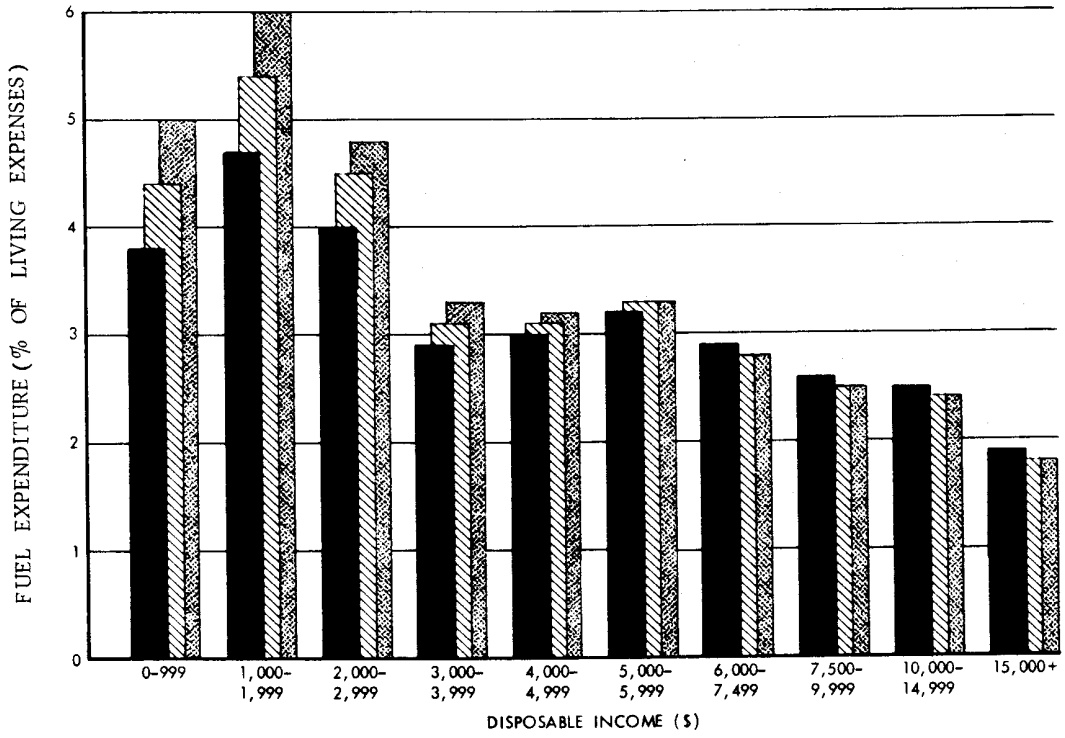
SUMMARY OF IMPACT OF FUEL PRICE INCREASES, EXPRESSED AS A PERCENTAGE OF LIVING EXPENSES, ON ALL URBAN FAMILIES AND SINGLE CONSUMERS, WESTERN UNITED STATES, 1960-1961

Income Group, $	Original Fuel Expenditures as % of Living Expenses	Short-Run, Electricity Only (Elasticity = -0.25)		Long-Run, Electricity Only, (Gas Cross Elasticity = +0.08)			Short-Run, All Fuels (Elasticity = -0.25)		Long-Run, All Fuels		
		50% Price Increase	100% Price Increase	50% Price Increase	100% Price Increase	Elasticity[a]	50% Price Increase	100% Price Increase	50% Price Increase	100% Price Increase	Elasticity[a]
0-999	3.8	4.4	4.9	4.4	5.0	-0.25	5.1	6.3	5.1	6.4	-0.24
1000-1999	4.7	5.5	6.3	5.4	6.0	-0.40	4.7	7.8	6.1	7.3	-0.35
2000-2999	4.0	4.7	5.3	4.5	4.8	-0.55	4.0	6.8	5.0	5.9	-0.45
3000-3999	2.9	3.4	3.8	3.1	3.3	-0.70	3.9	4.8	3.4	3.9	-0.55
4000-4999	3.0	3.5	4.0	3.1	3.2	-0.85	4.0	5.0	3.4	3.8	-0.65
5000-5999	3.2	3.8	4.3	3.3	3.3	-1.00	4.4	5.4	3.6	3.8	-0.74
6000-7499	2.9	3.4	3.9	2.8	2.8	-1.15	3.9	4.8	3.0	3.2	-0.84
7500-9999	2.6	3.1	3.5	2.5	2.5	-1.20	3.5	4.4	2.7	2.7	-0.93
10,000-14,999	2.5	3.0	3.4	2.4	2.4	-1.30	3.4	4.2	2.5	2.5	-1.03
15,000 and over	1.9	2.3	2.6	1.8	1.8	-1.40	2.6	3.3	1.8	1.8	-1.13
Reduction in consumption, %	0	10	16	36	53		10	16	28	43	

[a]Figures in this column represent the elasticities calculated in this report.



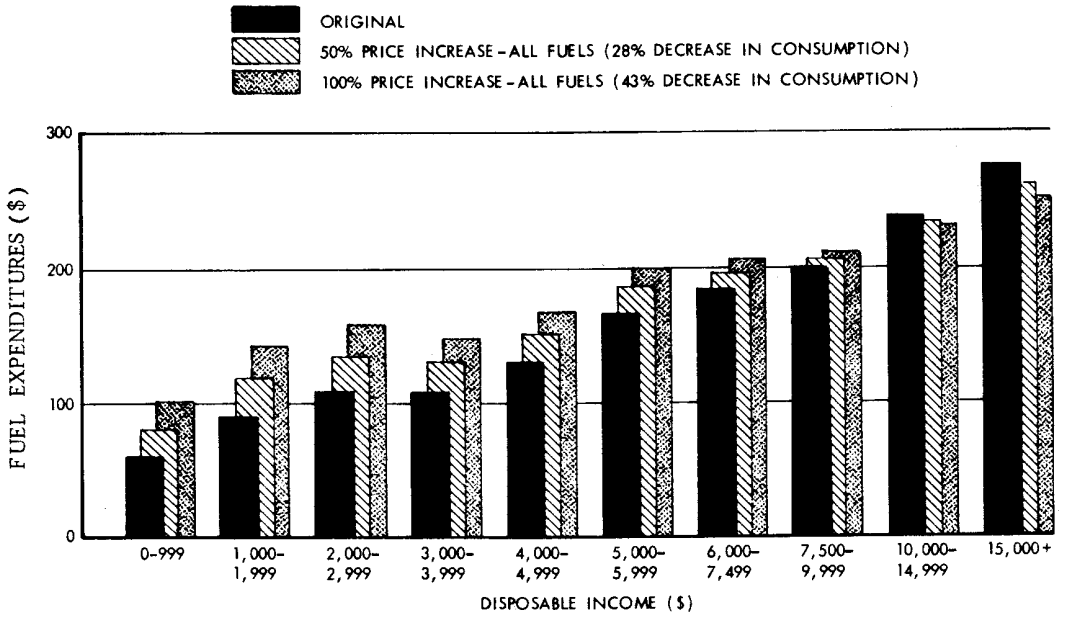
(a) Dollar cost of fuel for each disposable income group



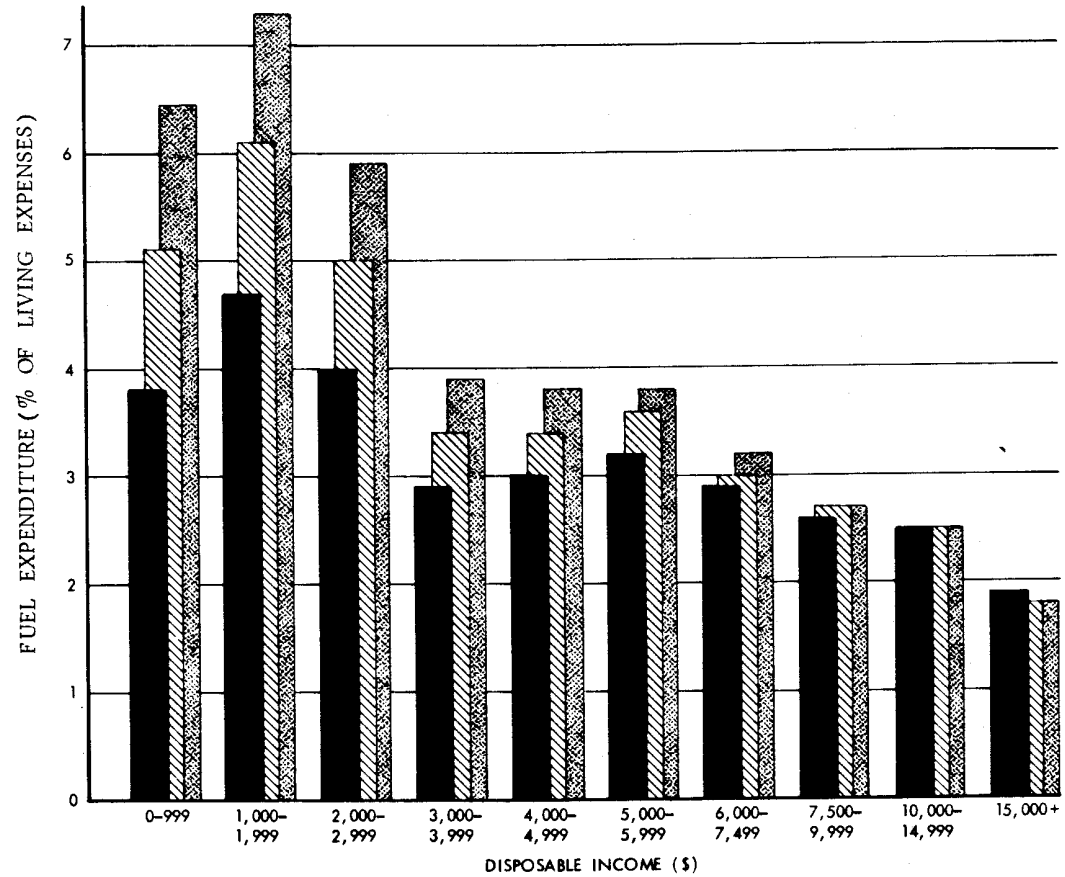
(b) Percent of living expenses for each disposable income group

Fig. 5—Long-run impact of price increases in electricity (varying elasticities) on fuel expenditures. All single consumers and urban families, Western United States, 1960-1961

tion originally achieved by substituting gas equipment for electric items, and then each group's price elasticity was adjusted so the overall weighted average was −0.8. These are shown, along with summary data, in Table 6. The impacts on each income group are portrayed graphically in Figs. 6(a) and 6(b). As anticipated, the impact is relatively heavier on the low income groups because of their larger share of nonreducible, nonsubstitutable necessities and the limited action available to them in improving efficiencies.



(a) Dollar cost of fuel for each disposable income group



(b) Percent of living expenses for each disposable income group

Fig. 6— Long-run impact of increasing all fuel prices by income groups. All single consumers and urban families, Western United States, 1960-1961

IV. POLICY IMPLICATIONS

The effects of residential price increases in electricity are independent of the source of the increase. (We assume that increases are uniformly applied to the current rate schedule.) Energy prices can rise quite naturally, by passing on to the consumer increases in costs related to production, distribution, and marketing of energy. On the other hand, if natural real price increases to curb demand do not occur, or come too slowly, public welfare might suffer because of spiraling energy demands. It might then be necessary to initiate legislative action to correct the situation. Legislative policies could increase prices indirectly through pollution taxes on utilities, more stringent pollution standards, power plant license fees, and bans on certain types of plant location and transmission methods. Alternately, legislative action could increase energy prices directly through a sales or use tax on residential consumption of energy. We do not suggest here that any of these policies are equally good or even that policies that affect prices are necessary. Although there are many policy options open to the government [1], we are concerned only with those that would increase the price of electricity to the residential consumer.

Price increases due to production costs and indirect government policies would accrue to the utilities. These increases would then be passed on to the consumer via the rate making process. This process is examined next.

THE RATE BASE

In spite of inflationary trends in most of the economy, electric utility companies were able to forestall price increases in electricity for many years. More recently, however, these companies have been faced with rising costs on practically every facet of operation—manpower, supplies, fuel, and capital costs—in addition to stringent environmental quality control programs. Rates are beginning to rise.

Rate increases are based on a specified rate of return that a utility company is allowed to earn on its capital investments. This return covers interest payable by the company on its long-term debt, dividends on preferred stock, earnings on com-

mon equity, institutional advertising expenditures, and future capital investments. It is expressed as a percentage of the capital used for production purposes.

The determination of a fair and reasonable rate of return is guided by criteria set forth by the U.S. Supreme Court [30]:

> What annual rate of return will constitute just compensation depends upon many circumstances and must be determined by the exercise of a fair and enlightened judgment, having regard to all relevant facts. A public utility is entitled to such rates as will permit it to earn a return on the value of the property which it employs for the convenience of the public equal to that generally made at the same time and in the same general part of the country on investments in other business undertakings which are attended by corresponding risks and uncertainties; but it has no constitutional right to profits such as are realized or anticipated in highly profitable enterprises or speculative ventures. The return should be reasonably sufficient to assure confidence in the financial soundness of the utility, and should be adequate under efficient and economic management to maintain and support its credit and enable it to raise duties. A rate of return may be reasonable at one time, and become too high or too low by changes affecting opportunities for investment, the money market, and business conditions generally.

Typical rates of return for California public utilities are about 7 or 8 percent. However, there is no exact formula for determining the rate of return and various interest groups interact during the rate setting process. For example, in a recent rate decision [30], the Public Utilities Commission staff recommended 7.2 percent of the capital base; AFL-CIO recommended 7.1 percent; the U.S. government, 7.0 percent; and Consumer Associates, 6.62 percent. A small change in the rate of return can have a substantial impact on both the ability of the utility to raise investment capital and on prices to the consumer.

Determining Rate Schedules

The selection of a fair or equitable rate of return is complicated by the allocation of rate changes among the various customer classes. The phrase "rate-spread" usually describes the unit demand charge and rate block within each customer class. Although this term implies a rather general or vague apportionment of rates among users, it is misleading because decisions at rate hearings are generally made with much deliberation and extensive testimony. At a recent California hearing [31], for example, the problem of rate scheduling was hotly contested and lasted over one-third of the duration of the meeting. Rates for electricity differ according to customer classes, which may be generally divided into domestic (residential), lighting and small power (commercial), large and very large power (industrial), railroads, agricultural and pumping, street lighting, and miscellaneous categories.

Within each class, the rates per kWh vary by total electrical energy usage. The larger users are generally charged less per kWh than the smaller users, who pay the highest unit charge for electricity. Because the small users are predominately the poor and the elderly, who can least afford to pay a higher unit cost for electricity,

the rate structure is regressive. Yet both utility companies and commissions that approve rate requests have avoided the thorny issue of setting rates according to "ability to pay" among the residential customers. This issue has been debated in rate hearings, but has always been dismissed as inappropriate or irrelevant to the determination of rate changes.

There have recently been a number of petitions in California for rate increases, and some of them have looked at fair rate apportionment among customers. The Pacific Gas and Electric Company (PG&E), for example, filed such an application before the state Public Utilities Commission in late 1969 [30]. After 47 days of intensive hearings, PG&E was granted overall rate increases approximating 8.2 percent for residents, 7.2 percent for the commercial sector, 7.0 percent for industry, 7.6 percent for agricultural customers, and similar rate changes for such remaining customers as state water projects, schools, and street lighting.

Within the residential sector, special rate treatment was considered for designated customer groups. Consumer-oriented groups[33] urged that no rate increase be forced on the elderly and small users of 200 kWh or less per month. The rationale behind this recommendation was that the poor and the elderly with fixed incomes are most susceptible to economic hardship from the rate increase. But such rate relief was vetoed by PG&E as well as the CPUC staff because, as PG&E stated, "welfare problems of the elderly and the poor are matters for legislative consideration and solution rather than being matters for this Commission to resolve [30]."

IMPLICATIONS OF THE RATE SETTING PROCESS

Section III showed that large increases in the price of electricity would have relatively greater impact (in the long run) on low income groups than on high income groups. Previous actions by the Public Utilities Commission indicate that they are reluctant to address differential impacts on consumer groups. Thus, if legislative action is taken that indirectly increases the price of electricity, it may be expected that lower income groups will experience the greater relative financial burden. The effect could be minimized by permitting low income families ($5000 or less gross income, 1970 dollars)[34] to deduct from their state income tax (or be reimbursed for) some proportion of the price increase induced by the governmental action. The funds could be provided by tax revenues gained from the government action that produced the price increase. If the government action produced no revenue (such as a pollution standard), then general revenues could be used. Reducing or eliminating the impact on low income users would also reduce or eliminate their incentive to curtail consumption. However, this effect would be slight because the three lowest income classes account for only 6 percent of total consumption and their opportunity for reducing usage is relatively small. For a 100-percent general price increase in electricity, the 53-percent reduction in residential consumption estimated in Section III would drop to 52 percent if low income consumers were totally exempted.[35] The revenues required to support such exemptions can be es-

timated roughly. Assuming 5,001,255 California families (17 percent of whom have incomes below $5000) [32] paying an average price of $0.04/kWh for an average 2500 kWh annually,[36] and also assuming a 100-percent price increase with total exemption provided for those consumers with incomes below $5000, $85 million would be required annually. Exemption from half the increase would require $33 million (less than half because some incentive to reduce consumption would remain). These estimates should be used only as points of reference; if a rebate policy were seriously considered, more precise techniques would be necessary. The important point is that a policy that indirectly increases the price of residential electricity can be structured to minimize adverse differential effects to consumers, with only minor changes in the total reduction of consumption and the transfer of some state revenues.

IMPLICATIONS OF SALES OR USE TAXES

If a policy of taxing electricity used by the consumer (a direct increase) were initiated, it would have the long-run effects shown in Section III, as would any other uniform method of increasing price. However, unlike the indirect increase, the effect of government action on each individual is easily computed by all taxpayers. Differential impacts on consumer groups could well cause difficulty in attempting to initiate such actions. Using the 1960-1961 data of this study, we have calculated the share of income devoted to the tax by each group (see Table 7).

For 100-percent taxation of electricity or all fuels, the burden for the lowest income group is two to three times higher than for the highest income groups. Thus, not only will low income groups have the greater differential effects discussed in Section III, as a class they would sustain a higher per household tax burden.

Table 7

ANNUAL TAX BURDEN DUE TO USE TAX FOR RESIDENTIAL CONSUMERS IN THE WESTERN UNITED STATES, 1960-1961

	Tax Electricity 100%		Tax All Fuels 100%	
Income Group, $	Annual Tax, $	% of Living Expenses	Annual Tax, $	% of Living Expenses
0-999	18	1.10	51	2.5
1000-1999	36	1.86	71	3.0
2000-2999	34	1.26	80	2.4
3000-3999	34	0.88	75	1.6
4000-4999	37	0.83	84	1.6
5000-5999	40	0.77	100	1.6
6000-7499	44	0.67	104	1.4
7500-9999	45	0.58	106	1.2
10,000-14,999	50	0.53	117	1.2
15,000 and over	50	0.35	126	0.9

There are several ways these effects could be minimized: (1) All consumers using less than 100 or 200 kWh[36] per month could be exempted from the tax; (2) the first "x" kWh for all consumers could be exempted, with a proportional increase in rate above that level to achieve some desired average rate increase (e.g., 65-percent increase in rates for consumption above 75 kWh per month would lead to about a 50-percent increase overall); and (3) the tax deduction/rebate method discussed in the previous section could be applied to low income consumers.

Method 1 suffers from a major defect in that not all low income users would be relieved because some use more than 100 to 200 kWh per month. Further, those high income users who fell in the low consumption category would not have the incentive to reduce consumption. A study commissioned by Con Edison (New York City) shows that there is considerable overlap[37] in consumption distribution of high and low income users. This is to be expected, since some low income users have very large families and some high income consumers have no families and/or spend more time away from home.

Although Method 2 also suffers from this defect, it does have at least two interesting characteristics. All consumers have some exemption, which might be useful in passing legislation, and the tax rate would be progressive by usage. The highest users would have the greatest increases in price and presumably the greatest ability to reduce electrical consumption (the majority are high income consumers). This would lead to a greater reduction in consumption (for a properly selected level of exemption) than was estimated in Section III.

Method 3 is the most equitable from the standpoint of minimizing adverse impact on low income consumers. They could be fully or partially exempted from any tax and all members of the class would be relieved regardless of their level of consumption. The total reduction in residential consumption would only be affected slightly,[35] and the only government cost would be that required to return tax already paid.

V. CONCLUDING REMARKS

We have attempted to show through descriptive statistics what impacts fuel price increases might have on residential consumers. Particular emphasis is given to the price and consumption of electricity and the differential effects on various economic groups. These effects are the same whatever the source of the price increase, i.e., production cost increases or tax-induced increases.

In the short run, consumers can react to a price increase only by decreasing the intensity of use of their existing stock of energy consuming devices. Short-term price elasticity is therefore expected to be very small (inelastic). All consumers will increase their expenditures for fuels and consumption will decrease only slightly. Major electric home devices are generally used from 4 to 20 years. Hence our discussion of the short-run reaction to price fluctuations can cover a long time interval. However, as appliances are replaced and new houses are built, the influence of price increases will become quite noticeable.

In the long run, it is estimated from econometric studies that the price elasticity of demand for electricity will range from -0.91 to -1.33 for the average residential consumer. This level of price elasticity is not, however, anticipated for each level of consumer income. The lowest economic group owns the smallest share of appliances that consume electricity. Those they do own are primarily necessities. These factors, as we have shown, cause the low income groups to be relatively price inelastic. High income groups, owning a larger stock of substitutable devices, have a much greater ability to reduce consumption and are thus price elastic. The results we have obtained indicate that the low income groups would have that portion of living expenses devoted to fuel expenditures increased from about 4 percent to as much as 7 percent if fuel prices doubled. In contrast, the more affluent consumer would spend nearly the same amount of income on energy after the price increase as he had before. His overall consumption of fuels would decline more than 40 percent if all fuel prices doubled.

For the data examined, consumers with less than $3000 annual income represent 17 percent of the population and consume only 6 percent of the electrical energy. This fact suggests that exemption of low income groups from price increases in electricity would have almost no effect on the desired overall decrease in consumption of electricity induced by such increases. It would, however, relieve those income

groups from the financial burden of additional expenses for electricity. Such exemptions could be implemented easily.

The study does not consider whether government action is necessary or what form it should take should it be found desirable. The report does provide a first step toward examining the dimension and magnitude of effects of fuel price increases on income groups, which may aid policymakers in their ultimate decisions concerning energy.

Appendix A

DETERMINATION OF APPLIANCE PURCHASE RELATION

The BLS *Survey of Consumer Expenditures* for the Western Region, 1960-1961 [4], provides appliance expenditure data for 10 disposable income groups and six family sizes. These data were used to determine the following relationship:

$$\$APP = 1.27 + \underset{(10.154)}{0.677} \times DI + \underset{(3.66)}{0.288} \times SOH$$

where $\$APP$ = the natural logarithms of annual appliance expenditures for all appliances
DI = the natural logarithm of 1960 family disposable income
SOH = the natural logarithm of number of people per family
R^2 = 0.78

and

Standard error is 0.314
45 degrees of freedom

This form of the relation was selected because it provides the best fit to the data.

Statistics are as follows: R^2 is a measure of the goodness of fit, 0 indicates no relationship, and 1 indicates a perfect relationship of the fit to the data. The t-statistic (given in parentheses under the $APP equation) measures the significance of each individual coefficient. Generally, values over 3 indicate very significant coefficients. The F-statistic measures the significance of R^2. Use of the standard error permits computation of the confidence region for estimates made using the relation. Degree of freedom is related to the size of the sample used in developing the relation and allows one to determine significance levels of t- and F-statistics. See Ref. 9 or another general econometric text for a more complete explanation.

Appendix B

DETERMINANTS OF EXPENDITURES FOR RESIDENTIAL FUELS (Gas, Fuel Oil, and Electricity)

Bureau of Labor Statistics report 237-37 [4] provides data by 8 to 10 disposable income classes for six family sizes. We used these data to develop a model of 1960-1961 fuel expenditure patterns for urban areas in the Western Region of the United States. The relevant equation is:

$$\text{Fuel} = 15.60 + \underset{(0.0014)^*}{0.0092} \times \text{CONS\$} + \underset{(1.74)}{17.88} \times \text{SOF} + \underset{(0.22)}{0.73} \times \text{HOW}$$

where CONS$ = average dollar expenditures for living expenses for each disposable income class
SOF = average size of family for each income class
HOW = average percentage of home owners all year for each income class
Fuel = average dollar expenditures for gas, fuel oil, and electricity
R^2 = 0.907 (adjusted)
F = 162.2

and

Standard error is $21.31
46 degrees of freedom

The highly significant coefficients show that in addition to income, family size and home ownership influence the purchase of fuels. This result is quite expected; the more people in the family, the greater the use of appliances, and the greater the income, the more the stock of appliances. It is also true that homes use more energy for light and heating than do apartments.

Statistics are discussed in the last paragraph on the preceding page.

* Parenthetic values are the standard errors of the coefficient, which are significant at the 0.01 level or higher.

Appendix C

RELATION BETWEEN DISPOSABLE INCOME AND EXPENDITURES FOR LIVING EXPENSES

Disposable income is often used to compare expenditures among households. However, when looking at income classes, especially low income classes, reliance on disposable income can distort the comparison. Low income classes normally spend more than they earn in a given year [33], either by borrowing (increasing liabilities) or by drawing against savings and investment (decreasing assets). For example, our lowest income group ($0-999) has a disposable income of $401 but spends $1601. Because the average age of this group is over 60 years, it is assumed that most of the extra money is derived from decreases in assets.

A relation between disposable income and living expenses for urban areas in the western United States was constructed from data in Ref. 4:

$$C = 1913 + \underset{(0.021)^*}{0.589} \times I$$

where C = living expenses, dollars
I = disposable income dollars (dollar income after taxes)
R^2 = 0.94
F = 802

and

Standard error is $860
48 degrees of freedom

The relation was developed using the 10 income classes for each of the six family sizes reported in the BLS survey [4]. This demonstration of the close relation between disposable income and living expenses permits use of the latter as a measure of a household's total cost of living.

An explanation of the statistics appears in the last paragraph of Appendix A.

* The value in parentheses is the standard error of the coefficient, which is significant at the 0.001 level.

Appendix D

DECREASES IN ELECTRICAL CONSUMPTION WITH FLUORESCENT LIGHTING

Savings of two-thirds in operating costs and consumption of electricity can be achieved by switching from incandescent to fluorescent lighting.* Table 8 compares the two types of lighting, and Table 9 gives the total annual costs for each lighting system for two prices of electricity.

Table 8

INCANDESCENT VERSUS FLUORESCENT LIGHTING EQUIPMENT

Item	Incandescent	Fluorescent[a]
Lumens	1750	1750
Watts	100	34
Life (hr)	750	11,500
Bulb cost ($)	0.25	3.25
Converter cost ($)	--	13.50
Annual interest penalty (@ 6%) for conversion	--	0.81

[a]General Electric 32 fluorescent bulb.

For higher prices for electricity, there are annual dollar savings associated with use of fluorescent lighting. These computations were based on a specially manufactured converter that can be screwed into ordinary incandescent lamp sockets. Greater savings would be achieved in new housing if the originally installed fixtures accommodated fluorescent bulbs.

* This information was provided by Lighting Conversions, Inc., San Rafael, California; it is in general agreement with information in *Consumer Bulletin*, September 1970.

Table 9

ANNUAL COST OF 1750-LUMEN INCANDESCENT VERSUS FLUORESCENT LAMP

(Assumes 10-yr life of converter)

	Annual Hours of Operation			
	1095 (3 hr/day)		2200 (6 hr/day)	
	Cost of Electricity, $/kWh			
Total Annual Cost, $	0.02	0.04	0.02	0.04
Incandescent	2.56	4.75	5.13	9.53
Fluorescent	3.22	3.97	4.28	5.78

NOTES

1. The term demand as used here means the total quantity of electricity consumed during a given time period (e.g., kilowatt-hours per year). This definition differs from that of the electric utility industry, which defines demand as the instantaneous rate of consumption of electricity.

2. For the purposes of this report, electricity is considered a fuel in the same context as gas and fuel oil, since in many respects they are interchangeable in the household.

3. See Ref. 4. The survey, which included both urban and rural areas, was made jointly by the Bureau of Labor Statistics and the U.S. Department of Agriculture. A three-stage sample design was used within each consumer unit. The population represented by each surveyed area was divided by the average family size in the area as determined by the survey to obtain the total number of families represented by each area. The comparable total for the Western Region was 8,766,285. Surveys were conducted by personal interviews.

4. This typical consumer unit in 1960 had 3.1 people, with 1.3 under 18 years of age and 0.2 over 64 years old. The average head of the household was 48 with 11.3 years of schooling. Roughly 35 percent owned their own homes, and 80 percent owned at least one automobile. Only 9 percent were nonwhite; they were primarily black. In 1970 the typical consumer unit in California had 2.9 people per household, 54.9 percent were home owners, the median number of rooms per dwelling was 4.7, 11 percent were black or other than white, 33.3 percent were under 18, 9 percent were over 65, and 88 percent owned at least one automobile. (From *General Population and Housing Characteristics for California,* Bureau of the Census, 1970.)

5. Original fuel cost data from the BLS survey included combination gas-electric bills in which no distinction is made between individual fuels. These bills were partitioned in the same ratio as individual gas and electric bills. Thus, for purposes of this study, gas and electric expenditures are each aggregated over individual bills and a reasonable portion of combined bills.

6. Estimates of consumption of electricity and average price were made by using the block-rate charges averaged for Oakland and Long Beach, California, from the 1960 *Typical Electric Bills* [6] to construct an average price per kWh versus kWh consumed curve. Knowing the amount spent on electricity permits, through a

series of iterations on the curve, determination of the unit price and kWh consumed, to yield the amount spent.

7. For example, a price elasticity of -1.0 indicates that a 1-percent increase in price will result in a 1-percent decrease in quantity demanded. Thus, total expenditures will remain constant. A price elasticity of -0.25 indicates that a 1-percent increase in price will result in only a 0.25-percent decrease in demand. Thus, total expenditures will increase. The condition in which price elasticity is between zero and plus or minus one is known as price inelasticity. When the elasticity is greater than 1.0 in magnitude, it is described as price elastic.

The relation used throughout this paper to evaluate the effect of a price increase is:

$$Q \sim Pe$$

where Q is the quantity demanded, P is the real price, and e is the elasticity.

8. The following withdrawals of consumption of electricity were used on the data of Table 4 to make the estimate:

0-40% lighting (allows for replacement by fluorescent fixtures)
0-20% water heating
0-25% washing machine, dishwasher, and clothes dryer
0-20% air conditioning

9. Real price means that the actual price is corrected to remove the effects of inflation (changes in the cost of living). Throughout the report all references to price or cost are meant as real.

10. The estimating method used by both Wilson and Anderson was ordinary least-squares regression analysis. Briefly, this method allows control of variables such as household income, size of household, cost of gas, and outside temperature for each observed point of the sample, so that accurate estimates may be made of the effect of the price of electricity. See Ref. 9 for more detailed treatment of regression analysis.

11. A second best, but highly desirable, method would be to employ the Fourth Count of the 1970 Census to estimate the price elasticity of saturation of the major household devices by income class. Nationwide data are available on water heaters, space heating, television sets, freezers, washing machines, stoves, clothes dryers, and dishwashers. Unfortunately these data were not available for use in this study. Another desirable method would be to select census tracts (based on income) from utility districts across the United States and obtain fuel consumption for each tract from utility records. The authors have successfully used this method in a case study of the Los Angeles Department of Water and Power operational region [10].

12. The average is obtained by weighting the saturations reported by the Los Angeles Department of Water and Power and Southern California Edison. The weights are the number of customers in each utility district. The LADWP district covers the City of Los Angeles, while the SCE area covers Orange County, parts of Los Angeles County, and outlying areas whose population is relatively small com-

pared to that in the counties. The saturation data are published annually in the February issue of *Merchandising Week* [12]. This saturation was allocated to each income group in the same proportion as shown by a consumer survey in the Houston metropolitan statistical area [13].

13. The average saturation for the Los Angeles area was obtained from the 1970 Census [5] and allocated to each income group in the same proportion as shown by a consumer survey in the Houston metropolitan statistical area [13].

14. The average was obtained by weighting the utility reported averages as discussed in Note 12. The average was allocated across income groups in the same proportion as national estimates from the U.S. Department of Commerce and the Industrial Conference Board [14].

15. Saturation for the Los Angeles area was obtained from the 1970 Census [5] for all air conditioners and was reduced 4 percent to reflect the national average of gas air conditioners [15]. The saturation was allocated to income groups in the same proportion as room air conditioners.

16. The average saturation for the Los Angeles area was obtained from the 1970 Census [5] and was distributed across income groups in the same proportion as electric clothes dryers. This assumes that it is more likely for a household with an electric dryer to have an electric water heater than a gas water heater. Operating costs are two to four times higher for electric dryers, which is offset by installation costs if gas connections are not available. Approximately 0.3 percent of all Los Angeles area households have no water heaters. These households are assumed to be in the lowest income group.

17. The saturation of vacuum cleaners was obtained from *Merchandising Week* [12]. It is so high (at 99 percent) that we assigned it to all income groups.

18. The saturation of room air conditioners was obtained from the 1970 Census [5] for the Los Angeles area. It was allocated across income groups in the same proportion as national estimates from the U.S. Department of Commerce and the Industrial Conference Board [14].

19. The average saturation for the Los Angeles area was obtained from the 1970 Census [5]. It was distributed across income groups in the same proportion as shown by a consumer survey in the Houston metropolitan statistical area [13].

20. The average saturation for electric and other fuel heating was obtained for the Los Angeles area from the 1970 Census [5]. The electric heating was distributed across income groups in the same proportion as room air conditioners. A check was made of the saturations in some low income areas (East Los Angeles, 4.4 percent; Compton, 3.9 percent) and some high income areas (Santa Monica, 11.5 percent; Beverly Hills, 7.8 percent; Palos Verdes, 11.0 percent), which shows the allocation is reasonable. Approximately 1.1 percent of all Los Angeles area housing is not heated; again, these were assumed to be concentrated in the lowest two income groups.

21. In Los Angeles County, for example, only 28 percent of all households with less than $5000 income are owner occupied. These data were obtained from preliminary Fourth Count Census computer tapes.

22. Approximately 135 housewives were questioned concerning 38 common household items. The survey attempted to research product symbolism by asking the respondent to rank the items in terms of their importance to her.

23. Annual consumption of electricity due to lighting was determined by using an average of 40.8 kWh per room per person for the first two income classes and 60.5 kWh per room per person for the last three. The former is considered typical and the latter optimum by the National Survey of Residential Lighting Loads [21]. The number of rooms and persons for each income class were derived from the 1970 Census of Housing. That a lower value for low income groups should be used is consistent with evidence presented in another study, which compared average household lighting loads and loads from a low-rent housing project (Ref. 22, p. 20).

24. The figure 7000 kWh for annual electric heating was obtained from all-electric homes for 1969 for the Los Angeles Department of Water and Power. Concurrence with this figure was obtained from officials of the Southern California Edison Company.

25. Gas furnace electric fan annual kilowatt-hours are based on an average of 394 kWh, but are adjusted by a linear function to reflect the differing sizes of households within each income class. Square footages ranged from 900 sq ft to 2100 sq ft.

26. The saturation for room air conditioners is based only on whether a household did or did not have this item, and does not reflect the number of units per household. This assumption was adjusted by determining the average number of room units per air-conditioned Los Angeles area household from the 1970 Census [5]. That value (1.14 units per household) was allocated over the income classes by using data for selected places in Los Angeles County. Ranges are from 1.025 in the lowest class to 1.3 in the highest.

27. Average consumption of electricity due to central air conditioning is based on data from all-electric homes for 1969 [23], with concurrence by officials of the Southern California Edison Company. The consumption of each income class is adjusted by a linear function to reflect varying household sizes across incomes. Square footages used ranged from 900 sq ft to 2100 sq ft.

28. There is evidence (Ref. 22, p. 19) that California, with its mild climate, has homes with very poor insulation. Homes in mild climates were shown to have up to twice the heat loss (30,000 Btu per degree per day) compared with areas where the climate is more severe. Mayers [24] claims that a 30- to 50-percent reduction in energy consumption can be achieved if the householder makes a small monetary outlay for better insulation than pre-1970 FHA standards. He estimates costs at about $240 for an 1800-sq-ft house. Ball [25] indicates savings of 33.3 percent with investments in insulation of only $168 in new units and $144 in existing units. A thorough cost analysis by the InterTechnology Corporation [26] shows reductions in energy consumption of 50 to 75 percent with insulation expenditures of from $280 to $2000 per house. With moderate discount rates (0 to 6 percent), the investment more than pays for itself in reduced operating costs. It is impossible to determine exactly how much Californians can benefit through insulation in the face of rising

fuel prices, but an estimate of 50 percent seems realistic based on the above information.

29. Whether food freezers are really economical is uncertain. For large families with high food turnover and/or great traveling distances to available sources, the answer is probably yes. However, it is not clear for others. See, for example, Ref. 27. This questionable economy is probably why Wilson observed relatively high reductions in use of freezers with increases in the price for electricity.

30. The variation in the percentage of lighting withdrawn reflects the larger number of high wattage bulbs assumed to be held by the highest income groups. Conversion to fluorescent lighting does not result in as great savings for lower wattage bulbs because of the high fixed cost of conversion. Thus, no reduction was allowed for low incomes since their lighting levels were originally assumed to be one-third lower per person per room. See also Note 23.

31. The 1960-1961 BLS data include 10 income groups and the income is expressed in disposable dollars. The estimates of price elasticity from the 1970-1971 Los Angeles-Orange Counties data were based on five income groups and income was expressed in gross income dollars. To reconcile these differences, we adjusted each BLS group upward to 1960-1961 gross income, and then applied a rough adjuster of 1.50 to yield 1970-1971 dollars. Next, the elasticities were apportioned over the 10 groups so that the average elasticity equaled -1.1.

32. The following end-use ratios of gas required to replace electricity were applied to the average consumption figures shown in Table 4: stove, 2.00; water heater, 1.45; electric heater, 1.41; and clothes dryer, 1.05. These were then multiplied by 3412 Btus/kWh to obtain equivalent Btus of gas required for replacement. See Ref. 29 for derivations.

33. These groups include the Association of California Consumers, California Farmers-Consumer Information Committee, Consumers Cooperative of Berkeley, Inc., Consumers Cooperative Society of Palo Alto, Inc., California State Council of Carpenters, Western Conference of Teamsters, U.A.W. Northern California Community Action Council, and Northern California District Council of I.L.W.U.

34. The 1960-1961 data give as the low income group those with $3000 and less disposable income; the 1970 equivalent class is roughly all those earning less than $5000 gross income.

35. The case study of Los Angeles [11] indicates that low income groups in Los Angeles in 1970-1971 accounted for approximately 12 percent of the consumption of electricity. Even if this figure is correct statewide, and low income consumers were exempted, total consumption would still be reduced by 50 percent.

36. The case study of Los Angeles [11] estimates average annual consumption for low income users in 1970-1971 at about 2500 kWh.

37. "Testimony of Abraham Gerber," PSC Case No. 2534 for Consolidated Edison Company (consulting by National Economic Research Associates), 1970. Two streets in New York City were analyzed—a low income block in Harlem (2610 meter readings) and a very high income block on East 72nd Street (2586 meter readings). The higher income families used more electricity on the average; however, there was

considerable overlap. The percent of families in each consumption class is shown below:

Bimonthly Consumption, kWh	% Families, Harlem	% Families, East 72nd St.
53 or less	1.7	2.8
54-169	15.2	12.1
170-320	41.7	20.4
321-512	26.6	18.1
Over 512	14.8	46.6

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