Regional Variations in U.S. Residential Sector Fuel Prices: Implications for Development of Building Energy Performance Standards

**L. A. Nieves
J. J. Tawil
T. J. Secrest**

March 1981

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SUMMARY

The Notice of Proposed Rulemaking for Energy Performance Standards for New Buildings (Federal Register 1979) presented life-cycle-cost based energy budgets for single-family detached residences. These energy budgets varied with regional climatic conditions but were all based on projection of national average prices for gas, oil and electricity. This study addresses the availability of fuel price projections, the variation in fuel prices and escalation rates across the U.S., and the effects of aggregating price data for cities to the state, the Department of Energy (DOE) Region, or the national level.

The problem in identifying the best set of energy prices for development of life-cycle-cost based standards is that fuel markets with homogeneous characteristics do not spatially correspond with the boundaries of governmental units (cities, states, etc.). Diverse sources of fuel supply, along with differing conversion and transportation costs, result in a wide range of fuel prices across the U.S. Not only do wide price variations exist among states, but within some states substantial differences in fuel prices exist among cities.

Because of the price variations across the country, policies and standards that affect or are affected by fuel prices, may have unintended impacts in some areas of the country. Generally, analysis has shown that the life-cycle-cost minimizing package of energy conserving investments, and hence the design energy budget, change when the fuel price deviates from the national average. In areas with mild winters the life-cycle-cost minimizing package may change with only a 10 to 15% variation in fuel prices. In 28 states the state average gas price exceeds the national average gas price by plus or minus 20% and in 16 states the same is true of electricity prices. Prices exceed this range in a far larger number of utility districts, where the prices to consumers are actually determined. Because the magnitude of the price variation within some states is almost as great as it is across the nation, there are many localities in which a building energy performance standard based on national average fuel prices would result in design energy

budgets that are either unreasonably high or low, considering local building practices and fuel prices. In particular, use of a national average price in New England would result in more lenient energy budgets than are warranted by prevailing prices.

This study has been more successful in determining the appropriate aggregation level for price data used in life-cycle cost analyses than in identifying suitable price projections. The Energy Information Administration (EIA) (specifically the Mid-range Energy Forecasting System) appears to be the best source of marginal and average regional price forecasts for gas, oil, and electricity. This is mainly due to the lack of more disaggregate alternative rather than to the suitability of the EIA price forecasts in their present form. While these price forecasts are developed for the nation and for each DOE Region, the residential fuel price data analysis has shown that neither the national nor DOE regional level is an appropriate level of data aggregation. Historic city-level data for natural gas, No. 2 fuel oil and electricity covering the years 1971 through 1978 are used in this analysis because state- and city-level price projections are not available. Regression techniques and statistical tests are used on the city data to determine the degree of homogeneity of mean fuel prices and escalation rates among cities within each state, states within each DOE region and DOE regions within the U.S.

The results of the statistical analysis of the aggregation alternatives may be summarized as follows:

- electricity - The highest level of aggregation that can be justified is that of state-level escalation rates. Considerable mean price variation is evident at all levels of aggregation.
- oil - Use of DOE Region price escalation rate estimates appear to be adequate, but missing data make this a weak conclusion. Price variation within states is relatively small, though it is evident at the regional and national levels.
- gas - City-level escalation rates seem to be the most appropriate alternative. Evidence of price variation among cities, states and DOE Regions is strong.

Use of a national average price is clearly rejected for all of the fuel types and aggregation cases considered. Data aggregation at the DOE Region level is also rejected in the majority of cases.

This analysis indicates the need to develop price forecasts for states or homogeneous larger regions. From the perspective of economic efficiency, the development of city level price forecasts would be even more desirable. However, the level of uncertainty inherent in such forecasts would probably be unacceptable for use in formulating standards.

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INTRODUCTION

The Notice of Proposed Rulemaking for Energy Performance Standards for New Buildings (Federal Register 1979) presented life-cycle-cost based energy budgets for single-family detached residences. These energy budgets varied with regional climatic conditions but were all based on projections of national average prices for gas, oil and electricity (see U.S. Department of Energy, Economic Analysis for analytical detail). The Notice of Proposed Rulemaking indicated that further analysis of the appropriateness of various price measures for use in setting the Standards was under way. This part of that ongoing analysis addresses the availability of fuel price projections, the variation in fuel prices and escalation rates across the U.S., and the effects of aggregating city price data to the state, Department of Energy (DOE) Region, or national level.

This study only provides a portion of the information required to identify the best price aggregation level for developing of the standards. Ideally, the administrative costs of developing and implementing standards at increasingly disaggregated levels should be considered. In addition, estimates are needed of consumer losses resulting from nonoptimal levels of conservation investment. Using efficient allocation of resources as the decision criterion, the best price aggregation level is the one at which increasing administrative costs for the standard equal the total cost to consumers due to deviation of the prices they face from the aggregate price. This study does not attempt to estimate either administrative or consumer costs, though some indication of potential impacts on consumers from using various price estimates in the standards will be available from ongoing DOE research.

Calculating life-cycle-costs to aid in choosing among energy-conserving investments requires price projections for electricity, heating oil, and natural gas. For efficient allocation of resources, these price projections should provide a reliable indication of future price and accurately represent energy prices in the area to which the standard is applied. This research seeks to ascertain the availability of fuel price projections for regions of the U.S. and, as far as possible, to examine indications of the reliability and

consistency of such projections. In addition, this study investigates the statistical justification for using price escalation rates at the regional aggregation level of the available price projections.

The findings of this study are important to the formulation of energy performance standards for several reasons.

- Use of inaccurate energy price projections in setting standards could lead to significant loss for building owners and tenants. If projections are too low, they could pay more for energy than necessary with cost-effective conservation investments.
- Use of inaccurate energy price projections could also lead to significant losses if the projections are too high and the resulting standards require conservation investments that do not pay off.
- If the national or regional price projections used in setting standards do not reflect the actual spread of prices in the nation or region, individuals and communities that face energy prices substantially different from the projections used will experience financial losses.

Thus, the research addresses some of the economic efficiency considerations necessary for design of a standard that affects heterogeneous regions. Other considerations, such as administrative costs, are not addressed in this study.

The first section of this report discusses the effects of price variation among and within regions on the efficiency of resource allocation when a standard is imposed. Some evidence of the extreme variability in fuel prices across the U.S. is presented here. In the second section, time series, cross-sectional fuel price data are statistically analyzed to determine the similarity in mean fuel prices and price escalation rates when the data are treated at increasing levels of aggregation. The findings of this analysis are reported in the third section, while the appendices contain price distributions details. In the fourth and last section of this report, the availability of price projections is discussed and some Energy Information Administration (EIA) projections are compared with actual prices.

CONCLUSIONS

This study identified the extent of variation in fuel prices and escalation rates evident among U.S. cities, states and DOE Regions over the period from 1971 to 1978. City price data revealed a price range from -40 to +260% of the volume-weighted, national average price for natural gas (American Gas Association 1977); -65 to +56% for electricity (Energy Information Center 1977); and -31 to +25% for distillate (Energy Information Center 1979). In addition to covering broad ranges, the price distributions for all three fuels are skewed to the right, so that the modal price category is less than the national mean price. This, national average fuel prices do not represent the fuel prices in most states, or even the price to most consumers, but are strongly influenced by the significantly higher prices and volumes used primarily by consumers in the Northeast.

Analysis of eight years of price data for 155 cities shows that the patterns of price variation are such that most states, and certainly most DOE Regions, appear to have significantly different price levels and price trends. Comparisons of the mean fuel prices and simple time trends in real prices generally showed a lack of basis for data aggregation above the state level. The implications of the statistical tests are as follows:

- electricity - The highest level of aggregation that can be justified is that of state-level escalation rates. Considerable mean price variation is evident at all levels of aggregation.
- oil - Use of DOE Region and escalation rates is supported, but missing data make this a weak conclusion. Price variation within states is relatively small although it is evident at the regional and national levels.
- gas - City-level escalation rates seem to be the most appropriate alternative. Evidence of price variation among cities, states and DOE Regions is strong.

Using a national average price is clearly rejected for all of the fuel types and aggregation cases considered. Data aggregation at the DOE Region level is also rejected in the majority of cases because a single price

estimate cannot adequately represent the actual range of prices (and escalation rates) over such broad and heterogeneous regions.

This analysis indicates the need to develop price forecasts for states or homogeneous larger regions. While it would be even more desirable to develop city-level price forecasts, that cannot be done with any reasonable level of confidence, and the cost of doing so would be exorbitant. Under the circumstances, one possible alternative is to use actual city or utility district prices in conjunction with estimated state escalation rates.

The effects of this fuel price variation on the Building Energy Performance Standard (BEPS) design energy budgets for residences were assessed by calculating the minimum life-cycle-cost for a prototype residence in a given locality over a range of fuel prices. Calculations for ten localities showed that the life-cycle-cost minimizing package of energy-conserving investment, and hence the design energy budget, differed in most cases when the fuel price deviation from the national average exceeded plus or minus 30%. (See Economic Analysis for a comprehensive sensitivity analysis.) Local prices within 10-15% of the national average also led to different optimal conservation investment levels in cities with moderate to mild winter weather. In 28 states state-average gas prices differ from the national average by more than 20% and in 16 states the same is true of electricity prices. The deviation of prices charged by utility districts from the national average is greater, of course, than the deviation of state average prices from the national average.

Because of this price variation there are many localities in which a building energy performance standard based on national average fuel prices would result in design energy budgets that are either unreasonably high or low, considering local building practices and fuel prices. In New England, particularly, using a national-average price could result in more lenient energy budgets than are warranted by prevailing prices. Because of the distribution of price extremes, a strong probability exists that design energy budgets based on national- or regional-average prices would be perceived as disadvantageous by more consumers in some regions than in others. However, the distribution of such effects has not been analyzed in this study.

Evaluating price projections for use in life-cycle-cost calculations identified only one source of relatively disaggregate projections based upon a consistent set of assumptions for all three fuels. The EIA (specifically the Mid-range Energy Forecasting System) appears to be the best source of marginal and average, regional price forecasts for gas, oil, and electricity. Unfortunately, this conclusion is due more to the lack of alternatives than to the suitability of the regional base currently used for EIA price forecasts. These price forecasts are developed for the nation and for each DOE Region, but the residential fuel price data analysis has shown that neither the national nor DOE Regional level is an appropriate level of fuel price data aggregation. Use of these projections in developing a building energy standard will result in problems due to the instability of the projections. This instability is caused mainly by changes in information regarding fuel supplies and technology from year to year, and especially by changes in the OPEC-administered oil price. As a result of the magnitude of the instability in EIA price projections, standards that are strictly based on life-cycle-cost minimization will fluctuate. Thus, there is a need to insulate the standards from much of the instability in the price projections used.

PRICE VARIATION AND RESOURCE ALLOCATION

A problem exists in identifying the best set of energy prices for use in developing life-cycle cost-based standards because fuel markets with homogeneous characteristics do not spatially correspond with the boundaries of governmental units (cities, states, etc.) In addition, fuel market boundaries are not consistent across fuel types. Some areas of the country depend almost exclusively upon domestic natural gas and others import their entire supply. Some regions use electricity generated primarily by hydro. In other areas the primary generating source is either oil, coal or nuclear, while in other areas a diverse mix of sources, including gas, is used. These diverse sources of supply, along with differing conversion and transportation costs, result in a wide range of fuel prices across the U.S.

This heterogeneity in fuel markets causes difficulty in designing broadly applicable and administratively practicable standards that serve the goals of increased economic and energy efficiency. As a result of the fuel price variation across the country, general policies and standards that affect or are affected by fuel prices may have quite different impacts in various areas. This section discusses the extent of price variation and its implications for decisions affecting resource allocation.

EVIDENCE OF PRICE VARIATION

The range of variation exhibited by state-level price data is substantial, and the range in city prices is even greater. In 1978, electricity prices per million Btu ranged from \$3.59 in Spokane, Washington to \$22.27 in New York City. For natural gas, the range in the mainland U.S. was from \$1.37 in Oklahoma to \$4.90 in New York City. Oil prices covered a narrower range, from \$2.39 in Georgia to \$4.29 in Rhode Island (American Gas Association, 1979). Substantial differences in fuel prices can also be found among cities within some states and these are shown in the Appendix A tables.

Fuel price data for 1977 are presented in Table 1 to illustrate the extent of variation in state-average fuel prices. Percentage-wise, the range in natural gas prices is the largest, from -40% to 260% of the national

TABLE 1. Average Residential Energy Prices by State

State	DOE Region	Natural Gas Prices ^(a)		Electricity Prices ^(b)		Distillate Prices ^(c)	
		1978 ¢/10 ⁶ Btu	% Deviation from National Average	1978 ¢/10 ⁶ Btu	% Deviation from National Average	1978 ¢/10 ⁶ Btu	% Deviation from National Average
Connecticut	1	463	+85	1282	+07	392	+14
Maine	1	552	+120	1039	-14	357	+04
Massachusetts	1	439	+75	1418	+18	356	+03
New Hampshire	1	362	+44	1376	+14	339	-01
Rhode Island	1	435	+73	1386	+15	359	+04
Vermont	1	409	+63	1316	+09	350	+02
New Jersey	2	368	+47	1513	+26	354	+03
New York	2	351	+40	1875	+56	353	+03
Puerto Rico	2	N/A	--	1716	+43	N/A	--
Virgin Islands	2	N/A	--	N/A	--	N/A	--
Delaware	3	340	+36	1382	+15	355	+03
District of Columbia	3	352	+40	1050	-13	373	+08
Maryland	3	339	+35	1201	+0	354	+03
Pennsylvania	3	276	+10	1312	+9	355	+03
Virginia	3	322	+28	1237	+3	348	+01
West Virginia	3	227	-09	1047	-13	344	0
Alabama	4	238	-05	1015	-16	356	+03
Florida	4	355	+42	1224	+02	364	+06
Georgia	4	243	-03	1121	-07	366	+06
Kentucky	4	197	-21	851	-29	359	+04
Mississippi	4	221	-12	1107	-08	337	-02
North Carolina	4	251	0	1085	-10	344	0
South Carolina	4	287	+15	1151	-04	349	+01
Tennessee	4	192	-24	742	-38	336	-02
Illinois	5	243	-03	1069	-12	362	+05
Indiana	5	222	-12	1011	-16	362	+05
Michigan	5	237	-06	1219	+01	340	-01
Minnesota	5	230	-08	1145	-05	336	-02
Ohio	5	240	-04	1206	0	339	-01
Wisconsin	5	265	+06	984	-18	339	-01
Arkansas	6	157	-37	870	-28	335	-03
Louisiana	6	208	-17	912	-24	326	-05
New Mexico	6	215	-14	1027	-15	329	-04
Oklahoma	6	186	-26	903	-25	306	-11
Texas	6	254	-01	1054	-12	315	-08

TABLE 1. (cont'd)

State	DOE Region	Natural Gas Prices ^(a)		Electricity Prices ^(b)		Distillate Prices ^(c)	
		1978 ¢/10 ⁶ Btu	% Deviation from National Average	1978 ¢/10 ⁶ Btu	% Deviation from National Average	1978 ¢/10 ⁶ Btu	% Deviation from National Average
Iowa	7	208	-17	1178	-02	353	+03
Kansas	7	163	-35	1032	-14	353	+03
Missouri	7	224	-11	1091	-09	335	-03
Nebraska	7	187	-25	957	-20	334	-03
Colorado	8	184	-27	1029	-14	358	+04
Montana	8	182	-27	655	-46	316	-08
North Dakota	8	219	-13	1054	-12	334	-03
South Dakota	8	198	-21	1018	-15	339	-01
Utah	8	167	-33	866	-28	329	-04
Wyoming	8	179	-29	719	-40	326	-05
Arizona	9	279	+11	1189	-01	362	+05
California	9	195	-22	1091	-09	379	+10
Hawaii	9	906	+261	1478	+23	376	+09
Nevada	9	234	-07	996	-17	326	-05
Alaska	10	183	-27	990	-18	362	+05
Idaho	10	345	+37	558	-51	258	+04
Oregon	10	354	+41	710	-41	328	-06
Washington	10	325	+30	419	-65	340	-01

(a) Gas Facts 1977.

(b) Electricity prices are for 1977 using the rate structure for 1,000 kWh monthly consumption. kWh are converted to Btu using 3,413 Btu/kWh. Typical Electrical Bills 1977.

(c) Distillate prices are for the residential sector in 1977. State Energy Fuel Prices by Major Economic Sector From 1960 Through 1977. Table A-1.

average. The highest price is found in Hawaii where the gas supply is LNG. For the continental U.S., the range of prices is from -40% to 120% of the national average. The natural gas data shown in Table 1 is displayed as a frequency distribution of prices in Figure 1. As this figure shows, the distribution of natural gas prices is highly skewed, with only six states having prices between 60% and 260% of the national average.

Electricity price data for states have the next largest range, from -65% to 56% of the national average. The electricity price distribution, which is shown in Figure 2, approximates a normal curve. The modal price category, however, is between -10% and -20% of the national average price, which is actually a volume-weighted mean.

The least variation is found in the oil price data shown in Table 1 and Figure 3. These data are suspect, however, since they are not developed from price observations for points within each state, but are "expanded" by DOE/EIA from data for 25 cities into data for all of the states. City-level data from another source (American Gas Association 1979) show a range in distillate prices from -31% to +25% of the national average.

Given the range of fuel prices for natural gas and electricity and the skewness of the price distributions, use of the average or volume-weighted average price as the key descriptive statistic is inappropriate, especially for natural gas and electricity.

FIGURE 1. Frequency Distribution of Average State Prices for Natural Gas, 1977

FIGURE 2. Frequency Distribution of Average State Prices for Electricity, 1977

FIGURE 3. Frequency Distribution of Average State Prices of No. 2 Fuel Oil, 1977

EFFECTS OF PRICES ON RESOURCE ALLOCATION

In the preceding discussion geographical variations in the prices of heating oil, natural gas and electricity were examined. The range of variation, as exhibited by state-level data, was found to be substantial, and the range in city prices was even greater. If average rather than actual prices are used to set energy performance standards, the implications for consumer welfare can be quite significant. In this section the implications of using average prices with respect to both efficient resource allocation and consumer welfare will be considered.

Life-cycle-cost calculations for energy conservation measures in new buildings require current and future prices for electricity, heating oil, and natural gas. Apart from the problem of obtaining reliable price projections for the life-cycle cost analyses, the question of whether to use national-, regional-, or state-average prices or actual local prices requires resolution. Two major issues need to be addressed in this regard: 1) Which set of prices best promotes efficient resource allocation? 2) How do the alternative pricing procedures affect the perceived welfare of individuals? The first issue pertains to the well-being of society as a whole, while the second pertains to individual welfare.

Ideally, the formulation of building energy performance standards should be consistent with efficient resource use, implying that the standards should require neither under- nor over-investments in energy conservation. If current market prices of energy were an accurate reflection of social, long-run marginal costs, then, under certain conditions, energy and other resources would be efficiently allocated. Without elaborating on the conditions under which this proposition holds, it is apparent that the current market prices for energy are generally not a good indicator of long-run marginal costs. Oil and natural gas prices, which are currently in the process of being deregulated, are rather quickly approaching private, long-run marginal cost levels. However, the private long-run marginal costs are probably less than the social long-run marginal costs of natural gas and heating oil because of the value attached to energy independence in national policy.

Current market prices for electricity are probably considerably less than social long-run marginal costs because 1) the price of electricity that is generated from oil and natural gas does not reflect the true social cost of these fuel inputs, 2) average-cost pricing prevails among electric utilities and 3) current rate-base pricing methods do not reflect the long-run marginal cost of capacity. Capacity included in the rate base is valued at original cost less depreciation, whereas the long-run marginal cost of capacity is determined by the least cost means of providing a given capacity under current conditions of factor supply and current technology. This means that capacity tends to be undervalued, especially in light of the recent sharp increases in the cost of adding capacity. As a result, geographical differences in current electricity prices may be explained more by the vintage of capacity than by regional variations in the long-run capacity supply (cost) curve.

Geographical variations in heating oil and natural gas retail prices were described and discussed previously. These price variations probably reflect differences in long-run marginal costs among regions, although the prices themselves may not correspond closely to marginal costs because price controls have not yet been completely lifted. The main sources of the geographical variation in current prices are transportation and distribution costs.

Geographical variations in electricity prices were also described and discussed in the previous section. Sources of regional variation include 1) prices of fuel and other factor inputs; 2) time required to site and construct new capacity; 3) willingness of local populations to accept particular technologies, such as nuclear; and 4) taxes. These variations largely explain long-run marginal costs and are in addition to the variations based on capacity vintage, as discussed earlier. Thus, geographical differences are likely to exist in the long-run marginal costs of electricity, but these differences do not necessarily coincide with retail price differences.

In summary, marginal-cost pricing of energy tends to promote efficient allocation of energy resources, but current heating oil, natural gas, and

electricity prices do not reflect marginal costs, although natural gas and oil have been moving rapidly in that direction. To be optimal, energy conservation investments should be based on long-run marginal costs, and this means that geographical variations in long-run marginal costs should be explicitly incorporated into the investment analysis. A standard based on price aggregations that obscure these geographical variations will tend to produce a misallocation of resources.

The second issue to consider is the extent to which the public is likely to accept energy policies that are not based on actual prices. In particular, are building energy performance standards that are based on state-, regional- or national-average energy prices as acceptable to individuals as standards based on local energy prices?

Clearly, the setting of standards based on national- or regional-average prices will be simpler administratively and will have less costly data requirements than the setting of standards based on local energy prices. On the other hand, the use of average national or regional prices means that some individuals--those facing prices below the average--may perceive that they are being required to overinvest in energy conservation. Incremental conservation investments may cost them more than the present value of the resulting energy savings, as calculated with current and expected local energy prices. This outcome, however, is not certain because investments in conservation are "lumpy" so that a given investment is consistent with a range of energy prices.

An analysis of the effects of price aggregation on consumers in different utility districts is needed to see if, in fact, consumers are individually made worse off as a result of aggregating and averaging prices.

Standards based on average national or regional--rather than actual local--prices may be viewed as inequitable, since only those individuals facing lower-than-average prices would be forced to overinvest in energy conservation. Those facing above-average prices however, may be rendered worse off if they accept the standards as optimal and, consequently, underinvest. Indeed, if all individuals invest at the level dictated by

standards based on average regional prices, then the overall effect is to produce approximately the same level of conservation investment that would be attained using actual prices. However, there would be substantial misallocation of resources within regions because the value of conservation investment would exceed the value of energy savings for some individuals and vice versa for others.

These results can be summarized as follows: Consumers generally face energy prices that are below long-run marginal costs. Individually, they will be made worse off by policies that require them to make investments that are excessive as determined by actual and expected energy prices. At the same time and from society's standpoint, energy prices that are below long-run marginal energy costs will yield underinvestments in energy conservation. Policies that stimulate investments above this level are socially beneficial, up to a point.

Of the alternatives considered here, the preferred alternative is to institute changes that will cause individuals to face prices equal to long-run marginal costs. To minimize resource misallocations, energy conservation levels should be based on actual prices.

STATISTICAL ANALYSIS OF PRICE AGGREGATION

This section discusses the data and methods used to evaluate the degree of similarity in fuel prices and price escalation rates across cities, states, DOE Regions and the nation. While this procedure is not a sufficient basis by itself for determining the best price aggregation level, it does shed light on the degree of price variation and the relative homogeneity of markets. Various data bases that could have been used in the analysis are described and the reasons for using the American Gas Association (AGA) Gas Househeating Survey (1972-79) are explained. The AGA data base is then described and procedures used to impute missing data are documented. Finally, the methods and statistical tests used in this analysis are discussed.

HISTORICAL FUEL PRICE DATA

To examine the fuel price variations across the country a data base that would fulfill several requirements was sought. First, the time series should be sufficient to allow examination of price escalation rates. Second, all areas of the country should be reasonably well represented in the sample. Third, the data should be as disaggregate as possible. The data bases considered and some of their salient characteristics are discussed below.

Bureau of Labor Statistics, Consumer Price Index: Average residential prices are reported for gas, No. 2 fuel oil and electricity. Since 1978 these data have been collected for 85 cities but are only reported for 28 cities and 4 regions.

American Gas Association, Gas Facts: The average price of natural gas since 1955 is available by major end-use sector for each state.

Edison Electric Institute, Statistical Yearbook: The average price of electricity by sector and state can be calculated from this data. The time series is available from 1926 to the present.

Oil Daily, Oil Express, Platt's Oil Price Handbook and Oilmanac: No. 2 fuel oil prices are available from these and other sources for no more than 25 cities, most of which are on the East Coast.

Energy Information Administration (EIA), Statistics of Publicly and Privately Owned Electric Utilities: The average cost of electricity for each sector could be calculated from these two data bases. The data are reported by utility and partially grouped by state.

Energy Information Administration (EIA), Federal Energy Data System: This is not an independent data source but a compilation of data from the EIA Natural Annual Gas Facts the EEI Statistical Yearbook and Platt's. Data are at the state level and most of the oil data are imputed.

American Gas Association, Gas Househeating Survey: This data base was used in the empirical analysis because it provided the most extensive set of oil data, complete geographical coverage, and the most disaggregate data available on a consistent basis for oil, gas and electricity. A more detailed discussion of this data base follows.

GAS HOUSEHEATING SURVEY DATA

The data base used in evaluating the justification for price aggregation was compiled from the American Gas Association's Gas Househeating Survey for 1971 through 1978. These data are collected from gas utility companies annually and represent the price charged to residential customers for the quantities of natural gas, No. 2 fuel oil and electricity generally required for space heating. The reported price differs from the average cost of these fuels to consumers in that the reported price does not take into account the cost effect of the base rate. Since the data represent prices over an eight-year period, the Consumer Price Index was used to convert all of the data to 1978 dollars per 10^6 Btu.

Examination of the published data revealed that the number of utilities and cities represented in the survey declined over the period from 1971 through 1978. Because of this data constraint, a (nonrandom) sample of utilities with the most complete data sets was selected, resulting in a sample

of 159 utilities serving 157 cities, with New York City and Houston each represented by two utilities. The sample includes at least one city in each state except Alaska.

Very few problems were encountered with the natural gas data, as one would expect given the source. However, the No. 2 fuel oil and electricity price data were beset with anomalous and missing values. These problems were handled as follows:

- The electricity data, especially in the early years of the series, had several values that were exactly two times their next nearest neighbors in time and/or across geographical space. These isolated anomalous values were adjusted by dividing by two.
- The electricity and, to a greater extent, the No. 2 fuel oil data, contained missing values in some regions of the country. No one method of imputing missing values was appropriate in most cases. For the early years of the time series, prices from neighboring cities excluded from the 157 city sample were substituted for missing values. Where such data were not available, an average of all available prices for cities in the state was substituted for the missing value. Since missing values tended to be clustered (i.e., no values for oil in all cities in a state in a given year), linear interpolation was used where the other alternatives were infeasible. Because linear interpolation was used on the oil price data in a number of states, the resulting price escalation rate estimates are only approximations.

It is recognized that the methods used to impute the missing values bias the statistical results. Although the constructed data points are obtained by varying techniques, they all affect the city-level price series by increasing the homogeneity of both the base price levels and escalation rates. This increase in homogeneity may result in failure to detect differences in the base price and/or escalation rate among cities. Thus, the statistical results may suggest that data aggregation may appear appropriate when it is not. As mentioned above, this consideration is most important for No. 2 fuel oil and to a lesser extent for electricity.

Statistical Methods

A simple linear regression model is used to examine the degree of homogeneity in fuel prices and to test the basis for aggregation of price escalation rates across regions. The model regresses the natural logarithm of the fuel price (dependent variable) upon time (independent variable) in the following form:

$$y_i = \alpha + \beta x_n$$

where

$y = \ln(\text{fuel price})$

$i = \text{city, state, region or nation}$

$x = \text{year}$

$n = 1971 - 1978$

The estimated coefficients provide the price level (intercept, α) and escalation rate (slope coefficient, β). The slope coefficient of the log-linear model is interpreted as the annual percentage change in the fuel price for the period 1971 to 1978, or more simply, the escalation rate.

Four possible ways of aggregating the data were examined: cities to states, states to DOE Regions, states to the nation, and DOE Regions to the nation. For each of the aggregations considered, two F tests were performed: the first to determine whether the intercepts and slopes jointly are significantly different between the individual and pooled regressions (e.g. cities individually and as a state), and the second to determine whether the slopes alone differ. The results of the statistical tests indicate whether fuel prices and escalation rates are relatively homogeneous at each of the four aggregation levels, and also whether the escalation rates alone are homogeneous within regions. The homogeneity question for the price level alone was not examined. It is variation in the standards (energy budget levels) as a result of the prices used that affects the choice of price aggregation level, not just the underlying price variation.

To test the null hypothesis that the intercepts and slopes are equal in the city-to-state aggregation case, for example, several pieces of information

are needed. For both the city and state data, we determine the sum of squares of the X's (where $W_{xxi} = \sum_t (x_{it} - \bar{x}_i)^2$ for each city i and similarly T_{xx} for the state), the sum of squares of the Y's (call them W_{yyi} and T_{yy}) and the cross products (W_{xyi} and T_{xy} respectively). These data are then used to determine the residual sum of squares for each city:

$$RSS_i = W_{yyi} - \frac{W_{xyi}^2}{W_{xxi}}$$

and the total RSS across cities, called S_1 , is then $\sum RSS_i$. For the state, the residual sum of squares, called S_2 , is

$$S_2 = RSS = T_{yy} - \frac{T_{xy}^2}{T_{xx}}$$

The relevant F test to determine the legitimacy of the null hypothesis is

$$F_c = \frac{(S_2 - S_1)/(2N - 2)}{S_1 / (\sum T_i - 2N)}$$

where N is the number of cities and T_i equals the number of observations in each city. If the calculated F statistic, F_c , is less than the Table F value associated with the desired significance level (0.05), the null hypothesis stands, and city price levels and escalation rates may be considered relatively homogeneous within the state. If F_c exceeds the Table F value, aggregation cannot be statistically justified and price variation effects on the impacts of the standards should be assessed. Similar calculations are then carried out for aggregation from states to DOE Regions, states to the national level, and DOE Regions to the national level.

The test of the null hypothesis that the slopes are equal requires somewhat different information. To use the city-to-state example again, a total

sum of squares of the X's, W_{xx} , defined to be the sum of the W_{xxi} 's calculated above, is used. That is, $W_{xx} = \sum_i W_{xxi}$. Likewise, $\sum_i W_{xyi} = W_{xy}$, and $\sum_i W_{yyi} = W_{yy}$. S_3 is calculated as $W_{yy} - W_{xy}^2/W_{xx}$. The first test becomes

$$F_c = \frac{S_3 - S_1 / (N - 1)}{S_1 / (\sum T_i - 2N)}$$

If the calculated F , F_c , does not exceed the threshold Table F value, differences between the slopes are not statistically significant and aggregation is reasonable. That is, the use of a single escalation rate to represent price change over a whole state is an appropriate procedure. If the calculated F_c is greater than the Table F , aggregation of the escalation rates is not statistically justified. The results of the statistical analysis are presented in the following section.

FINDINGS OF THE STATISTICAL ANALYSIS

This section first discusses the distribution of natural gas, oil and electricity prices within states and DOE Regions. These distributions were examined for evidence of change in the range of prices over time. Second, the trends in real fuel prices over the period from 1971 to 1978 are presented for each state. Finally, the statistical analysis assesses the homogeneity of price data over increasing levels of spacial aggregation.

PRICE DISTRIBUTIONS

In examining the distribution of natural gas, No. 2 fuel oil, and electricity prices, all of the city data (AGA Gas Househeating Survey) were used, rather than the subsample used in the statistical analysis. Figures 4 and 5 provide two examples of regional price distributions in 1978. Figure 4 shows the distribution of electricity prices by state for the Middle Atlantic states. Each "X" indicates the 1978 electricity price within one city in this DOE Region. Although the highest prices are 2.3 times the lowest, this DOE Region does not represent extreme price variation. Rather, it is one of the regions with the lowest incidence of missing data values and, thus, one in which the extent of price variation is relatively certain. Figure 5 was chosen on the same basis to illustrate the generally smaller range of variation in oil prices. In this region the highest oil price is roughly 1.2 times the lowest. Similar figures for all three fuels and all ten DOE Regions are contained in Appendix A, which indicates that most of the other DOE Regions show a larger range of price variation than the examples shown here.

Data for 1971 were compared on a region-by-region basis with the 1978 data to discover any change in the range of price variation over time. For each of the three fuel types, the range of price variation in DOE Regions appears to be the same or slightly decreased in 1978 as compared to 1971. The fact that smaller cities have been dropped from the AGA survey over this period may be the major factor responsible for the slight decrease in variation. Therefore, it is felt that there is no basis for assuming that the variation in prices is decreasing significantly over time.

FIGURE 4. Department of Energy Region 3: Utility Reported Electricity Prices per 10⁶ Btu in 1978

Source: AGA Gas Househeating Survey; 1978

FIGURE 5. Department of Energy Region 1: Utility Reported No. 2
Fuel Oil Prices per 10⁶ Btu in 1978

Source: AGA Gas Househeating Survey: 1978

PRICE TRENDS OVER TIME

As an intermediate output in the analysis of price homogeneity across the U.S., estimates of the rate of change in the real price of fuels were developed. These price trends for 1971 through 1978 were estimated for cities, states, DOE Regions and the U.S., though only the state-level price trends are reported here. Table 2 shows the range of estimated state-level mean prices and price escalation rates during this period for each fuel type. All of the states showed a positive rate of change in the real price of oil.

TABLE 2. Range of Real Estimated Fuel Price Means and Escalation Rates for States, 1971-1978

	<u>Gas</u>		<u>Oil</u>		<u>Electricity</u>	
	<u>High</u>	<u>Low</u>	<u>High</u>	<u>Low</u>	<u>High</u>	<u>Low</u>
Mean of prices (1978 \$/10 ⁶ Btu)	4.27	1.12	3.68	2.47	13.95	4.38
% Annual Escalation	14.1	-1.6	9.0	2.9	12.8	-6.6

In contrast, several states, as well as DOE Region 8 as a whole, showed negative real rates of change in electricity prices. (The direction of change in Region 8 may be attributable to the fact that several large coal-fired generating plants with relatively low costs began operation in the region during the study period.) The state-level estimates for each of the fuels are listed in Table 3. The values listed in the mean price columns represent the average real price over the 1971-1978 period.

Since the distributions of fuel prices and escalation rates are difficult to visualize, maps displaying the data have been included in Appendix B. Three data maps are provided for each of the three fuel types: Figures B.1 through B.3 for gas, Figures B.4 through B.6 for oil and Figures B.7 through B.9 for electricity. Two maps showing mean prices and escalation rates in 5 categories from high to low are provided for each of the fuel types. Examination of the categorical maps for mean prices indicates that most states fall into the same relative price category for at least two out of three fuels. This categorization is to be expected since the fuels are substitutes to some

TABLE 3. State Fuel Prices and Escalation Rates, 1971 to 1978

State	Oil		Gas		Electricity	
	Mean Price ^(a) (1978 \$ per million Btu)	Annual Per- centage Esca- lation Rate	Mean Price ^(a) (1978 \$ per million Btu)	Annual Per- centage Esca- lation Rate	Mean Price ^(a) (1978 \$ per million Btu)	Annual Per- centage Esca- lation Rate
Region 1						
Connecticut	3.356	6.4	3.358	7.3	12.402	5.3
Massachusetts	3.475	5.8	3.226	5.7	12.064	7.5
Maine	3.045	8.9	3.386	3.9	8.779	6.9
New Hampshire	3.348	5.9	3.034	4.4	13.954	10.3
Rhode Island	3.435	4.6	3.396	8.4	12.378	6.3
Vermont	3.244	7.7	2.819	8.4	7.695	4.2
Region 2						
New Jersey	3.245	6.0	2.559	4.1	9.859	3.9
New York	3.362	6.6	2.990	7.0	10.840	7.0
Region 3						
Pennsylvania	3.180	6.7	2.298	6.4	10.897	8.3
Dist. of Columbia ^(b)	3.208	7.4	2.612	5.0	8.570	5.2
Delaware	3.368	7.7	2.420	6.9	10.190	6.6
Maryland	3.151	7.1	2.575	6.9	9.077	11.4
Virginia	3.167	6.9	2.388	5.2	8.646	9.5
West Virginia	3.045	6.9	1.772	11.9	8.485	12.8
Region 4						
Florida	3.581	5.8	2.892	3.3	12.040	5.4
Georgia	3.042	5.0	1.840	3.7	8.776	3.7
North Carolina	3.189	7.2	2.555	7.8	9.661	7.0
South Carolina	3.290	6.0	2.240	5.4	9.925	9.1
Alabama	3.312	4.5	2.192	6.5	8.206	3.1
Kentucky	3.092	5.2	1.739	6.1	7.955	3.8
Mississippi	2.755	2.9	1.734	12.7	10.041	1.0
Tennessee	2.955	5.9	2.071	4.4	6.399	7.9
Region 5						
Illinois	2.852	9.0	1.882	5.5	8.546	-1.1
Indiana	3.042	8.1	1.754	5.6	7.140	5.3
Michigan	3.095	6.8	1.917	6.1	10.835	6.3
Ohio	3.116	6.9	1.926	7.8	8.645	9.3
Wisconsin	3.165	6.1	2.066	5.8	9.233	4.7
Minnesota	3.136	8.0	2.101	7.1	8.819	5.5
Region 6						
Arkansas	2.844	6.7	1.682	0.2	7.134	12.7
Louisiana	2.801	8.3	1.667	14.1	9.737	11.7
Oklahoma	3.035	4.7	1.407	7.2	9.654	9.1
Texas	3.207	6.3	1.999	12.7	9.902	11.8
New Mexico	2.870	7.4	2.002	9.7	10.621	1.0
Region 7						
Iowa	2.920	5.8	1.629	5.9	8.523	9.8
Kansas	2.956	5.7	1.220	6.9	8.886	6.1
Missouri	2.853	8.3	1.744	10.0	6.324	0.1
Nebraska	2.843	7.0	1.508	5.4	7.309	7.2
Region 8						
North Dakota	3.029	8.7	2.122	6.6	7.024	0.5
South Dakota	2.937	7.1	1.696	3.3	9.846	-3.5
Colorado	2.928	3.9	1.393	7.4	9.668	-0.3
Montana	2.892	5.2	1.588	5.6	7.119	-4.0
Utah	2.791	5.1	1.295	7.1	6.212	5.7
Wyoming	3.081	7.1	1.118	7.1	6.843	-2.9
Region 9						
Arizona	3.114	4.0	1.966	8.0	11.979	6.5
Nevada	3.681	6.1	2.265	3.5	8.964	7.9
California	3.071	5.3	1.657	5.8	10.725	5.7
Hawaii	2.474	5.5	4.265	-1.6	13.960	4.3
Region 10 ^(b)						
Idaho	3.265	3.0	2.995	5.9	7.447	-6.6
Oregon	3.336	3.5	2.898	9.8	5.826	4.6
Washington	3.252	6.7	2.768	6.5	4.389	4.4

(a) The mean price is calculated over the period 1971 to 1978. Thus, to apply the escalation rate in making price estimates, the mean price should be treated as occurring in early 1975.

(b) The available data base led to inclusion of the District of Columbia and omission of Alaska.

extent. The highest prices for each of the fuel types are generally found in the Eastern seaboard and Southwestern border states. In the remaining maps, the mean prices for each of the states during the 1971 to 1978 period are shown in a relief projection. These figures provide an indication of the degree of difference in average fuel prices across contiguous states.

REGIONAL HOMOGENEITY OF PRICE ESCALATION RATES

The justification for aggregation of price escalation rates from the city-to-state level, state-to-DOE Regional level, state-to-national level and DOE Region-to-national level is examined in the statistical analysis. Results of this analysis are summarized for the nation, DOE Regions and states in Tables 4, 5 and 6. Because of the volume of information involved, the price trends estimated for cities are not reported. A consistent format is used in those tables, and the column headings are defined as follows:

Mean - the estimated average real fuel price over the 1971 to 1978 period.

Standard Deviation - the standard error of the estimated mean prices.

Annual percentage change - the real annual rate of increase in the fuel price.

α 's and β 's F_C - the calculated F value for the Chow test (Maddala 1977 and Murphy 1973) on both the intercepts and slopes across the independent and pooled regressions.

β 's F_C - the calculated F value for the Chow test on the slopes of the independent and pooled regressions.

Number of cases - the number of DOE Regions, states or cities included in each step of the data aggregation.

In all three tables, the statistics are set off by brackets for those states where missing data values amounted to 25% or more of the total. Those F values that are significant at the 0.05 level, indicating a 95% probability that pooling the data is statistically inappropriate, are designated with an asterisk.

Electricity

Results of the statistical analysis related to electricity prices are shown in Table 4. The variation in electricity price escalation rates across both the states and the DOE Regions is too great to justify aggregation to the national level. In addition, the F_c values for the slopes were significant for 4 of the 10 DOE Regions, indicating considerable difference in the degree of homogeneity in state price trends among DOE Regions. Aggregation of escalation rates from the city to the state level is rejected in only 11 of the 41 states for which data are available for more than one city. As a result, use of state-level escalation rates appears reasonable. At the national, regional, and state aggregation levels use of pooled escalation rates is only rejected in about half as many cases as is the pooling of both slopes and intercepts across data aggregation levels. Therefore, the variation in city price levels appears to be much more pervasive than variation in price escalation rates.

Number 2 Fuel Oil

The statistical summary for the oil price analysis is presented in Table 5. For oil prices, aggregation of escalation rates to the national level from both states and DOE Regions is rejected. In the state-to-DOE Region analysis, homogeneity of both slopes and intercepts is rejected in 5 regions, but homogeneity is rejected in only one Region when slope (escalation rate) is considered alone. Hence, use of escalation rates at the DOE Region level is reasonable. Missing data values are a problem in the case of oil prices, and the problem is worse in those states and DOE Regions where the volume of oil consumption for heating is low relative to that of gas and electricity. Very few data points are missing in DOE Regions 1, 2, and 3, and in those Regions data aggregation appears to be justified.

For the city-to-state price aggregation case only eight F_c statistics for the α 's and β 's together are significant. Thus, the within state price variations appear to be relatively small. Because of the severity of the missing value problem, however, this analysis does not clearly indicate the degree of variation in oil prices.

TABLE 4. Residential Electricity Prices for 1971 Through 1978 (1978 \$)

	Price		Annual Percentage Change	α 's + β 's (a)		Number of Cases
	Mean	Standard Deviation		F_c	β 's (a) F_c	
Nation	9.138	3.305	5.7			
aggregated from DOE Regions				27.83*	8.80*	10
aggregated from states				7.15*	1.79*	50
DOE Regions aggregated from states						
1 New England	11.987	3.752	7.4	4.24*	0.66	6
2 New York - New Jersey	10.572	3.289	6.1	1.02	1.38	2
3 Middle Atlantic	9.319	3.021	9.5	3.02*	0.94	6
4 South Atlantic	8.738	2.664	5.4	9.95*	39.25*	8
5 Midwest	8.750	2.406	5.3	12.64*	5.71*	6
6 Southwest	9.584	3.552	10.2	3.64*	2.45	5
7 Central	7.641	2.811	6.0	8.42*	8.07*	4
8 North Central	8.046	2.197	-1.7	0.84	0.19	6
9 West	11.155	4.268	6.3	1.74	0.12	4
10 Northwest	5.377	1.744	2.6	10.94*	3.65*	3
States aggregated from cities						
1 Connecticut	12.401	3.482	5.3	1.21	1.33	2
2 Massachusetts	12.064	3.192	7.5	1.37	1.88	5
3 Maine	[8.779	1.685	6.9			1]
4 New Hampshire	13.954	4.441	10.3	1.46	1.13	3
5 Rhode Island	12.378	2.814	6.3			1
6 Vermont	7.695	1.447	4.2			1
7 New Jersey	9.859	1.755	3.9	1.39	0.72	3
8 New York	10.840	3.681	7.0	8.93*	3.28*	8
9 Pennsylvania	10.897	2.680	8.3	1.85	1.13	3
10 Illinois	8.546	1.800	-1.1	5.37*	1.51	4
11 Indiana	7.140	1.725	5.3	2.16*	2.36	6
12 Michigan	10.835	2.176	6.2	0.69	0.46	4
13 Ohio	8.645	2.712	9.3	3.46*	0.88	7
14 Wisconsin	9.233	1.741	4.7	3.36*	1.36	5
15 Iowa	8.523	3.534	9.8	8.56*	6.70*	4
16 Kansas	[8.886	2.593	6.1	13.31*	18.20*	3]
17 Minnesota	[8.819	2.567	5.5	2.19	1.36	5]
18 Missouri	6.324	2.057	0.1	4.46*	3.52*	4
19 Nebraska	7.309	2.400	7.2	1.59	1.20	6
20 North Dakota	[7.024	0.683	0.5	0.76	0.73	2]
21 South Dakota	[9.846	2.952	-3.5	4.46*	4.04*	3]
22 District of Columbia	8.570	1.864	5.2			1
23 Delaware	10.190	2.673	6.6			1
24 Florida	[12.040	2.861	5.4	1.26	1.66	2]
25 Georgia	8.776	1.871	3.7	1.46	0.89	3]
26 Maryland	9.077	2.605	11.4	0.48	0.37	3
27 North Carolina	9.661	2.328	7.0	2.55*	0.30	4
28 South Carolina	[9.925	2.875	9.1	1.61	3.23	2]
29 Virginia	8.646	3.287	9.5	2.87*	2.56*	6
30 West Virginia	8.485	3.131	12.8	11.07*	17.09*	2
31 Alabama	8.206	1.806	3.1	2.82	0.58	3
32 Kentucky	7.955	2.496	3.8	8.92*	0.38	4
33 Mississippi	10.041	1.264	1.0			1
34 Tennessee	6.399	1.650	7.9	7.52*	2.46	4
35 Arkansas	[7.134	2.795	12.7	6.90*	0.48	2]
36 Louisiana	[9.737	2.812	11.7	0.46	0.33	3]
37 Oklahoma	9.654	4.576	9.1	102.09*	5.92*	2
38 Texas	9.902	3.603	11.8	7.61*	10.77*	7
39 Arizona	11.979	5.657	6.6	4.00*	0.44	4
40 Colorado	9.668	1.518	-0.3	2.45	2.38	3
41 Idaho	7.447	1.583	-6.6			1
42 Montana	[7.119	1.485	-4.0	0.88	0.66	3]
43 New Mexico	10.621	3.220	1.0	0.43	0.71	2
44 Nevada	[8.964	2.845	7.9	55.88*	20.00*	2]
45 Utah	6.212	0.923	5.7			1
46 Wyoming	[6.843	0.875	-2.9	1.88	1.19	3]
47 California	10.725	3.049	5.7	8.32*	8.30*	4
48 Hawaii	[13.960	1.498	4.3			1]
49 Oregon	[5.826	1.175	4.6	7.32*	0	2]
50 Washington	[4.389	1.380	4.4	13.03*	1.74	3]

NOTE: Statistics in brackets are developed from data with missing values totaling at least 25% of all observations.

- (a) α = regression intercept coefficient
 β = regression slope coefficient
 F_c = calculated F statistics across the independent and pooled regressions

TABLE 5. Residential Number 2 Fuel Oil Prices for 1971 Through 1978 (1978 \$)

	Price		Real Annual Percentage Change	α 's + β 's (a) Fc	β 's (a) Fc	Number of Cases
	Mean	Standard Deviation				
Nation	3.120	0.600	6.4			
aggregated from DOE Regions				22.89*	2.42*	10
aggregated from states				6.01*	1.37*	50
DOE Regions aggregated from states						
1 New England	3.374	0.574	6.2	1.54	0.92	6
2 New York - New Jersey	3.330	0.564	6.4	2.70	0.30	2
3 Middle Atlantic	3.167	0.557	7.0	0.15	0.08	6
4 South Atlantic	[3.152	0.620	5.6	2.20*	0.63	8]
5 Midwest	3.074	0.596	7.5	3.07*	1.47	6
6 Southwest	[3.083	0.670	6.7	2.98*	0.74	5]
7 Central	[2.884	0.556	6.8	0.94	1.30	4]
8 North Central	[2.958	0.501	6.2	2.20*	3.10*	6]
9 West	[3.144	0.616	5.0	8.06*	0.56	4]
10 Northwest	[3.282	0.529	5.0	0.15	0.83	3]
States aggregated from cities						
1 Connecticut	3.356	0.544	6.4	0.86	0.57	2
2 Massachusetts	3.475	0.576	5.8	0.31	0.05	5
3 Maine	3.045	0.675	8.9			1
4 New Hampshire	3.348	0.569	5.9	0.06	0.16	3
5 Rhode Island	3.435	0.465	4.6			1
6 Vermont	3.244	0.648	7.7			1
7 New Jersey	3.245	0.559	6.0	0.60	1.00	3
8 New York	3.362	0.566	6.6	1.41	0.41	8
9 Pennsylvania	3.180	0.549	6.7	0.13	0.26	3
10 Illinois	2.852	0.658	9.0	1.92	0.57	4
11 Indiana	3.042	0.611	8.1	0.92	1.84	6
12 Michigan	3.095	0.560	6.8	0.06	0.04	4
13 Ohio	3.116	0.560	6.9	0.31	0.26	7
14 Wisconsin	3.165	0.567	6.1	0.04	0.10	5
15 Iowa	[2.920	0.507	5.8	0.91	1.28	4]
16 Kansas	[2.956	0.501	5.7	2.29	3.14	3]
17 Minnesota	[3.136	0.616	8.0	1.42	2.19	5]
18 Missouri	2.853	0.637	8.3	0.49	0.12	4
19 Nebraska	2.843	0.569	7.0	4.42*	2.73*	6
20 North Dakota	[3.029	0.626	8.7	0.34	0.50	2]
21 South Dakota	2.937	0.553	7.1	0.36	0.11	3
22 District of Columbia	3.208	0.596	7.4			1
23 Delaware	3.368	0.674	7.7			1
24 Florida	[3.581	0.879	5.8	6.65*	0.41	2]
25 Georgia	[3.042	0.546	5.0	1.06	1.00	3]
26 Maryland	3.151	0.603	7.1	0.73	0.09	3
27 North Carolina	3.189	0.578	7.2	0.13	0.04	4
28 South Carolina	[3.290	0.555	6.0	0.08	0.15	2]
29 Virginia	3.167	0.544	6.9	0.21	0.11	6
30 West Virginia	3.045	0.519	6.9	0	0	2
31 Alabama	[3.312	0.566	4.5	0.55	0.16	3]
32 Kentucky	3.092	0.603	5.2	1.00	0.15	4
33 Mississippi	[2.755	0.410	2.9			1]
34 Tennessee	2.955	0.576	5.9	0.27	0.17	4
35 Arkansas	[2.844	0.504	6.7	2.67	0	2]
36 Louisiana	[2.801	0.657	8.3	7.57*	0.23	3]
37 Oklahoma	[3.035	0.492	4.7	0.03	0.07	2]
38 Texas	[3.207	0.641	6.3	4.87*	3.10*	7]
39 Arizona	[3.114	0.535	4.0	5.60*	4.77*	4]
40 Colorado	[2.928	0.484	3.9	9.33*	3.58*	3]
41 Idaho	3.265	0.350	3.0			1
42 Montana	[2.892	0.373	5.2	1.47	2.50	3]
43 New Mexico	[3.353	0.900	7.4	3.30	0.05	2]
44 Nevada	[3.681	0.672	6.1	5.05*	1.27	2]
45 Utah	2.791	0.356	5.1			1
46 Wyoming	[3.081	0.538	7.1	0.67	0.29	3]
47 California	[3.071	0.509	5.3	2.33	1.11	4]
48 Hawaii	[2.474	0.360	5.5			1]
49 Oregon	[3.336	0.347	3.5	0	0.50	2]
50 Washington	[3.252	0.673	6.7	8.73*	0.30	3]

NOTE: Statistics in brackets are developed from data with missing values totaling at least 25% of all observations.

- (a) α = regression intercept coefficient
 β = regression slope coefficient
 F_c = calculated F statistic across the independent and pooled regressions

Natural Gas

The statistical summary for natural gas is shown in Table 6. Consistent with the findings for electricity, escalation rate aggregation to the national level from both state and DOE Regional levels is rejected. The use of Region-wide escalation rates is rejected in 2 Regions. Pooling of escalation rates is rejected in 17 of the states as well. These are stronger findings against escalation rate aggregation at the state level than for either oil or electricity, and they are based on the most complete data. The use of city-level escalation rates appears to be the best alternative. The statistical tests on the intercepts and slopes combined indicate greater price variation at each level of aggregation than in the case with either electricity or oil.

TABLE 6. Residential Natural Gas Prices for 1971 Through 1978 (1978 \$)

	1975 Price		Annual Percentage Change	α 's + β 's (a)		Number of Cases
	Mean	Standard Deviation		F_c	β 's F_c	
Nation	2.118	0.752	6.7			
aggregated from DOE Regions				70.35*	2.46*	10
aggregated from states				36.20*	7.15*	50
DOE Regions aggregated from states						
1 New England	3.196	0.623	5.9	2.00*	1.27	6
2 New York - New Jersey	2.661	0.601	6.2	1.67	2.96	2
3 Middle Atlantic	2.342	0.569	6.6	1.36	0.39	6
4 South Atlantic	2.155	0.620	5.8	9.78*	1.46	8
5 Midwest	1.929	0.439	6.4	3.91*	0.87	6
6 Southwest	1.824	0.681	10.3	6.96*	6.66*	5
7 Central	1.541	0.415	6.9	12.77*	2.81*	4
8 North Central	1.528	0.534	6.1	9.52*	0.52	6
9 West	2.117	0.872	5.5	20.08*	2.13	4
10 Northwest	[2.349	0.626	7.5	2.70*	2.95	3]
States aggregated from cities						
1 Connecticut	3.358	0.751	7.3	10.33*	11.89*	2
2 Massachusetts	3.226	0.614	5.7	1.28	0.58	5
3 Maine	3.386	0.429	3.9			1
4 New Hampshire	3.034	0.464	4.4	2.73	3.35	3
5 Rhode Island	3.396	0.852	8.4			1
6 Vermont	2.319	0.612	8.4			1
7 New Jersey	2.559	0.421	4.1	5.52*	5.30*	3
8 New York	2.990	0.655	7.0	11.63*	6.79*	8
9 Pennsylvania	2.298	0.630	6.4	35.26*	3.56*	3
10 Illinois	1.822	0.361	5.5	8.88*	6.13*	4
11 Indiana	1.754	0.368	5.6	9.80*	1.40	6
12 Michigan	1.917	0.336	6.1	2.71*	2.48	4
13 Ohio	1.926	0.431	7.8	3.06*	0.59	7
14 Wisconsin	2.066	0.376	5.8	3.34*	0.50	5
15 Iowa	1.629	0.321	5.9	0.34	0.53	4
16 Kansas	[1.220	0.267	6.9	0.63	0.67	3]
17 Minnesota	2.101	0.602	7.1	11.19*	2.63	5
18 Missouri	1.744	0.525	10.0	7.58*	12.93*	4
19 Nebraska	1.508	0.352	5.4	8.27*	4.67*	6
20 North Dakota	2.122	0.348	6.6	55.29*	7.14*	2
21 South Dakota	1.696	0.370	3.3	4.63*	0.31	3
22 District of Columbia	2.612	0.342	5.0			1
23 Delaware	2.420	0.523	6.9			1
24 Florida	[2.892	0.542	3.3	7.18*	0.82	2]
25 Georgia	[1.840	0.366	3.7	2.00	0.16	3]
26 Maryland	2.575	0.513	6.9	1.21	1.61	3
27 North Carolina	2.555	0.571	7.8	1.27	0.77	4
28 South Carolina	[2.240	0.472	5.4	3.29	6.58*	2]
29 Virginia	2.388	0.473	5.2	8.43*	0.80	6
30 West Virginia	1.772	0.568	11.9	3.83	0.40	2
31 Alabama	2.192	0.519	6.5	3.11*	5.10*	3
32 Kentucky	1.739	0.442	6.1	19.65*	1.19	4
33 Mississippi	1.734	0.551	12.7			1
34 Tennessee	2.071	0.610	4.4	4.67*	0.33	4
35 Arkansas	1.682	0.285	0.2	38.69*	20.40*	2
36 Louisiana	[1.667	0.613	14.1	4.90*	4.53*	3]
37 Oklahoma	1.407	0.311	7.2	0.46	0.92	2
38 Texas	1.999	0.727	12.7	3.86*	2.26	7
39 Arizona	1.966	0.672	8.0	30.28*	2.42	4
40 Colorado	1.393	0.336	7.4	7.46*	4.35*	3
41 Idaho	2.995	0.439	5.9			1
42 Montana	1.588	0.423	5.6	12.34*	7.91*	3
43 New Mexico	2.002	0.672	9.7	37.32*	15.32*	2
44 Nevada	[2.265	0.515	3.5	37.20*	50.83*	2]
45 Utah	1.295	0.252	7.1			1
46 Wyoming	1.118	0.255	7.1	0.89	0.08	3
47 California	1.657	0.316	5.8	7.79*	4.21*	4
48 Hawaii	[4.265	0.237	-1.6			1]
49 Oregon	[2.898	0.857	9.8	2.22	4.50	2]
50 Washington	[2.768	0.498	6.5	3.67*	1.75	3]

NOTE: Statistics in brackets are developed from data with missing values totaling at least 25% of all observations.

- (a) α = regression intercept coefficient
 β = regression slope coefficient
 F_c = calculated F statistic across the independent and pooled regressions

EVALUATION OF PRICE PROJECTIONS

To calculate life-cycle-costs as the basis for developing a building energy performance standard, a price data base with the following characteristics was sought:

- a relatively reliable prediction of prices at least ten years into the future for each fuel type
- a level of aggregation such that each data point is reasonably representative of prices in the region with which it is associated.

The search for such a data base was limited to published price projections available from government and industry sources. Numerous models that project national fuel prices for ten to twenty years into the future are available. As a rule, these models are either capable of producing regional price projections for one fuel or of producing national projections for several fuels. In the category of marginal price projections, the only source of regional prices for several fuels is the Energy Information Administration's Mid-Range Energy Forecasting System (MEFS). This model projects short-run marginal costs for 1985, 1990, and 1995 by end-use sector at the DOE Region level. In the category of average price projections, the MEFS model is also the major resource. As with marginal prices, the average price estimates are calculated on the DOE Region level and are for 1985, 1990, and 1995.

Since 1985 is the first year for which MEFS and its predecessor, the PIES model, have produced price projections, no means exists as of yet for evaluating the accuracy of the forecasts. The MEFS projections, which are published in current dollars each year, are converted to constant 1978 dollars and shown in Table 7. For 1976, the projection is an aggregate, rather than a sector-specific price estimate and is taken from the pessimistic supply scenario of the PIES model. From 1977 on, the model became increasingly sophisticated, and the estimates are for the mid-level demand, mid-level supply scenario for the residential sector.

TABLE 7. MEFS Projected Fuel Prices for the Residential Sector

Year Production was Made	Forecast Year	Prices in 1978 \$/10 ⁶ Btu			Sources
		Electricity	Natural Gas	Distillate	
1976(a)	1985	10.40	2.29	4.94	FEA, <u>National Energy Outlook, 1976</u> , pp. G-20; (pessimist supply case)
1977	1985	12.15	3.21	4.07	EIA, <u>Annual Report to Congress 1977</u> , Vol. II, Tables 5.7, 5.9 (mid-mid scenario)
	1990	12.44	3.91	4.25	
1978	1985	12.29	3.47	3.65	EIA, <u>Annual Report to Congress 1978</u> , Vol. III, Tables 17.6-17.8 (mid-mid scenario)
	1990	12.73	3.85	4.36	
	1995	13.00	4.27	5.34	
1979	1985	11.55	3.26	3.43	EIA, <u>Historical and Forecasted Energy Prices by DOE Region and Fuel Type for Three Macroeconomic Scenarios, July 1979</u> , Table 19 (mid-mid scenario)
	1990	11.96	3.62	4.10	
	1995	12.21	4.02	5.02	
1980	1985	14.12	3.47	5.33	EIA, <u>Annual Report to Congress 1979</u> , Vol. III, Table 4.9 (mid-mid scenario)
	1990	14.88	4.18	6.74	
	1995	14.51	4.55	7.35	

(a) The 1976 price projection is for all sectors.

For comparison, actual national average prices expressed in 1978 dollars are listed in Table 8. These figures show considerable difference in price trends among the fuel types. Oil prices exhibit a strong, upward trend, especially since 1978, while the price of natural gas increased gradually until 1979, followed by a decrease in 1980. The real cost of electricity, on the other hand, peaked in 1977 and was lower in early 1980 than in 1974. For comparative purposes Figures 6, 7, and 8 show the actual fuel costs for each year juxtaposed with the price projections made in that same year. The electricity projections shown in Figure 6 first increase, then decrease in 1979, and then increase substantially in 1980. Until 1980, the electricity price projected for 1985 was always lower than actual price in that year. In contrast, the natural gas price projections shown in Figure 7 are relatively consistent across years after 1977 and also show a consistent relationship between actual and projected prices. The comparison of actual with projected oil prices in Figure 8 shows an entirely different picture. While actual prices increased, the projections for 1985 decreased steadily until 1980, when they increased dramatically to just below the level of actual price.

The changes in the MEFS Projections reflect changing information, and some of the projections may eventually prove to be reasonably accurate. Such changes in projections may not be detrimental in formulating national energy policy but do create significant difficulties in developing of life-cycle-cost

TABLE 8. Historical Energy Prices for the Residential Sector
(1978 \$/10⁶ Btu)

	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>
Electricity	12.03	12.47	12.53	12.78	12.63	12.20	11.43
Natural Gas	1.63	1.83	2.07	2.39	2.57	2.84	2.44
Distillate	3.31	3.30	3.36	3.57	3.56	4.25	5.60

Sources: EIA Monthly Energy Review, January 1978.
EIA Monthly Energy Review, June 1980.

FIGURE 6. Actual and Projected Residential Sector Electricity Prices

based standards. The percentage change in the real projected fuel prices is shown in Table 9. Changes in price projections for 1985 and 1990 are especially important to life-cycle-costs and these have varied enough since 1977 to cause the life-cycle-cost minimizing level of fuel use to fluctuate from year to year in some areas of the country. This fluctuation would occur in areas where the life-cycle-costs of various energy-conserving option "packages" are closely clustered.

FIGURE 7. Actual and Projected Residential Sector Natural Gas Prices

FIGURE 8. Actual and Projected Residential Sector Distillate Prices

TABLE 9. Annual Change in MEFS Real Price Projections

	<u>1977 to 1978</u>	<u>1978 to 1979</u>	<u>1979 to 1980</u>
1985 Projection			
Electricity	+ 01%	- 06%	+ 22%
Gas	+ 08%	- 06%	+ 06%
Distillate	- 10%	- 06%	+ 55%
1990 Projection			
Electricity	+ 02%	- 06%	+ 24%
Gas	- 02%	- 06%	+ 15%
Distillate	- 03%	- 06%	+ 64%
1995 Projection			
Electricity	NA	- 06%	+ 19%
Gas	NA	- 06%	+ 13%
Distillate	NA	- 06%	+ 46%

REFERENCES

American Gas Association. 1972-1979. Gas Househeating Survey: 1971-1978.
AGA, Arlington, Virginia.

American Gas Association. 1977. Gas Facts. AGA, Arlington, Virginia.

Energy Performance Standards for New Buildings; Proposed Rule. 1979. 44 Fed.
Reg. 68120-68181.

Maddala, G. S. 1977. Econometrics. McGraw-Hill, New York, New York.

Murphy, J. L. 1973. Introductory Econometrics. Richard D. Irwin, Inc.,
Homewood, Illinois

U.S. Department of Energy, Energy Information Administration. 1977. Typical
Electric Bills - January 1, 1977. DOE/EIA-0040(79), GPO, Washington, D.C.

U.S. Department of Energy, Energy Information Administration. 1979. State
Energy Fuel Prices by Major Economic Sector from 1960 Through 1977. DOE/EIA
-0190, EIA, Washington, D.C.

U.S. Department of Energy, Office of Conservation and Solar Energy. 1979.
Economic Analysis, Energy Performance Standards for New Buildings.
Administrative Record No. 9568.00, DOE, Washington, D.C.

APPENDIX A

DISTRIBUTION BY STATE AND DOE REGION
OF 1978 FUEL PRICES
REPORTED FOR UTILITIES

TABLE A.1. Department of Energy Region 1: Utility Reported
Electricity Prices per 10⁶ Btu in 1978

21.00									
20.00									
19.00									
18.00									
17.00		X							
16.50									
16.00									
15.50				X					
15.00				X					
14.50					X				
14.00									
13.50									
13.00		X		X					
12.50				X	X				
12.00	X	XX							NATIONAL
11.50	X								AVERAGE
11.00	X	X							
10.50									
10.00			X			X			
9.50									
9.00		X							
8.50									
8.00									
7.50									
7.00									
6.50									
6.00									
5.50									
5.00									
4.50									
4.00									
3.50									
	CT	MA	ME	NH	RI	VT			

Source: AGA Gas Househeating Survey: 1978.

TABLE A.2. Department of Energy Region 2: Utility Reported
Electricity Prices per 10⁶ Btu in 1978

21.00	X									
20.00										
19.00										
18.00										
17.00										
16.50										
16.00										
15.50										
15.00	X									
14.50										
14.00	X									
13.50										
13.00	XX									
12.50										
12.00	X									
11.50	X									
11.00	X									
10.50										
10.00		X								
9.50		X								
9.00	X									
8.50										
8.00										
7.50										
7.00										
6.50										
6.00										
5.50										
5.00										
4.50										
4.00										
3.50										
	NY	NJ								NATIONAL AVERAGE

Source: AGA Gas Househeating Survey: 1978.

TABLE A.3. Department of Energy Region 3: Utility Reported
Electricity Prices per 10⁶ Btu in 1978

21.00									
20.00									
19.00									
18.00									
17.00									
16.50									
16.00	XX								
15.50									
15.00									
14.50	X								
14.00									
13.50									
13.00			X	X	X	X			
12.50	X				X				
12.00	XX								
11.50									
11.00	X		X			XX			
10.50									
10.00	X								
9.50					XXX				
9.00					X	X			
8.50									
8.00	X	X		X					
7.50									
7.00					X				
6.50									
6.00									
5.50									
5.00									
4.50									
4.00									
3.50									
	PA	DC	DE	WV	V	MD			NATIONAL AVERAGE

Source: AGA Gas Househeating Survey: 1978.

TABLE A.4. Department of Energy Region 4: Utility Reported
Electricity Prices per 10⁶ Btu in 1978

21.00									
20.00									
19.00									
18.00									
17.00									
16.50									
16.00									
15.50									
15.00						X			
14.50									
14.00									
13.50	X								
13.00				X					
12.50	X			X					
12.00	X		X						
11.50									
11.00			X						
10.50									
10.00		X			X		XX		
9.50			X						
9.00				X	X	X	X	XXXX	
8.50		X						X	
8.00									
7.50									
7.00							X		
6.50									
6.00							X	X	
5.50									
5.00									
4.50									
4.00									
3.50									
	FL	GA	NC	SC	AL	MS	KY	TN	NATIONAL AVERAGE

Source: AGA Gas Househeating Survey: 1978.

TABLE A.5. Department of Energy Region 5: Utility Reported
Electricity Prices per 10⁶ Btu in 1978

21.00									
20.00									
19.00									
18.00									
17.00									
16.50									
16.00				X	X				
15.50									
15.00				X					
14.50			X			X			
14.00									
13.50									
13.00									
12.50				X	X				NATIONAL AVERAGE
12.00	X	X	XX		X	X			
11.50					X				
11.00			X	X	X				
10.50									
10.00			X		XX				
9.50				X	X				
9.00		XXX	X		X				
8.50	XX	X							
8.00	X			XXXX		X			
7.50		XX				X			
7.00	XXXX			X		X			
6.50									
6.00						X			
5.50									
5.00									
4.50									
4.00									
3.50									
	IL	IN	MI	OH	WI	MN			

Source: AGA Gas Househeating Survey: 1978.

TABLE A.6. Department of Energy Region 6: Utility Reported
Electricity Prices per 10⁶ Btu in 1978

21.00									
20.00									
19.00									
18.00									
17.00			X						
16.50									
16.00				X	X				
15.50									
15.00									
14.50				X					
14.00									
13.50									
13.00				XX					
12.50		X							NATIONAL
12.00	X	XX		X					AVERAGE
11.50									
11.00									
10.50									
10.00				X					
9.50									
9.00				X					
8.50									
8.00									
7.50									
7.00			X						
6.50									
6.00									
5.50	X								
5.00									
4.50									
4.00									
3.50									
	AR	LA	OK	TX	NM				

Source: AGA Gas Househeating Survey: 1978.

TABLE A.7. Department of Energy Region 7: Utility Reported
Electricity Prices per 10⁶ Btu in 1978

21.00									
20.00									
19.00									
18.00									
17.00									
16.50									
16.00	X								
15.50									
15.00									
14.50									
14.00	X			X					
13.50			X						
13.00		X	X						
12.50									
12.00	X		X						
11.50									
11.00									
10.50									
10.00	X			X					
9.50									
9.00		X							
8.50									
8.00	X			XX					
7.50									
7.00			XX						
6.50									
6.00				X					
5.50				X					
5.00			X						
4.50									
4.00									
3.50									
	IA	KS	MO	NB					NATIONAL AVERAGE

Source: AGA Gas Househeating Survey: 1978.

TABLE A.8. Department of Energy Region 8: Utility Reported
Electricity Prices per 10⁶ Btu in 1978

21.00								
20.00								
19.00								
18.00								
17.00								
16.50								
16.00								
15.50								
15.00								
14.50								
14.00								
13.50								
13.00								NATIONAL
12.50								AVERAGE
12.00			X					
11.50								
11.00								
10.50								
10.00						X		
9.50						X		
9.00			X					
8.50			X			XX		
8.00		X	X					
7.50								
7.00	XXX	X						
6.50		X						
6.00								
5.50								
5.00								
4.50		X						
4.00								
3.50								
	MT	WY	ND	SD	UT	CO		

Source: AGA Gas Househeating Survey: 1978.

TABLE A.9. Department of Energy Region 9: Utility Reported
Electricity Prices per 10⁶ Btu in 1978

21.00									
20.00									
19.00									
18.00									
17.00									
16.50									
16.00									
15.50	X			X					
15.00		X							
14.50			X						
14.00	X		XXX						
13.50			X						
13.00		XX							
12.50									
12.00									
11.50									
11.00									
10.50									
10.00		X							
9.50									
9.00									
8.50									
8.00	X								
7.50									
7.00									
6.50									
6.00									
5.50									
5.00									
4.50									
4.00									
3.50									
	NV	AZ	CA	HI					NATIONAL AVERAGE

Source: AGA Gas Househeating Survey: 1978.

TABLE A.10. Department of Energy Region 10: Utility Reported
Electricity Prices per 10⁶ Btu in 1978

21.00										
20.00										
19.00										
18.00										
17.00										
16.50										
16.00										
15.50										
15.00										
14.50										
14.00										
13.50										
13.00										
12.50										
12.00										
11.50										
11.00										
10.50										
10.00										
9.50										
9.00										
8.50										
8.00										
7.50										
7.00		X								
6.50	X									
6.00										
5.50										
5.00										
4.50										
4.00	X		XX							
3.50			X							
	ID	OR	WA	AK						

NATIONAL
AVERAGE

Source: AGA Gas Househeating Survey: 1978.

TABLE A.11. Department of Energy Region 1: Utility Reported
Natural Gas Prices per 10⁶ Btu in 1978

4.50	X								
4.25									
4.00		XX			XX				
3.75	X		X						
3.50		X X		X					
3.25	X					X			
3.00		X X		XX					
2.75									
2.50									NATIONAL AVERAGE
2.25									
2.00									
1.75									
1.50									
1.25									
1.00									
	CT	MA	ME	NH	RI	VT			

Source: AGA Gas Househeating Survey: 1978.

TABLE A.12. Department of Energy Region 2: Utility Reported
Natural Gas Prices per 10⁶ Btu in 1978

Source: AGA Gas Househeating Survey: 1978.

A.13

Source: AGA Gas Househeating Survey: 1978.

TABLE A.14. Department of Energy Region 4: Utility Reported
Natural Gas Prices per 10⁶ Btu in 1978

Source: AGA Gas Househeating Survey: 1978.

TABLE A.15. Department of Energy Region 5: Utility Reported
Natural Gas Prices per 10⁶ Btu in 1978

4.50									
4.25									
4.00									
3.75									
3.50						X			
3.25									
3.00	X			X	XX	X			
	X					X			
2.75				X	XXX	XX			
2.50	X	XXX		XX	XX				NATIONAL AVERAGE
	XX		XXXX	XXXXX	X				
2.25	XX	XX	XX	X	X				
	XX	X				X			
2.00									
1.75	X	XX							
1.50									
1.25									
1.00									
	IL	IN	MI	OH	WI	MN			

Source: AGA Gas Househeating Survey: 1978.

TABLE A.16. Department of Energy Region 6: Utility Reported
Natural Gas Prices per 10⁶ Btu in 1978

A.16

Source: AGA Gas Househeating Survey: 1978.

TABLE A.17. Department of Energy Region 7: Utility Reported
Natural Gas Prices per 10⁶ Btu in 1978

4.50									
4.25									
4.00									
3.75									
3.50									
3.25									
3.00	X								
2.75			XXX						
2.50				X					
2.25	X XX			X X X					
2.00	X			X					
1.75			X	X					
1.50		XX	X						
1.25				X					
1.00									
	IA	KS	MO	NB					

NATIONAL
AVERAGE

A.17

Source: AGA Gas Househeating Survey: 1978.

TABLE A.18. Department of Energy Region 8: Utility Reported
Natural Gas Prices per 10⁶ Btu in 1978

Source: AGA Gas Househeating Survey: 1978.

TABLE A.19. Department of Energy Region 9: Utility Reported
Natural Gas Prices per 10⁶ Btu in 1978

4.50			X							
4.25										
4.00										
3.75										
3.50	X									
3.25			X							
3.00		X								
2.75		X								
2.50	X									NATIONAL AVERAGE
2.25			X							
2.00	X									
1.75		X	X							
1.50			X							
1.25										
1.00										
	NV	AZ	CA	HI						

NOT AVAILABLE

Source: AGA Gas Househeating Survey: 1978.

TABLE A.20. Department of Energy Region 10: Utility Reported
Natural Gas Prices per 10⁶ Btu in 1978

Source: AGA Gas Househeating Survey: 1978.

TABLE A.21. Department of Energy Region 1: Utility Reported
No. 2 Fuel Oil Prices per 10⁶ Btu in 1978

4.50									
4.25				X	X				
4.00	X XX	X XXX	X	XX X	X	X			
3.75									
3.50		X							NATIONAL AVERAGE
3.25									
3.00									
2.75									
2.50									
2.25									
2.00									
1.75									
1.50									
1.25									
1.00									
	CT	MA	ME	NH	RI	VT			

Source: AGA Gas Househeating Survey: 1978.

TABLE A.22. Department of Energy Region 2: Utility Reported
No. 2 Fuel Oil Prices per 10⁶ Btu in 1978

Source: AGA Gas Househeating Survey: 1978.

TABLE A.23. Department of Energy Region 3: Utility Reported
No. 2 Fuel Oil Prices per 10⁶ Btu in 1978

Source: AGA Gas Househeating Survey: 1978.

TABLE A.24. Department of Energy Region 4: Utility Reported
No. 2 Fuel Oil Prices per 10⁶ Btu in 1978

Source: AGA Gas Househeating Survey: 1978.

TABLE A.25. Department of Energy Region 5: Utility Reported
No. 2 Fuel Oil Prices per 10⁶ Btu in 1978

4.50									
4.25						X			
4.00		X	X		XX	X			
3.75	X XX X	X X	X X	XXXX X	X XXX	X X			
3.50	XXX	X	XX	XXX XX	X X	XX			NATIONAL AVERAGE
3.25		XXX							
3.00			X		X				
2.75	X								
2.50									
2.25									
2.00									
1.75									
1.50									
1.25									
1.00									
	IL	IN	MI	OH	WI	MN			

Source: AGA Gas Househeating Survey: 1978.

TABLE A.26. Department of Energy Region 6: Utility Reported
No. 2 Fuel Oil Prices per 10⁶ Btu in 1978

Source: AGA Gas Househeating Survey: 1978.

TABLE A.27. Department of Energy Region 7: Utility Reported
No. 2 Fuel Oil Prices per 10⁶ Btu in 1978

Source: AGA Gas Househeating Survey: 1978.

TABLE A.28. Department of Energy Region 8: Utility Reported
No. 2 Fuel Oil Prices per 10⁶ Btu in 1978

Source: AGA Gas Househeating Survey: 1978.

TABLE A.29. Department of Energy Region 9: Utility Reported
No. 2 Fuel Oil Prices per 10⁶ Btu in 1978

Source: AGA Gas Househeating Survey: 1978.

**TABLE A.30. Department of Energy Region 10: Utility Reported
No. 2 Fuel Oil Prices per 10⁶ Btu in 1978**

4.50									
4.25									
4.00	X		X X						
3.75									NATIONAL AVERAGE
3.50	X	X	X						
3.25									
3.00									
2.75									
2.50									
2.25									
2.00									
1.75									
1.50									
1.25									
1.00									
	ID	OR	WA	AK					

Not Available

Source: AGA Gas Househeating Survey: 1978.

APPENDIX B

MAPS OF FUEL PRICE AND ESCALATION RATE DISTRIBUTIONS

B.1

FIGURE B.1. Mean Prices of Natural Gas Over the Period 1971 - 1978

FIGURE B.2. Relative Mean Prices of Natural Gas Over the Period 1971 - 1978

B.3

FIGURE B.3. Real Escalation Rates for Natural Gas Over the Period 1971 - 1978

FIGURE B.4. Mean Prices of Oil Over the Period 1971 - 1978

FIGURE B.5. Relative Mean Prices of No. 2 Oil Over the Period 1971 - 1978

FIGURE B.6. Real Escalation Rates for Oil Prices Over the Period 1971 - 1978

B.7

FIGURE B.7. Mean Prices of Electricity Over the Period 1971 - 1978

FIGURE B.8. Relative Mean Prices of Electricity Over the Period 1971 - 1978

B.9

FIGURE B.9. Real Escalation Rates for Electricity Over the Period 1971 - 1978

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