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IMPACT OF ELECTRICITY UTILITY RATE REFORM IN OAKLAND AND LIVINGSTON COUNTIES, MICHIGAN

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ABSTRACT

Disadvantaged households are more adversely affected by rising energy costs than the rest of the population. Lifeline rates have been proposed or enacted in a number of states, including Michigan, to ease the burden of electric price hikes on the poor. Inherent in the Michigan legislation is the proposition that electricity usage is positively associated with income and family status. This analysis of data from a sample of 1100 households in Oakland and Livingston Counties, Michigan, revealed that socio-economic and demographic variables are poor predictors of household electricity usage. Appliance mix and size of dwelling units appear to be better indicators of electricity usage. In fact, the Michigan legislation, as presently structured, will improve the economic well-being of many middle-class and affluent households, and further exacerbate the plight of a significant number of low-income households.

INTRODUCTION

America is a prodigious user of energy. With only about 6 per cent of the world's population, America's usage accounts for nearly 40 per cent of the world's energy consumption. Until the 1973 Arab Oil Embargo, we assumed that cheap energy and a 3 to 4 per cent annual increase in energy use would be

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a part of the national growth pattern. But since the oil embargo and formation of the OPEC cartel, our economic system and lifestyle have been jarred by the 1600 per cent increase in the price of an imported barrel of oil, and the rapid increase in the price of other energy sources.

The economic jarring has jolted the poor and near poor because of their inability to absorb these increased costs [1]. Some twenty-three to twenty-five million poor people in the U. S. spend 15 to 50 per cent of their after-tax income on energy [2]. In contrast, their more affluent counterparts spend only 3 to 7 per cent of their disposable income on energy [3]. Increases in food and medical care costs have further exacerbated the plight of the poor.

A number of states, including Michigan, have proposed or enacted legislation intended to promote conservation and minimize the impact of rising electric power costs on the poor [4]. Traditionally, electric rate structures have fostered increased usage, as the cost per kilowatt hour (kwh) declined with higher utilization. Proponents of electric utility rate reform argued that promotional rates discriminated against the low volume user [5]. For this reason, in Michigan the promotional or declining block rate structure was replaced with a flat per kwh rate in 1975. But the flat rate structure did not encourage conservation of electricity, and was replaced with an incremental rate structure in 1978. The price per kwh of electricity in Michigan now rises as consumption increases [6].

As a result of the adverse impact of rising electricity costs on low income households, advocates for the poor in Michigan have recently enacted electric utility rate reform legislation, referred to as lifeline rates. Under a lifeline plan, the initial block of electricity consumed (i.e., the amount required for basic necessities such as lighting, cooking, refrigeration, etc.) is offered at a low uniform rate, usually below production costs [7]. Above the designated lifeline block, the cost of electricity increases incrementally. Inherent in the lifeline concept are six basic assumptions [8, 9]:

1. the disadvantaged are low volume users of electricity;
2. middle income and affluent households are large volume users of electricity;
3. people in need would benefit;
4. the affluent would pay as they are large users;
5. substantial savings would result; and
6. electricity usage and family size are directly related.

Proponents of lifeline rates argue that income will be redistributed to low income households if electricity is provided to small volume users at reduced costs [10].

While the lifeline concept is conceptually appealing, previous research has raised considerable doubt about whether lifeline rates (i.e., based on the six assumptions outlined above) will mitigate the energy problems of the poor [11, 12]. These studies have concluded that lifeline rates would be an ineffective mechanism for redistributing income to disadvantaged households, because the variables on which the proposed rate reform is based (primarily income and family size) are poor predictors of electricity consumption. For example, a study by the authors concerning the amount of electricity consumed by a sample of disadvantaged households in Oakland and Livingston Counties, Michigan revealed that socio-economic and demographic characteristics accounted for less than 20 per cent of the total variance in electricity usage. The results suggest that critical variables have been ignored in formulating the lifeline concept.

The primary objective of this article is to provide further insights into the factors responsible for variation in residential electricity consumption. Previous research suggests a number of variables that have been ignored in most lifeline proposals, but which may be important determinants of electricity usage [13, 14]. These include the

1. type of residence (i.e., trailer, single family detached unit, or apartment);
2. structure and size (number of rooms) of dwelling units;
3. type, quality, and number of appliances (including the energy efficiency of the household's electric devices);
4. attitudes towards electricity use and conservation; and
5. living characteristics of the population (i.e., leisure activities, year-round or seasonal dwelling, and home related daily activity patterns).

Geographic location may also influence electricity consumption. According to Dahl [15], for example, average electricity consumption in San Francisco Bay area cities was 300 kwh per month, while customers in the cities of California's Central Valley used an average of 600 kwh per month.

Several of the above mentioned variables (numbers 1, 2, and 3) are considered in this analysis. A second objective is to discuss the implications of the findings vis-a-vis the lifeline legislation recently enacted in the state of Michigan.

DATA AND METHOD

Data utilized in this study were taken from the 1978 Detroit Edison Appliance Saturation Survey [16], which included information on the socio-physical characteristics of a representative sample (n = 1100) of all residential customers served by the Detroit Edison Company in Oakland and Livingston Counties. These two counties, located in the southeastern portion of Michigan's lower peninsula, were selected, in part, because they were deemed representative of the diverse urban and rural regions of the state.

Three categories of data were obtained from the Appliance Saturation Survey (see Table 1):

1. characteristics of the dwelling units, including number of rooms and the age, size and type of dwelling;

Table 1. Variable List

Categories	*Items*
1. Characteristics of dwelling	Number of rooms Age of dwelling Type of dwelling
2. Appliance saturation	Weighted number of electrical appliances (excluding major and supplementary heat systems)
3. Family characteristics	Age of household head Number of people in household Annual household gross income Residential status
4. Electricity usage	Average monthly usage (April 1977 – April 1978)

SOURCE: *Detroit Edison 1978 Appliance Saturation Survey.*

2. appliance saturation, that is, the number and type of electrical appliances; and
3. family characteristics, including age of household head, family size, annual gross family income, and residential status.

In addition, data on the amount of electricity consumed by the 1100 households over the twelve-month period preceding the Appliance Saturation Survey were provided by the Detroit Edison Company.[1]

Two statistical techniques were used in this analysis. A bivariate correlation model provided an assessment of the strength and direction of the relationships between electricity usage and the family, housing, and appliance saturation characteristics of the Oakland-Livingston sample. The relative and cumulative proportions of the variance in electricity usage accounted for by the thirteen family, housing, and appliance variables listed in Table 1 were evaluated using a stepwise multiple model; specifically, the Maximum R-Squared Improvement Technique was used. Unlike the basic stepwise procedure which identifies a single "best" model of the relationship between a dependent variable and a series of independent variables, the Maximum R-Square Technique identifies a series of "best" models, including the "best" one-variable model, the "best" two-variable model, the "best" three-variable model, and so on until all independent variables are accepted into the equation. With this technique, the variable with the largest

[1] The authors would like to especially thank Stuart Hehtu and James Malinowski of Detroit Edison for their assistance with this study.

R square statistic, i.e., the variable that explains the largest amount of the total variance in the dependent variable, enters the equation on the first step. This is the "best" one-variable model. At the second step, the independent variable that explains the largest amount of the variance unaccounted for by the variable entering at the first step is accepted into the equation. At this juncture, the two variables in the equation, say x_1 and x_2, are compared with each of the remaining independent variables (e.g., x_3 through x_{13}) to determine if the R-square value can be increased by substituting one of the excluded independent variables for one of the two already in the equation. After the comparisons are made, the two variables that maximize the R-square statistics are accepted as being the "best" two-variable model. At the third step, the variable accounting for the largest amount of the remaining unexplained variance enters the equation, and the process of "comparison and switching" is repeated until the "best" three-variable model is formed. As indicated earlier, the process continues until all of the independent variables have been accepted into the equation.

ANALYSIS

This analysis confirms the two basic assumptions of the lifeline concept, namely that low-income households and small families are low-volume users of electricity, and upper-income and large families are high-volume users (see Table 2). There was a moderate positive relationship between both income ($r = +.44$; $p = .001$) and family size ($r = +.46$; $p = .001$) and electricity usage. Among the remaining family characteristic variables, electricity usage was positively related to home ownership status ($r = +.28$; $p = .001$) and inversely related to renter status ($r = -.28$; $p = .001$). These findings suggest that families who either own or are buying their homes tend to use more electricity than renters. The correlation between age of household head ($r = -.03$; $p = .25$) and electricity consumption was not statistically significant.

Relationships between electricity usage and the age, size, and type of dwelling unit and household electrical appliance mix were also considered in this study. Electricity usage was positively related to the size ($r = +.38$; $p = .001$) and age ($r = +.11$; $p = .001$) of the dwelling units, which indicates that there is a tendency for larger, older units to use more electricity than smaller, more recently built dwellings. Further, electricity usage was directly associated with single-family dwelling units ($r = +.23$; $p = .001$), but inversely related to apartments ($r = -.24$; $p = .001$), duplexes ($r = -.07$; $p = .009$), mobile homes ($r = -.04$; $p = .25$), and townhouses ($r = -.002$; $p = .90$). The relationships between electricity usage and both mobile home and townhouse units were not statistically significant (see Table 2).

The final variable considered in the correlation analysis was the number of household electric appliances (appliance saturation). This variable was strongly

Table 2. Correlation Coefficients (N = 1100)

Variables	*Number of Respondents (N)*	*R-Value*	*Significance*
Appliance mix	1074	+ .57	.0001
Income	925	+ .44	.0001
Number of people	1072	+ .46	.0001
Number of rooms	1036	+ .38	.0001
Ownership status	1073	+ .28	.0001
Single family dwelling	1081	+ .23	.0001
Renter status	1073	- .28	.0001
Apartment	1088	- .24	.0001
Year structure was built	954	+ .11	.0000
Duplex	1088	- .07	.0096
Mobile home	1088	- .04	.1439[a]
Age of household head	1073	- .03	.2501[a]
Townhouse	1088	-.002	.928[a]

SOURCE: Compiled by authors from Detroit Edison 1978 Appliance Saturation Survey.
[a] Not statistically significant.

correlated with electricity usage ($r = .57$; $p = .001$).[2] In fact, the magnitude of the correlation suggests that appliance mix may be a better determinant of electricity consumption than any of the other variables considered in this analysis, including income and family size – the two variables on which the lifeline concept is based. The relationships between the other twelve variables and electricity consumption were weak-to-moderate, indicating that there are substantial variations in usage within as well as between subclasses of each

[2] Appliances were weighted by average contribution to annual khw consumption as follows:

APPLIANCE MIX (X_1) = APPLMIX = 1.2X ESTOVE + EFRIG + 1.1 XFRZR + .36 XDSHW + .1 X CLWSH + CLOTHDRY + 2.3X CENA/C + 1.1 X ROOMA/C + 1.5 XBWTV + .4 XCLRTV + .38 X DEHUMD + .16 X HUMD

where the following are (1,0) dummy variables indicating ownership of the appliance:

ESTOVE	– electric range	ROOMA/C	– room air conditioning
EFRIG	– electric refrigerator		
FRZR	– electric food freezer	BWTV	– black and white television
DSHW	– electric dishwasher		
CLWSH	– electric clothes washer	CLRTV	– color television
CLOTHDRY	– electric clothes dryer	DEHUMD	– dehumidifier
CENA/C	– central air conditioning	HUMD	– humidifier

Table 3. Coefficients of Determination: Stepwise Regression Model

Variables	*Beta Weights*	*R-Square*	*R-Square Change*
Appliance mix	81.6	.320	.320
Number of rooms	32.7	.421	.101
Number of people	68.3	.443	.022

SOURCE: *Compiled by authors from Detroit Edison 1978 Household Appliance Saturation Survey.*

variable (e.g., income subgroups). Several relationships were not statistically significant.

The previous correlation analysis has shed some light on the validity of the two major assumptions undergirding the lifeline concept, as well as on the relationship between electricity usage and a number of other socio-physical variables. In the real world, however, electricity usage is a function of the interaction or interrelationships among all of the variables considered in the correlation analysis and perhaps others. The results of the regression analysis revealed the extent to which the thirteen variables together explain variations in electricity consumption among the households surveyed in Oakland and Livingston Counties.

Once the interaction and interrelationships among all thirteen independent variables were taken into consideration, the maximum R square regression technique revealed that the model that "best" explained electricity usage in the Oakland-Livingston Counties sample consisted of three independent variables. As Table 3 shows, appliance mix or saturation was the most important determinant of electricity usage, accounting for 32 per cent of the total variance. The second most important variable was the number of rooms in the dwelling, accounting for 10 per cent of the variance. The third important explanatory variable was family size, contributing 2 per cent to the explained variance. Together, these three variables accounted for 44 per cent of the total variation in electricity consumption among the Oakland-Livingston Counties sample (Table 3). It is important to point out that annual gross family income was not one of the explanatory variables. One possible reason for this is that much of the explanatory power of the income variable was accounted for by the appliance saturation variable. In essence, appliance mix appears to be a better predictor of electricity usage than income.

SUMMARY AND IMPLICATIONS

Disadvantaged households are more adversely affected by rising energy costs than the rest of the population. Lifeline rates have been proposed or enacted in a number of states, including Michigan, to ease the burden of electric price hikes on the poor. Inherent in the Michigan legislation is the proposition that electricity usage is positively associated with income and family status. Electricity usage in disadvantaged households is assumed to be restricted to basic necessities (i.e., lighting, cooking, refrigeration, etc.), while middle and upper income households are characterized as high volume users, in large part because their homes are more likely to be equipped with more and larger sized electrical appliances. Advocates of lifeline rates believe that income will be redistributed to disadvantaged households if an initial block of electricity (i.e., the amount used out of necessity) is offered at a low uniform rate.

In spite of statistically significant correlations between electricity consumption and both income and family size (the postulates of the lifeline concept), previous studies [9, 11] have concluded that lifeline rates will *not* effectively mitigate the impacts of sharp increases in the price of electricity on disadvantaged households. This conclusion is based, in part, on the results of rigorous multivariate regression analyses, which revealed that socio-economic and demographic variables are poor predictors of household electricity usage. This analysis of data on the socio-physical characteristics and electricity consumption of a sample of households in Oakland and Livingston Counties, Michigan supports this finding. Income, assumed by proponents of lifeline rates to be the most important predictor of electric usage, was *not* a statistically significant determinant of electricity consumption, and family size accounted for only 2 per cent of the total variance in electricity consumption: the dependent variable. Neither of these variables is a good discriminator. Under the Michigan lifeline legislation, approximately one-fourth of the affluent households (annual income greater than $15,000) in the Oakland-Livingston Counties sample will pay less for electricity in the future. Conversely, over half (52%) of the disadvantaged households (annual income less than $15,000) will pay more, because their monthly consumption exceeds the lifeline rate block of 500 kwh per month. Thus, the Michigan legislation, as presently structured, will improve the economic well-being of many middle class and affluent households, and further exacerbate the plight of a significant number of low-income households.

Appliance mix and size of dwelling units appear to be better indicators of electricity usage than either income or family status. Even if a lifeline proposal based on size of dwelling unit and appliance mix was developed, the stress of rising energy cost on low- and fixed-income families cannot be lessened solely by electricity rate adjustments for three reasons. First, other types of household energy sources are as burdensome on low- and fixed-income households as electricity. Second, lifeline electricity rates separate the needs of the disadvantaged from overall energy needs. According to Henderson [18]:

> Artificial separation of the needs of socio-economic minorities from overall energy needs may be counterproductive . . . a separate energy . . . "bill of rights" for residential consumers is less helpful than a single "bill of rights" which includes low-income consumers.

Third, lifeline provides the poor with no incentives to reduce electricity consumption and, as suggested above, may even increase their dependence on social welfare or energy assistance programs. In this regard, Henderson states that [18]:

> . . . Special and remedial energy programs for the needy should *reduce* dependency on government while achieving energy conservation, efficiency, and economic goals. When government intervention is necessary, it should be efficacious, cost effective, and administratively efficient to preclude burden on other consumers or on commerce and industry.

In short, lifeline is a piecemeal energy policy which is an inadequate and ineffective solution to the poor's energy problems. What is needed is a comprehensive energy policy which includes all forms of household energy (not just electricity), takes into consideration such variables as size of dwelling unit and household appliance mix, and seeks, through a system of information, feedback, and incentives, to reduce energy consumption through wise use or conservation in *all* households (not just those of the disadvantaged). A number of behavioral studies in psychology [19] have recently shown that by providing information about energy conservation, feedback on daily usage, and financial or other kinds of incentives, it is possible over the short-run to assist families to reduce their energy usage (especially electricity) by as much as 20 per cent. Such an energy policy would assist low-income households to essentially "help themselves" cope with rising energy prices [20].

REFERENCES

1. E. Cose (ed.), *Energy and Social Equity: Some Social Concerns,* Joint Center for Political Studies, Washington, D.C., 1979.
2. National Advisory Council on Economic Opportunity, *Eleventh Report,* U. S. Government Printing Office, Washington, D.C., 1979.
3. How to Help the Poor Buy Heat, *The New York Times,* p. A-16, August 1979.
4. Does Your State Have Lifeline?, *The Power-Line, 4,* p. 6, 1976.
5. F. P. Morrisey, The Changing Structure of Utility Rates, *Public Utilities Fortnightly, 97,* pp. 15-19, 1976.
6. Department of Energy, *National Electric Rate Book,* U. S. Government Printing Office, Washington, D.C., 1978.
7. Rate Structure Glossary, *The Power-Line, 5,* p. 5, 1977.
8. U. S. Congress, House Committee on Interstate and Foreign Commerce, *Electric Utility Reform and Regulatory Improvements,* 94th Congress, 2nd Session, U. S. Government Printing Office, Washington, D.C., 1976.
9. C. T. Everett and J. R. Malko, Measuring the Impact of Residential Gas and Electric Rates, *Public Utilities Fortnightly, 100,* pp. 20-24, 1977.
10. R. H. Frank, Lifeline Proposals and Economic Efficiency Requirements, *Public Utilities Fortnightly, 99,* pp. 11-15, 1977.

11. J. W. Howe, Lifeline Rates – Benefits for Whom?, *Public Utilities Fortnightly, 97,* pp. 22-25, 1976.
12. G. Burgess and M. Paglin, Lifeline Electric Rates as an Income Transfer Device, *Land Economics, 57,* pp. 41-47, 1981.
13. B. M. Morrison, *Socio-Physical Factors Affecting Energy Consumption in Single Family Dwellings: An Empirical Test of a Human Ecosystem Model,* unpublished doctoral dissertation, Michigan State University, East Lansing, Michigan, 1977.
14. S. Z. Klausner, Household Organization and Use of Electricity, *Energy Policy in the United States: Social and Behavioral Dimensions,* S. Warkov (ed.), Praeger Publishers, New York, pp. 45-59, 1978.
15. A. J. Dahl, California Lifeline Policy, *Public Utilities Fortnightly, 102,* pp. 13-22, 1978.
16. Detroit Edison Company, *1978 Appliance Saturation Survey,* Detroit, Michigan, 1978.
17. A. J. Barr, et al., *A User's Guide to SAS,* SAS Institute, Raleigh, North Carolina, pp. 251-252, 1976.
18. L. J. Henderson, Jr., Energy Policy and Social Equity, R. Lawrence (ed.), *New Dimensions to Energy Policy,* Lexington Books, p. 149, 1979.
19. L. McCelland and S. W. Cook, Promoting Energy Conservation in Master-Metered Apartments Through Group Financial Incentives, *Journal of Applied Social Psychology, 10,* pp. 20-31, 1980.
20. B. Stokes, Helping Ourselves, *The Futurist, 15,* pp. 44-51, 1981.

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