Design of a Fuel Assistance Benefit Distribution Formula

Stephen P. Coelen
Massachusetts Institute for Social and Economic Research (MISER)
University of Massachusetts
Amherst, MA

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I, however, accept responsibility for any error which may have crept into this final report.

Stephen P. Coelen
Director, MISER
Professor, Political Science
University of Massachusetts at Amherst
October 1994

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1. Introduction

This report describes the design of a formula for providing fuel assistance to households who qualify for such support on the basis of their low income. The formula used in Massachusetts' Low Income Home Energy Assistance Program (LIHEAP) has historically contained a component differentiating among households on the basis of whether or not they were additionally qualified for and in receipt of housing assistance. To the extent that those receiving housing allowance assistance were paid less from the fuel assistance formula, the formula partially negated the intended stand-alone impact of the housing assistance formula. On the basis of this and other considerations, the Federal government made a preliminary determination in early 1993 that reference to receipt of housing assistance should be eliminated in fuel assistance formulae. Therefore, our work gave primary consideration to eliminating the housing assistance component in the Massachusetts state formula, and in doing so, leaving the housing assistance and fuel assistance programs intact with their independent program goals.

These policy changes are made more significant because federal and state dollars allocated for fuel assistance have been declining since the mid- 1980's (see Figure 1). Because numbers of qualified recipients have not declined at an equal pace, actually increasing, the maximum benefit payable per recipient in Massachusetts has been dramatically reduced (see Figure 2). Consequently, the current prospect of eliminating the distinction between subsidized and non-subsidized housing brings with it further reductions of benefit levels for non-subsidized housing recipients (about four fifths of all fuel assistance recipients). In turn, this raises concern for equity

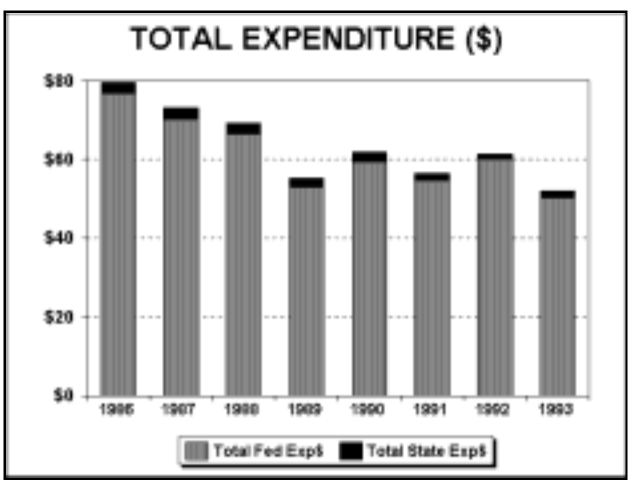

Figure 1: Federal/ State Spending on LIHEAP

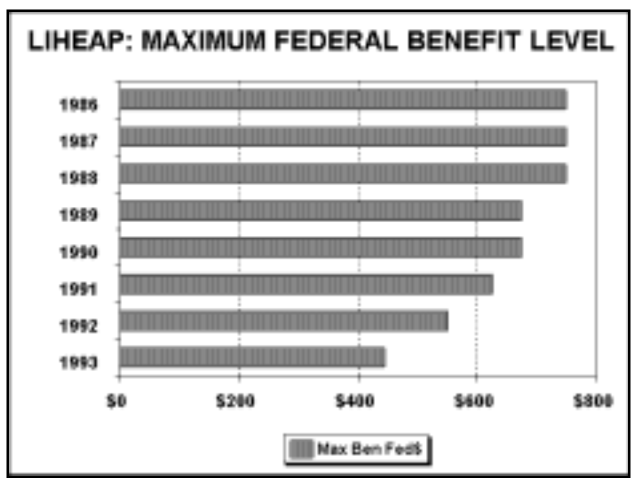

Figure 2: Maximum LIHEAP Benefit

in the fuel assistance allocation formula.[1]

Our report begins describing a mechanism for eliminating the housing assistance component in section 2 which leaves the basic formula as unchanged as possible. Section 3 launches a theoretical inquiry about the principles inherent to the foundation of a fuel assistance formula, showing that, on the basis of equity, the existing formula and modest changes to it are insufficient. Section 4 describes the fuel use survey carried out to facilitate required aspects of the study, and section 5 proposes a new reimbursement system to eliminate the inequities common to the prior formula and derivatives thereof.

2. Eliminating the Subsidized Housing Components of the Existing Formula

The existing formula reimburses Massachusetts households by size and income relative to poverty. One reimbursement rate is given to each of three relative income categories for those fuel assistance recipients who do not also receive housing allowance assistance. A second set of rates is established for households by income class if they receive housing allowance assistance. Finally, a third set of rates is established for each category if the household consumes propane as its fuel type. Propane use is relatively small, constituting less than two percent of all LIHEAP recipients between 1986 and 1993 (see Figure 3) and is consequently not considered further in this report.

The existing benefit matrix is given in Table 1. Inspection of this matrix shows that family size influences the amount of income that can be earned at each of the three relative poverty levels, but does not directly influence the amount of the benefit received. Benefits are constant for different families regardless of size, so long as their incomes relative to poverty are equal.

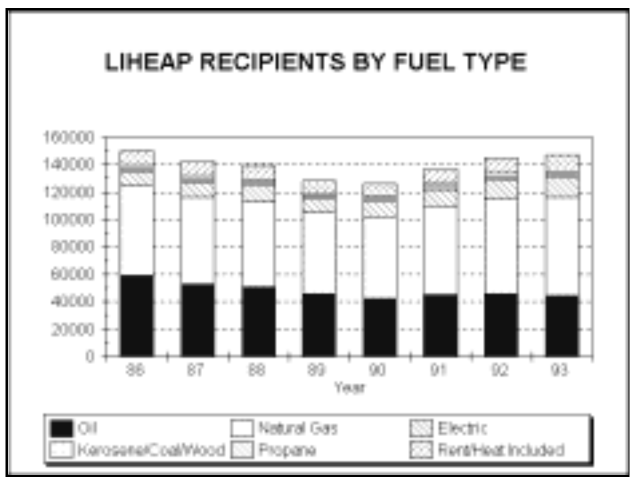

Figure 3

[1] Amounts represented as Federal expenditures in Figures 1 and 2 are actually LIHEAP payments to persons in the lowest two income categories qualifying for the program. In years prior to 1990, some payments to such households were supported by state spending which was otherwise reserved for payments to households in the one higher qualifying income category. Therefore, the decline of State spending is more marked than shown; the totals are correct as shown.

TABLE 1: Qualifying Income and Benefits of Households by Size—FY 1993

	Maximum Income for Qualification into Relative Poverty Category		
Household Size	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	$8,513	$10,215	$11,918
2	$11,488	$13,785	$16,083
3	$14,463	$17,355	
4	$17,438	$20,925	
5	$20,413	$24,495	
6	$23,388	$28,065	
7	$26,363	$31,635	
8	$29,338	$35,205	
Over 8	Add $2,975 For Each Additional Member	Add $3570 For Each Additional Member	
	Benefit Paid to Households of Qualifying Relative Income		
Ordinary recipients	$445	$265	$225
if housing assisted	$150	$90	$75
if propane user	$535	$320	$270

note: larger family sizes at high relative (to poverty) incomes are not included in the benefit "design" matrix under the existing formula.

MISER attempted to collect data from all 22 Massachusetts sub-grantee agencies on the population of fuel assistance clients in the 1992-93 fuel year, a period running from October 1992 through March 1993. Efforts failed to collect 100% of the data on client households from sub-grantee administrative records. Only 83.2% of the 147,502 household records were recovered with sufficient information to reflect household size, income, fuel type used, and whether the household received housing assistance in addition to fuel assistance. Our record of less than 100% recovery was primarily due to computerization problems of a few of the sub-grantee agencies or their hired computer vendors.

Tables 2 through 4 show the distribution of clients across the various income and household size ranges. Table 2 shows total clients according to household size and relative income. Table 3 shows the distribution of clients into housing subsidized and non-subsidized clients. Table 4 shows the federal poverty definition for households of various sizes as well as the mean income for fuel assisted households as they were classified by size and relative income.

TABLE 2: Household Clients by Size and Relative Income—FY '93

	Maximum Income for Qualification into Relative Poverty Category		
Household Size	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	38,790	7,185	3,188
2	26,689	4,438	3,119
3	24,288	2,532	
4	18,257	2,120	
5	9,338	1,011	
6	3,720	385	
7	1,403	142	
8	504	36	
Over 8	339	17	

note: data in this table reflects a completed sample size of 122,667 clients of a population of 147,502; data reported has been enlarged to reflect the population.[2]

[2]The "sampling rate" for the administrative records of all clients was (122,667/147,502)=83.2%. The table, as reported, has been "blown up" to population proportions by a constant factor of 1/.832. It adds to only 147,501 because of rounding. It may also include some discrepancy due to sampling bias. There were two sub-grantee agencies for whom data could not be obtained, leading to such discrepancies, for example, that while summaries of the client data base of EOCD show that there were 6,500 households with income between 150 and 175%, the enlarged sample showed only 6,307.

TABLE 3: Household Clients by Size, Relative Income, and Subsidized/Un-subsidized Housing Status Classification—FY '93

	Numbers of Households by Size, by Relative Poverty Category, and by Subsidized/Un-subsidized Housing Classification		
Household Size	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	5,133/33,657	407/6,777	194/2,993
2	6,023/20,665	476/3,963	249/2,870
3	6,210/18,079	288/2,244	
4	4,267/13,990	211/1,909	
5	2,027/7,312	86/926	
6	813/2,907	23/362	
7	308/1,095	17/125	
8	103/401	0/36	
Over 8	83/256	2/14	

TABLE 4: Average Income of Fuel Assistance Recipients by Size and Income Class Relative to Poverty—FY '93

		Mean Income by Size and by Relative Poverty Category		
Household Size	**Poverty Income Definition**	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	$6,810	$6,048	$9,309	$10,977
2	$9,190	$6,949	$12,617	$14,868
3	$11,570	$7,988	$15,872	
4	$13,950	$9,616	$19,041	
5	$16,330	$11,447	$22,342	
6	$18,710	$13,117	$25,618	
7	$21,090	$14,727	$28,922	
8	$23,470	$15,476	$31,564	
Over 8	$25,850	$17,312	$36,644	

In order to determine the level of benefits that would exist given the previous year's spending level, where there is no discrimination between subsidized and non-subsidized households, we use data from Table 3, defining:

N^l_{ns} = non-housing subsidized clients of income < 125% of poverty;
N^m_{ns} = non-housing subsidized clients of income < 150% of poverty;
N^h_{ns} = non-housing subsidized clients of income < 175% of poverty;
N^l_s = housing subsidized clients of income < 125% of poverty;
N^m_s = housing subsidized clients of income < 150% of poverty;
N^h_s = housing subsidized clients of income < 175% of poverty;
B^l = prior benefit level for non-subsidized households with income < 125% of poverty;
B^m = prior benefit level for non-subsidized households with income < 150% of poverty;
B^h = prior benefit level for non-subsidized households with income < 175% of poverty; and
S = the spending level allowed to the program under prior Federal and State allotments, then

$$(N^l_{ns}+N^l_s)(\lambda B^l)+(N^m_{ns}+N^m_s)(\lambda B^m)+(N^h_{ns}+N^h_s)(\lambda B^h)=S \qquad \textbf{(1)}$$

where λ is the percentage by which benefits would need to be reduced for clients without housing subsidies, if all subsidized and non-subsidized clients alike are to be reimbursed at the same common rate. This equation merely states that the previous spending level, S, must be spread to all clients so that each recipient in each income class will get the same fraction, λ, of the previously established benefit level (for the non-subsidized households of each income category). The relative size of benefits, compared across relative income classes, will remain the same proportionally under this new formula as established under the old.

Since all of the N's and B's are all known in equation 1 and since we can determine what the benefit levels would be at any level of spending (last year's, for example), then equation 1 has only one unknown, λ. Results of performing the calculations required by equation (1), correcting for the less than 100% sampling rate, and assuming that the subsidized housing clients are 18.5% of the total clients (as reported in the annual FY '93 LIHEAP report issued May 1993 by EOCD) show that benefits would need to be reduced to 87.2% of their former level in order to keep total spending constant. Benefits for the three groups (< 125%, < 150%, and < 175%, respectively) are therefore reduced to \$388, \$231, and \$196, respectively. These benefits had originally been \$445, \$265, and \$225, per household, as shown in Table 1. One notes that equation (1) treats S, the spending level, as parametric to the equation. That is, equation (1) can be used to determine benefit levels with any level of spending, given the equation's objective. Thus the equation provides a handy means of quick evaluation of benefit levels whatever happens to federal and state spending on fuel assistance.

3. Principles of Formulary Assistance Programs

Assistance programs are designed to give persons who are at or near the defined poverty level financial support to supplement their own resources and consequently increase the degree of equity which exists within society. Recognizing the importance of equity as the founding principle for giving aid in the first place, the equity principle should also be used as the criterion for distributing public subsidies among recipients. Theoretically, assistance programs should leave each recipient household in roughly parallel condition to each other, comparable recipient household. We use this theory as a goal, but also recognize that equity is rarely defined precisely within assistance programs because political processes focus so much more on the equity between those assisted and those unassisted that little emphasis is left for equity within the pool of recipients.

It is the responsibility of the policy analyst to attempt to educate the decision making body about possible solutions to questions facing policy makers. The analyst cannot approve or disapprove of principles, but she can, and should, define reasonable parameters to be considered. This work, involving variable definitions and explanations of assumptions made, should be considered in a public hearing or other forum for debate.

If we were to leave persons at roughly equal conditions after their support for fuel purchase, several alternative rules might apply:

- subsidies should be provided equally to all households of the same relative income levels;
- subsidies should be differentiated on both the size of the household as well as its relative income;
- subsidies should make up the difference between minimum payments for heat required from recipient households from their own earned incomes and the cost of the household's total fuel payment.

Surely, there are as many different formulae as thinkers contemplating ideas about appropriate distribution formulations. Hence, there is an ambiguity over what the appropriate, definitive assistance criterion might be. We suggest herein only a few of the possible kinds of subsidy formulae; there is no way to determine which is theoretically more "correct". In order to do that, one would need to submit the alternatives to voters to see which best fits their preferences for meting welfare.

Subsidy payments are intended to help those households which cannot otherwise pay for minimal winter heat. In addition, a fuel assistance program should stress conservation rather than support excessive fuel use. Consequently, if factors requiring some households to use more heat than others could be determined, those factors could be appropriately utilized in designing a fuel assistance formula. Degree days, extent of weatherization, newness (thus, efficiency) of the heating equipment, and other factors would ideally be used in developing an assistance formula. Such data are not administratively available, however, from the current data base for use in a formula.

We searched the literature for information on determinants of fuel use; there was not much to be found. A study of Washington State's LIHEAP program[3] evaluated factors affecting fuel use such as family size, housing type, and county heating degree days. Using regression analysis, researchers concluded there were no good predictors of heat use and costs. Analyzed independently or combined, the ability to predict heating costs for specific households was poor, finding even that the presence of vulnerable residents (young children, elderly and disabled) did not significantly explain differential household heating use. Discouragingly, even the most significant finding in Washington (that the type of fuel used *does* influence key differences in *energy* consumption) does not translate into significant differences in the dollar amount spent on fuel, given market price variations among fuel types that result from efficiency in the fuel market.

In earlier work, P. Stern, (1986), noted that detailed, idiosyncratic elements of consumer behavior influence fuel cost, and make predictions difficult.[4] Intangible factors such as whether individuals wear sweaters indoors on cooler nights or frequently regulate the thermostat have significant effects which influence fuel use sometimes more than physical conditions within residences. At the same time, we continue to expect that variables such as square footage, number of rooms, age of home, type of heating equipment, and type of insulation, would help to identify and predict fuel use and cost. Where available, actual cost of household fuel use should be obtained and used as a factor in formula-based assistance. Debra Knapp et al. (1991) have proposed a program in Colorado which utilizes this information via an automated data base.

Roger Colton (1990), too, concluded in his article on income-based energy assistance programs that price theory, strategic behavior and other "black-board" economic terms do not apply to most low income clients on fixed budgets.[5] However difficult to predict, statements of need for fuel assistance provide cause for the continued search for determinants which would be available to the policy maker in creating a fuel assistance formulae.

4. Fuel Use Survey

Failing to obtain better information on fuel use determinants from the literature, MISER conducted a survey to determine the fuel use per household so as to relate this to family size and income, variables already included in the formula design matrix. A 5% sample of clients whose records were already held was undertaken through fuel assistance sub-grantee agencies in Massachusetts. Fuel vendors were asked about monthly fuel purchases of clients and about monthly

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[3] Washington State Department, LIHEAP Policy Study, July, 1992, Page 40.

[4] P. Stern "Blind Spots in Policy Analysis: What Economists Don't Say About Energy Use" Journal of Policy Analysis and Management", Vol. 5, No. 2, 1986.

[5] Roger Colton "Client Consumption Patterns Within An Income-Based Energy Assistance Program" Journal of Economic Issues, Vol. 24, No. 4, Dec. 1990.

totals of use during the five LIHEAP months, November (1992) through March (1993) and in the preceding seven non-LIHEAP months, April through October (1992). All results were reported back to MISER but given funding and time pressures, only the summarized results were spliced back into the original data base.

Recognizing that various fuels can be used for various purposes, especially during different seasons (see Figure 4), an algorithm was developed to isolate only that amount of fuel (gas and electric) used only for heating purposes. This algorithm divided the heating season total by five, noted as A/5, and then subtracted the non-heating season total divided by seven, noted as B/7. Though working perfectly for gas and oil, the algorithm fails for households who utilize electricity for air conditioning purposes in that heating fuel use would be understated by the algorithm. However, on the presumption that in Massachusetts, air conditioning is not widely used in residential situations by low income households, the algorithm probably does little damage. Further, however, a data censoring algorithm was implemented to sort out those household observations which seemed to be outliers with fuel use much different from their group's central tendency, a condition which might have arisen (at least in part) from air conditioning use of electricity.

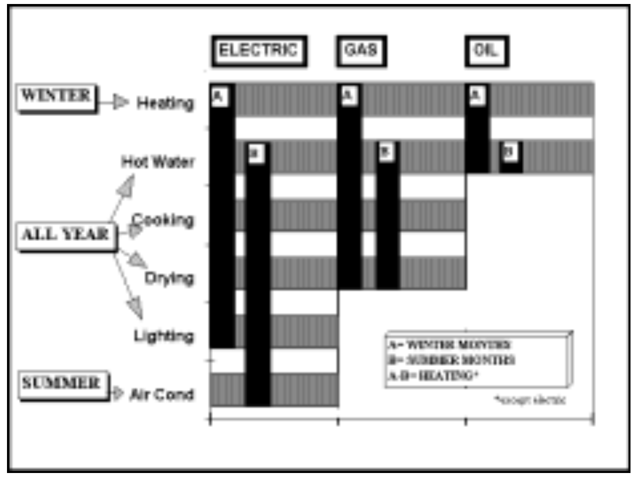

Figure 4

The algorithm described for isolating heating use in electric and gas fuel consumption works well in comparison to oil largely because of the nature of fuel consumption records for these fuels. Namely, gas and electric clients receive, in general, regular monthly bills, and there is little ability to store up one's stock of these fuels for later use. When gas is bottled, as opposed to piped into the home, the rationale for the algorithm is less perfect, but holds approximately given small bottle sizes, compared to the much larger oil tank volumes.

For oil use, the implemented algorithm was different, largely because oil purchase is often put off when the tank is only a little low, or done early if the household can afford it at one time of the year even for later planned use in the heating season. The algorithm took the total of A and B, the total of heating and non-heating seasonal uses, and divided by 5. The algorithm was applied only to those who reported that water for personal non-heating uses was heated in their household by other than oil. Since the algorithm was not applied to households who used oil for both heating of the household space and water, a considerable amount of data was not utilized. We believed this to be warranted, nonetheless, in its improvement of overall results.

Once "purified" by this algorithm, the data was further "cleaned" by two additional steps. The tail ends of the distribution of consumption (within each of the size by income design matrix cells) were whittled off, and the remaining data were analyzed with regression analysis so as to separate out average usage increases associated with household size and income. The regression was done using weighted least squares which gave more weight to those cells with the most observations on fuel use by clients. The weighted regression had an R^2 of .99; the un-weighted, an R^2 of .15. These results are quite reasonable, and imply that if we consider the numbers of households in each cell (Table 2) when using weighted regression, we could do a better job explaining variations among means. Weighted regression is the equivalent of running regressions on data where the same mean occurs as often as there are households in the cell. In both regressions, family size and income had the expected positive effects and in the weighted regression, both were significant with much less than a 10% risk of an alpha type error[6].

The results of MISER's "cleaned" and projected data from regression analysis and the Census Bureau's Public Use Micro Sample (PUMS) data are given in Table 5. Both data series

TABLE 5: Annualized Costs of Fuel Use by Size and Relative Income

	Annualized Spending on Fuel Use by Family Size and by Relative Poverty: MISER Survey/Census PUMS		
Household Size	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	$498/854	$561/$875	$614/$879
2	$546/$943	$640/$937	$712/$949
3	$595/$957	$718/$992	
4	$648/$1026	$795/$992	
5	$702/$1100	$873/$989	
6	$755/$1191	$952/$1107	
7	$808/$1226	$1030/$1175	
8	$855/$1184	$1101/$1130	
Over 8	$909/$1114	$1200/$1131	

are presented in Table 5 for corroboration of their closeness. These data, as will be seen below, are crucial to the construction of an equitable fuel assistance formula.

[6]This was nearly true in the un-weighted regression as well. The significance of the income variable (measured as 20% of income for the lowest relative income group, 33% for the middle relative income group and 42.8% for the highest relative income group — the percentages reflecting the relative standing of each) remained nearly constant at .06 alpha error. Weighting primarily accentuated the significance of the family size variable which had an associated alpha error of .136 in the un-weighted regression and of .000 in the weighted regression.

Comparison of these series show that the MISER numbers are smaller for all but one of the cells. This is to be expected, for even though the MISER results hold for a period nearly three years later than that relevant for the Census numbers, MISER's data carefully eliminates the use of fuels for purposes other than heating. The PUMS numbers reflect questions asked on the 1990 Census about "fuel used for heating" and "the costs of utilities and fuel". It is quite likely that respondents provided cost estimates for uses of fuel other than just heating within their responses. It is difficult for households to separate the amount of electricity used on heating when this fuel is simultaneously being used for other purposes such as cooking, lighting, drying, etc. Only a careful "culling" out of winter costs from summer costs as accomplished in our algorithms can produced the desired result. And even then, there is no ability to consider that fuel use for cooking and lighting changes between seasons in such a way that "culling" fully separates the uses.

5. Proposed Equitable Formula for Fuel Assistance Support Payments

Failing yet to have sufficiently sophisticated data on factors which explain fuel use among clients so as to determine their minimum heating requirements, we develop formulae in this section which exclusively use existing data. These formulae allow us to differentiate amounts of subsidy to be received by households depending on the size and income of the household. Such formulae depend upon fuel use burdens, developed from the data in Table 5 and information on average income by relative income and size category. Burdens measured per dollar of total income and per dollar of income beyond poverty of recipient households are both shown in Table 6, and reveal considerable inequity among households as classified by size and relative income.

The burden drops from 22.4% of "post-poverty" income for the mid-relative income category to only 14.7% of post-poverty income for largest households in this income range. Burdens on post-poverty income for the lowest relative income category are immeasurably greater because income is so low for these households (as opposed to being large because of high fuel consumption costs). Burdens in this category cannot be calculated relevant to income beyond poverty because this group's absolute income does not exceed the federally defined poverty line.

TABLE 6: Percentage of Income Spent on Fuel Use by Size and Relative Income

	Percentage of Income Spent on Fuel Use by Relative Poverty Category of Total Income/of Income Beyond Poverty Line		
Household Size	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	.082/ *	.060/.224	.056/.147
2	.079/ *	.051/.187	.048/.125
3	.075/ *	.045/.167	
4	.067/ *	.042/.156	
5	.061/ *	.039/.145	
6	.058/ *	.037/.138	
7	.055/ *	.036/.132	
8	.055/ *	.035/.136	
Over 8	.053/ *	.033/.111	

* implies that household income is below the poverty line.

The evidence in Table 6 represents *prima facia* evidence of existing formulary inequities, the dissolution of which requires another benefit distribution which would leave households equally well off. Such a formula should be neutral to family size and relative income—whatever variables fuel payments to clients may be based upon. The following three sections provide examples of how benefit distribution formulae may be calculated while achieving specific goals.

A. Equal Burdens Relative to Income Among All Benefit Recipients

This benefit distribution formula requires two sets of equations:

$$\sum_{i,j} N_{i,j} B_{i,j} = S \qquad \textbf{(2)}$$

where:

$N_{i,j}$ =numbers of households in the i^th size and the j^th relative income class;
$B_{i,j}$ =benefits to be paid to the i^th size and the j^th relative income class; and
S =spending on the fuel assistance program

Equation (2) merely states that what is spent by the state on fuel assistance is the sum of the numbers of households in each benefit category multiplied times the level of benefit for each class of benefit recipients. This is the first equation; the second set is:

$$\{F_{i,j} - B_{i,j}\} / \psi_j Y_{i,j} = \delta \qquad \textbf{(3)}$$

which holds for all i and j, where:

$F_{i,j}$ = spending on fuel by households in the i^{th} size and the j^{th} relative income class;

$\psi_j Y_{i,j}$ = that portion of income of households in the i^{th} size and the j^{th} relative income class, which might be expected to be used in part or in total for payments toward fuel use. ψ_j will exclude from a household's expected contribution base that portion of their income which is required for housing, food and mandatory expenditures; and

δ = the constant factor of proportionality for all groups to spend on fuel after subsidy of their supra-poverty income

Equation (3) actually represents 20 separate equations, given the i,j combinations inherent in the benefit design matrix. The equations state that the proportion of each benefit class' expenditure on fuel, after each class receives its "appropriate" assistance amount, per unit of discretionary income that might be spent on fuel will be equal for each benefit class. That is, the burden of net expenditures on fuel will be equal to the same constant, δ, as a percentage of spendable income for each benefit class. This equation effectively defines what the "appropriate" assistance amount is for each class of households.

Because Equation 3 represents as many equations as there are cells in Table 6, which in turn are associated with unknown subsidy amounts ($B_{i,j}$'s), Equations 2 and 3 together would seem then represent a system with one more equation than unknowns. The system, however, is fine because there are an equal number of unknowns: not only are there as many $B_{i,j}$'s as there are cells in Table 6, but also there is a δ, which represents the constant proportionality factor - what each group will be required to spend out of its post-poverty income on fuel for heating.

Equations 2 and 3 can be solved, for the unknown values of the variables, $B_{i,j}$ and δ:

$$B_{i,j} = F_{i,j} - \frac{(\Sigma N_{i,j} F_{i,j} - S)}{\Sigma N_{i,j} \psi_j Y_{i,j}} \psi_j Y_{i,j} \quad \textbf{(4)}$$

for all i and j combinations, and:

$$\delta = (\Sigma N_{i,j} F_{i,j} - S) / \Sigma N_{i,j} \psi_j Y_{i,j} \quad \textbf{(5)}$$

These equations represent the "reduced forms" of equations (2) and (3). δ is shown clearly to be the specific fuel burden of clients in any cell of the benefit matrix as well as the societal burden, in aggregate, of all fuel assistance recipients. It is the sum of all spending on fuel, $\Sigma N_{ij} F_{ij}$, less total assistance, S, per total dollar spending on fuel, $\Sigma N_{ij} \psi_j Y_{ij}$. B_{ij}, the client assistance amount (by client category), is the difference between fuel use, F_{ij}, and what could be expected to be paid toward the purchase by the recipient. The latter, in turn, represents the application of the client's burden measure, $(\Sigma N_{ij} F_{ij} - S) / \Sigma N_{ij} \psi_j Y_{ij}$, multiplied by the client's available income, $\psi_j Y_{ij}$.

Applying Equations (4) and (5) to current conditions yields the benefit distribution matrix given in Tables 7-A and 7-B. It is useful to point out that equations (4) and (5) do more than just calculate the benefit solutions. These equations also allow simulation of the effects of changes on the fuel assistance programs. Such changes might include: shifts in the overall level of funding (S); shifts in average incomes or the numbers of households falling in a particular size/relative income category; or shifts in definition of terms. The latter is demonstrated in the differences between Tables 7-A and 7-B, resulting from shifts in the definition of "available income" used to construct each table.

Simulation models of this type are extremely useful to policy makers and administrators. Though the models themselves can be complicated mathematically, their application is made simple through the use of computers and simulation software. The effects of changes to definitions or parameters are easily seen, and the positive and negative outcomes are easily anticipated.

In the cases shown in both Tables 7A and 7B, benefits received decline with increasing relative income compared to the poverty line. Benefits also increase with household size within the lowest relative income class; this, of course, occurred in the existing benefit matrix (Table 1) as well. It seems appropriate that these formulae give greater support to families with large size since one might expect on equity grounds to give greater support to larger families at constant relative income because of their greater consumption of fuel in (presumably) larger houses. But what happens when this point is violated, as for example, in the drop in benefit levels for households of increasing size in Table 7B for mid- and high-relative income households.

Explanation of such decreases is found in Figure 5 which shows the explicit relationship between households' absolute income for those actually receiving fuel assistance in Massachusetts and the definitional income maximum that just qualifies households for classification in the 125%, 150% and 175% of poverty categories. The average income for all households sizes classified in the lowest relative income category is consistently below the poverty level. As household size increases, household income declines in absolute terms father and further below the poverty line. In contrast, average household incomes for households classified in the middle- and high-relative income categories rise above poverty levels as household size increases.

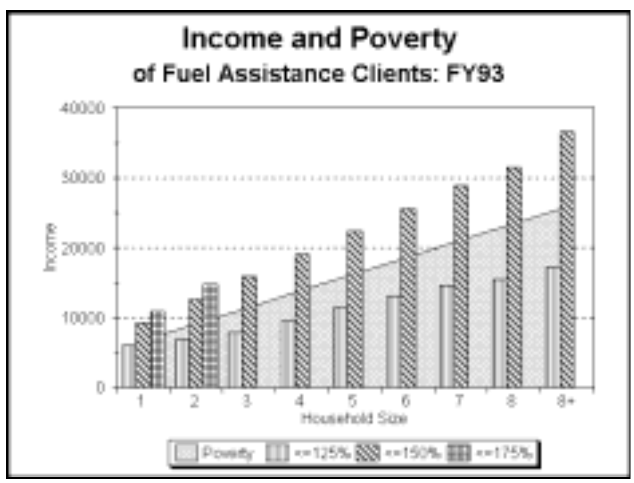

Figure 5

TABLE 7A: Benefit Matrix A — Proportional Equity by Family Size and Income

	Relative Poverty Category		
Household Size	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	$306	$49	
2	$405		
3	$493		
4	$526		
5	$540		
6	$570		
7	$605		
8	$718		
Over 8	$733		

<u>note:</u> this table represents assistance benefits payable under the assumption that clients can make available that part of their income beyond the level representing 60% of the federally defined poverty line. Where cells are missing, in this and the next table, it is implied that household income was too high to qualify for support.

TABLE 7B: Benefit Matrix B — Proportional Equity by Family Size and Income

	Relative Poverty Category		
Household Size	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	$356	$268	$126
2	$383	$238	$46
3	$408	$214	
4	$423	$198	
5	$434	$169	
6	$448	$142	
7	$463	$113	
8	$493	$153	
Over 8	$504		

This table also assumes that clients make available 10% of their gross income or 50% of their income beyond poverty, whichever is greatest.

<u>note:</u> see not above

The relationship between average household income and poverty levels can be defined largely by the definitions used for each income class. The lowest income group consists of households at or below 125% of the poverty level, and is an open-ended category whose average is "pulled down" by households with no or very little income. For the mid- and high-relative income groups, the categorization is closed-ended. The household must be above poverty to qualify. Given that the definition is stated in percentage terms (125%, 150% and 175%), the higher the absolute income, the greater the excess of income over poverty. This fact alone can lead us to conclude then that by most reasonable standards of equity, the outcomes in Tables 7A and B are warranted. Larger households in the low-relative income category fall furthest below poverty. Because they can give the fewest of their own dollars for fuel use, social support must be the greatest for them. Larger households in the upper two relative income categories have more spending power in absolute excesses of dollars beyond necessities which define the poverty line. The case for subsidies for such households cannot be made unless we put more dollars into the entire assistance program. While the fuel costs of relatively higher income, larger sized households are unarguably higher than those for smaller households, these costs rise more slowly than their incomes have so their relative need is less warranted.

It is important to note here, however, the significant differences that definitions make in the formulation of the benefit matrix, and in policy formulation in general. Large variations arise between Tables 7A and 7B from the use of different definitions of the appropriate portion of a household's total income should be applied to fuel costs. What exactly is the appropriate portion is a normative question open to debate. It is our recommendation that this debate, and others like it, take place in a public forum where the opinions of fuel assistance recipients, vendors, policy makers, and administrators are heard. It should be recognized that the definitions used in formulating policy are just as important as the benefit principles that underlie the usually more explicit statement of policy.

That many of the cells in the middle relative income column are not filled is an impermissible aspect of Tables 7A and 7B because by current interpretation of the LIHEAP regulations, households in such cells cannot be excluded from receipt of benefits. Once a household falls within the defined recipient group by virtue of its relative income, then it must receive benefits, regardless of its actual income burden brought on by fuel consumption. By contrast, in Table 7A, only the smallest family size cell within only the middle relative income column is filled. For such cases where cells are empty, the benefit formula described in equation system (2)-(3) yielded negative values. This implied that, given the general level of burden imposed upon the recipients — burdens common to all regardless of income level, some recipients have sufficient income to pay for their own fuel consumption. The negative values obtained from the algorithm suggest that these households, as relatively poor as they are, could have contributed some of their income to other more poor households, providing higher subsidies to others with less income without raising their total burden of own-purchased and contributed fuel above the burdens of the truly poor. Of course, we do not mean that they should do this and would not calculate such a result without including the many others in the much broader society who hold much higher income.

B. Equal Burdens Within Relative Income Classifications, But Different Burdens Across Classifications

A second benefit principle might state that fuel-use burdens should be equalized within, but not across, relative income categories. This principle would suggest that it may be more equitable, and socially responsible, to allocate more fuel assistance to poorer households. In order to implement such a benefit allocation, the distributional algorithm must require households with more income to pay for proportionately more of their fuel use. To do this, we introduced additional factors into the equation system used to determine benefit levels by changing equation (3) to differentiate between relative income levels.

Using θ as a proxy for the proportion of household income which might be expected to be allocated towards fuel use, a new equation is introduced:

$$(F_{ij} - B_{ij})/\psi_j Y_{ij} = \theta_j \delta_1 \qquad \textbf{(3')}$$

where, as before, i represents household size and j, its relative income category. The θ, however, have been chosen equal to 1.25/1.25 for poorest households, 1.25/1.5 for middle-income households, and 1.25/1.75 for households with the greatest relative income. These ratios for θ were chosen to be consistent with the relative income that each group earns. Because poorer households have smaller incomes, it is reasonable to expect that they spend a greater portion of their overall income on fuel use; if we expected, to the contrary, that poorer households spend a smaller portion (and more well off households, a larger portion) of their income on net fuel costs post benefits, then the still poor, but relatively higher income households would receive no benefits at all. Consequently, the value for θ was chosen to be greater for households with lower relative incomes. The use of θ's for different income categories does not disturb the requirements taht the system impose the same burden within different income categories; it merely allows a differentiation of burdens among relative income groups.

Solving equations 2 and 3' for the $B_{i,j}$ and applying the resulting formulae to our data, the following benefit matrix results:

Table 8 awards larger benefits to those households in the lowest income category. However, as can be seen examining the middle column, the benefits still fall, as they did in Table 7-B, with increases in household size. What this does, nonetheless, is to eliminate the inequity among averages across the cells within the same income classification while enforcing a rigid relationship among the burdens across the cells differing by relative income. This relationship is as we set out initially in equation 3', that the burdens must be held by people in proportion to the relative incomes of their respective income categories.

TABLE 8: Benefit Matrix — Proportional Benefits Over Family Size, Different Inc. Burdens

	Relative Poverty Category		
Household Size	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	$346	$299	$240
2	$372	$281	$202
3	$394	$267	
4	$406	$262	
5	$415	$244	
6	$426	$229	
7	$438	$210	
8	$466	$254	
Over 8	$475	$70	

This does not, however, eliminate inequity. The two benefit principles suggested thus far in sections 5A and B only eliminate the average inequities of fuel assistance benefits when the latter is measured as a percent of the average household income within a income/household size classification. None of the techniques used in producing Tables 7A, 7B, or Table 8 succeeds entirely in eliminating inequity among households by size or income class. Specifically, benefit matrices resulting from the application of these benefit principles produces inequities ***within*** the cells of a benefit matrix — i.e., for any given household size and income class there are inequities among the households within their common cell. Households alternately at the high and low ends of the income range for a given cell will have different burdens (although burdens will be the same for the average households within the income category).

Intra-cell inequities are displayed in Table 9. This table whows the range of burdens borne by households of a given size and income range. Burdens are calculated as the ratio of net fuel costs (forecasted use less benefits received) to a portion of household income. In comparison to inequities reflected in Table 6 showing the fuel use burdens as varying widely with income and household size, Table 9 shows a wider range of values which are extremely high at the minimum end of the lowest income category (largely a result of the category's open-endedness, and our assumption of $1,000 as the minimum income for any household in that category). Beyond this, the range is narrow— with net fuel costs (after subsidy) running from 13% to 30% of a household's disposable income. In the middle income category, a typical household with income at the low end of that category bears a 30% burden, while a household in that same range, but with income at the high end of the category, has a burden of only 16%.

TABLE 9: Intra-cell inequities in the Fuel Use Burdens Associated with Table 8

	Relative Poverty Category		
Household Size	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	1.18,0.20	0.30,0.16	0.21,0.15
2	1.35,0.18	0.30,0.16	0.22,0.15
3	1.54,0.17	0.30,0.16	
4	1.84,0.17	0.30,0.16	
5	2.18,0.17	0.30,0.16	
6	2.49,0.17	0.30,0.16	
7	2.79,0.17	0.30,0.16	
8	2.93,0.16	0.28,0.15	
Over 8	3.27,0.13	0.27,0.13	

In order to further narrow intra-cell inequities, it seemed appropriate to divide the open-ended category of households, adding one income category for those households with incomes less than poverty and another for those with incomes between poverty and 125% of poverty.[7] These changes produce the following benefit matrix, Table 10.

Notice how distinctly the design of the benefit program changes the results. Now instead of the second and following columns declining with household size, benefits in the second relative income column also rise with household size. Table 10, furthermore, succeeds in reducing the within cell inequities by narrowing the size of the open-ended income category. These results are shown in Table 11.

[7] Under this revision, the value of θ for the (new) lowest relative income household becomes 1.25/1.

TABLE 10: Benefit Matrix —Proportional Benefits Over Family Size, Different Inc. Burdens

	Relative Poverty Category			
Household Size	Household income< Poverty	Household income < 125% Poverty	Household income < 150% Poverty	Household income < 175% Poverty
1	$344	$366	$317	$266
2	$370	$373	$305	$237
3	$379	$382	$298	
4	$392	$390	$298	
5	$402	$399	$287	
6	$408	$409	$278	
7	$414	$421	$266	
8	$437	$422	$312	
Over 8	$421	$423	$147	

TABLE 11: Intra-cell inequities in the Fuel Use Burdens Associated with Table 10

	Relative Poverty Category			
Household Size	Household income< Poverty	Household income < 125% Poverty	Household income < 150% Poverty	Household income < 175% Poverty
1	1.34,0.17	0.20,0.18	0.28,0.15	0.20,0.14
2	1.30,0.14	0.20,0.18	0.28,0.15	0.20,0.14
3	1.63,0.14	0.20,0.18	0.28,0.15	
4	1.92,0.14	0.20,0.18	0.28,0.15	
5	2.25,0.14	0.20,0.18	0.28,0.15	
6	2.60,0.14	0.20,0.18	0.28,0.15	
7	2.96,0.14	0.20,0.18	0.28,0.15	
8	3.16,0.14	0.20,0.18	0.26,0.14	
Over 8	3.73,0.12	0.19,0.14	0.25,0.12	

Another problem occurs, however, in moving to the benefit matrix represented in Table 10.

The benefits for any given household size do not decline uniformly with their (absolute and relatively) increasing income. This occurs because fuel use increases reasonably rapidly compared to income. Therefore, in order to maintain burdens at preset levels, the fuel subsidy must rise across income categories. Not only is this likely to be an unacceptable social solution to the problem but also it is a logistical and administrative problem. The lowest income households of size 6, for example, can legitimately say that if they qualify for $408 by virtue of the fact that their incomes are below the poverty line, they can also legitimately qualify for $410 because their incomes are also below 125% of poverty. This problem is remedied by slightly revising the formula used to determine the benefit levels. By changing the values of θ for the two lowest income categories to 1.05 and 1.0 (respectively), the benefit matrix, Table 12, results.

TABLE 12: Benefit Matrix—Proportional Benefits Over Family Size and Income

	Relative Poverty Category			
Household Size	**Household income< Poverty**	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	$356	$350	$295	$234
2	$384	$351	$275	$193
3	$396	$354	$259	
4	$413	$356	$253	
5	$426	$360	$233	
6	$436	$365	$216	
7	$446	$370	$196	
8	$471	$365	$239	
Over 8	$461	$359	$50	

Table 12 successfully eliminates the problem inherent in Table 10 of increasing benefits with increasing income, holding household size fixed; it still produces an acceptable benefit matrix. This exercise also highlights the ability to tailor the benefit matrices for fuel assistance to policy requirements through the use of computer simulation.

C. Equal Benefits Relative to Fuel Use Among Benefit Recipients

A third benefit principle is derived from the following set of three equations, and is applied to the case where there are three relative income classes:

$$\frac{B_{i,j}}{F_{i,j}} = \delta_j \tag{6}$$

where, as before, $B_{i,j}$ and $F_{i,j}$ are benefits and fuel consumption for households of different size (i) and income (j), and where

δ_j is a constant factor of proportionality unique to each relative income group.

This is inherently different from the earlier benefit principles because here we are not trying to equalized the spending relative to income. Notice that income of the recipients does not enter the equation at all. Equation (6) merely states that the proportion of fuel use that will be subsidized for each income class will be fixed at δ_j. This will be a constant for each of the j income groups. To this specification are added two additional equations:

$$\delta_1 = (1.9888)\delta_3 \tag{7}$$

$$\delta_2 = (1.18)\delta_3 \tag{8}$$

These equations, (7) and (8), imply that the proportion of fuel use that is subsidized should vary inversely with income associated with the recipient's relative income class. The income classes have factors of proportionality which vary among the classes in the same way as does the maximum level of income that gives entrance into the classes. Finally, an equation which requires that total spending be set at some value S is required:

$$\sum\sum B_{i,j} = S \tag{9}$$

Equation (9) allows a policy maker to set S equal to the prior year's level of spending so as to make the total amount of awarded benefits invariant to changes in the formula, allowing comparisons among formulae benefit distributions. Alternatively, the policy maker can adjust the level of S, parametrically, to account for any amount of spending anticipated in the current benefit year. Applying Equations (6)-(9) to current conditions yields the benefit distribution matrix given in Table 13.

TABLE 13: Benefit Matrix to Fuel Use By Household Size and Income

	Relative Poverty Category		
Household Size	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	$329	$220	$204
2	$361	$251	$236
3	$393	$281	
4	$428	$312	
5	$464	$342	
6	$499	$373	
7	$534	$404	
8	$565	$432	
Over 8	$601	$470	

This formulae has no logical connection to attempts to minimize the equity differences among fuel subsidy recipients. It was set into a formulae for one reason only: it is administratively more simple to show recipients what percentage of their bill will be paid, rather than to state that a flat amount will be paid for each recipient. When a "flat" benefit is paid, without referencing actual use, it is plausible that individuals will receive amounts in excess of their actual consumption. The intra-cell burdens as shown in Table 14 vary more widely than in all other situations which we analyzed.

TABLE 14: Intra-cell Burdens Associated With Table 13

	Relative Poverty Category		
Household Size	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	1.36,0.22	0.39,0.21	0.23,0.17
2	1.45,0.19	0.33,0.17	0.20,0.14
3	1.56,0.17	0.29,0.16	
4	1.63,0.16	0.27,0.14	
5	1.69,0.15	0.25,0.14	
6	1.76,0.14	0.24,0.13	
7	1.83,0.13	0.23,0.12	
8	1.94,0.13	0.22,0.12	
Over 8	2.00,0.10	0.17,0.09	

As Table 11 exhibited, by breaking the open-ended income category into two sub-categories, it was possible to reduce intra-cell inequities. Intra-cell inequities can be reduced further by creating a fifth income category. Table 15 shows the fuel-assistance benefits produced using the third benefit priniciple of equal benefits relative to fuel use among beneift recipients, when households are broken into five income classifications. The intra-cell inequities associated with Table 15 are shown in Table 16.

TABLE 15: Benefit Matrix to Fuel Use By Household Size and Income

	Relative Poverty Category				
Household Size	**Household income < 60% Poverty**	**Household income < Poverty**	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	$464	$278	$247	$227	$213
2	$507	$304	$276	$259	$247
3	$549	$329	$305	$290	
4	$592	$355	$335	$321	
5	$634	$381	$364	$353	
6	$677	$406	$393	$384	
7	$720	$432	$421	$416	
8	$762	$457	$452	$445	
Over 8	$805	$483	$483	$484	

Comparing Tables 14 and 16, it is worthwhile to note that the within cell burdens are not much different for the two highest income categories, though they are not exactly the same. This is because benefits awarded to households in these categories have changed somewhat (they are higher in Table 15 than in Table 13) as a result of the addition of income categories, and households' burdens are lower in these categories.

The most noticible difference between Tables 14 and 16 is the reduction of intra-cell inequities that occurred when the open-ended income category was broken into three separate categories. In Table 14, burdens ranged from 1.36 to 2.00 for those households at the low end of the lowest income category to 0.22 to 0.10 for households at the high end of that same category. In Table 16, the discrepancy between burdens for the low and high ends of the lowest income category (now less than 60% of the poverty level) range, at most, from -0.10 to -0.01. Intra-cell inequities for other income groups less than 125% of poverty have also been reduced significantly.

TABLE 16: Intra-cell Burdens Associated With Table 15

	Relative Poverty Category				
Household Size	**Household income < 60% Poverty**	**Household income < Poverty**	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	-0.06,-0.01	0.44,0.26	0.38,0.31	0.38,0.20	0.23,0.16
2	-0.06,-0.01	0.36,0.21	0.31,0.26	0.32,0.17	0.20,0.14
3	-0.07,-0.01	0.31,0.18	0.27,0.23	0.28,0.15	
4	-0.08,-0.01	0.27,0.16	0.25,0.21	0.26,0.14	
5	-0.08,-0.01	0.25,0.15	0.23,0.19	0.24,0.13	
6	-0.09,-0.01	0.23,0.14	0.21,0.18	0.23,0.13	
7	-0.09.-0.01	0.22,0.13	0.20,0.18	0.22,0.12	
8	-0.10,-0.01	0.21,0.13	0.19,0.17	0.21,0.12	
Over 8	-0.10,-0.01	0.20,0.10	0.17,0.13	0.17,0.09	

6. Recommendation on a Personalized Benefit Matrix

Throughout this paper, the treatment of households within any of the design matrix cells has been as an average—even when there have been considerable inherent differences in fuel consumption and income among households in the same cell. This suggests extending the enhanced distribution of benefits already introduced in this report (in the treatment of differences in benefits to each of the individual cells in the design matrix) to permit variation in benefits among individual fuel assistance clients. Specific variations among individuals can be related to individual client's income and fuel consumption.

If the desire to place the fuel assistance formula on a percentage of bill is strong enough, this may be done with any of the formula developed herein. We use Table 8 as an example. When interpreted as a percent fuel use burden (i.e. benefit as a percent of fuel use), households in the lowest income category consistently have a greater percentage of their fuel use paid for by the benefit. When interpreted as such, the dollar amounts in the benefit matrix shown in Table 8 translate into 69.5% for the lowest income category, 53.4% for the middle income category, and 39.1 for the highest income category (and smallest household size), see Table 17.

TABLE 17: Benefit Percentages of Fuel Use Associated With Table 8

	Relative Poverty Category		
Household Size	**Household income < 125% Poverty**	**Household income < 150% Poverty**	**Household income < 175% Poverty**
1	69.5	53.4	39.1
2	68.0	43.9	28.4
3	66.3	37.3	
4	62.7	33.0	
5	59.1	27.9	
6	56.4	24.0	
7	54.2	20.4	
8	54.5	23.1	
Over 8	52.2	5.8	

"Individualizing" the benefit distributions could eliminate the design matrix altogether, knocking out the limitations caused by open-ended classes inherent in the current design matrix for those with incomes at less than 125% of poverty. Figure 5 has already demonstrated that the use of such open-ended classes establishes very wide categorizations of clients with large, attendant variance of income among them. The increase in attention to differences in benefits for the averages of individual cells in the design matrix given in the benefit matrices of Tables 7A-B and 8 eliminated some of the inequities inherent in the current benefit matrix. However, the largest inequities in the LIHEAP program will continue to exist as long as there exist the large, open-ended category for the lowest relative income group of recipients.

A personalized benefit distribution system has many facets which must be considered. First, what income and consumption would one use in the benefit formula? Current and historical income differ significantly for some; and it is precisely when a job is lost, and income has substantially dropped that a fuel assistance program is most valuable. Fuel consumption will differ for a household unit between pairs of years as climate, household size or the inhabited housing unit shifts. The latter two particularly change quickly for persons of low income, so therefore it is important for the LIHEAP program to pick up current consumption.

The reliance on current values of income and consumption, however, will make it difficult to predict the amount of LIHEAP funds which will be utilized in a given year. At a minimum, the distribution of income across all qualifying income classifications must be determined. How does this change with shifts in the aggregate market conditions — unemployment and income? These questions must be answered before a benefit distribution can be established within an individualized benefit matrix framework.

7. Conclusions

Current formulae for fuel assistance do not take enough into account to eliminate inequities in fuel costs by family size. Specifically, current formulae fail by not recognizing the implicit relationship inherent between absolute income and relative income. Appropriate new formulae must consider these factors.

The construction of more appropriate LIHEAP benefit distribution formulae is relatively straight-forward if we utilize such concepts as the equalization of fuel use burdens among households or proportionality of benefits to fuel use. The construction of such formulae requires agreement on appropriate definitions, e.g., the income against which the burden of fuel use purchases can be measured. Even more importantly, the choice among alternate formulae cannot be made by the policy analyst in isolation. Such choice ultimately becomes a political decision requiring decision making about tradeoffs among principles involved.

Formulae are proposed which utilize quite different income definitions and equally different principles, equal burden relative to income versus equal proportionate benefits relative to fuel use. These show quite different results among derived benefit matrices.