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Costs Incurred by Residential Electricity Consumers Due to Power Failures

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The theoretical model presented here suggests that the principal cost of power failures to residential electricity consumers is the loss of leisure, while the marginal value of leisure equals the household's net income earning rate. Results of a Brazilian survey support this hypothesis and reveal activity patterns in urban households.

The principal categories of electricity users include industrial, commercial, and residential consumers. As the first two types (and most other categories of use) produce an output having a market value, one measure of outage costs would be the disruption of the stream of output caused by the electric supply interruption, such as due to spoilage of materials, factors of production made idle, etc. However, as households generally do not produce a marketable output, a different approach must be used.

In this paper, an explicit theoretical framework for measuring residential outage costs is presented and empirically tested using the results of a survey of household electricity consumers in the city of Cascavel, Brazil (population approximately 90,000 in 1976). Although the model or variations thereof are relevant to most countries, simplicity of application has been emphasized because of data constraints in developing countries. In brief, it is argued that:

1. The principal outage cost imposed on a household is the loss of leisure during the evening hours when electricity is essential, because during the daytime there is sufficient slack in the execution of household activities that are interrupted by the outage, such as cleaning and washing, to permit rescheduling of these functions without much inconvenience.

2. The marginal monetary value of this lost leisure

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1 If market prices are too distorted, appropriate shadow prices could be used (Munasinghe and Warford 1979; Squire and van der Tak 1979).

2 Expenditures on standby electricity generating equipment could also be considered outage-related costs. However, in this case it would be difficult to determine at what level of outages (i.e., frequency and duration) users would feel that it was worthwhile to install a captive generating plant.
is equal to the effective net income earning rate on the basis of the consumer’s labor-leisure choice.

RESIDENTIAL ELECTRICITY USERS

It is convenient to adopt the approach of treating the household as a productive unit that uses inputs, such as the household members’ time and market goods (electric appliances, electricity itself, etc.), to produce outputs, such as leisure and nutrition, that provide utility. The cost of an unexpected outage ⁴ may then be estimated in terms of inputs spoiled or made idle, i.e., opportunity costs, as in the case of the industrial and commercial user categories.

Even though the household can be logically viewed as a productive unit, the measurement of residential outage costs is not straightforward, because most of the “outputs” are consumed within the household, e.g., leisure, and are thus not valued in the market, whereas the value of inputs into this production process, especially household members’ time, is also often not determined in the market. Households that utilize electricity as one of their principal market inputs are of special interest, particularly with regard to housekeeping, nutrition, and leisure.

Of particular relevance to housekeeping activities is the possible flexibility of rescheduling household chores, thereby minimizing outage costs. Typically, interruptions in electricity supply will affect the functioning of household electrical appliances used for ironing, washing, vacuuming, etc. However, sometimes there is the possibility of substitutability between such electricity-using and other nonelectricity-using housekeeping activities. In addition, over a given period of time, e.g., one day, there will be some degree of substitutability between housekeeping and other nonhousekeeping activities in the home. Thus, the outage cost resulting from idle resources used for housekeeping will be small. Nevertheless, there will be some cost, including the psychological costs of disruptions in the normal routine, as long as it is assumed that household producers rationally allocate their time to various kinds of production before the outage.

Food preparation is an activity that could be hampered by outages at particular times of day, especially if electricity is essential for cooking and lighting. For interruptions of relatively short duration, the outage costs may involve only the inconvenience of a delayed meal, but in other cases food may have to be supplied from outside the home, and paid for as an unexpected expense. In areas where outage expectation is high, households may incur additional indirect outage-associated expenses by purchasing nonelectric appliances, such as small kerosene stoves for standby purposes, i.e., in addition to their electric stoves. On the other hand, where cooking is carried out exclusively through the use of other fuels (kerosene, gas, or firewood), outage costs are likely to be small. ⁵ If the expenses associated with nonelectric cooking facilities exceed the costs of purchasing and using an electric stove, and if the former were preferred to the latter, specifically because of the low reliability of electricity supply, then the difference in costs between the two alternatives would also constitute an indirect outage cost.

Leisure differs from the housekeeping and food preparation activities in ways that make the associated outage costs more important. First, the production and enjoyment of leisure in most households is constrained, particularly for wage earners, to a relatively fixed period of time, usually in the evening. It is assumed that housewives are not constrained to enjoy leisure only during the evening hours, and because of the substitution possibilities between evening and daytime leisure their outage costs are small. Even if electricity-dependent daytime leisure activities such as TV watching were interrupted by outages, there would be sufficient substitutability with nonelectricity-dependent leisure or household activities to minimize the outage costs. ⁶

Second, in the case of leisure activities, such as television viewing, reading, etc., which would require the use of electricity during the nighttime hours, there would be limited substitution possibilities for nonelectricity-using activities during an outage, at least in the short-run. As the loss of leisure activities is likely to be the most significant component of residential outage costs, a model of household activity based on the consumer’s labor-leisure choice is developed here, to estimate the welfare loss associated with interruptions in electricity supply.

In addition, power outages will impair the functioning of equipment such as refrigerators, air conditioners, and heaters, which may be only partially associated with the types of household activity just discussed. In these cases, the effects of the disruption would be significant only for outages of longer duration (e.g., several hours), which generally occur far less frequently. However, besides the loss of services from such equipment, the damage to and reduced life span of motors and equipment due to voltage variations would have to be taken into account.

Households may also incur indirect outage costs by

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⁴ See Becker (1965), Lancaster (1966), and Gronau (1973) for a more complete discussion of household production theory.

⁵ The effects of known or planned power failures are neglected because costs may be minimized by rescheduling activities, etc. Similarly the effects of brown-outs due to voltage drops and frequency fluctuations may be ignored.

⁶ In Cascavel, no significant outage cost was observed because cooking is done almost entirely by gas.

⁷ Thus, it is possible to avoid complications arising from having to estimate the value of housewives’ time (Gronau 1973).
purchasing standby generators, storage batteries, kerosene lamps, and so on. In this respect, the consequences of outages may be inequitably distributed, because wealthier consumers will be better able to afford voltage-boosting devices and alternative energy sources, thereby reducing direct outage costs. On the other hand, poorer users may be less dependent on electricity, and therefore less susceptible to outages.

**VALUE OF FOREGONE LEISURE**

Consider a typical household that maximizes utility over some period of time (D days). Utility, \( U \), is expressed as a function of leisure type \( S \), which cannot be enjoyed without electricity, leisure type \( V \), which is electricity independent, and income, \( I \) (net of expenses incurred to enjoy the leisure), which represents all other consumption.

\[
U = U(S, V, I). \tag{1}
\]

Next, leisure type \( S \) is specified as a function of the inputs—time \( t \) (hours), electricity consumption \( e \) (kwh), flow of services \( z \) from the stock of electricity using equipment (TV), and other inputs represented by \( x \):

\[
S = S(t, e, z, x). \tag{2a}
\]

Similarly, leisure type \( V \) is a function of time, \( \theta \), and other inputs represented by \( m \), i.e.:

\[
V = V(\theta, m). \tag{2b}
\]

Furthermore, \( e \) and \( z \) may be written as functions of the stock of electricity using capital \( k \) (the value of appliances annuitized over their useful life), and of time \( t \) that is a measure of intensity of use. Therefore, \( e = e(k, t) \) and \( z = z(k, t) \).

The household budget constraint may be written:

\[
I = w(H - t - \theta) - pe - bk - cx - rm, \tag{3}
\]

where:

- \( w \) = effective net income earning rate (per hour);
- \( H \) = maximum feasible number of hours of work in the time period;
- \( p \) = mean price per kwh of electric energy;
- \( b \) = equivalent income foregone per unit of \( k \) in the time period;
- \( c \) = cost per unit of other inputs \( x \) used;
- \( r \) = cost per unit of other inputs \( m \) used.

Initially, we examine the longer-term situation, e.g., a time period of one year. Maximizing utility subject to the linear budget constraint is equivalent to unconstrained maximization of the expression:

\[
L = U(S, V, I) - \lambda \left[ H - t - \theta - \frac{1}{w} (I + pe + bk + cx + rm) \right]. \tag{4}
\]

As shown in the Appendix, manipulating the first order conditions for maximizing, yields an expression involving the marginal rate of substitution of income for electricity-dependent leisure, keeping utility constant, as derived from the consumers' long-run decision.

\[
MRS_{S, I} dS = wdt + pde + bdk + cdx. \tag{5}
\]

\( MRS_{S, I} \) measures the marginal monetary value of electricity dependent leisure, i.e., it is the income increase that will compensate the consumer just enough for this type of leisure foregone at the margin, to remain on the same indifference curve (Willing 1976).

Now, consider the effect of an unexpected outage during the evening hours when leisure type \( S \), is being enjoyed by the household. Ex-post and over the short-run period of the outage, it is argued that \( e \) and \( z \) depend on \( t \), i.e., assuming a putty-clay type of relationship between \( k, e, \) and \( z \). For example, in the short-run, electricity use may be linearly proportional to time. Therefore, it is possible to write:

\[
e = \phi(t). \]

Using the above expressions to evaluate Equation 5, and replacing \( dS \) by \( \Delta S \), and so on, we get:

\[
MRS_{S, I} \Delta S = \left( w + p \frac{\partial \phi}{\partial t} \right) \Delta t + c \Delta x + b \Delta k. \tag{6}
\]

Thus the left-hand side of Equation 6 represents the overall welfare decrease due to an incremental loss of leisure \( \Delta S \) resulting from the unexpected outage of duration \( \Delta t \), while the right-hand side is a measure of the value of the inputs that are required to produce the leisure.

However, the household's electricity bill will also be reduced by the amount \( p(\partial \phi/\partial t) \Delta t \) due to kwh not used during the outage. Therefore, the net incremental welfare loss or outage cost due to an unexpected outage of duration \( \Delta t \) may be written:

\[
OC^u = MRS_{S, I} \Delta S - p \frac{\partial \phi}{\partial t} \Delta t = w \Delta t + c \Delta x + b \Delta k. \tag{7}
\]

As also derived in the Appendix, the marginal rate of substitution of income for electricity-independent leisure, keeping utility constant (\( MRS_{I, V} \)) is:

\[
MRS_{I, V} \Delta V = w \Delta \theta + r \Delta m, \tag{8}
\]

where \( \Delta V \) has been used instead of \( dV \), and so on.

Equation 8 is analogous to Equation 6, and mea-
ures the welfare change due to an incremental change in the availability of electricity-independent leisure $\Delta V$, in terms of the value of the inputs, i.e., time $\Delta t$ and other input $\Delta o$, which are required to produce this leisure.

As mentioned earlier, the empirical estimation of residential outage costs is particularly difficult because of the nonmarketable nature of the household outputs produced by using electricity. From a practical point of view, data on wages and income are far easier to obtain than information on the use of appliances and other inputs. Fortunately, in most instances the dominant term in Equation 7 would be the wage term. Therefore, in practice the following expression may be used as a good approximation to Equation 7:

$$\frac{\Delta OC}{\Delta t} \approx w. \tag{9}$$

Arguing analogously, that the wage term is likely to dominate the second term on the right hand side of Equation 8, it is possible to derive another approximate relationship:

$$MRS_{Vt} \frac{\Delta V}{\Delta t} = w. \tag{10}$$

Therefore, the incremental monetary values of both electricity-dependent and independent types of leisure per unit time are roughly equal to the wage (or income earning) rate.

In practical terms, the theoretically derived link between the two types of leisure and the income earning rate is intuitively reassuring, because electricity-dependent leisure and actual working hours may not be direct physical substitutes for each other. For example, the normal workday could extend from 9:00 A.M. to 5:00 P.M., whereas electricity-dependent leisure may begin only after 7:30 P.M., i.e., the hours of darkness. Therefore, the marginal trade off between electricity-dependent leisure and extended working hours may have to occur via an adjustment in the intervening electricity-independent leisure period.

As discussed earlier, a principal practical advantage of this method of estimating the outage costs of residential consumers on the basis of foregone leisure, is its reliance on relatively easy-to-obtain income data.

Often it may be possible to obtain a good correlation between family income and kwh electricity consumption for a typical sample of residential consumers by using the utility company’s billing records and information from household budget surveys. In this way the income levels of electricity-using households could be estimated.

Still, this method of estimating residential consumers’ outage costs may sometimes lead to incorrect estimates for five reasons. First, it is assumed that workers can vary their hours of work to equate their wage with the marginal value of their leisure time. Traditional work practices such as the 40-hour week, union restrictions on hours worked, or insufficient employment alternatives might prevent this. If workers are unable to work as much as they wish, their wages will overestimate the value of lost leisure. A related point is that the daytime wage rate may not be a good proxy for the value of leisure; the marginal wage rate corresponding to the leisure hours may be more appropriate, and in some cases this may be the overtime rate of pay.

Second, the cost to nonwage-earning members of the family is effectively ignored, by allowing only the wage earner to represent the household as an income-earning unit. For example, the value of the housewife’s time may be estimated in terms of the average earning rate of women workers, although the corresponding outage cost may not be very accurate because of the greater work-leisure substitution possibilities for housewives, as well as differences between the productivity of housewives and women workers.

Third, residential consumers may develop outage expectations, presumably because of the frequency of such occurrences in the past, so that the possibility of interruptions in electricity supply will be considered when labor-leisure decisions are made. The cost of the outage will then be less than in instances where there is no such outage expectation.

Fourth, if some leisure is enjoyed outside the household that is affected by the outage, then ideally, this case should be treated separately. Finally, in certain unusual situations, there is the possibility that outages themselves may provide some consumption benefits to residential consumers, e.g., perhaps the enjoyment of a novel situation.

These difficulties indicate that the estimate of outage costs inferred from the consumers' labor-leisure choice ought to be independently verified. The short-run outage cost is likely to exceed the willingness-to-pay for the lost kwh, based on the household’s longer-run demand curve. Hence, empirical verification of Equation 9 must depend on the determination of the consumers’ willingness-to-pay in the short-run, to avoid an unexpected outage, as described in the next section.

* Take, for example, a television set that is one of the more expensive items of electrical equipment commonly used for leisure. Assuming a purchase price of $250 and a six-year lifetime (independent of usage and of outages), and a discount rate of 10 percent, the capitalized value is $55.70 a year. For a set that is used four hours a day, on the average, the corresponding value of $\Delta A$ is $4e per hour of outage, which is likely to be a negligible amount, even compared with minimum income earning rates for relatively poor households using electricity. Thus, the difficulties of obtaining data on ownership of electrical appliances, or other inputs used during leisure time, will most often far outweigh any resulting refinement to the basic estimate of outage costs derived purely on the basis of more readily available income data.

* In Caswell, unemployment is very low due to rapid economic growth in the area, and union pressures are minimal.
COSTS OF POWER FAILURES TO HOUSEHOLDS

SURVEY RESULTS

A random sample of 27 residential consumers selected from the 1976 list of approximately 9,000 electricity-using households in Canada were subjected to an in-depth survey to determine their opinion of the quality and value of electrical service, electricity consumption, income, leisure-time habit patterns, and the value they placed on foregone leisure during an outage.\(^8\)

All households in the sample indicated that electricity was an essential service in their daily lives; in general, the poorer consumers felt that they were getting good value for money, whereas some of the higher income households thought that the price of electricity services was too great. A direct estimate of outage costs was obtained by asking consumers how much extra they would be willing to pay to avoid outages of different durations at various times during the day (Questions 4 and 5). Customers indicated no willingness to pay extra to avoid daytime outages. The direct amounts that consumers were willing to pay in order to avoid evening outages was found to be linearly proportional to outage duration, on the average, over the range 3 to 80 minutes, and the estimate of outage cost is based on values in this range. For outages of less than a few minutes many people indicated that they would "sit out" the inconvenience rather than pay, and for outages over 1.5 hours the outage cost per unit time tended to also fall off quite rapidly, as households were unwilling to pay large sums of money, i.e., the impact on income became important.

Indirect estimates of outage costs were obtained by determining what additional amounts each household considered reasonable: (a) for payment to the utility company, if the existing (known) incidence of outages was halved; and (b) as a compensatory refund on their electricity bill, if the existing outage rate was doubled (Questions 3, 9, and 12).

The evening time outage cost estimates in Table 1 are average values of the direct and the two indirect estimates, for each household. Questions 4, 9, and 12 were not all asked consecutively, to minimize the possibility of consumers giving consistent answers to later questions, based on rational extrapolation from the earlier questions. In fact, good agreement was obtained between the various estimates of outage costs for each household, and this was taken as an added sign of reliability of the estimates.\(^9\)

The daily leisure period during which electricity was considered essential had a fairly uniform duration of about 1.5 hours (standard error = 12 minutes), and occurred somewhere within the broader time interval 1,930-2,320 hours. Approximately 60 percent of the latter interval was devoted to TV watching, 25 percent to dining and the remainder to other activities, such as reading and conversing. The differences between households were minor; for example, the standard error for the TV watching period was only about 10 percent of the mean.\(^10\) The mean household size was 5.1 persons, with a standard error of 1.4 persons, and the average time at which families went to sleep was about 2,300 hours, with a standard error of 45 minutes.

Assuming that all the usual conditions of the ordinary least squares (OLS) model are fulfilled (Johnston 1972), a basic unrestricted equation of the form,

$$OC = \beta_1 + \beta_2 Y + \mu_i,$$

is fitted to the observations, where $OC$, $Y$, and $\mu_i$ are the outage cost per hour, net income earning rate per hour, and random disturbance term, respectively, for the ith household.\(^11\) The estimated coefficients are $\beta$,

\(^8\) See Appendix for complete questionnaire. Unfortunately the sample size was limited by the time and manpower resources available to carry out the survey. In view of the difficulty of obtaining meaningful answers to questions on outage costs involving hypothetical willingness-to-pay, considerable time had to be devoted to explaining the problem to the consumers, and putting them at their ease. Care had to be taken also to avoid giving the impression that the interviewers wished to actually increase or decrease their electricity bill, obtain information on incomes for tax purposes, etc. At least two adult members of each home were required to be present, to obtain replies that were representative of the household. Consequently, a team of three persons (including a translator) took one week to complete the 27 interviews.

\(^9\) As expected, in general the indirect estimate of outage cost from Question 9 tended to be lower than the estimate from Question 12; these two estimates most often straddled the value of the direct estimate of outage cost.

\(^10\) Only one household in the sample did not possess a TV set; however, in this case about 50 percent of their leisure time was spent listening to the radio, and special TV programs, such as football games, were watched on the neighbor's set. Thus, these results confirmed the view expressed by local municipal authorities, that practically all electricity-using homes owned a TV set.

\(^11\) Net income earning rate - gross income earning rate - tax (estimated from known tax rates). Total household income was in most cases the earnings of a single wage earner.
OUTAGE COSTS VERSUS NET INCOME EARNING RATE FOR RESIDENTIAL CONSUMERS

\[ OC = Y + U. \] (12)

This corresponds to the solid line in Figure A, where the new SSR = 3650.2. A Chow test (Chow 1960; Fisher 1970) was performed to ascertain whether the free Equation 11 fits the observed values significantly better (in terms of the sum of squares of the residuals), than the restricted Equation 12 derived from the theoretical model. From the results of the regression \( F = 1.634; \) but \( F^2; (0.20) = 1.72, \) and, therefore, the null hypothesis \( H_0: \beta_1 = 0 \) and \( \beta_2 = 1 \) is accepted at the 20 percent level,\(^{14}\) i.e., we accept the restricted equation as the correct one.

The slope (\( \beta_2 \)) of Equation 11 is less than unity. A possible explanation is that the ratio of nonwage to wage income tends to rise as the income level increases. This nonwage income (e.g., property or investment income) may not enter into the consumers' labor-leisure decision. Therefore, since net total income (irrespective of source) is plotted along the X-axis of Figure A, rather than net wage income, this would tend to reduce the slope of the fitted line, especially for the higher income levels. Unfortunately, it was very difficult to obtain further information concerning the breakdown of income by source.

Saturation effects could also occur at high income levels, which would tend to impose a ceiling on the willingness-to-pay. Similarly, at the low end of the income scale, there could be a minimum level of outage costs (greater than zero), although it is doubtful whether such poor households would have electricity service. Both of these effects would tend to reduce the slope \( \beta_2 \). The impact of the other (neglected) terms in Equation 7 would be to increase the slope of the solid line.

The foregoing analysis has focused on the outage costs per hour of outage, by income level. These results may be examined from a different viewpoint by using the survey data presented in Figure B, a graph of the average annual electricity consumption versus the net annual income of households.\(^{15}\) As expected kWh consumption increases monotonically, with evidence of saturation at the upper end of the income scale.

\(^{14}\) This statistic is distributed as \( F \) with 2 and 25 degrees of freedom: \( F = \frac{3650.2 - 3228.22/(3228.2/25)}{25} = 1.634. \) Acceptance at the 20 percent level implies acceptance at all lower levels, i.e., 10 percent, 5 percent, 1 percent, etc., for a right-tail test.

\(^{15}\) Based on an independent municipal survey of 701 residential electricity consumers, carried out by city government in 1976.
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Next, using Figure 13.

For the rest of this analysis, the population is divided into four income classes: lower (L), lower-medium (LM), upper-medium (UM) and upper (U). The net income and electricity consumptions per annum (Figure B), by income class, are shown in Columns 2 and 3 of Table 2. Corresponding outage costs per hour of leisure-time outage are shown in Column 4, assuming that these costs are equal to the mean income earning rate. Next, using Figure B, and the daily pattern of household electricity consumption (i.e., 75 percent of the kwh usage, during the period 1930-2230 hours), the outage costs per kwh lost due to leisure-time outages are calculated (Column 5). It may be seen that while outage costs per hour rise steadily with income level, the outage costs per kwh lost are much more stable; but there is a slight jump in outage costs per kwh lost for the highest income class, due to the saturation effects in Figure B, discussed earlier.

The analysis thus far has ignored income distribution considerations. Therefore, the results in Columns 4 and 5 have been evaluated in terms of so-called efficiency prices. However, by treating an outage cost like foregone consumption income, it may be argued, on the basis of diminishing marginal utility of consumption income, that the outage costs of poorer households should be weighted more heavily. This type of weighting may be termed social pricing.

Consider a very simple weighting function of the form \( W(C) = (C^C)\), where \( C \) is the household income, \( C \) is some critical (or benchmark) income level, and \( N \) is a parameter. For convenience, we choose \( N = 1 \) and \( C = Cr\$67.7 \times 10^6 \) per annum = mean income level of all Casewel households (including non-electricity-consuming homes). This gives us the social weight 3.679, 1.419, 0.694, and 0.296 to be applied to the outage costs of the L, LM, UM, and U income groups, respectively.

The results of social pricing are shown in Columns 6 and 7 of Table 2: the situation is inverted with respect to the efficiency pricing regime. The choice of the social weighting function has ensured that the outage costs per hour are constant at Cr\$32.05, while the outage costs per kwh lost during leisure-time vary widely, between Cr\$13 and Cr\$142.

CONCLUSIONS AND DISCUSSION

The results of the Casewel survey confirm that the chief outage cost imposed on this category of users is the loss of leisure during the evening hours, approximately over a 1.5 hour period. Furthermore, we conclude that during this critical period the mean income earning rate for a household is an acceptable monetary measure of the marginal leisure loss due to an outage. Although the sample size is small, the strong correlation between outage costs and income justifies this conclusion.

Generally, this measure of outage cost is considerably higher than the value of kwh lost, if the latter were priced at the consumer tariff level. In terms of the (short-run) household demand curve for electricity, Equation 9 underlines the fact that the kwh lost due to a random outage are not marginal. Therefore, the outage cost reflects not just the small wedge shaped area of consumers' surplus lying between the downward sloping demand curve and the horizontal price, owing to kwh lost at the margin, but rather a much larger amount of consumers' surplus foregone, corresponding to inframarginal kwh lost. The willingness of residential consumers to pay the equivalent of their net income earning rate to avoid eveningtime outages is not surprising in terms of the absolute amounts of money involved. For example, on this basis, in 1976, a typical electricity-using household in Casewel with an annual income of Cr\$60,000 (about Cr\$28.5 per working hour) would have to pay only Cr\$57 more (about 6 percent of their electricity bill x Cr\$920 per

\( ^{10} \) This terminology is derived from cost-benefit analysis; see, for example, Little and Mirlees (1974) and Squire and van der Tak (1975).

\( ^{11} \) Cr\$ indicates Cruzeiros (Brazilian currency).

\( ^{12} \) This point is often overlooked; see, for example, Priestman (1977) or Webb (1977).
annum) if the incidence of evening outages was halved from four to two hours per annum.

If income distribution considerations are ignored (i.e., efficiency pricing) then outage costs per hour of outage rise with income, whereas outage costs per kwh lost are stable. If outage costs are weighted according to the linearly diminishing marginal utility of income, i.e., social pricing, the situation is reversed; outage costs per hour of outage are constant, but outage costs per kwh lost decrease with increasing income.

The principal advantage of this method for estimating the leisure costs of outages to residential consumers is its reliance on relatively easy-to-obtain income data. For example, as in the case of Cascalvel, it is often possible to obtain a good relationship between family income and kwh electricity consumption for a typical sample, and thus on the basis of the electric utility company's billing records, the income levels of the electricity-using households may be estimated. Ultimately, the empirical test of the value of leisure lost due to an outage depends on the willingness-to-pay criterion.

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APPENDIX

A. Derivation of Outage Costs

Consider maximization of the expression:

\[
I - US. V. I = \lambda \left[ H + \frac{1}{w} (I + pc + bk + cx + rm) \right].
\]

The necessary first order conditions are:

\[
\frac{\partial L}{\partial t} = \frac{\partial U}{\partial S} \left[ \frac{\partial S}{\partial t} + \frac{\partial S}{\partial c} \frac{\partial c}{\partial t} + \frac{\partial S}{\partial x} \frac{\partial x}{\partial t} \right] + \lambda \left[ 1 + \frac{p}{w} \frac{\partial c}{\partial t} + b \right] = 0, \quad (A1a)
\]

\[
\frac{\partial L}{\partial k} = \frac{\partial U}{\partial S} \left[ \frac{\partial S}{\partial c} \frac{\partial c}{\partial k} + \frac{\partial S}{\partial x} \frac{\partial x}{\partial k} \right] + \lambda \left[ \frac{p}{w} \frac{\partial c}{\partial k} + b \right] = 0, \quad (A1b)
\]

\[
\frac{\partial L}{\partial c} = \frac{\partial U}{\partial S} \frac{\partial S}{\partial c} + \lambda = 0, \quad (A1c)
\]

\[
\frac{\partial L}{\partial d} = \frac{\partial U}{\partial S} \frac{\partial S}{\partial d} + \lambda = 0, \quad (A1d)
\]

\[
\frac{\partial L}{\partial \theta} = \frac{\partial U}{\partial S} \frac{\partial S}{\partial \theta} + \lambda = 0. \quad (A1e)
\]

Multiplying equations A1a, A1b, and A1c by \(dt\), \(dk\), and \(dc\), respectively, summing the three resulting equations, and rearranging terms yields:

\[
\frac{\partial U}{\partial t} \frac{\partial S}{\partial t} + \lambda (w + p + bk + cd) = 0. \quad (A2)
\]

Dividing Equation A2 by Equation A1d yields:

\[
MRS_t = ds - w + p + bk + cd,
\]

where,

\[
MRS_t = \frac{\partial U}{\partial S} \left| \frac{\partial U}{\partial d} = \frac{dt}{ds} \right| \text{constant}.
\]

Next, multiplying Equations A1e and A1f by \(d\theta\) and \(dm\), respectively, summing the two resulting equations, and rearranging terms as before, yields:

\[
\frac{\partial U}{\partial V} \left( \frac{\partial V}{\partial d} + \frac{\partial V}{\partial m} \right) + \lambda d\theta = \frac{\lambda rdm}{w} = 0.
\]

This may be rewritten:

\[
\frac{\partial U}{\partial V} dV + \frac{\lambda}{w} (w + rdm) = 0. \quad (A3)
\]

Once again, dividing Equation A3 by Equation A1d, yields:

\[
MRS_t dV = w + rdm.
\]

B. Residendntial Consumer Survey 
Questionnaire

The information from this survey will be used by COPEL to analyze and improve the quality of elec-
electricity services to customers. All responses will be treated as strictly confidential.

1. What was your average monthly electricity consumption during the last three months?
   __________ kwh per month __________ Cr$ per month

2. Do you feel that:
   a. Your electricity supply is good Yes No
   b. There are many electric power outages Yes No

3. a. On average, how many minutes of unexpected outages per month have you experienced during the last three months?
      __________ minutes per month
   b. During what hours is electricity essential for the enjoyment of your leisure?

   c. Approximately what fraction of outages occurred during these critical hours?
      __________

4. If an unexpected outage occurred during these critical hours while you were enjoying your leisure (e.g., watching TV, listening to the radio, reading, having dinner, etc.), how much extra would you be willing to pay to avoid:
   a. A one-minute interruption __________ Cr$
   b. A five-minute interruption __________ Cr$
   c. A thirty-minute interruption __________ Cr$
   d. A sixty-minute interruption __________ Cr$
   e. A ninety-minute interruption __________ Cr$
   f. A two-hour interruption __________ Cr$

5. If an unexpected outage occurred at any other time (e.g., while housekeeping) how much extra would you be willing to pay to avoid:
   a. A one-minute interruption __________ Cr$
   b. A five-minute interruption __________ Cr$
   c. A thirty-minute interruption __________ Cr$
   d. A sixty-minute interruption __________ Cr$
   e. A ninety-minute interruption __________ Cr$
   f. A two-hour interruption __________ Cr$

6. Do you feel that:
   a. Electricity is an important service Yes No
   b. The service is too expensive Yes No

7. On the average, how do you spend your evening night-time leisure hours?
   a. Watching TV __________ hours
   b. Listening to the radio __________ hours
   c. Reading __________ hours
   d. Having dinner __________ hours
   e. In conversation __________ hours
   f. Going out __________ hours
   g. Other __________ hours

8. When do you normally go to sleep? __________

9. If we were to reduce the incidence of unexpected outages to half its present level, how much extra would you be willing to pay on your monthly electricity bill?

10. How many persons live in this household?
    __________ persons

11. a. What are your principal sources of income?
    __________

   b. What was the average monthly income (gross of taxes) of your household during the last three months?
    __________ Cr$ per month

12. If the level of unexpected outages were to double, what reduction in your monthly electricity bill would you consider to be fair?
    __________ Cr$ per month

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The Direction of Causality Between Perceptions, Affect, and Behavior: An Application to Travel Behavior

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This study investigates the relationship between perceptions, affect, and behavior regarding changes of transportation modes. Applying nonrecursive structural equations to a sample of over 800 respondents, the hypothesis that attitudes and behavior mutually influence each other is confirmed. It is also shown that affect can moderate the impact of attitude perception on behavior for a brand influences people's evaluations of its attributes (Beckwith and Lehmann 1976, Huber and James 1978; Wilkie, McCann, and Reibstein 1974). In this paper we hope to position the issue of attitude-behavior causality in the broader context of understanding the nature of consumer decision processes and how they are influenced.

Attitudinal Components and Some Modeling Perspectives

The literature on attitudes is enormous, reflecting both the central role of this concept in the development of social psychology and the difficulties that theorists have had in agreeing on both definition and conceptualization. One reason for such variation is the wide range of specific areas to which attitude research has been applied. These include ethnic prejudices, religion, workplace behavior and job satisfaction, political views and voting behavior, and consumer behavior in the marketplace.

Most social psychologists have long seen attitudes as being structured into three interrelated components: cognitions (beliefs), affect (feelings), and conation (behavioral intentions) (Rosenberg and Holyland 1960). Fishbein and Ajzen (1975) argue that beliefs are the fundamental building blocks in this conceptual structure and devote considerable space to a discussion of the three ways in which they may be formed - through receipt of information, inference, and personal experience (behavior).

The continuing debate in attitude research has concerned the precise nature of interaction among the

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