VARIABILITY OF SEASONAL TOTAL HEATING FUEL DEMAND IN THE UNITED STATES

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A Report to
The Energy Policy Office
Executive Office of the President

Prepared by
Special Task Group[1]
The National Oceanic and Atmospheric Administration
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CONTENTS

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1. INTRODUCTION

1.1. Motivation for this study. In the face of a potentially critical shortage of heating fuels in the United States during the 1973/74 winter heating season, NOAA was asked by Dr. Edward Miller of the Energy Policy Office, Executive Office of the President, for its assistance in determining the extent to which the National total demand for heating fuels in the 1973/74 season will depend on the weather. Aware that temperature conditions during the winter months are the principal weather variable involved, it was mutually agreed that a straight-forward probability analysis of the nationwide variability of seasonal total heating degree-days, based on temperature data available for a period of many years and combined with information on the geographical distribution of heating fuel demand, would provide a valuable guide for national planning as we approach the heating season. A special NOAA task group was formed to undertake such an analysis and to submit its findings to Dr. Miller.

1.2. Approach taken in this study. The starting point for the analysis was to calculate the seasonal total heating degree-days for each State of the Union (48 conterminous States only), and for each of the 42 heating seasons from 1931/32 to 1972/73. The heating degree-day totals for each State were then averaged together into a nationally averaged heating degree-day total for each of the 42 heating seasons, using five different weighting procedures based on the contribution of each State to the National total demand for fuel in each of five categories: (1) all fuels, (2) gas, (3) oil, (4) electricity, and (5) LPG (chiefly propane). The series of 42 nationally averaged heating degree-day totals for each of the five fuel categories was then treated as a direct measure of the relative variations of total National heating fuel demand in that fuel category, for the assumption of a constant economy. Each such series was examined for evidence of systematic trends. Finally, the 42 values in each series were treated as random samples from populations of such data. This provided a rationale for constructing appropriate statistical models for the assessment of (unconditional) probabilities of extreme fuel demands in an arbitrarily chosen heating season such as the 1973/74 season. Following this approach, it was possible to define the weather influence on heating-fuel demand in terms that are totally independent of the long-term growth of demand attributable to economic, demographic, and technological trends (the latter being outside the competence of NOAA to consider in necessary detail).

2. PROCEDURE

2.1. Geographical scope. All data referred to in this study pertain to the 48 conterminous states. No consideration is given to Alaska, Hawaii, or any territory or possession (other than the District of Columbia, treated here as part of Virginia). Of the areas omitted, only Alaska contributes a non-trivial share of the national total demand for heating fuels (about 0.5% of the national demand for oil and 0.1% or less of that for other fuels).

2.2. Source of temperature data. Temperature data used in a study of this kind should be representative of thermal conditions near each and every center of population. Data available from over 300 First-Order National Weather Service stations were considered for use here but rejected for several reasons having mainly to do with uneven lengths of record, troublesome effects of station relocations and local urban warming, inadequate representation of all centers of population, and other complications.

An alternative source of temperature data, available through the NOAA National Climatic Center, was chosen for use in this study. These data are the monthly average temperatures compiled on a routine basis from the thousands of cooperative climatological station reports sent in to the Center each month, and available for each of the approximately 350 state climatological divisions into which the nation has been divided. (Most larger states have 9 or 10 climatological divisions each and smaller ones usually have fewer than 10 each.) Divisionally averaged mean monthly temperatures have been calculated at the National Climatic Center for all divisions, for each month of each year since January 1931.

2.3. Calculation of heating degree-days. Each division mean temperature (in each month and year of record) was converted to its equivalent monthly total heating degree-days (base 65°F) using an estimation procedure developed by Thom (1)*. Standard deviations of monthly mean temperature, required in the application of the Thom procedure, were computed from the 42 values of mean temperature for the appropriate division and calendar month between July 1931 and June 1973. The monthly total heating degree-days were then summed for each division and for each heating season (July through June).

2.4. Derivation of State average heating degree-days. Because the fuel demand data available for analysis in this study are not resolved below State level, it was necessary to combine the divisional degree-day statistics into State-wide average degree-day statistics. Thus, the basic geographical unit used in this study (both degree-day data and fuel demand data) is the State. The State average degree-day total for each State and each heating season was derived by averaging the divisional degree-day totals in each heating season after weighting each division by its total (1970) population adduced from Bureau of the Census data (2). This population-weighting procedure assures that the degree-day averages for the States as a whole are biased toward conditions existing in the more populous sections of the States, as appropriate to the present study.

2.5. Derivation of National average heating degree-days. The State average heating degree-day data were further averaged into a National average heating degree-day value for each heating season and for each of five categories of heating fuels. Each National average value was derived as a weighted sum of the State average values in

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*Numbers in parentheses refer to the list of references at the end of this report.

accordance with the fraction of the total National heating-fuel demand that is contributed by each State. Five weighting criteria were used, identified as follows:

- ALL FUELS. Weights proportional to the total population of each State. Assumes that each person in the U.S. requires the same caloric heating-fuel demand per heating degree-day regardless of geographical location. Population data based on 1970 census (2).
- GAS. Weights proportional to consumption of natural gas used for space heating in each State. Based on 1971 data in <u>Gas Facts</u> (3), adjusted for heating degree-day anomaly in each State during 1971.
- OIL. Weights proportional to total sales of distillate heating oils in each State. Based on 1968 data in <u>Petroleum Facts and Figures</u> (4), adjusted for heating degree-day anomaly in each State during 1968.
- ELECTRICITY. Weights proportional to estimated total electric energy used for space heating in each State. Based on 1971 gas consumption data (3) proportioned by data on numbers of occupied housing units heated by gas and by electricity, in <u>Gas House Heating Survey</u> (5).
- LPG. Weights proportional to estimated total consumption of propane gas used for space heating in each State. Based on 1971 gas consumption data (3) proportioned by data on numbers of occupied housing units heated by gas and by LPG, in <u>Gas House Heating Survey</u> (5)

Further information on the procedures followed for estimating the State weighting factors is contained in APPENDIX 1. The weighting factors themselves are listed for each State in APPENDIX 2.

3. RESULTS

3.1. <u>Time series of National average heating degree-days.</u> The nationally averaged heating degree-day values for each heating season and for each of the five fuel types are tabulated in Table 1 and plotted as time series in Figure 1. Several characteristics of these data can be pointed out. First, it is seen that the National average degree-day values are systematically highest when weighted for oil and systematically

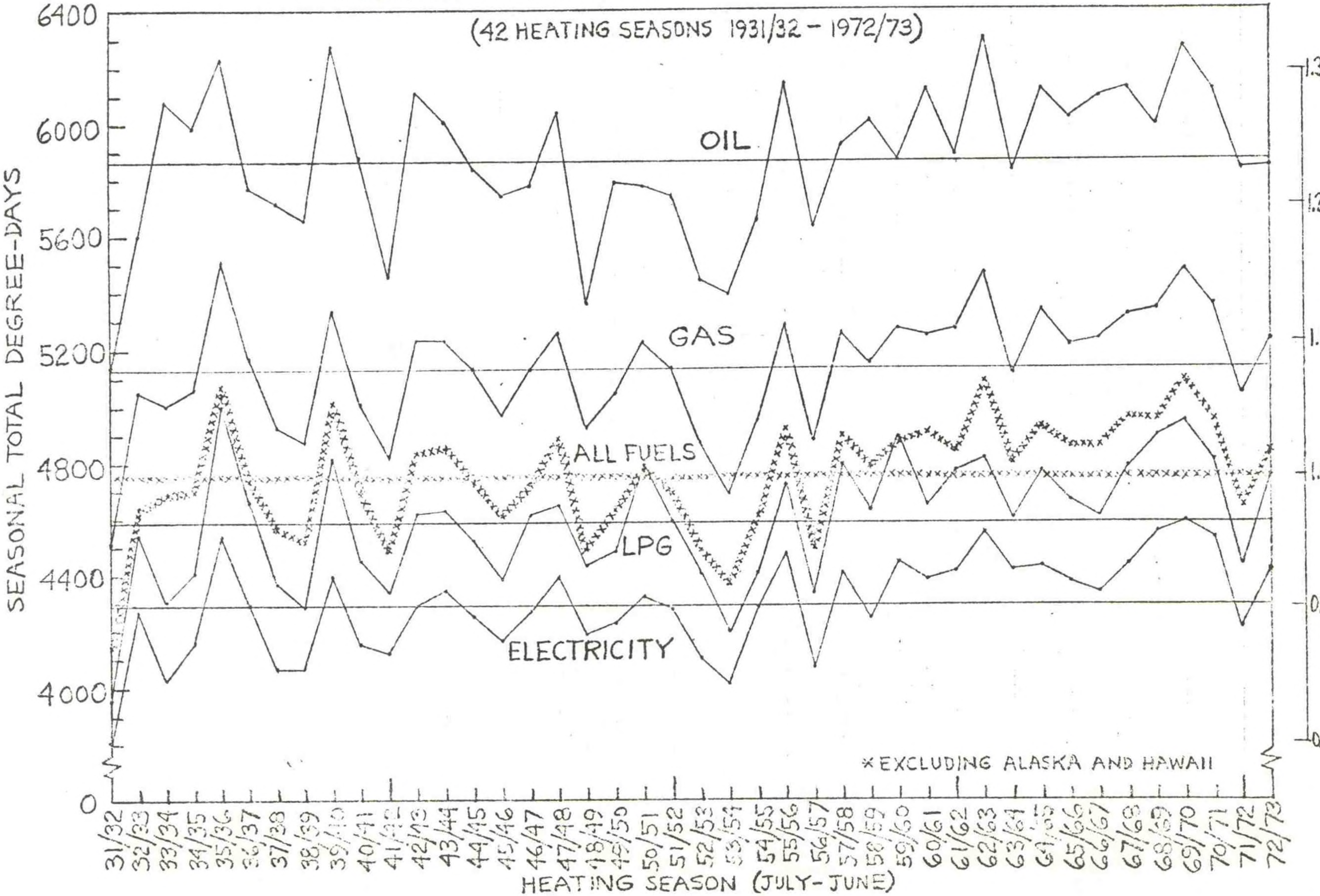
TABLE 1

NATIONAL AVERAGE HEATING DEGREE-DAYS, AND RATIOS TO 42-YEAR MEANS, WEIGHTED BY FUEL TYPE

HEATING SEASON	ALL FUELS		GAS		OIL		ELECTRICITY		LPG	
1931/32	4147	.873	4515	.880	5140	.876	3810	.887	3959	.863
1932/33	4637	.976	5054	.985	5598	.954	4269	.995	4539	.989
1933/34	4684	.986	5003	.975	6078	1.036	4029	.939	4302	.938
1934/35	4696	.988	5061	.987	5986	1.021	4162	.970	4406	.960
1935/36	5074	1.067	5502	1.073	6225	1.061	4539	1.058	5001	1.090
1936/37	4738	.997	5173	1.008	5766	.983	4292	1.000	4658	1.015
1937/38	4563	.960	4927	.960	5709	.973	4066	.947	4364	.951
1938/39	4519	.951	4876	.950	5649	.963	4066	.947	4281	.933
1939/40	5011	1.055	5332	1.039	6275	1.070	4394	1.024	4817	1.050
1940/41	4689	.987	5009	.976	5868	1.001	4154	.968	4453	.971
1941/42	4484	.944	4823	.940	5453	.930	4121	.960	4339	.946
1942/43	4832	1.017	5232	1.020	6106	1.041	4285	.998	4621	1.007
1943/44	4849	1.020	5230	1.020	6004	1.024	4342	1.012	4627	1.009
1944/45	4732	.996	5136	1.001	5826	.993	4253	.991	4522	.986
1945/46	4611	.970	4967	.968	5736	.978	4163	.970	4381	.955
1946/47	4725	.994	5132	1.000	5770	.984	4266	.994	4612	1.005
1947/48	4883	1.028	5255	1.024	6037	1.029	4389	1.023	4646	1.013
1948/49	4488	.944	4926	.960	5362	.914	4182	.974	4428	.965
1949/50	4635	.975	5049	.984	5782	.986	4226	.985	4480	.976
1950/51	4776	1.005	5220	1.018	5773	.984	4321	1.007	4789	1.044
1951/52	4689	.987	5137	1.001	5729	.977	4277	.997	4590	1.000
1952/53	4485	.944	4871	.950	5437	.927	4100	.955	4402	.959
1953/54	4369	.920	4692	.915	5388	.919	4014	.935	4197	.915
1954/55	4601	.968	4946	.964	5645	.962	4285	.998	4404	.960
1955/56	4921	1.036	5281	1.029	6141	1.047	4468	1.041	4722	1.029
1956/57	4495	.945	4881	.951	5623	.959	4068	.948	4335	.944
1957/58	4898	1.031	5255	1.024	5918	1.009	4405	1.026	4795	1.045
1958/59	4793	1.009	5148	1.004	6009	1.025	4244	.989	4630	1.009
1959/60	4867	1.024	5266	1.025	5859	.999	4444	1.035	4892	1.066
1960/61	4906	1.033	5243	1.022	6113	1.042	4385	1.022	4649	1.013
1961/62	4842	1.019	5265	1.025	5878	1.002	4408	1.027	4773	1.040
1962/63	5083	1.069	5460	1.064	6299	1.074	4550	1.060	4816	1.050
1963/64	4799	1.010	5115	.997	5824	.993	4417	1.029	4602	1.003
1964/65	4926	1.037	5332	1.039	6111	1.042	4428	1.032	4768	1.039
1965/66	4857	1.022	5210	1.016	6016	1.026	4374	1.019	4661	1.016
1966/67	4859	1.022	5234	1.020	6081	1.037	4337	1.010	4609	1.005
1967/68	4961	1.044	5314	1.036	6117	1.043	4438	1.034	4785	1.043
1968/69	4955	1.043	5332	1.039	5992	1.022	4554	1.061	4895	1.067
1969/70	5091	1.071	5466	1.066	6263	1.068	4587	1.069	4941	1.077
1970/71	4953	1.043	5345	1.042	6107	1.041	4530	1.055	4804	1.047
1971/72	4642	.977	5040	.982	5824	.993	4206	.980	4438	.967
1972/73	4838	1.018	5225	1.019	5828	.994	4407	1.027	4753	1.036
MEANS	4752	1.000	5130	1.000	5865	1.000	4292	1.000	4588	1.000

FIGURE 1

WEIGHTED U.S. NATIONAL AVERAGE HEATING DEGREE-DAYS*



lowest when weighted for electricity. Values for gas are also relatively high, and those for LPG relatively low. This is a reflection of the fact that the dominant heating fuel differs from one part of the Nation to another. The highest demand for oil tends to be concentrated in the northeastern and northern-midwestern states (see APPENDIX 1). This is potentially disturbing for two reasons. Inasmuch as oil is one of the heating fuels in shortest supply at present, it appears that a disproportionately large number of Americans who rely on this fuel reside in the coldest tier of states where shortages could be expected to incur especially severe human hardships. In addition, many of these same states lie in a region of unusually large climatic variability from year to year. This means that the climatological probability of a winter sufficiently cold to increase the demand for oil in those states by a critical increment above normal demand is higher than it would be in other states.

Figure 1 can be consulted for evidence of systematic trends in heating-fuel demand over the 42-year period of analysis. In general, such trends are not in evidence. However, it can be seen that with few exceptions the heating seasons since that of 1957/58 have been quite uniformly colder (higher degree-day averages) than the average in earlier heating seasons. One of the exceptions to this pattern was the winter of 1971/72. By far the warmest winter was that of 1931/32; other relatively warm winters are seen to have included several winters in the early 1950's but very few since then.

3.2. Probability distribution of National average heating degree-days. In the absence of clearly definable trends or other systematic timewise behavior of the National degree-day data, it seems prudent as the basis of future planning to assume strictly random timewise behavior and resort to a simple unconditional probability analysis of the data as a means of assessing future risks of abnormally high National fuel demands. Such a probability analysis requires first that the simple probability distribution of the data be estimated. It has been found that the probability distributions of all five sets of data in Table 1 are indistinguishable from Gaussian "normal" probability distributions with means and standard deviations given by their sample values in Table 2. In each case the fit to the Gaussian normal distribution was accepted at the 95% confidence level on the basis of the Kolmogorov-Smirnov test for normality with mean and variance unknown (6). An example of the closeness of the fit is shown in Figure 2. This makes it possible to assess the probabilities of seasonal heating degree-day excursions of any arbitrarily specified magnitude, with reasonable confidence.

By reference to the Gaussian normal probability distribution fitted to each of the five fuel-weighted series in Table 1, estimates can be made of the magnitude of total National heating-fuel demand likely to be exceeded (or not exceeded) on an average of once in an arbitrarily specified number of heating seasons. The results of this procedure are illustrated in Table 3 for six criteria of practical interest. It is seen from Table 3, for example, that in only one year out of 100 years should one expect the National total demand for heating oil to exceed its long-term average demand (for constant economy) by as much as 10.6%. Similarly, the demand for heating oil can be expected to exceed its average demand (for constant economy) by at least 3.8% on an average of one heating season in five.

In general, this probability analysis reveals the problem of weather in relation to National total heating-fuel demand as a 5% problem on the time scale of decades, and as a 10% problem on the time scale of centuries. This assessment, however, should be understood to apply if and only if systematic changes of climate from decade to decade, or from century to century, do not occur. Available evidence of global climate behavior on such time scales implies very strongly that significant climatic changes do indeed take place, and that depending on the future direction and magnitude of such changes the above assessment of the weather factor in the heating-fuel situation might turn out to be appreciably over-optimistic (or over-pessimistic) as a guide for the long-term future. But when interpreted as a statement of risks for one or more winters <u>in the immediate future</u>, this assessment is unlikely to be seriously compromised by the influence of climatic trends in so short a period of time.

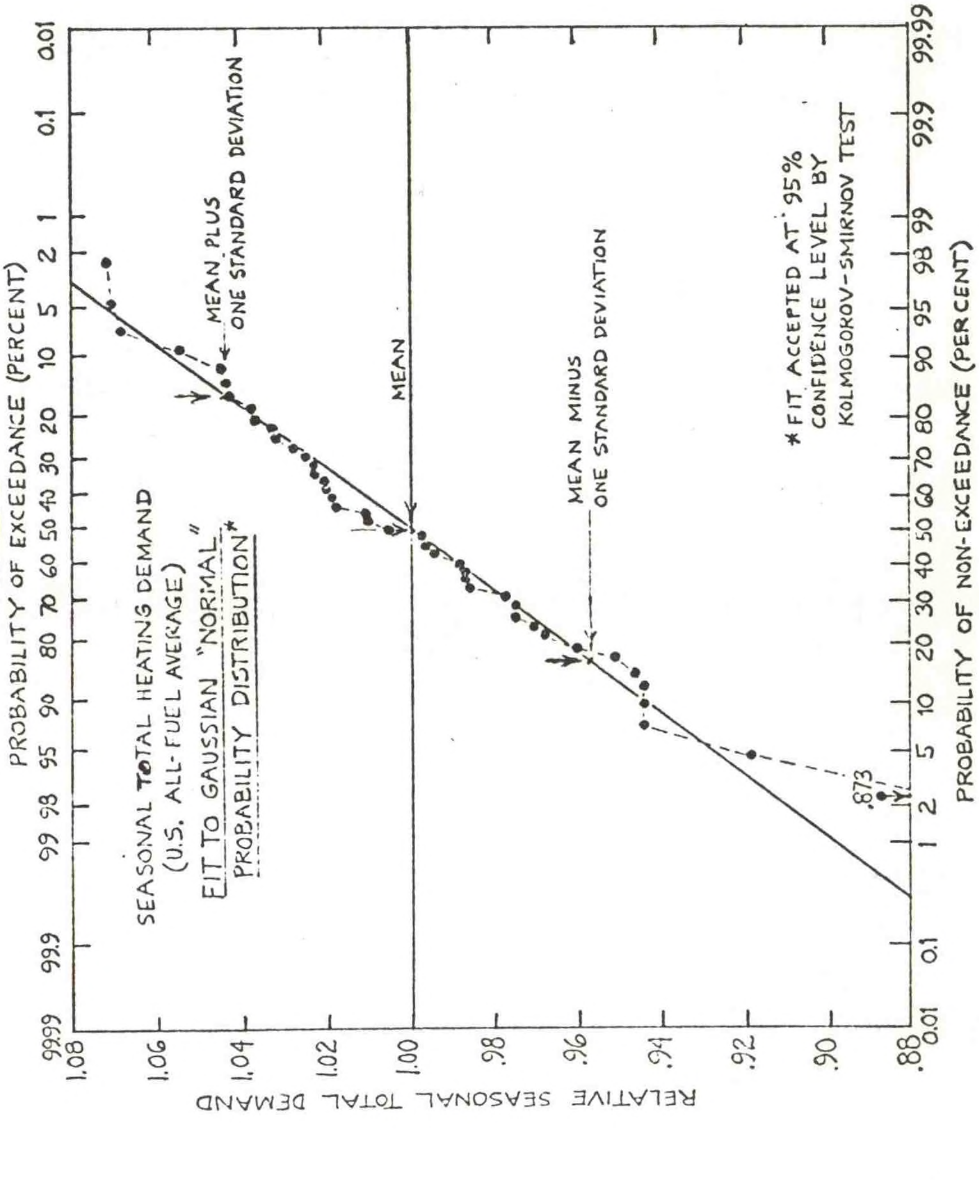
TABLE 2
MEANS AND STANDARD DEVIATIONS OF NATIONAL AVERAGE
HEATING DEGREE-DAYS WEIGHTED BY FUEL TYPE

	ALL FUELS	GAS	OIL	ELECTRICITY	LPG
Mean (42-yr average)	4752	5130	5865	4292	4588
Standard Deviation	203.21	208.43	267.12	171.67	221.94
Standard Deviation as Ratio to the Mean	.0428	.0406	.0455	.0400	.0484

TABLE 3
EXTREME NATIONAL TOTAL HEATING DEMAND BY FUEL TYPE
IN PER CENT OF 42-YR AVERAGE DEMAND

CRITERION	ALL FUELS	GAS	OIL	ELECTRICITY	LPG
Coldest year in 100	110.0	109.4	110.6	109.3	111.3
Coldest year in 10	105.5	105.2	105.8	105.1	106.2
Coldest year in 5	103.6	103.4	103.8	103.4	104.1
Average year	100.0	100.0	100.0	100.0	100.0
Warmest year in 5	96.4	96.6	96.2	96.6	95.9
Warmest year in 10	94.5	94.8	94.2	94.9	93.8
Warmest year in 100	90.0	90.6	89.4	90.7	88.7

FIGURE 2


PROBABILITY OF EXCEEDANCE (PERCENT)
99.99 99.9 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.1 0.01
SEASONAL TOTAL HEATING DEMAND
(U.S. ALL-FUEL AVERAGE)
FIT TO GAUSSIAN "NORMAL" PROBABILITY DISTRIBUTION*
MEAN PLUS ONE STANDARD DEVIATION
MEAN
MEAN MINUS ONE STANDARD DEVIATION
* FIT ACCEPTED AT 95% CONFIDENCE LEVEL BY KOLMOGOROV-SMIRNOV TEST
.873
RELATIVE SEASONAL TOTAL DEMAND
1.08 1.06 1.04 1.02 1.00 .98 .96 .94 .92 .90 .88
PROBABILITY OF NON-EXCEEDANCE (PERCENT)
0.01 0.1 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.9 99.99

4. REGIONAL ANALYSIS

4.1. Regional average heating degree-days. In referring to the weather factor in National heating-fuel demand, it should be carefully noted that when one section of the Nation is colder than average it is not unusual for other sections to be warmer than average. In other words, in a situation where the National total heating-fuel demand is higher than average it is quite likely that the excess demand would be found to center on one section of the Nation where the problem is severe, while near-average, or even less than average, demands would be found in other sections. To the extent that heating fuels are not readily redistributed from one part of the Nation to another to help meet such regional emergencies, it is appropriate to consider the situation on a regional basis from the same general point of view that we have already considered it from the National point of view.

In common with the practice followed in the gas industry, we divide the Nation into a total of nine census regions as defined and used by the Bureau of the Census (2). The States belonging to each of the nine regions are listed in APPENDIX 3. The time series of regionally averaged heating degree-days, for each of the 42 heating seasons since the 1931/32 season, are included as APPENDIX 4.

The 42-year means and standard deviations for each region and for each of the five fuel categories defined on page 4 are listed in Table 4. On the assumption that these data can be fitted to Gaussian "normal" distributions, as in the case of the National data, probability assessments of the likelihood of extreme heating-fuel demands during the forthcoming heating season, in each region, are summarized in Table 5. As expected, the probable extreme deviations (when expressed as percentage deviations from average regional demands) are found to be somewhat larger than those applicable to the Nation as a whole, especially in the southern and pacific States. It is important to keep in mind, however, that not all regions would be

TABLE 4
MEANS AND STANDARD DEVIATIONS OF SEASONAL TOTAL
HEATING DEGREE-DAYS WEIGHTED BY FUEL TYPE

REGION		ALL FUELS	GAS	OIL	ELECTRICITY	LPG
1. NEW ENGLAND	Mean	6481	6244	6527	6413	6726
	Std. Dev. ...	354.55	352.89	354.42	355.29	357.26
	Ratio to Mean	.0547	.0565	.0543	.0554	.0531
2. MIDDLE ATLANTIC	Mean	5774	5763	5760	5741	5771
	Std. Dev. ...	339.73	339.12	341.59	339.28	339.52
	Ratio to Mean	.0588	.0588	.0593	.0591	.0588
3. EAST NORTH CENTRAL	Mean	6234	6181	6416	6121	6294
	Std. Dev. ...	319.93	319.46	320.32	322.93	321.71
	Ratio to Mean	.0513	.0517	.0499	.0528	.0511
4. WEST NORTH CENTRAL	Mean	6527	6298	7464	6539	6143
	Std. Dev. ...	341.07	333.88	385.48	340.59	334.52
	Ratio to Mean	.0523	.0530	.0516	.0521	.0545
5. SOUTH ATLANTIC	Mean	3070	3669	3733	2363	2218
	Std. Dev. ...	268.68	295.96	291.10	240.07	248.71
	Ratio to Mean	.0875	.0807	.0780	.1016	.1121
6. EAST SOUTH CENTRAL	Mean	3356	3484	3834	3555	3060
	Std. Dev. ...	331.18	332.59	341.94	339.93	323.87
	Ratio to Mean	.0987	.0955	.0892	.0956	.1058
7. WEST SOUTH CENTRAL	Mean	2245	2368	2490	2283	2536
	Std. Dev. ...	228.91	230.44	232.33	229.29	234.19
	Ratio to Mean	.1020	.0973	.0933	.1004	.0923
8. MOUNTAIN	Mean	5626	6097	6843	5100	6196
	Std. Dev. ...	334.22	350.94	422.80	336.23	341.35
	Ratio to Mean	.0594	.0576	.0618	.0659	.0551
9. PACIFIC	Mean	3323	2977	5371	4298	3361
	Std. Dev. ...	275.49	270.39	358.13	305.18	276.30
	Ratio to Mean	.0829	.0908	.0667	.0710	.0822
ALL REGIONS COMBINED*	Mean	4752	5130	5865	4292	4588
	Std. Dev. ...	203.21	208.43	267.12	171.67	221.94
	Ratio to Mean	.0428	.0406	.0455	.0400	.0484

*From Table 2

TABLE 5
EXTREME REGIONAL TOTAL HEATING DEMAND BY FUEL TYPE
IN PER CENT OF 42-YR AVERAGE DEMAND

CRITERION	ALL FUELS	GAS	OIL	ELECTRICITY	LPG
REGION 1 -- NEW ENGLAND					
Coldest year in 100	112.7	113.1	112.6	112.9	112.4
Coldest year in 10	107.0	107.2	107.0	107.1	106.8
Coldest year in 5	104.6	104.8	104.6	104.7	104.5
Warmest year in 5	95.4	95.2	95.4	95.3	95.5
Warmest year in 10	93.0	92.8	93.0	92.9	93.2
Warmest year in 100	87.3	86.9	87.4	87.1	87.6
REGION 2 -- MIDDLE ATLANTIC					
Coldest year in 100	113.7	113.7	113.8	113.8	113.7
Coldest year in 10	107.5	107.5	107.6	107.6	107.5
Coldest year in 5	105.0	105.0	105.0	105.0	105.0
Warmest year in 5	95.0	95.0	95.0	95.0	95.0
Warmest year in 10	92.5	92.5	92.4	92.4	92.5
Warmest year in 100	86.3	86.3	86.2	86.2	86.3
REGION 3 -- EAST NORTH CENTRAL					
Coldest year in 100	111.9	112.0	111.6	112.3	111.9
Coldest year in 10	106.6	106.6	106.4	106.8	106.6
Coldest year in 5	104.3	104.4	104.2	104.4	104.3
Warmest year in 5	95.7	95.6	95.8	95.6	95.7
Warmest year in 10	93.4	93.4	93.6	93.2	93.4
Warmest year in 100	88.1	88.0	88.4	87.7	88.1
REGION 4 -- WEST NORTH CENTRAL					
Coldest year in 100	112.2	112.3	112.0	112.1	112.7
Coldest year in 10	106.7	106.8	106.6	106.7	107.0
Coldest year in 5	104.4	104.5	104.3	104.4	104.6
Warmest year in 5	95.6	95.5	95.7	95.6	95.4
Warmest year in 10	93.3	93.2	93.4	93.3	93.0
Warmest year in 100	87.8	87.7	88.0	87.9	87.3
REGION 5 -- SOUTH ATLANTIC					
Coldest year in 100	120.4	118.8	118.2	123.6	126.1
Coldest year in 10	111.2	110.3	110.0	113.0	114.4
Coldest year in 5	107.4	106.8	106.6	108.6	109.4
Warmest year in 5	92.6	93.2	93.4	91.4	90.6
Warmest year in 10	88.8	89.7	90.0	87.0	85.6
Warmest year in 100	79.6	81.2	81.8	76.4	73.9

TABLE 5 (CONTINUED)

CRITERION	ALL FUELS	GAS	OIL	ELECTRICITY	LPG
REGION 6 -- EAST SOUTH CENTRAL					
Coldest year in 100	123.0	122.2	120.8	122.2	124.6
Coldest year in 10	112.7	112.2	111.4	112.3	113.6
Coldest year in 5	108.3	108.0	107.5	108.0	108.9
Warmest year in 5	91.7	92.0	92.5	92.0	91.1
Warmest year in 10	87.3	87.8	88.6	87.7	86.4
Warmest year in 100	77.0	77.8	79.2	77.8	75.4
REGION 7 -- WEST SOUTH CENTRAL					
Coldest year in 100	123.7	122.6	121.7	123.4	121.5
Coldest year in 10	113.1	112.5	112.0	112.9	111.8
Coldest year in 5	108.6	108.2	107.9	108.5	107.8
Warmest year in 5	91.4	91.8	92.1	91.5	92.2
Warmest year in 10	86.9	87.5	88.0	87.1	88.2
Warmest year in 100	76.3	77.4	78.3	76.6	78.5
REGION 8 -- MOUNTAIN					
Coldest year in 100	113.8	113.4	114.4	115.3	112.8
Coldest year in 10	107.6	107.4	107.9	108.4	107.1
Coldest year in 5	105.0	104.8	105.2	105.5	104.6
Warmest year in 5	95.0	95.2	94.8	94.5	95.4
Warmest year in 10	92.4	92.6	92.1	91.6	92.9
Warmest year in 100	86.2	86.6	85.6	84.7	87.2
REGION 9 -- PACIFIC					
Coldest year in 100	119.3	121.1	115.5	116.5	119.1
Coldest year in 10	110.6	111.6	108.6	109.1	110.5
Coldest year in 5	107.0	107.6	105.6	106.0	106.9
Warmest year in 5	93.0	92.4	94.4	94.0	93.1
Warmest year in 10	89.4	88.4	91.4	90.9	89.5
Warmest year in 100	80.7	78.9	84.5	83.5	80.9
ALL REGIONS COMBINED*					
Coldest year in 100	110.0	109.4	110.6	109.3	111.3
Coldest year in 10	105.5	105.2	105.8	105.1	106.2
Coldest year in 5	103.6	103.4	103.8	103.4	104.1
Warmest year in 5	96.4	96.6	96.2	96.6	95.9
Warmest year in 10	94.5	94.8	94.2	94.9	93.8
Warmest year in 100	90.0	90.6	89.4	90.7	88.7

*From Table 3

expected to approach the same extreme conditions in Table 5 in the same years.

4.2. Inter-regional correlations of degree-day anomalies. To elucidate further the tendency for abnormal heating-fuel demands in certain regions to be shared only partially by those in other regions, correlation coefficients have been computed between each pair of regions based on the ALL FUELS data in APPENDIX 4. These correlations, listed in Table 6, indicate that it usual for all regions east of the Rocky Mountains to vary more or less in parallel as to fuel demand, and for the Pacific and Mountain regions to vary in parallel. The correlations also indicate that variations of fuel demand east of the Rockies tend to vary in anti-parallel with those in the Pacific and Mountain regions. These indications are consistent with meteorological experience in revealing a tendency for climatic anomalies to be opposite on the two sides of the Rockies, together with a much weaker (less consistent) tendency for climatic anomalies to differ very much between the northern tiers of States and the southern tiers.

5. CONCLUSIONS

On the basis of this study it appears that fairly reliable assessments can be made of the risk of unusual weather-related heating fuel demand in the United States during the forthcoming heating season. For the Nation as a whole, the risk of unusually high or unusually low seasonal total demand is shown for each fuel type in Table 3. The same measure of risk is shown for each of the nine census regions of the Nation in Table 5.

The risk assessments listed in Tables 3 and 5 cannot be regarded as bona fide forecasts in a real-time sense, inasmuch as they "predict" the same situation in any future heating season and not merely the 1973/74 season. Such assessments are likely to be reasonably accurate until such time, in the relatively remote future, that the cumulative influence of systematic (and as yet unpredictable) trends of climate may tend to outdate them.

TABLE 6

INTER-REGIONAL CORRELATION OF HEATING DEGREE-DAYS*
(BASED ON SEASONAL TOTALS FOR PAST 42 YEARS)

	1. NEW ENGLAND	2. MIDDLE ATLANTIC	3. EAST NORTH CENTRAL	4. WEST NORTH CENTRAL	5. SOUTH ATLANTIC	6. EAST SOUTH CENTRAL	7. WEST SOUTH CENTRAL	8. MOUNTAIN	9. PACIFIC
1. NEW ENGLAND	1.000	.951	.650	.176	.651	.446	.160	-.433	-.473
2. MIDDLE ATLANTIC	. .	1.000	.644	.283	.808	.615	.318	-.451	-.534
3. EAST NORTH CENTRAL	. .	. .	1.000	.768	.772	.716	.485	-.174	-.356
4. WEST NORTH CENTRAL	. .	. .	. .	1.000	.391	.468	.459	.293	.093
5. SOUTH ATLANTIC	. .	. .	. .	. .	1.000	.932	.650	-.251	-.480
6. EAST SOUTH CENTRAL	. .	. .	. .	. .	. .	1.000	.808	-.015	-.357
7. WEST SOUTH CENTRAL	. .	. .	. .	. .	. .	. .	1.000	.324	-.141
8. MOUNTAIN	. .	. .	. .	. .	. .	. .	. .	1.000	.756
9. PACIFIC	. .	. .	. .	. .	. .	. .	. .	. .	1.000

* Product-moment correlation coefficients

Based on the 42 years of record available for this study, there is an indication of a systematic bias toward higher National total heating-fuel demand in recent years (relative to the average demand in earlier years). This bias, however, was interrupted by the relatively warm winter of 1971/72 and there is no assurance that it will persist in the future. Whether or not this behavior is a manifestation of a persistent long-term trend in the climate of the Nation cannot be established with certainty.

With the possibility of systematic climatic changes in mind, the data presented in this report can be summarized in a different way to indicate the most probable heating fuel demand in the 1973/74 season. On the one hand, the 1973/74 demand can be estimated, for the assumption of no climatic change, as the 42-year average demand between 1931/32 and 1972/73. On the other hand, the 1973/74 demand can be estimated for the assumption that the last ten years of experience are a more meaningful guide for the future than the past 42 years. The latter assumption is one way of hedging against climatic change. In this case the 1973/74 demand can be estimated as the 10-year average demand between 1963/64 and 1972/73. The results, compared for the two assumptions, are as indicated in Table 7 (for National total demand by fuel type) and in Table 8 (for regional total demand, for the case of ALL FUELS only). In these tables, the 1973/74 most probable fuel demands are expressed as per cent deviations from the corresponding 1972/73 demands (for a constant economy).

In summary, the results of this study suggest that if the Nation had the capability of preparing this year for the heating fuel demand anticipated only two or three years hence, allowing for its typical growth of a few per cent per year, the Nation would be able to hedge quite effectively against all but the most extreme winter coldness such as that visited upon it once or twice a century.

TABLE 7

MOST PROBABLE 1973/74 NATIONAL TOTAL HEATING FUEL DEMAND
AS PER CENT DEVIATION FROM 1972/73 DEMAND
BASED ON TWO CRITERIA, FOR CONSTANT ECONOMY

CRITERION	DEVIATION FROM 1972/73 DEMAND (BY FUEL TYPE)				
	ALL FUELS	GAS	OIL	ELECTRICITY	LPG
1973/74 weather equal to average of past 42 years (neglects climatic trend)	-1.8%	-1.9%	+0.6%	-2.6%	-3.5%
1973/74 weather equal to average of past 10 years (hedge against climatic trend)	+1.1%	+0.7%	+3.2%	+0.5%	-0.6%

TABLE 8

MOST PROBABLE 1973/74 REGIONAL TOTAL HEATING FUEL DEMAND
AS PER CENT DEVIATION FROM 1972/73 DEMAND
BASED ON TWO CRITERIA, FOR CONSTANT ECONOMY
ALL FUELS

CRITERION	DEVIATION FROM 1972/73 DEMAND (BY REGION)								
	1	2	3	4	5	6	7	8	9
1973/74 weather equal to average of past 42 years (neglects climatic trend)	+0.8	+1.8	+1.0	-2.3	+0.7	-4.8	-18.4	-10.8	-5.3
1973/74 weather equal to average of past 10 years (hedge against climatic trend)	+3.8	+4.7	+3.1	-0.7	+6.1	+1.9	-14.8	-8.2	-4.5

APPENDIX 1

DERIVATION OF STATE WEIGHTING FACTORS FOR FUELS

(Ralph N. Rotty)

Gas for heating. Total gas consumed in each State was determined from 1971 data in Gas Facts (3). These data refer to sales to three classes of customers in each State: residential, commercial, and industrial. Not all the gas sold to residential or commercial customers is used for space heating, and in these cases it was necessary to subtract estimates of the amounts used in cooking, drying, lighting, water heating, and air conditioning. The appropriate corrections were estimated following discussions with Mr. Robert Griffith of the American Gas Association, who has studied the fractions of gas consumed for various purposes in homes in each region of the Nation, and who estimates that between 45 and 60% of all gas sold to commercial customers is used for space heating. Thus, the following factors in each customer class were adopted:

REGION	FACTOR BY WHICH TOTAL GAS SALES MULTIPLIED TO YIELD ESTIMATED SPACE HEATING DEMAND		
	Residential	Commercial	Industrial
1. NEW ENGLAND	.686	.55	.00
2. MIDDLE ATLANTIC	.699	↓	↓
3. EAST NORTH CENTRAL	.760	↓	↓
4. WEST NORTH CENTRAL	.735	↓	↓
5. SOUTH ATLANTIC	.619	↓	↓
6. EAST SOUTH CENTRAL	.712	↓	↓
7. WEST SOUTH CENTRAL	.536	↓	↓
8. MOUNTAIN	.771	↓	↓
9. PACIFIC	.648	↓	↓

Total gas consumed in the United States during 1971 for space heating purposes is estimated through the above procedure to have been 4704 billion cubic feet. Using an energy factor of 1000 Btu per cubic foot this represents 4704×10^{12} Btu as the National space heating load met by gas in 1971. Since total U.S. consumption of gas in 1971 was 16,680 billion cubic feet, the space heating demand is estimated to have accounted for about 28% of the total 1971 gas demand.

Oil for heating. Total sales of distillate heating oils in each State were determined from 1968 data in Petroleum Facts and Figures (4). On the assumption that all sales of this type of oil were actually used for space heating purposes, the fraction of the National total heating oil demand for space heating that was contributed by each State in 1968 was readily determined.

It is noteworthy that nearly 75% of the total National demand for heating oil was accounted for by only eleven states in the Northeast and northern Midwest. These states are Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Ohio, Indiana, Illinois, Michigan, Wisconsin, and Minnesota.

Total distillate heating oils consumed in the United States during 1968 aggregated to 508 million barrels. This was equivalent to roughly 2450×10^{12} Btu as the National space heating load met by oil in 1968.

Electricity for heating. Separating the electricity used for space heating from the total electric energy consumption in each State was more difficult than in the case of gas or oil inasmuch as no estimates of the space heating fraction could be found from either government or industry sources. Based on 1970 census data it was possible to obtain a ratio for each State of the number of occupied housing units heated electrically to the number of such units heated by gas. These ratios, together with the gas consumption data for space heating already noted, led to what is believed to be a fairly reliable estimate of the total space heating demand in each State met by electricity in 1971. In reaching this estimate, however, a uniform insulation factor of 0.8 was applied in recognition of the fact that housing units heated by electricity are generally better insulated than those heated by other fuels such as gas.

Total electricity consumed in the United States during 1971 for space heating purposes is estimated through the above procedure to have been 133 billion KWH, or about 454×10^{12} Btu. Compared to a total National electric power generation of 1638 billion KWH in 1970 (7), this represents about 8%.

LPG for heating. Data in Petroleum Facts and Figures (4) pertaining to total sales of LPG and ethane are inadequate to derive reliable estimates of the fractions of total sales in each State used for space heating. Thus, a procedure for estimating the total space heating demand for each State met by LPG was followed here which exactly parallels the procedure described above for estimating the demand met by electricity. The results of this procedure revealed no major inconsistencies with rough estimates possible from the total sales data in Petroleum Facts and Figures.

Total LPG sales in the United States during 1971 for space heating purposes is estimated to have aggregated to the equivalent of 450×10^{12} Btu.

Normalization of weights to average heating degree-days. The weighting factors for each fuel, to be applied in deriving suitably averaged National total heating degree-day data presented in this report, were adjusted from those obtained from the fuel sales data in specific years by due consideration of the temperature anomalies in each State during those years. In this way, the State weighting factors (listed in APPENDIX 2) were made to refer to normal weather conditions in each State rather than to the conditions prevailing in 1968 (in the case of oil) or in 1971 (in the case of all other fuels).

APPENDIX 2

ADJUSTED WEIGHTS RE-NORMALIZED TO YEAR OF ENERGY DATA

(Oil = 1968, Gas = 1971, Electric = 1971, LPG = 1971)

	Region #/ State	ALL FUELS (Population)	Gas	Oil	Electric	LPG
1.	Connecticut	0.0150	0.0060	0.0344	0.0117	0.0030
	Maine	0.0049	0.0001	0.0166	0.0012	0.0008
	Massachusetts	0.0281	0.0172	0.1006	0.0202	0.0065
	New Hampshire	0.0037	0.0007	0.0131	0.0022	0.0022
	Rhode Island	0.0047	0.0024	0.0128	0.0022	0.0009
	Vermont	0.0022	0.0002	0.0087	0.0023	0.0025
2.	New Jersey	0.0355	0.0288	0.0937	0.0172	0.0074
	New York	0.0902	0.0650	0.1779	0.0281	0.0182
	Pennsylvania	0.0583	0.0599	0.0796	0.0410	0.0133
3.	Illinois	0.0550	0.0984	0.0465	0.0342	0.0592
	Indiana	0.0257	0.0329	0.0325	0.0284	0.0368
	Michigan	0.0439	0.0733	0.0496	0.0258	0.0334
	Ohio	0.0527	0.0998	0.0309	0.0319	0.0275
	Wisconsin	0.0219	0.0236	0.0379	0.0080	0.0308
4.	Iowa	0.0140	0.0212	0.0148	0.0055	0.0469
	Kansas	0.0111	0.0195	0.0018	0.0059	0.0303
	Minnesota	0.0188	0.0216	0.0272	0.0099	0.0255
	Missouri	0.0231	0.0321	0.0130	0.0116	0.0854
	Nebraska	0.0073	0.0126	0.0045	0.0043	0.0261
	North Dakota	0.0031	0.0023	0.0070	0.0018	0.0085
	South Dakota	0.0033	0.0029	0.0054	0.0018	0.0124
5.	Delaware	0.0027	0.0014	0.0061	0.0016	0.0011

Region #/ State		ALL FUELS (Population)	Gas	Oil	Electric	LPG
	Florida	0.0336	0.0042	0.0119	0.0751	0.0549
	Georgia	0.0227	0.0159	0.0054	0.0245	0.0522
	Maryland	0.0232	0.0115	0.0246	0.0100	0.0052
	North Carolina	0.0251	0.0059	0.0258	0.0355	0.0208
	South Carolina	0.0128	0.0040	0.0095	0.0111	0.0160
	Virginia	0.0230	0.0125	0.0305	0.0265	0.0081
	West Virginia	0.0086	0.0103	0.0013	0.0062	0.0032
6.	Alabama	0.0171	0.0119	0.0008	0.0248	0.0436
	Kentucky	0.0159	0.0163	0.0039	0.0185	0.0240
	Mississippi	0.0110	0.0064	0.0006	0.0111	0.0353
	Tennessee	0.0194	0.0114	0.0043	0.1137	0.0185
7.	Arkansas	0.0095	0.0082	0.0005	0.0052	0.0284
	Louisiana	0.0180	0.0101	0.0009	0.0061	0.0131
	Oklahoma	0.0127	0.0131	0.0014	0.0068	0.0247
	Texas	0.0554	0.0321	0.0023	0.0267	0.0476
8.	Arizona	0.0088	0.0088	0.0003	0.0111	0.0060
	Colorado	0.0109	0.0219	0.0021	0.0084	0.0192
	Idaho	0.0035	0.0023	0.0104	0.0059	0.0038
	Montana	0.0034	0.0059	0.0019	0.0027	0.0082
	Nevada	0.0024	0.0021	0.0084	0.0161	0.0053
	New Mexico	0.0050	0.0059	0.0003	0.0018	0.0096
	Utah	0.0052	0.0093	0.0018	0.0029	0.0048
	Wyoming	0.0016	0.0032	0.0011	0.0010	0.0057
9.	California	0.0987	0.1319	0.0020	0.1135	0.0489
	Oregon	0.0104	0.0050	0.0124	0.0518	0.0067
	Washington	0.0169	0.0080	0.0210	0.0862	0.0075

APPENDIX 3

CENSUS REGIONS OF THE UNITED STATES

1.	NEW ENGLAND	Connecticut Maine	Massachusetts New Hampshire	Rhode Island Vermont
2.	MIDDLE ATLANTIC	New Jersey	New York	Pennsylvania
3.	EAST NORTH CENTRAL	Illinois Indiana	Michigan Ohio	Wisconsin
4.	WEST NORTH CENTRAL	Iowa Kansas Minnesota	Missouri Nebraska North Dakota	South Dakota
5.	SOUTH ATLANTIC[1]	Delaware Florida Georgia	Maryland North Carolina South Carolina	Virginia West Virginia D.C.
6.	EAST SOUTH CENTRAL	Alabama Kentucky	Mississippi	Tennessee
7.	WEST SOUTH CENTRAL	Arkansas Louisiana	Oklahoma	Texas
8.	MOUNTAIN	Arizona Colorado Idaho	Montana Nevada New Mexico	Utah Wyoming
9.	PACIFIC[2]	California	Oregon	Washington

[1] D.C. combined into Virginia for purposes of degree-day analysis in this study.

[2] Pacific Division normally includes also Alaska and Hawaii, omitted in this study.

APPENDIX 4

REGIONAL AVERAGE DEGREE DAYS (REGION # 1)
WEIGHTED BY

HEATING SEASON	POPULATION	GAS	OIL	ELECTRIC	LPG
31/32	5823	5595	5880	5756	6079
32/33	5967	5760	6009	5910	6191
33/34	7006	6747	7061	6929	7279
34/35	6733	6480	6787	6661	6994
35/36	6526	6299	6569	6464	6767
36/37	6175	5933	6227	6109	6439
37/38	6376	6161	6424	6313	6604
38/39	6420	6158	6474	6342	6689
39/40	7039	6826	7079	6986	7272
40/41	6664	6433	6702	6603	6889
41/42	6063	5814	6103	5991	6295
42/43	6841	6590	6885	6775	7097
43/44	6728	6453	6763	6663	6991
44/45	6409	6161	6445	6345	6650
45/46	6492	6233	6532	6419	6737
46/47	6267	5992	6303	6194	6527
47/48	6834	6584	6874	6766	7080
48/49	5696	5454	5737	5622	5921
49/50	6356	6102	6402	6283	6616
50/51	5986	5752	6034	5921	6236
51/52	6191	5940	6248	6118	6472
52/53	5877	5664	5924	5810	6102
53/54	5962	5735	6011	5889	6199
54/55	6215	5980	6262	6143	6460
55/56	6885	6653	6931	6817	7137
56/57	6328	6064	6374	6246	6582
57/58	6338	6114	6365	6296	6590
58/59	6761	6489	6810	6684	7034
59/60	6177	5959	6217	6116	6406
60/61	6908	6677	6948	6847	7146
61/62	6391	6171	6432	6323	6602
62/63	6993	6751	7030	6932	7235
63/64	6517	6294	6561	6447	6734
64/65	6815	6568	6867	6737	7061
65/66	6682	6455	6728	6616	6917
66/67	6846	6606	6894	6771	7082
67/68	6793	6572	6844	6725	7028
68/69	6503	6282	6561	6435	6760
69/70	6812	6610	6852	6765	7047
70/71	6829	6606	6887	6758	7074
71/72	6561	6322	6623	6479	6810
72/73	6429	6188	6487	6349	6671
AVERAGES	6481	6244	6527	6413	6726
S.D.	354.55	352.89	354.42	355.29	357.26

REGIONAL AVERAGE DEGREE DAYS (REGION # 2)
WEIGHTED BY

HEATING SEASON	POPULATION	GAS	OIL	ELECTRIC	LPG
31/32	4968	4942	4967	4898	4960
32/33	5379	5364	5371	5338	5374
33/34	6294	6259	6303	6204	6283
34/35	6021	5987	6065	5944	6011
35/36	6067	6057	6048	6035	6064
36/37	5526	5508	5516	5475	5521
37/38	5641	5623	5630	5593	5635
38/39	5590	5564	5591	5522	5582
39/40	6386	6361	6386	6321	6378
40/41	5921	5901	5923	5870	5915
41/42	5348	5324	5350	5287	5341
42/43	5998	5967	6000	5918	5988
43/44	6012	5991	6005	5956	6005
44/45	5779	5763	5766	5734	5774
45/46	5655	5633	5643	5595	5648
46/47	5602	5594	5578	5573	5600
47/48	5999	5968	6001	5919	5990
48/49	5101	5095	5077	5078	5099
49/50	5596	5578	5582	5545	5590
50/51	5466	5482	5428	5497	5471
51/52	5485	5486	5459	5481	5485
52/53	5248	5251	5225	5249	5249
53/54	5301	5297	5285	5287	5300
54/55	5529	5521	5512	5503	5527
55/56	6063	6046	6051	6016	6058
56/57	5467	5452	5456	5424	5462
57/58	5908	5910	5879	5905	5909
58/59	5965	5951	5947	5924	5961
59/60	5616	5614	5586	5604	5616
60/61	6217	6219	6193	6215	6218
61/62	5663	5661	5638	5652	5662
62/63	6370	6371	6340	6364	6370
63/64	5806	5812	5776	5813	5808
64/65	5972	5969	5948	5960	5971
65/66	5975	5972	5958	5963	5974
66/67	6068	6062	6053	6049	6066
67/68	6140	6141	6116	6136	6141
68/69	5817	5809	5802	5791	5815
69/70	6242	6245	6218	6243	6243
70/71	5956	5949	5938	5933	5954
71/72	5688	5677	5670	5655	5684
72/73	5672	5667	5650	5653	5671
AVERAGES	5774	5763	5760	5741	5771
S.D.	339.73	339.12	341.59	339.28	339.52

REGIONAL AVERAGE DEGREE DAYS (REGION # 3)
WEIGHTED BY

HEATING SEASON	POPULATION	GAS	OIL	ELECTRIC	LPG
31/32	5284	5229	5472	5163	5348
32/33	6048	5984	6257	5923	6141
33/34	6311	6271	6475	6190	6317
34/35	6193	6134	6404	6048	6252
35/36	6871	6811	7071	6746	6950
36/37	6257	6193	6469	6125	6341
37/38	6053	5999	6244	5929	6108
38/39	5865	5812	6054	5736	5908
39/40	6591	6548	6744	6491	6619
40/41	6062	6020	6218	5945	6087
41/42	5679	5635	5839	5570	5720
42/43	6562	6504	6774	6414	6624
43/44	6303	6262	6463	6184	6334
44/45	6246	6205	6400	6130	6271
45/46	6019	5969	6199	5891	6065
46/47	6283	6232	6466	6156	6332
47/48	6272	6222	6452	6151	6321
48/49	5780	5727	5960	5662	5860
49/50	6162	6095	6388	6025	6249
50/51	6572	6506	6775	6454	6673
51/52	6258	6197	6464	6132	6343
52/53	5886	5829	6073	5776	5962
53/54	5644	5595	5813	5540	5692
54/55	5866	5809	6050	5757	5930
55/56	6364	6305	6556	6247	6418
56/57	5949	5887	6159	5826	6024
57/58	6406	6359	6559	6318	6460
58/59	6433	6372	6631	6319	6499
59/60	6474	6415	6657	6378	6553
60/61	6361	6320	6500	6278	6390
61/62	6342	6283	6528	6237	6435
62/63	6787	6737	6956	6688	6830
63/64	6019	5978	6147	5944	6058
64/65	6495	6431	6705	6371	6576
65/66	6312	6257	6492	6206	6370
66/67	6388	6331	6579	6280	6449
67/68	6493	6452	6629	6411	6525
68/69	6399	6344	6568	6303	6471
69/70	6730	6681	6887	6637	6757
70/71	6491	6429	6683	6384	6568
71/72	6164	6100	6369	6035	6237
72/73	6171	6116	6351	6068	6244
AVERAGES	6234	6181	6416	6121	6294
S.D.	319.93	319.46	320.32	322.93	321.71

REGIONAL AVERAGE DEGREE DAYS (REGION # 4)
WEIGHTED BY

HEATING SEASON	POPULATION	GAS	OIL	ELECTRIC	LPG
31/32	5787	5567	6694	5805	5415
32/33	6530	6299	7466	6545	6144
33/34	6063	5825	7030	6071	5657
34/35	6342	6101	7329	6352	5940
35/36	7367	7096	8455	7379	6942
36/37	6914	6672	7903	6930	6504
37/38	6275	6037	7249	6288	5874
38/39	6098	5850	7096	6117	5672
39/40	6647	6447	7458	6653	6321
40/41	6166	5956	7028	6177	5804
41/42	5927	5732	6718	5940	5607
42/43	6774	6508	7866	6784	6323
43/44	6502	6308	7300	6511	6169
44/45	6406	6186	7305	6415	6043
45/46	6204	5952	7224	6217	5785
46/47	6674	6431	7657	6691	6265
47/48	6544	6307	7490	6564	6143
48/49	6541	6330	7405	6558	6187
49/50	6738	6457	7867	6758	6283
50/51	7031	6779	8066	7038	6619
51/52	6752	6512	7731	6767	6357
52/53	6331	6116	7228	6336	5963
53/54	5943	5718	6855	5959	5553
54/55	6144	5921	7063	6158	5755
55/56	6875	6612	7939	6895	6438
56/57	6342	6110	7285	6359	5943
57/58	6544	6372	7263	6547	6252
58/59	6526	6303	7456	6532	6150
59/60	7028	6821	7885	7034	6689
60/61	6355	6157	7179	6358	6024
61/62	6911	6696	7812	6917	6554
62/63	6494	6289	7355	6494	6145
63/64	6100	5909	6884	6110	5780
64/65	6941	6675	8035	6955	6497
65/66	6553	6297	7593	6571	6127
66/67	6550	6291	7604	6568	6109
67/68	6517	6311	7347	6530	6181
68/69	6904	6686	7787	6917	6553
69/70	6857	6626	7799	6866	6474
70/71	6789	6565	7722	6798	6400
71/72	6474	6211	7552	6488	6031
72/73	6683	6487	7493	6696	6334
AVERAGES	6527	6298	7464	6539	6143
S.D.	341.07	333.88	385.48	340.59	334.52

REGIONAL AVERAGE DEGREE DAYS (REGION # 5)
WEIGHTED BY

HEATING SEASON	POPULATION	GAS	OIL	ELECTRIC	LPG
31/32	2354	2865	2942	1746	1594
32/33	2809	3401	3443	2121	1981
33/34	3133	3759	3884	2366	2174
34/35	2972	3562	3690	2254	2063
35/36	3373	4007	4090	2619	2452
36/37	2841	3421	3513	2147	1980
37/38	2972	3551	3638	2281	2119
38/39	2770	3347	3421	2092	1932
39/40	3574	4208	4295	2815	2659
40/41	3203	3799	3891	2487	2328
41/42	2905	3443	3481	2274	2161
42/43	3029	3634	3728	2302	2130
43/44	3116	3734	3822	2375	2210
44/45	3003	3600	3683	2294	2122
45/46	2917	3491	3565	2235	2093
46/47	2969	3559	3625	2277	2131
47/48	3052	3655	3768	2307	2152
48/49	2571	3139	3190	1909	1773
49/50	2740	3309	3382	2064	1912
50/51	3168	3750	3797	2477	2353
51/52	2848	3421	3492	2166	2011
52/53	2874	3436	3467	2220	2105
53/54	2841	3403	3440	2185	2056
54/55	3016	3580	3635	2353	2209
55/56	3214	3829	3915	2479	2313
56/57	2676	3230	3302	2018	1862
57/58	3483	4098	4123	2769	2651
58/59	3103	3727	3769	2370	2235
59/60	3248	3860	3865	2544	2444
60/61	3351	4004	4066	2577	2428
61/62	3059	3664	3739	2358	2193
62/63	3432	4092	4124	2670	2527
63/64	3347	3958	3972	2699	2545
64/65	3088	3710	3789	2347	2193
65/66	3290	3908	3965	2559	2432
66/67	3162	3783	3864	2426	2263
67/68	3441	4096	4128	2682	2555
68/69	3396	3994	4007	2703	2616
69/70	3520	4166	4215	2766	2626
70/71	3242	3863	3896	2519	2396
71/72	2805	3397	3452	2112	1960
72/73	3050	3641	3696	2354	2228
AVERAGES	3070	3669	3733	2363	2216
S.D.	268.68	295.96	291.10	240.07	248.71

REGIONAL AVERAGE DEGREE DAYS (REGION # 6)
WEIGHTED BY

HEATING SEASON	POPULATION	GAS	OIL	ELECTRIC	LPG
31/32	2457	2575	2870	2609	2207
32/33	3214	3334	3677	3419	2927
33/34	3082	3231	3614	3286	2758
34/35	2950	3079	3420	3137	2661
35/36	3631	3777	4171	3842	3307
36/37	3104	3241	3603	3293	2807
37/38	3060	3186	3525	3249	2772
38/39	3001	3123	3472	3208	2710
39/40	3877	4016	4384	4077	3566
40/41	3334	3455	3791	3534	3049
41/42	3245	3351	3651	3421	2995
42/43	3182	3316	3698	3408	2862
43/44	3311	3440	3801	3521	3007
44/45	3211	3352	3740	3427	2890
45/46	3127	3245	3566	3310	2855
46/47	3344	3476	3846	3555	3037
47/48	3295	3421	3766	3480	3013
48/49	2932	3051	3393	3133	2648
49/50	2935	3079	3449	3127	2625
50/51	3543	3682	4051	3745	3230
51/52	3118	3252	3604	3311	2819
52/53	3252	3365	3686	3448	2980
53/54	3185	3301	3622	3376	2910
54/55	3249	3371	3701	3441	2966
55/56	3423	3558	3914	3620	3119
56/57	2895	3028	3355	3059	2618
57/58	3863	3991	4328	4051	3574
58/59	3521	3651	3985	3696	3238
59/60	3786	3910	4255	3982	3498
60/61	3653	3792	4148	3842	3348
61/62	3433	3566	3915	3617	3144
62/63	3797	3938	4305	3994	3485
63/64	3730	3843	4156	3918	3461
64/65	3404	3533	3888	3606	3107
65/66	3563	3696	4061	3773	3252
66/67	3385	3514	3866	3586	3089
67/68	3854	3986	4364	4081	3535
68/69	3828	3945	4294	4054	3528
69/70	3939	4072	4463	4185	3607
70/71	3651	3773	4130	3875	3345
71/72	3047	3170	3525	3269	2745
72/73	3524	3633	3973	3745	3240
AVERAGES	3356	3484	3834	3555	3060
S.D.	331.18	332.59	341.94	339.93	323.87

REGIONAL AVERAGE DEGREE DAYS (REGION # 7)
WEIGHTED BY

HEATING SEASON	POPULATION	GAS	OIL	ELECTRIC	LPG
31/32	1799	1902	2004	1845	2019
32/33	2285	2405	2518	2330	2570
33/34	1903	2021	2135	1941	2191
34/35	1857	1977	2098	1891	2142
35/36	2463	2597	2730	2507	2783
36/37	2384	2517	2650	2438	2678
37/38	2012	2130	2253	2047	2285
38/39	2062	2175	2285	2104	2328
39/40	2516	2640	2761	2551	2827
40/41	2270	2389	2506	2309	2550
41/42	2293	2401	2508	2325	2554
42/43	2081	2207	2335	2118	2379
43/44	2294	2422	2551	2338	2585
44/45	2139	2266	2391	2183	2440
45/46	2101	2212	2320	2136	2375
46/47	2356	2476	2594	2399	2632
47/48	2445	2577	2709	2489	2749
48/49	2227	2373	2523	2283	2545
49/50	1900	2039	2184	1941	2223
50/51	2236	2371	2508	2268	2569
51/52	2001	2139	2280	2038	2329
52/53	2134	2253	2372	2167	2422
53/54	2082	2188	2292	2115	2344
54/55	2047	2158	2267	2079	2321
55/56	2200	2333	2466	2239	2525
56/57	2001	2139	2279	2049	2314
57/58	2595	2720	2847	2631	2893
58/59	2413	2527	2639	2450	2688
59/60	2657	2790	2927	2695	2972
60/61	2324	2438	2548	2358	2603
61/62	2380	2510	2639	2420	2690
62/63	2369	2479	2592	2393	2644
63/64	2480	2580	2681	2506	2722
64/65	2292	2420	2551	2334	2590
65/66	2266	2370	2474	2296	2519
66/67	2100	2208	2317	2126	2364
67/68	2519	2638	2755	2553	2808
68/69	2459	2589	2724	2488	2775
69/70	2515	2643	2772	2547	2826
70/71	2185	2322	2467	2210	2519
71/72	1895	2019	2147	1931	2183
72/73	2753	2877	2999	2806	3027
AVERAGES	2245	2368	2490	2283	2536
S.D.	228.91	230.44	232.33	229.29	234.19

REGIONAL AVERAGE DEGREE DAYS (REGION # 8)
WEIGHTED BY

HEATING SEASON	POPULATION	GAS	OIL	ELECTRIC	LPG
31/32	5900	6330	7280	5437	6424
32/33	6147	6599	7505	5655	6694
33/34	4481	4875	5373	3986	4987
34/35	5346	5788	6665	4837	5902
35/36	5596	6070	6959	5043	6202
36/37	6051	6521	7413	5573	6639
37/38	5239	5707	6297	4731	5832
38/39	5654	6119	6681	5135	6198
39/40	5120	5598	6062	4531	5713
40/41	5382	5843	6371	4850	5922
41/42	5943	6448	7223	5400	6520
42/43	5301	5791	6715	4743	5921
43/44	5785	6254	6893	5261	6335
44/45	5659	6128	6834	5141	6235
45/46	5437	5868	6638	4944	5957
46/47	5664	6179	6830	5057	6272
47/48	5819	6296	6900	5328	6379
48/49	6095	6559	7489	5683	6676
49/50	5534	6011	7053	5027	6149
50/51	5559	6062	6732	4877	6229
51/52	5983	6440	7344	5464	6562
52/53	5457	5898	6546	4964	6000
53/54	5082	5490	6242	4614	5616
54/55	5784	6203	7326	5354	6305
55/56	5438	5897	6830	4922	6041
56/57	5606	6076	7069	5118	6195
57/58	5487	5917	6552	4995	6013
58/59	5325	5801	6509	4760	5931
59/60	5751	6219	7099	5214	6325
60/61	5364	5809	6441	4845	5901
61/62	6051	6563	7368	5527	6649
62/63	5366	5828	6537	4875	5916
63/64	5890	6331	7162	5371	6370
64/65	5849	6356	7005	5279	6452
65/66	5619	6103	6733	5081	6192
66/67	5494	5971	6648	5013	6046
67/68	5691	6214	6786	5047	6266
68/69	5822	6318	7052	5265	6417
69/70	5717	6226	6817	5134	6301
70/71	5841	6348	7076	5286	6431
71/72	5665	6146	7012	5166	6238
72/73	6308	6857	7336	5674	6892
AVERAGES	5626	6097	6843	5100	6196
S.D.	334.22	350.94	422.80	336.23	341.35

REGIONAL AVERAGE DEGREE DAYS (REGION # 9)
WEIGHTED BY

HEATING SEASON	POPULATION	GAS	OIL	ELECTRIC	LPG
31/32	3544	3204	5560	4504	3582
32/33	3701	3353	5762	4682	3740
33/34	2645	2340	4455	3507	2676
34/35	3288	2955	5262	4228	3325
35/36	3225	2842	5490	4303	3266
36/37	3589	3232	5701	4594	3628
37/38	3081	2760	4983	3986	3117
38/39	3293	2967	5229	4215	3329
39/40	2674	2354	4569	3576	2711
40/41	2935	2634	4718	3783	2972
41/42	3388	3060	5327	4311	3429
42/43	3151	2774	5384	4214	3193
43/44	3413	3088	5331	4326	3452
44/45	3468	3167	5247	4315	3503
45/46	3391	3060	5350	4323	3429
46/47	3317	2968	5383	4300	3355
47/48	3634	3308	5565	4553	3671
48/49	3958	3603	6059	4958	3997
49/50	3588	3181	5999	4736	3631
50/51	3148	2789	5276	4161	3184
51/52	3650	3307	5681	4617	3687
52/53	3357	3045	5198	4233	3394
53/54	3182	2819	5335	4207	3220
54/55	3647	3267	5899	4719	3692
55/56	3511	3114	5869	4634	3551
56/57	3270	2882	5571	4365	3314
57/58	3096	2804	4823	3918	3130
58/59	2771	2390	5023	3843	2810
59/60	3128	2722	5527	4270	3172
60/61	3147	2823	5067	4061	3182
61/62	3556	3203	5646	4551	3596
62/63	3317	2989	5256	4240	3355
63/64	3458	3132	5388	4376	3498
64/65	3428	3065	5577	4451	3465
65/66	3242	2914	5186	4167	3280
66/67	3337	3031	5152	4201	3373
67/68	2957	2633	4946	3909	3006
68/69	3504	3149	5602	4503	3541
69/70	3107	2740	5284	4143	3149
70/71	3534	3158	5755	4591	3575
71/72	3408	3034	5621	4461	3447
72/73	3509	3169	5526	4469	3545
AVERAGES	3323	2977	5371	4298	3361
S.D.	275.49	270.39	358.13	305.18	276.30

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