ENERGY USE IN AGRICULTURAL PROCESSING: A SUMMARY OF SELECTED INDUSTRY GROUPS IN THE MIDWEST

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ENERGY USE IN AGRICULTURAL PROCESSING: A SUMMARY OF SELECTED INDUSTRY GROUPS IN THE MIDWEST

Summary of Important Findings

This report presents energy use data from a random sample of midwestern firms involved in food processing and related activities. The data indicated (1) the importance of specific fuels in several food industries, (2) a relationship between fuels used and firm size, and (3) the nature of seasonal demand for various fuels in those industries.

Importance of Individual Fuels

Most fuels are used in generally characteristic ways: gasoline usually serves as a motor fuel, natural gas mostly serves as a source of heat energy. So, the fuels consumed in a particular industry reflect (1) the physical activities carried out in that industry, (2) the proportion of smaller firms and larger firms, (3) available technology--which determines what fuels are applicable to a given physical activity--and (4) relative prices of fuels.

It is not surprising, for instance, that natural gas was the most important energy source among sample firms. Natural gas has been one of the least expensive energy sources, at least in the last three to four decades. Most firms in the sample performed some type of processing which required heat energy; and almost all firms required some space heating. Technology is rarely limiting in applications requiring direct heating via natural gas.

In Table I, fuels are ranked according to their importance to the entire sample. The proportion of the sample's energy supplied by each fuel, and characteristic uses of each fuel are also presented.

Table I

Energy Supplied by Major Fuels,
and Characteristic Uses

FUEL	Percentage of Energy Supplied	Characteristic Uses
Natural Gas	61.3	HEAT ENERGY: direct heating, process steam, etc.
Fuel Oil	15.8	HEAT ENERGY: direct heating, process steam, etc.
Electricity	12.4	PHYSICAL ENERGY: motors: refrigeration, materials handling, etc.
LP Gas	3.9	HEAT ENERGY: direct heating, process steam, space heating, etc.
Coal	2.9	(Insufficient observations)
Diesel	2.2	MOTOR FUEL: heavy truck transportation, some deliveries, etc.
Gasoline	1.5	MOTOR FUEL: mostly smaller vehicles, for deliveries, etc.
TOTAL	100.0	

Natural gas and fuel oil were mainly utilized as sources of heat energy. They were extremely important in large scale, industrial-type processing activities. Examples are: meat packing, fruit and vegetable canning, and oilseed (soybean) processing.

Electricity was sometimes used in heating, but more often served as a source of physical energy: to drive compressors in refrigeration; or to extrude, grind, mix, or move materials in the production process. Lighting was a widespread use of electricity, but was of relatively minor importance as a proportion of total electricity consumed. Among firms in the sample, large-scale processing operations were again the chief users of electricity. However, as a proportion of energy consumed by individual firms, electricity was generally more important to small firms: grain elevators, warehouses, freezer provisioners, etc. Electricity powered a wider variety of functions in small firms than in large ones. Large firms also benefitted from technologic and economic efficiencies that accrue to size. That is to say, economies of size in electric energy use were evident in most industry groups.

LP gas was most commonly used as a heat energy source. Among large firms in the sample it was often used along with, or as a substitute for, natural gas and fuel oil. Like electricity, though, LP gas was more important to small firms; especially grain elevators and farm suppliers/grain handlers. Ready availability in rural and small urban areas may have contributed to greater LP gas use by small firms. Small firms were more often located away from natural gas pipelines.

Coal appeared to be relied on mostly for heat energy. However, coal use in this sample was not widespread. Since coal was important to only 5 percent of sample firms, generalizations about how coal is used in Midwest food processing cannot be drawn from the data.

Diesel and gasoline are most important as motor fuels. Among sample firms,

transportation of raw and finished products was the major use of these two fuels. Both were also used in processing, but to a very limited extent. Diesel fuel and gasoline were relied on most heavily by wholesalers, warehouses, and farm supply retailers. Transportation was a major function of these firms.

Fuel Type/Firm Size Relationship

The discussion immediately above suggests that some fuels were used to a greater extent by large firms involving heavy-industry, while other fuels were relied upon more by small firms. This fuel type/firm size relationship was tested using simple regression analysis. The percentage of energy derived from diesel, gasoline, electricity, and LP gas (combined) was found negatively related to firm size. The percentage of energy derived from natural gas and fuel oil (combined) was found positively related to firm size. Both relationships were significant at the 0.001 level.

Seasonal Energy Consumption

Demands for specific fuels were quite seasonal in many of the industry groups studied. Such seasonal consumption seemed most related to variations in throughput, though respondents' throughput data were inadequate to allow statistical inference on this point. Climatic conditions also effect fuel consumption: seasonal demands for heating and refrigeration energy were greatest in winter and summer, respectively.

Some fuels exhibited seasonal consumption patterns which were similar across most industries. Natural gas consumption often fell in winter, especially among large firms. This was because they had interruptable-service gas contracts. Fuel oil and LP gas were common substitutes for natural gas during winter, and were sole sources of winter energy for space heating in many firms. Electricity exhibited little seasonality except where it was used in refrigeration systems (creating high summer demand) or in highly seasonal activities such as vegetable

canning. Use of diesel fuel and gasoline appeared mostly related to transportation activity.

Energy Use in Agricultural Processing: A Summary of Selected Industry Groups in the Midwest

Introduction

Food-related activities in the U.S., including agricultural production, involve about 16.5 percent of the nation's total annual energy consumption. Processing raw food products, transporting, and marketing to the final consumer together account for about two-fifths of this 16.5 percent--more than twice the energy needed for agricultural production of food.[1] Yet, a little data is available on energy consumed in getting food from its raw state to the form consumers take home from grocery stores or eat at restaurants.

This report addresses energy use in food processing, food marketing, and related industries. Results from a survey of midwestern firms in various food industries help describe (1) quantities of each energy source used, (2) seasonal consumption of each energy source, and (3) other energy use characteristics of these industries. This information should enable more informed discussion and decisions concerning (a) fuel allocation to specific food industries, (b) timing of allocations with need, and (c) conservation of energy within food industries.

The report is organized into three sections. First, data sources and reporting methods are described. Second, typical functional roles and importance of each fuel are discussed, along with fuel type/firm size relationships. Finally,

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[1] The 16.5 percent of annual energy consumed in food-related activities is broken down as follows: 2.9 percent for agricultural production; 6.5 percent for processing, transportation, and marketing, and 7.1 percent for cooking and other food preparation by customers.

total and seasonal reliance on particular fuels are described for eight major food industry groups.

Data Sources and Reporting Methods

The Sample

Energy data were gathered from a random sample of midwestern food and feed processing and marketing firms, drawn from a master list maintained by the Agricultural Stabilization and Conservation Service (ASCS). Slightly over 200 firms completed usable questionnaires. Firms provided data on (1) the quantity, type, and gross value of products/services produced, (2) quantities of each energy source--fossil fuels, electricity, etc.--consumed each month, from April 1977 through March 1978, and energy conservation measures they had initiated.

Geographically, the sample was drawn from North Central and Great Plains states (Illinois, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin). The sample represented a random cross section of most food-related industries in this region. However, data from the sample cannot be considered random: bias may have existed among firms responding to the mail questionnaire.

Respondent Classifications

Respondent firms were grouped according to their three-digit Standard Industrial Classification (SIC) codes.[1] Results are reported for each of these SIC groups (see Table 1). Other classifications--based on specific products, industries, gross sales categories, etc--are also used, but mainly to help explain energy usage patterns for the broader, three-digit SIC groupings.

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[1]The Standard Industrial Classification is a four digit code designed by the Office of Management and Budget, U.S. government, to standardize reporting of industry statistics. The code defines industries based on the type of economic activity they involve. Since our data was classed based on the first three digits of the code it is categorized into broader industry groups than defined by all four digits of the code.

Table 1

TYPES OF FIRMS RESPONDING TO THE MAIL QUESTIONNAIRE

SIC Code	SIC Group Name	Types of Firms Responding
201	Meat Products	Pork, poultry, beef, and mixed-specie meat packers; sausage, cured meat and other prepared meat processors; frozen, dried, and liquid egg producers.
202	Dairy Products	Fluid milk receiving and processing plants; nonfat dry milk, powdered milk, and condensed milk processors; cheese producers; butter producers.
203	Canned and Preserved Fruits and Vegetables	Fruit, fruit juice, and vegetable canners and processors; fruit products (pie fillings, fruit glazes, etc.) producers.
204	Grain Mill Products	Farm service and supply firms; corn (corn starch, dextrose, hominy, grits) processors; livestock feed manufacturers.
207	Fats and Oils	Soybean oil, meal, flour and soybean milk producers.
422	Public Warehousing	Cold storage food product warehouses; potato warehouses; grain cluster and warehousing firms.
514	Groceries and Related Products	Food storage warehouses; egg handlers.
542	Meat and Fish (Seafood) Markets, Including Freezer Provisioners	Freezer and locker provisioners; custom meat and meat product processors.

NOTE: Data collected for SICs 205, 206, 208, and 209 contained too few observations to report separately. Observations from these SICs are included, however, in data aggregated for the entire sample.

BTU Conversions

Firms in the sample were asked to report quantities of coal, diesel fuel, electricity, fuel oil, gasoline, liquified petroleum gas (LP gas), and natural gas used in all parts of their operations. Reported fuel quantities were converted to British thermal units (Btus). (See Table 2 for the conversion factors used.) This conversion allowed comparison of the energy obtained from each fuel, rather than just comparing fuel quantities.

Uses and Importance of Energy Sources in the Food Industry

Importance of Specific Fuels

Table 3 shows how fuels ranked in importance to the entire sample.

Natural gas was by far the most important energy source. It provided nearly two-thirds of all energy consumption reported by the sample. This substantial use of natural gas is due, in considerable measure, to its availability and favorable price. Natural gas was used most heavily by large industrial-type processing firms. Smaller firms in the sample--those involved in service activities, transportation, retailing, etc.--on average used less total energy, but also had a proportionally smaller reliance on natural gas. In general, the most important uses of natural gas were in direct heating and in heating water to produce process steam.

Like natural gas, fuel oil use appeared heaviest among large firms. Apparently, firms on interruptable-service natural gas contracts tended to substitute fuel oil for natural gas when supplies of the latter were limited. This could be a major reason for fuel oil to rank second to natural gas in energy importance. Major uses of fuel oil were likely the same as for natural gas: direct heating, and heating water to produce steam piped into plant processes.

Electricity was an important and fairly universal power supply for both large and small firms. However, small firms in the sample tended to use larger propor-

Table 2

FUEL-BTU CONVERSION FACTORS

Fuel	Unit	BTUs per Unit
Coal	Ton	22,800,000
Diesel Fuel	Gallon	138,700
Electricity	Kilowatt Hour	3,412
Fuel Oil	Gallon	138,700
Gasoline	Gallon	125,000
LP Gas	Gallon	95,500
Natural Gas	Cubic Foot	1,021

NOTE: BTU Values are amounts theoretically obtainable from each fuel unit. Energy inefficiencies in the production or consumption of these fuels are not accounted for.

Table 3

PERCENTAGE OF TOTAL ANNUAL ENERGY NEEDS
MET BY VARIOUS FUELS, FOR THE
ENTIRE SAMPLE

Fuel	Percentage of Energy Supplied
Natural Gas	61.3
Fuel Oil	15.8
Electricity	12.4
LP Gas	3.9
Coal	2.9
Diesel	2.2
Gasoline	1.5
TOTAL	100.0

tions of electricity than did large firms. Large firms may tend to use energy sources (i.e., natural gas) which have historically been cheaper than electricity, for plant operations which small firms accomplish via electricity (i.e., refrigeration). Uses of electricity were quite varied but typically included refrigeration, grinding, crushing, mixing, and material movement through production processes.

LP gas was more likely to be relied upon by small firms than large firms. Availability could be a factor in this pattern. Small plants are often located away from a natural gas pipeline, but large firms have tended to locate where there was natural gas due to cost considerations. Indications are that LP gas applications commonly involved space heating or direct heating in plant processes (such as grain drying).

Coal use by firms in this sample is not likely representative of the food industry. Only a handful of firms reported using any coal at all. Moreover, 99 percent of the coal consumed was used by one extremely large plant. Therefore, though coal provided more total energy to the sample than did either gasoline or diesel, results should not be considered representative of the food processing industry.

The data on diesel and gasoline use is the least reliable in this study. Some firms reported only diesel and gasoline used directly in processing. Others reported diesel and gasoline used for transportation. Thus, our data overestimate the diesel and gasoline used for transportation. Thus, our data overestimate the diesel and gasoline used directly for processing, but under-report the amount used for transportation of raw and/or processed commodities. We do know that smaller firms reported a proportionally heavier use of diesel and gasoline use than did larger firms. This may have resulted from the considerable involvement of small firms in product distribution, service, and retailing activities.

Fuel Type/Firm Size Relationships

As noted above, the use of certain fuels appeared related to firm size. Large firms (as measured by value of gross sales) relied most heavily on natural gas and fuel oil, while small firms relied more heavily on diesel fuel, gasoline, electricity, and LP gas. To test this relationship a regression analysis was completed, using the percentage of energy each firm obtained from various fuels as a dependent variable of gross sales.[1]

Figure 1 shows the estimated statistical relationship between firm size and type of energy consumed. The solid line in Figure 1 represents the percentage of total energy which firms obtained from diesel, gasoline, electricity, and LP gas combined. The percentage of energy obtained from these fuels decreases, moving from left to right in Figure 1, while average firm size increases. The broken (dotted) line in Figure 1 represents the percentage of total energy obtained from natural gas and fuel oil, combined. As firm sizes increase firms tend to derive a larger proportion of their energy from natural gas and fuel oil, combined.

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[1] Equations (1) and (2) resulted from the regression analysis. Neither model has a high coefficient of determination (R^2), which attests to the extreme variability in factors affecting fuel use among firms, and to the problem of using gross sales as a measure of firm size. However, t-tests on parameter estimates for the independent variable, gross sales, were significant at the 0.0001 level in both models.

(1) Percentage of total energy from diesel, gasoline, electricity, and LP gas, combined. $= \left(\text{sine } (2.046 - 0.084 \cdot \log_e \text{ gross sales})\right)^2$, $R^2 = 0.1219$

(2) Percentage of total energy from natural gas and fuel oil, combined. $= \left(\text{sine } (-0.52 + 0.086 \cdot \log_e \text{ gross sales})\right)^2$, $R^2 = 0.1256$

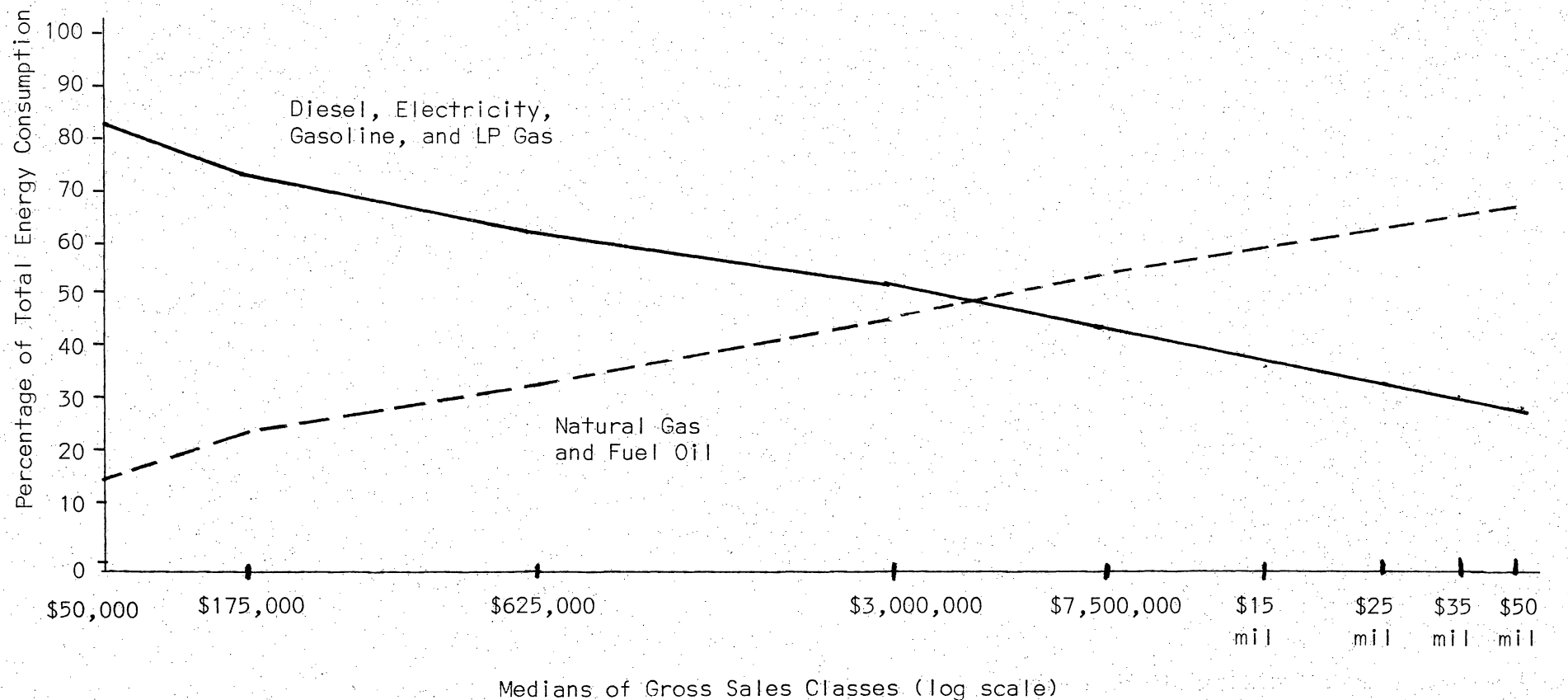
To stabilize variance in the error terms an arc sine transformation was used on the dependent variable. Thus the original form of the model was:

$$2 \cdot \text{arc sine } (Y_i) = \beta_o + \beta_1 (X_i)$$

where Y_i is the value of the dependent variable in the ith observation, β_o and β_1 are parameters, and X_i is the value of the independent variable on the ith trial.

Figure 1

Percentage of Total Energy Derived From Selected Fuel Groups, by Gross Sales



This statistical relationship between energy source and firm size was quite strong. That is, there is only a very small chance that the estimated relationship does not represent the true fuel/type firm size relationship.

Fuel Consumption and Seasonality for Eight Food Industry Groups

As discussed in the previous section, reliance on particular fuels was generally found related to plant size and to type of physical activity performed (cooking, grinding, cooling, space heating, etc.). Variations in seasonal consumption of fuels was found related to plant throughput and to type of physical activity performed. In this section the energy contribution of major fuels, and seasonal consumption of those fuels, are described for eight food industry groups.

How the Data are Presented

As mentioned, respondent firms were classed into eight groups based on their three-digit Standard Industrial Classification codes. Within some groups subgroups were also identified. These subgroups represented more narrowly defined industries than did the three-digit SIC groupings.

Tables in this section show, for each group or subgroup, (1) the percentage of total energy consumption coming from each fuel, (2) seasonal consumption of each fuel and (3) seasonal consumption of all fuels combined. The percentage of total energy supplied by each fuel (item 1) was computed by dividing the BTU contribution of that fuel by the group's total reported BTU consumption. Seasonal consumption of each fuel (item 2) and of all fuels combined (item 3) are presented as monthly energy use indexes. These indexes were computed by dividing fuel consumption in a given month by the average monthly consumption of that fuel (or fuels).

To examine energy consumed in processing separately from that consumed in transportation, gasoline and diesel fuel were assumed to be used only for transportation. This assumption facilitates examining the energy supplied by fuels which are used almost solely in processing and/or plant operations. Though not

entirely valid, the assumption reasonably represents reality: only small amounts of gasoline and diesel fuel supplied energy directly to processing.

Average gross sales figures are presented for each group, as a proxy for average firm size. These sales figures were derived from medians of gross sales classes reported by firms on the mail questionnaire. (Refer to Table 4 to see class ranges and medians, in dollars.) Classes reported by each firm were used to compute group average gross sales, in the following manner: (1) For each group, the median of each gross sales class was multiplied by the number of firms reporting in that class, and the results summed across all nine gross sales classes. (2) This sum was divided by the number of firms in the group. The result might best be termed an "average of medians" of the gross sales classes reported. Therefore, gross sales figures reported figures are useful only in making loose, ordinal comparisons between groups.

Meat Products Group (SIC 201)

About two-thirds of the firms reporting in SIC 201 were meat or poultry packers; the rest being either specialty meat processors or egg product processers. Thirteen beef packers comprised about two-fifths of the group but accounted for over half the reported energy consumption. The remainder of the group consisted of six sausage and prepared meat firms, four poultry packers, and a few pork and mixed-specie meat packers and egg product processors. In the discussion which follows, the entire group and a subgroup are considered. The subgroup consists of the nineteen meat and poultry packers.

Total energy seasonality. Looking at the "All Fuels" row on Tables 5 and 6, one finds no pattern evident in seasonal energy consumption: "above average" and "below average" months are fairly randomly distributed over the year. Data on monthly output were inadequate to allow computing an output-weighted seasonality index. Such an index would have facilitated separation of purely seasonal

Table 4

GROSS SALES CLASSES OF
RESPONDENT FIRMS

Gross Sales Class	Class Gross Sales Range	Class Median Gross Sales	Number of Firms in Class
1	$ 0 - $ 99,999	$ 50,000	10
2	$100,000 - $249,999	$175,000	15
3	$250,000 - $999,999	$625,000	30
4	$1 - 4.99 million	$3,000,000	49
5	$5 - 9.99 million	$7,500,000	26
6	$10 - 19.99 million	$15,000,000	20
7	$20 - 29.99 million	$25,000,000	6
8	$30 - 39.99 million	$35,000,000	2
9	$40 million or more	$50,000,000	21

Table 5

S.I.C. 201 - MEAT PRODUCTS

INDEX OF MONTHLY ENERGY USE (BTUs), BY FUEL TYPE

(April 1977 through March 1978)

FUEL	No. of Observations[1]	APR '77	MAY '77	JUN '77	JUL '77	AUG '77	SEP '77	OCT '77	NOV '77	DEC '77	JAN '78	FEB '78	MAR '78
Natural Gas	21	1.16	1.03	1.21	0.89	0.95	1.17	1.29	0.94	0.92	0.88	0.62	0.89
Fuel Oil	9	0.33	0.12	0.21	0.22	0.36	0.26	0.18	0.11	2.18	2.99	3.59	1.39
Electricity	23	0.81	0.85	1.04	1.05	1.10	1.11	1.07	1.44	0.92	0.92	0.78	0.86
LP Gas	5	0.56	0.00	0.00	0.00	0.56	0.00	0.02	0.00	3.32	4.18	2.19	1.13
Coal	0	--	--	--	--	--	--	--	--	--	--	--	--
PROCESSING FUELS	N/A	1.03	0.92	1.10	0.87	0.94	1.09	1.16	0.99	1.03	1.07	0.89	0.93
Diesel	5	0.98	0.92	1.04	0.91	0.94	0.96	0.91	1.02	1.07	1.25	0.97	0.98
Gasoline	9	0.67	0.69	0.93	0.89	1.08	1.45	1.32	1.10	1.08	0.92	0.91	0.90
TRANSPORTATION FUELS	N/A	0.89	0.85	1.01	0.90	0.99	1.12	1.04	1.05	1.07	1.15	0.95	0.96
ALL FUELS	N/A	1.02	0.92	1.09	0.85	0.94	1.09	1.15	0.99	1.03	1.07	0.89	0.93

[1]Some firms supplied only annual or partial year (i.e., quarterly) data. Seasonality indexes were computed using only observations reporting monthly data.

Table 6

MEAT PACKER SUBGROUP OF S.I.C. 201
INDEX OF MONTHLY ENERGY USE (BTUs), BY FUEL TYPE
(April 1977 through March 1978)

FUEL	No. of Obser-vations[1]	APR '77	MAY '77	JUN '77	JUL '77	AUG '77	SEP '77	OCT '77	NOV '77	DEC '77	JAN '78	FEB '78	MAR '78
Natural Gas	14	1.18	1.08	1.30	0.90	0.97	1.21	1.33	0.89	0.87	0.83	0.58	0.86
Fuel Oil	8	0.26	0.13	0.13	0.23	0.30	0.28	0.11	0.12	2.19	3.12	3.67	1.46
Electricity	16	0.80	0.86	1.07	1.03	1.11	1.12	1.07	1.61	0.92	0.86	0.75	0.82
LP Gas	3	0.80	0.00	0.00	0.00	0.80	0.00	0.03	0.00	2.66	3.51	2.62	1.59
Coal	0	--	--	--	--	--	--	--	--	--	--	--	--
PROCESSING FUELS	N/A	1.03	0.95	1.15	0.87	0.94	1.11	1.17	0.96	1.00	1.04	0.88	0.90
Diesel	3	0.92	0.69	1.19	0.62	0.77	0.87	0.63	1.09	1.30	2.09	0.88	0.93
Gasoline	5	0.60	0.65	0.95	0.94	1.14	1.68	1.46	1.11	1.04	0.84	0.83	0.76
TRANSPORTATION FUELS	N/A	0.74	0.67	1.06	0.80	0.98	1.33	1.10	1.10	1.16	1.38	0.85	0.83
ALL FUELS	N/A	1.02	0.95	1.15	0.87	0.94	1.11	1.17	0.96	1.00	1.05	0.88	0.90

[1]Some firms supplied only annual or partial year (i.e., quarterly) data. Seasonality indexes were computed using only observations reporting monthly data.

weather effects from throughput effects (i.e., number of animals slaughtered).

Natural gas and fuel oil. As shown in Table 7, natural gas was the most important energy source, meeting nearly two-thirds of total energy needs. About four-fifths of energy used in processing was supplied by natural gas and fuel oil combined. The meat packer subgroup comprised only two-thirds of the group, yet accounted for over four fifths of the group's consumption of these two fuels. Rendering animal fats, cooking and drying by-products (tankage, blook, etc.), and cooling processed carcasses require enormous energy inputs. These inputs, in large plants at least, most often come from natural gas and fuel oil.

These two fuels exhibited a seasonal consumption relationship noted in several industry groups. In winter months one might expect natural gas consumption to be greater than normal due to added heating needs. However, natural gas use was curtailed during the November 1977 through March 1978 period. (See Tables 5 and 6.) A considerable portion of the sample had interruptable-service gas contracts and, evidently, experienced a disruption in service during the winter to which the questionnaire applied. Natural gas supplies were short during that winter, and natural gas deficits appeared to have been offset by increased use of fuel oil and LP gas. During winter months fuel oil consumption was two to four times the monthly average.

Electricity was also important, supplying about one-fifth of total energy. Small plants were generally more reliant upon electricity than were large plants. Meat speciality (sausage making, meat curing, deboning, etc.) processor's, for example, were generally smaller in size than the group average, and derived about one-third of their total energy from electricity. Refrigeration, grinding, chopping, and mixing in meat speciality plants; and refrigeration in small meat packing plants, are activities which may have been more amenable to electricity than to other energy forms.

Table 7

S.I.C. 201 - MEAT PRODUCTS GROUP, AND MEAT PACKER SUBGROUP

PERCENTAGE OF TOTAL ENERGY OBTAINED FROM SPECIFIC FUELS

(April 1977 through March 1978)

FUEL	MEAT PRODUCTS Avg. Gross Sales = $18.1 million			MEAT PACKER SUBGROUP Avg. Gross Sales = $27.4 million		
	No. of Observations	% of Processing Energy	% of Total Energy	No. of Observations	% of Processing Energy	% of Total Energy
Natural Gas	27	68.2	62.4	16	70.6	65.8
Fuel Oil	15	11.1	10.2	9	11.3	10.5
Electricity	28	20.2	18.5	17	17.8	16.6
LP Gas	5	0.4	0.3	1	0.3	0.3
Coal	1	0.1	0.1	0	0.0	0.0
PROCESSING FUELS	30	100.0	91.5	19	100.0	93.2
Diesel	8	--	6.7	4	--	5.8
Gasoline	15	--	1.7	7	--	1.0
TRANSPORTATION FUELS	16	--	8.4	8	--	6.8
ALL FUELS	30	--	100.0	19	--	100.0

One reason for large plants to use smaller proportions of electricity lies in economies of plant size. In most large packing plants refrigeration is complementary to processing activities. These plants use high volumes of pressurized steam in processing and clean-up operations; and, this steam can be used to compress a refrigerant before it reaches the kill floor. Small plants may find such technology economically unfeasible. For them, refridgeration and steam generation are usually carried out via separate systems. Hence, small plants rely mostly on electricity for refrigeration, while larger plants might use another fuel such as natural gas, from which they reap additional benefits.

Greater electricity use in summer and fall than in winter and spring could have resulted from increased refrigeration needs in summer and/or from greater plant throughput. However, the data were not sufficiently detailed to provide an explanation.

Coal and LP gas contributed insignificantly to energy supplies of the group. However LP gas, as mentioned above, appeared to be an important substitute for natural gas during winter. Winter-time indices of LP gas consumption were as much as four times the monthly average.

Transportation Fuels. Gasoline and diesel, combined, contributed about one-twelfth of the group's total energy; even less in the meat packer subgroup. This result agrees with the hypothesized firm size/fuel type relationship. Meat packers, being larger than the rest of the group in terms of gross sales, exhibited less reliance on gasoline and diesel fuel. Survey responses indicated these fuels were consumed mostly in transporting processed products. Increased gasoline use over the summer and diesel fuel use in January may be the result of truck refrigeration unit use in the summer and bulk diesel purchases in the winter.

Dairy Products Group (S.I.C. 202)

The sample of S.I.C. 202 consisted largely of cheese manufacturers (24 firms; or about three-fifths). Besides cheese, these firms produced a wide range of complementary products and by-products of cheese manufacture: liquid whey, condensed whey, dried whey, lactose, whey cream, etc. Slightly over one-fifth of the sample firms were producers of non-fat dry milk, condensed milk, butter, and related products. The remainder were involved in raw milk receiving, processing (pasteurization, packaging, etc.), and delivery. In the following discussion, data from the cheese manufacturers and from the entire group are examined.

Total energy seasonality. Energy consumption was not greatly seasonal in this group. (See Tables 8 and 9.) Consumption below average was noticed in the fall, but again, output data are insufficient to explain this occurrence.

Natural gas and fuel oil. As in the meat products group this fuel combination was the major source of energy for dairy processors, providing 80 percent of all energy consumed. (See Table 10.) Cheese manufacturers and powdered milk producers were especially dependent on these fuels.

Energy serves in cheese processing for heating milk, product agitation, maintaining temperatures during bacterial culturing and aging, and other activities. However, a very large portion goes into processing by-products and complementary products--dried whey, condensed milk, powdered milk, etc.--which require heating to evaporate water. Powdered milk producers are also big users of natural gas and fuel oil.

Differences in the proportions used of these two fuels should be noted. Cheese manufacturers used relatively larger proportions of fuel oil than did the group as a whole, but used relatively smaller proportions of natural gas. A possible reason is that fuel oil may have been more readily available than natural gas, to the smaller cheese manufacturing firms.

Table 8

S.I.C. 202 - DAIRY PRODUCTS

INDEX OF MONTHLY ENERGY USE (BTUs), BY FUEL TYPE

(April 1977 through March 1978)

FUEL	No. of Obser-vations[1]	APR '77	MAY '77	JUN '77	JUL '77	AUG '77	SEP '77	OCT '77	NOV '77	DEC '77	JAN '78	FEB '78	MAR '78
Natural Gas	17	1.18	1.25	1.28	1.12	1.11	0.89	0.83	0.90	0.92	0.86	0.75	0.91
Fuel Oil	17	0.73	0.74	0.78	0.68	0.70	0.82	0.70	0.91	1.83	1.46	1.39	1.27
Electricity	27	1.02	1.05	1.16	0.92	1.06	1.04	0.87	0.90	0.99	1.02	0.98	1.00
LP Gas	9	0.18	0.12	0.10	0.08	0.13	0.13	0.11	0.27	2.10	3.76	3.88	1.13
Coal	0	--	--	--	--	--	--	--	--	--	--	--	--
PROCESSING FUELS	N/A	1.05	1.10	1.14	0.99	1.00	0.86	0.78	0.87	1.13	1.09	1.01	0.99
Diesel	7	0.80	0.78	0.61	0.74	0.86	0.75	0.18	0.83	1.36	1.80	2.20	1.10
Gasoline	14	1.16	1.20	1.42	1.09	1.00	0.97	0.81	0.97	0.82	0.83	0.81	0.91
TRANSPORTATION FUELS	N/A	1.01	1.03	1.09	0.95	0.94	0.88	0.56	0.91	1.04	1.22	1.37	0.99
ALL FUELS	N/A	1.04	1.10	1.14	0.99	0.99	0.86	0.76	0.88	1.12	1.10	1.03	0.99

[1]Some firms supplied only annual or partial year (i.e., quarterly) data. Seasonality indexes were computed using only observations reporting monthly data.

Table 9

CHEESE MANUFACTURERS OF S.I.C. 202

INDEX OF MONTHLY ENERGY USE (BTUs), BY FUEL TYPE

(April 1977 through March 1978)

FUEL	No. of Obser-vations[1]	APR '77	MAY '77	JUN '77	JUL '77	AUG '77	SEP '77	OCT '77	NOV '77	DEC '77	JAN '78	FEB '78	MAR '78
Natural Gas	5	1.21	1.27	1.35	1.22	1.18	0.81	0.76	0.84	0.93	0.87	0.68	0.88
Fuel Oil	12	0.80	0.91	0.92	0.85	0.80	0.95	0.80	0.93	1.74	1.11	1.03	1.15
Electricity	16	0.97	1.02	1.18	1.10	1.06	1.01	0.82	0.84	1.10	1.00	0.98	0.92
LP Gas	3	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.12	2.10	3.79	4.06	1.24
Coal	0	--	--	--	--	--	--	--	--	--	--	--	--
PROCESSING FUELS	N/A	1.00	1.07	1.12	1.02	0.99	0.83	0.73	0.82	1.27	1.14	1.02	0.99
Diesel	1	1.78	1.78	1.78	1.18	1.18	1.18	0.52	0.52	0.52	0.52	0.52	0.52
Gasoline	11	1.52	1.61	1.58	1.35	1.09	0.76	0.62	0.67	0.63	0.66	0.61	0.88
TRANSPORTATION FUELS	N/A	1.53	1.62	1.59	1.34	1.10	0.77	0.62	0.67	0.63	0.66	0.61	0.87
ALL FUELS	N/A	1.02	1.09	1.14	1.04	0.99	0.82	0.73	0.81	1.25	1.12	1.01	0.98

[1]Some firms supplied only annual or partial year (i.e., quarterly) data. Seasonality indexes were computed using only observations reporting monthly data.

Table 10

S.I.C. 202 - DAIRY PRODUCTS GROUP AND
CHEESE MANUFACTURER SUBGROUP

PERCENTAGE OF TOTAL ENERGY OBTAINED FROM SPECIFIC FUELS

(April 1977 through March 1978)

FUEL	DAIRY PRODUCTS Avg. Gross Sales = $10.0 million			CHEESE MANUFACTURERS Avg. Gross Sales = $5.6 million		
	No. of Observations	% of Processing Energy	% of Total Energy	No. of Observations	% of Processing Energy	% of Total Energy
Natural Gas	20	68.3	63.4	7	51.1	49.6
Fuel Oil	26	18.9	17.6	17	32.9	32.0
Electricity	33	8.6	8.0	22	7.6	7.4
LP Gas	11	4.2	3.9	5	5.8	5.6
Coal	0	0.0	0.0	0	0.0	0.0
PROCESSING FUELS	39	100.0	92.9	24	100.0	94.6
Diesel	9	--	3.1	2	--	1.3
Gasoline	17	--	4.0	13	--	4.1
TRANSPORTATION FUELS	20	--	7.1	14	--	5.4
ALL FUELS	39	--	100.0	24	--	100.0

Seasonal use of natural gas and fuel oil, along with LP gas, exhibited the pattern found in the meat products group: natural gas consumption fell in winter, while fuel oil and LP gas consumption rose. Seasonal deviations from average were less in this group than in meat products, possibly because the proportion of small plants in this group was greater. As mentioned, small plants were less likely to be on interruptable-service natural gas contracts.

Electricity provided about one-twelfth of processing energy. There was not much seasonal variability among cheese manufacturers, nor in the group as a whole.

LP gas use was reported by about one-fourth of the group. Though unimportant relative to total energy consumption, LP gas appeared quite important during winter for space heating and as a substitute for natural gas.

Transportation fuels. Gasoline and diesel, together, contributed less than 6 percent of the group's energy. However, they were quite important to dairy plants delivering milk, cheese, butter, etc., at the wholesale level. Gasoline and diesel provided over one-third of the energy consumed by those firms.

Canned and Preserved Fruits and Vegetables (SIC 203)

Two thirds of reporting firms in SIC 203 were canners and/or freezers of fruits or vegetables. They are considered as a separate subgroup in the discussion below. The other third consisted of firms making miscellaneous fruit or vegetable products--frozen dinners, fruit pies, fruit glazes, etc. Energy data for the subgroup and for the entire group are not greatly different, because over 95 percent of reported energy use was by firms in the canning and freezing subgroup.

Total energy seasonality. Seasonal fuel consumption, mostly related to plant throughput, was quite evident in this group. (See Tables 11 and 12.) Consumption was high from August through October, peaking in September at nearly

Table 11

S.I.C. 203 - CANNED AND PRESERVED FRUITS AND VEGETABLES
INDEX OF MONTHLY ENERGY USE (BTUs), BY FUEL TYPE
(April 1977 through March 1978)

FUEL	No. of Observations[1]	APR '77	MAY '77	JUN '77	JUL '77	AUG '77	SEP '77	OCT '77	NOV '77	DEC '77	JAN '78	FEB '78	MAR '78
Natural Gas	12	0.54	0.62	0.76	1.09	1.57	1.67	1.43	1.17	0.99	0.86	0.74	0.50
Fuel Oil	5	0.28	0.26	0.24	0.07	0.14	0.09	0.09	0.02	1.33	3.00	2.78	3.63
Electricity	13	0.58	0.65	1.28	1.34	1.72	1.68	1.60	0.91	0.63	0.56	0.48	0.52
LP Gas	1	0.83	0.12	0.20	0.25	1.14	1.86	2.30	2.40	2.03	0.82	0.00	0.00
Coal	0	--	--	--	--	--	--	--	--	--	--	--	--
PROCESSING FUELS	N/A	0.51	0.58	0.73	0.98	1.39	1.46	1.26	1.00	1.02	1.13	1.00	0.94
Diesel	2	1.12	2.40	2.15	0.74	1.46	1.03	1.09	0.46	0.33	0.45	0.29	0.41
Gasoline	4	1.41	0.70	2.00	2.81	1.25	1.01	0.62	0.52	0.34	0.48	0.35	0.44
TRANSPORTATION FUELS	N/A	1.28	1.48	2.07	1.88	1.35	1.03	0.84	0.49	0.34	0.47	0.33	0.43
ALL FUELS	N/A	0.54	0.60	0.78	1.00	1.38	1.44	1.24	0.97	0.99	1.10	0.97	0.91

[1]Some firms supplied only annual or partial year (i.e., quarterly) data. Seasonality indexes were computed using only observations reporting monthly data.

Table 12

FRUIT AND VEGETABLE CANNERS AND FREEZERS OF S.I.C. 203
INDEX OF MONTHLY ENERGY USE (BTUs), BY FUEL TYPE
(April 1977 through March 1978)

FUEL	No. of Observations[1]	APR '77	MAY '77	JUN '77	JUL '77	AUG '77	SEP '77	OCT '77	NOV '77	DEC '77	JAN '78	FEB '78	MAR '78
Natural Gas	9	0.54	0.63	0.77	1.11	1.59	1.70	1.44	1.16	0.99	0.85	0.73	0.50
Fuel Oil	5	0.29	0.26	0.24	0.08	0.15	0.09	0.09	0.03	1.34	3.00	2.78	3.64
Electricity	8	0.58	0.64	1.32	1.36	1.76	1.72	1.56	0.92	0.63	0.54	0.46	0.50
LP Gas	1	0.83	0.13	0.20	0.25	1.15	1.86	2.31	2.41	2.03	0.83	0.00	0.00
Coal	0	--	--	--	--	--	--	--	--	--	--	--	--
PROCESSING FUELS	N/A	0.51	0.58	0.74	0.98	1.41	1.48	1.26	0.99	1.01	1.12	0.99	0.93
Diesel	2	1.12	2.41	2.16	0.75	1.47	1.04	1.10	0.46	0.33	0.46	0.29	0.41
Gasoline	4	1.41	0.71	2.00	2.82	1.26	1.02	0.62	0.52	0.34	0.49	0.36	0.45
TRANSPORTATION FUELS	N/A	1.28	1.48	2.07	1.88	1.35	1.03	0.84	0.49	0.34	0.47	0.33	0.43
ALL FUELS	N/A	0.54	0.61	0.79	1.02	1.40	1.46	1.25	0.97	0.98	1.10	0.97	0.91

[1]Some firms supplied only annual or partial year (i.e., quarterly) data. Seasonality indexes were computed using only observations reporting monthly data.

50 percent above average. This period coincides with the harvest periods of many fruit and vegetable crops. In the spring, when temperatures are mild and little processing of fresh crops was occurring, there was less need for space heating and for plant process energy. In winter, throughput is likewise low but space heating needs were greater due to cold air temperatures; hence the reason for greater energy consumption in winter than in spring.

Natural gas and fuel oil were again major energy inputs, providing over 85 percent of total energy, and over 90 percent of processing energy. (See Table 13.) Natural gas was important in processing, as indicated by heavy consumption during harvest and processing months. Fuel oil was used in processing too, but may have served mostly as a natural gas substitute in winter. From December through March, natural gas consumption was below average, but fuel oil was consumed at double or triple the average rate. Both fuels are essential to the cooking and canning operations of the (generally large) plants in this sample.

Electricity supplied less than 10 percent of energy needs but appeared seasonally important in processing operations, as indicated by high summer and fall use indexes.

LP gas was almost insignificant for the group as a whole, and was used by only four firms. However, as seen in Table 12, its use was heaviest during the summer and fall harvest/processing season.

Transportation fuels. Together, gasoline and diesel contributed less than 5 percent of the group's energy. Most firms relied on rail transportation or private trucking for product deliveries. Less than half did any transportation of either final product or of raw materials (fresh vegetables, etc.). Seasonal data on motor fuel use were not reported by enough firms to account for the seasonality found; but, as with other fuels, heaviest consumption was during harvest.

Table 13

S.I.C. 203 - CANNED AND PRESERVED FRUITS AND VEGETABLES, AND FRUIT AND VEGETABLE CANNERS AND FREEZERS ONLY

PERCENTAGE OF TOTAL ENERGY OBTAINED FROM SPECIFIC FUELS

(April 1977 through March 1978)

FUEL	CANNED AND PRESERVED FRUITS AND VEGETABLES Avg. Gross Sales = $11.3 million			FRUIT AND VEGETABLE CANNERS AND FREEZERS ONLY Avg. Gross Sales = $13.5 million		
	No. of Observations	% of Processing Energy	% of Total Energy	No. of Observations	% of Processing Energy	% of Total Energy
Natural Gas	17	78.0	74.4	12	78.0	74.3
Fuel Oil	9	12.6	12.0	10	12.9	12.3
Electricity	18	8.9	8.5	13	8.8	8.3
LP Gas	4	0.4	0.4	5	0.4	0.4
Coal	0	0.0	0.0	0	0.0	0.0
PROCESSING FUELS	21	100.0	95.3	13	100.0	95.3
Diesel	4	--	2.4	4	--	2.4
Gasoline	9	--	2.3	9	--	2.4
TRANSPORTATION FUELS	9	--	4.7	9	--	4.8
ALL FUELS	21	--	100.0	14	--	100.0

Grain Mill Products Group (SIC 204)

This SIC may contain a more diverse array of firm types than any other in the sample. Thirty of the group's forty-eight firms may be classified as farm service and supply retailers and grain handlers. They performed activities including fertilizer, feed, seed, and herbicide sales; custom fertilizer and herbicide application; feed manufacture; hardware retailing; grain handling; and others. Gross sales categories reported by these firms were equally variable ranging from less than $99,999 up to $20 million. The farm suppliers/grain handlers are examined below as a subgroup of SIC 204.

The sample also contained six livestock feed producers, two corn product millers, and miscellaneous producers of flour, breakfast cereals, cake mixes, and the like. These latter firms were, on average, much larger than firms in the farm supplier/grain handler subgroup.

Total Energy Seasonality. As Table 14 shows, firms in SIC 204 experienced their highest average energy consumption from October through March. This pattern can be partially explained by (a) grain drying activities of grain handlers at harvest (October through December), (b) heavier average throughput of grains by flour and cereal millers during the winter months, and (c) space heating necessitated by cold winter temperatures.

Table 15 reveals the seasonal importance of harvest-time grain drying among farm suppliers/grain handlers. Total energy consumption was about double the average rate during October and November.

Natural gas and fuel oil provided about 70 percent of the energy for both farm suppliers/grain handlers and the entire group. (See Table 16.) However, large industrial plants--livestock feed processors, wet corn millers, flour millers, etc.--were dependent upon natural gas and fuel oil. On average, these larger plants relied on the natural gas/fuel oil combination for about 80 percent

Table 14

S.I.C. 204 - GRAIN MILL PRODUCTS

INDEX OF MONTHLY ENERGY USE (BTUs), BY FUEL TYPE

(April 1977 through March 1978)

FUEL	No. of Observations[1]	APR '77	MAY '77	JUN '77	JUL '77	AUG '77	SEP '77	OCT '77	NOV '77	DEC '77	JAN '78	FEB '78	MAR '78
Natural Gas	23	0.87	0.86	0.90	0.85	0.92	1.06	0.93	1.26	1.05	1.20	0.75	1.18
Fuel Oil	12	0.34	0.45	1.23	0.44	0.34	0.12	1.35	1.35	1.40	1.98	1.58	1.39
Electricity	35	0.99	0.96	1.01	1.03	1.03	1.04	1.07	1.01	0.88	0.93	0.99	0.99
LP Gas	13	1.10	0.08	0.08	0.08	0.08	0.16	1.52	2.05	1.47	1.68	1.76	1.87
Coal	1	1.84	1.35	0.53	1.31	1.38	1.05	0.84	0.66	0.77	0.85	0.60	0.77
PROCESSING FUELS	N/A	0.94	0.83	0.80	0.83	0.83	0.81	1.23	1.22	1.12	1.22	1.07	1.09
Diesel	11	0.93	0.98	0.99	0.94	0.93	0.91	1.10	1.35	1.02	0.92	0.93	0.94
Gasoline	25	1.14	0.95	1.36	0.72	1.11	1.13	0.92	0.94	0.97	0.94	0.86	0.88
TRANSPORTATION FUELS	N/A	1.04	0.97	1.17	0.84	1.02	1.02	1.02	1.16	1.00	0.94	0.90	0.92
ALL FUELS	N/A	0.91	0.90	0.93	0.84	0.87	0.87	1.04	1.19	1.07	1.27	0.94	1.16

[1]Some firms supplied only annual or partial year (i.e., quarterly) data. Seasonality indexes were computed using only observations reporting monthly data.

Table 15

FARM SUPPLIER/GRAIN HANDLER SUBGROUP OF S.I.C. 204
INDEX OF MONTHLY ENERGY USE(BTUs), BY FUEL TYPE
(April 1977 through March 1978)

FUEL	No. of Obser-vations[1]	APR '77	MAY '77	JUN '77	JUL '77	AUG '77	SEP '77	OCT '77	NOV '77	DEC '77	JAN '78	FEB '78	MAR '78
Natural Gas	12	0.21	0.06	0.02	0.10	0.05	0.37	1.49	6.35	2.20	0.41	0.36	0.37
Fuel Oil	5	4.77	0.48	0.49	0.49	0.48	0.02	0.64	1.03	0.62	1.09	1.34	0.58
Electricity	21	0.67	0.66	0.74	0.78	0.87	1.00	1.40	1.92	1.27	1.04	0.87	0.78
LP Gas	9	0.32	0.27	0.26	0.27	0.33	0.83	4.47	3.72	0.42	0.37	0.36	0.37
Coal	0	--	--	--	--	--	--	--	--	--	--	--	--
PROCESSING FUELS	N/A	1.42	0.28	0.28	0.31	0.32	0.47	2.02	3.88	1.26	0.64	0.66	0.46
Diesel	8	0.99	1.01	0.98	0.95	0.95	0.91	1.15	1.45	1.02	0.87	0.84	0.87
Gasoline	20	1.14	0.96	1.44	0.69	1.15	1.17	0.89	0.96	0.98	0.92	0.85	0.86
TRANSPORTATION FUELS	N/A	1.07	0.98	1.21	0.82	1.05	1.04	1.02	1.20	1.00	0.89	0.84	0.87
ALL FUELS	N/A	1.29	0.55	0.64	0.51	0.60	0.69	1.63	2.85	1.16	0.74	0.73	0.62

[1]Some firms supplied only annual or partial year (i.e., quarterly) data. Seasonality indexes were computed using only observations reporting monthly data.

Table 16

S.I.C. 204 - GRAIN MILL PRODUCTS, AND FARM SUPPLIER SUBGROUP

PERCENTAGE OF TOTAL ENERGY OBTAINED FROM SPECIFIC FUELS

(April 1977 through March 1978)

	GRAIN MILL PRODUCTS Avg. Gross Sales = $8.7 million			FARM SUPPLIERS/GRAIN HANDLERS Avg. Gross Sales = $2.7 million		
FUEL	No. of Observations	% of Processing Energy	% of Total Energy	No. of Observations	% of Processing Energy	% of Total Energy
Natural Gas	31	52.0	50.9	16	54.2	35.6
Fuel Oil	19	19.4	19.0	9	19.2	12.6
Electricity	42	16.0	15.6	26	10.4	6.8
LP Gas	14	2.3	2.3	7	16.2	10.6
Coal	1	10.4	10.2	0	0.0	0.0
PROCESSING FUELS	48	100.0	98.0	30	100.0	65.6
Diesel	14	--	0.9	9	--	14.3
Gasoline	32	--	1.1	27	--	20.0
TRANSPORTATION FUELS	33	--	2.0	27	--	34.3
ALL FUELS	48	--	100.0	30	--	100.0

of their energy. Smaller firms in the sample--farm service and supply retailers, small grain collection elevators, etc.--relied more on other fuels.

A noticeable difference of this group is the high natural gas consumption during the winter. The number of small firms--28 had gross sales under $5 million--may have contributed to this consumption pattern, because fewer small firms had interruptable natural gas service contracts.

Uses of natural gas and fuel oil help explain their seasonal consumption. Grain drying was the major use of natural gas among farm supply firms. Firms other than farm suppliers relied more on natural gas year-round for processing energy. Therefore, for the group as a whole, use of natural gas was not as seasonal as it was among farm suppliers. High winter-time fuel oil consumption may be explained by curtailed availability of natural gas and/or by demands for additional space heating during cold weather.

Electricity was not as important to farm suppliers as to the entire group. The group as a whole derived about twice the proportion of their energy from electricity as did farm suppliers. Notable electricity consumers were livestock feed producers and grain millers, who derived one-fourth and one-fifth of their energy, respectively, from electricity. In feed production, electricity serves in grinding and conveying materials, and in pelleting feeds--a high energy consumption activity. Likewise, grain milling involves considerable amounts of grinding, crushing, mixing and movement of materials through the production process. Electricity appears to be the energy form most commonly employed for these activities.

Electricity use showed only minor seasonality in the whole group. Farm suppliers, however, used more electricity during fall and winter, the principal period for grain drying and transport.

LP gas. Contrasted with electricity, LP gas was a major energy source for farm suppliers but of little importance to the group as a whole. Only about 2

percent of the group's processing energy was derived from LP gas, while farm suppliers got over 16 percent of their processing energy from it. A primary use of LP gas among farm suppliers was, again, in drying grain. Seasonal LP gas use (Table 15) provides strong evidence for this. About four times the average LP gas consumption was reported for October and November--the primary harvest months. For some other firms in the group LP gas may have been an important natural gas substitute. This is evidenced in Table 14 by higher than average use of LP gas from December through March.

The farm supply subgroup provides supportive evidence for the fuel type/firm size relationships mentioned. The small, primarily rural firms in this subgroup had heavier reliance on LP gas vis-a-vis natural gas, compared with larger firms in the group.

Coal supplied 10 percent of the group's energy. However, all of this 10 percent was the result of coal consumption by one extremely large plant--a breakfast cereal maker. Neither the total energy supplied by coal nor coal use seasonality should be considered representative of SIC 204.

Transportation fuels were unimportant to the group as a whole, but very important to farm suppliers. Gasoline and diesel together contributed over one-third of the farm supply subgroup's energy. Because so much of the farm supply business involves delivery of supplies, and transport and application of chemicals, fertilizers, etc., motor fuels are integral to business operations.

Seasonal use of gasoline and diesel fuel was most related to activities of the farm suppliers. Slightly elevated consumption of both fuels in the spring probably resulted from fertilizer and chemical application, and supply (seed, fertilizer, etc.) deliveries. Diesel consumption was notably higher at harvest when grain transportation by truck is considerable.

Fats and Oils (SIC 207)

All respondents in this group were soybean processors, producing soybean

oil, meal, flour, and other soybean products.

Total energy seasonality in SIC 207 was mostly related to throughput. Abundant supplies of soybeans at harvest and through the winter provided greater incentives to crush soybeans then than during the rest of the year. (See Table 17.)

Natural gas and fuel oil. Holding true to the contention that energy source and plant size are generally related, these plants--all larger than average for the sample--derived over 90 percent of their energy from natural gas and fuel oil. (See Table 18.) The process of removing oil from soybeans requires considerable heat for steam generation (to cook soybeans) and drying. Both processes are well suited to natural gas and fuel oil.

These two fuels, with LP gas, exhibited the commonly found seasonal relationship. Fuel oil and LP gas tended to substitute for natural gas during winter months.

Electricity was the only other fuel of much consequence for the group, supplying about one-fifteenth of total energy. Materials movement through the production process, and possibly soybean oil extrusion, are major applications of electricity in soybean processing.

Electricity's monthly consumption index implies a fairly strong linkage between throughput and electricity usage. Electricity is used for few activities outside of direct soybean processing. Most indirect energy uses--plant heating, transportation, etc.--rely on energy sources other than electricity. Therefore, electricity consumption may be more related to throughput than is consumption of any other fuel.

LP gas was reported by only one firm in this group. For this firm LP gas appeared to have been an important winter-time energy source.

Transportation fuels provided less than 1 percent of total energy. Transportation activities were conspicuously limited among these firms, with only three doing any transport of product at all. None of the three transported more

Table 17

S.I.C. 207 - FATS AND OILS

INDEX OF MONTHLY ENERGY USE (BTUs), BY FUEL TYPE

(April 1977 through March 1978)

FUEL	No. of Observations[1]	APR '77	MAY '77	JUN '77	JUL '77	AUG '77	SEP '77	OCT '77	NOV '77	DEC '77	JAN '78	FEB '78	MAR '78
Natural Gas	8	1.07	1.03	1.06	1.09	1.05	1.20	1.18	1.13	0.81	0.67	0.85	0.79
Fuel Oil	5	0.28	0.45	0.09	0.05	0.16	0.01	0.29	0.65	1.75	4.52	2.28	1.47
Electricity	7	0.86	0.87	0.85	0.91	0.94	1.00	1.14	1.14	0.99	1.02	1.14	1.09
LP Gas	1	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.96	1.65	3.37	3.40	2.35
Coal	0	--	--	--	--	--	--	--	--	--	--	--	--
PROCESSING FUELS	N/A	0.91	0.92	0.88	0.90	0.88	0.98	1.02	1.05	0.99	1.38	1.14	0.95
Diesel	3	0.97	1.51	0.46	0.42	0.85	0.78	0.78	1.30	1.04	0.91	1.36	1.56
Gasoline	2	0.69	0.56	0.72	1.08	2.56	0.71	1.63	0.90	0.52	0.98	1.33	0.27
TRANSPORTATION FUELS	N/A	0.96	1.46	0.48	0.47	0.95	0.78	0.84	1.28	1.02	0.92	1.36	1.49
ALL FUELS	N/A	0.91	0.92	0.88	0.89	0.88	0.98	1.02	1.05	0.99	1.38	1.14	0.95

[1]Some firms supplied only annual or partial year (i.e., quarterly) data. Seasonality indexes were computed using only observations reporting monthly data.

Table 18

S.I.C. 207 - FATS AND OILS

PERCENTAGE OF TOTAL ENERGY OBTAINED FROM SPECIFIC FUELS

(April 1977 through March 1978)

	FATS AND OILS		
	Avg. Gross Sales = $34.1 million		
FUEL	No. of Observations	% of Processing Energy	% of Total Energy
Natural Gas	8	72.9	72.5
Fuel Oil	8	19.6	19.4
Electricity	8	6.7	6.6
LP Gas	1	0.9	0.9
Coal	0	0.0	0.0
PROCESSING FUELS	9	100.0	99.4
Diesel	3	--	0.4
Gasoline	2	--	0.0
TRANSPORTATION FUELS	3	--	0.4
ALL FUELS	9	--	100.0

than one-third of their total output. Products left plants mostly via rail, private trucking firms, or were hauled by the buyer.

Because of limited reporting, seasonal consumption data for gasoline and diesel fuel may not be representative of the group. Monthly indexes are somewhat erratic for both fuels because firms often reported the occurrence of bulk fuel purchases; not actual consumption. Diesel fuel consumption does, however, appear related to throughput. Through the fall and winter diesel fuel was used at a rate well above average. Consumption was likely divided between in-shipment of soybeans and out-shipment of soybean products.

Public Warehousing (SIC 422)

The sample of SIC 422 contained fourteen grain elevators, seven food cold storage warehouses, three apple and/or apple juice warehouses, and three potato warehouses. Insufficient observations and sketchy reporting by respondent firms prevents generalization within these specific industries. Therefore, data is only reported for the group as a whole, and for the grain elevator subgroup.

Total energy seasonality. The definitely seasonal energy consumption found in SIC 422 (see Table 19) resulted largely from grain drying activities of public warehousing elevators. High indexes of energy use can be found in October, November and December, major grain harvesting months, for the grain elevator subgroup. (See Table 20.) Relatively high energy consumption from January through March is partly explained by space heating, needed in some warehouses to prevent freezing of food products, etc.

Natural gas and fuel oil. The public warehousing group represents a significant departure from patterns common to other groups discussed. For warehousing the natural gas/fuel oil combination supplied less than half--about 40 percent--of the group's energy needs. (See Table 21.) About 50 percent of the grain elevators' energy came from natural gas, primarily due to its use in drying grains.

Table 19

S.I.C. 422 - PUBLIC WAREHOUSING

INDEX OF MONTHLY ENERGY USE (BTUs), BY FUEL TYPE

(April 1977 through March 1978)

FUEL	No. of Observations[1]	APR '77	MAY '77	JUN '77	JUL '77	AUG '77	SEP '77	OCT '77	NOV '77	DEC '77	JAN '78	FEB '78	MAR '78
Natural Gas	7	0.76	0.64	0.52	0.33	0.16	0.17	1.37	1.95	2.33	1.32	1.27	1.14
Fuel Oil	3	0.41	0.00	0.00	0.00	0.00	0.41	1.57	0.68	2.20	2.08	2.77	1.85
Electricity	16	1.03	0.98	1.11	1.07	1.05	0.76	1.00	1.12	1.07	0.97	0.94	0.85
LP Gas	5	0.02	0.02	0.00	0.00	0.00	1.71	4.39	5.46	0.06	0.16	0.08	0.06
Coal	1	0.65	0.00	0.00	0.00	0.00	0.00	0.65	1.31	2.63	2.76	2.63	1.31
PROCESSING FUELS	N/A	0.86	0.79	0.80	0.69	0.61	0.53	1.30	1.66	1.61	1.11	1.08	0.96
Diesel	3	1.10	0.98	1.10	0.94	0.93	1.03	0.95	0.97	0.94	0.88	1.03	1.10
Gasoline	6	1.20	1.79	1.11	1.08	1.01	1.19	0.84	0.64	0.64	0.86	0.81	0.77
TRANSPORTATION FUELS	N/A	1.12	1.11	1.11	0.96	0.95	1.05	0.94	0.92	0.90	0.88	1.00	1.06
ALL FUELS	N/A	0.88	0.81	0.82	0.71	0.63	0.57	1.27	1.60	1.55	1.09	1.07	0.96

[1] Some firms supplied only annual or partial year (i.e., quarterly) data. Seasonality indexes were computed using only observations reporting monthly data.

Table 20

GRAIN ELEVATOR SUBGROUP OF S.I.C. 422
INDEX OF MONTHLY ENERGY USE (BTUs), BY FUEL TYPE
(April 1977 through March 1978)

FUEL	No. of Obser-vations[1]	APR '77	MAY '77	JUN '77	JUL '77	AUG '77	SEP '77	OCT '77	NOV '77	DEC '77	JAN '78	FEB '78	MAR '78
Natural Gas	3	0.70	0.66	0.55	0.32	0.12	0.12	1.47	2.16	2.46	1.20	1.11	1.11
Fuel Oil	0	--	--	--	--	--	--	--	--	--	--	--	--
Electricity	7	1.02	1.01	1.15	1.03	1.04	0.50	0.88	1.13	1.16	1.03	1.08	0.98
LP Gas	3	0.00	0.00	0.00	0.00	0.00	1.24	4.78	5.87	0.00	0.00	0.00	0.00
Coal	0	--	--	--	--	--	--	--	--	--	--	--	--
PROCESSING FUELS	N/A	0.80	0.78	0.79	0.62	0.52	0.34	1.38	1.90	1.76	1.07	1.04	1.00
Diesel	0	--	--	--	--	--	--	--	--	--	--	--	--
Gasoline	3	1.49	1.69	0.90	1.59	0.80	1.39	0.60	0.60	0.60	0.70	0.85	0.80
TRANSPORTATION FUELS	N/A	1.49	1.69	0.90	1.59	0.80	1.39	0.60	0.60	0.60	0.70	0.85	0.80
ALL FUELS	N/A	0.81	0.79	0.79	0.62	0.52	0.35	1.37	1.89	1.75	1.07	1.04	1.00

[1]Some firms supplied only annual or partial year (i.e., quarterly) data. Seasonality indexes were computed using only observations reporting monthly data.

Table 21

S.I.C. 422 - PUBLIC WAREHOUSING, AND GRAIN ELEVATOR SUBGROUP

PERCENTAGE OF TOTAL ENERGY OBTAINED FROM SPECIFIC FUELS

(April 1977 through March 1978)

FUEL	PUBLIC WAREHOUSING Avg. Gross Sales = $5.2 million			GRAIN ELEVATOR SUBGROUP Avg. Gross Sales = $3.9 million		
	No. of Observations	% of Processing Energy	% of Total Energy	No. of Observations	% of Processing Energy	% of Total Energy
Natural Gas	12	45.0	39.3	9	51.9	50.1
Fuel Oil	5	0.9	0.8	2	0.4	0.3
Electricity	22	47.4	41.4	10	40.0	38.6
LP Gas	8	6.0	5.3	6	7.8	7.5
Coal	1	0.7	0.6	0	0.0	0.0
PROCESSING ENERGY	26	100.0	87.4	14	100.0	96.5
Diesel	6	--	8.1	2	--	0.8
Gasoline	12	--	4.6	7	--	2.7
TRANSPORTATION FUELS	14	--	12.7	8	--	3.5
ALL FUELS	26	--	100.0	14	--	100.0

Again one finds firm size and physical activity related to the fuel types used. At $5.2 million, average gross sales in this group (SIC 422) were smaller than in all but one other group (SIC 542). Warehousing food products, grains, and other agricultural commodities does not involve much processing. Since needs for direct heating were low (except in grain elevators which dry grain) natural gas and fuel oil were not used to a high degree.

In general, seasonal consumption of fuel oil and natural gas exhibited the usual relationship, with fuel oil substituting for natural gas during the winter. Heavy natural gas consumption from October through December attests to its use in drying grain. Above average use of both fuels throughout the winter may have resulted mostly from space heating.

Electricity was a major power source for the grain elevators, but even more so for other firms in the group. Nearly 50 percent of the group's processing energy was supplied by electricity.[1] It was most important to the food cold storage warehouses; apparently being used to fill a large need for refrigeration.

Seasonality in electricity use was not large and, because of limited throughput data, cannot be explained.

LP gas was the source of about 5 percent of the group's energy, but supplied a slightly larger proportion of the energy consumed by grain elevators. LP gas was quite important as a grain drying fuel. That which was used was consumed almost exclusively in September, October, and November.

Coal was reported by only one firm. According to the monthly consumption index, reported in Table 19, coal was an important source of winter energy for that firm.

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[1] This comment pertains to electricity's contribution to energy not used in transportation, but does not imply that electricity was used in processing, per se. Though warehousing firms did little actual processing, the "processing" fuels served in many non-transportation activities such as refrigeration, lighting, and heating.

Transportation fuels contributed about one-eighth of the whole group's energy, but were relatively unimportant to grain elevators. Over half the group (15 of 26) performed at least some transportation of stored goods--food products, grains, potatoes, etc.--making gasoline and diesel fuel quite important to those firms. For instance, the three potato warehouses derived about 70 percent of their total energy from gasoline and diesel fuel.

Groceries and Related Products (SIC 514)

This group's sample contained six general grocery warehouses and two shell egg handlers. A couple of the warehouses performed some processing (i.e., coffee roasting, soft drink mix manufacture) in addition to warehousing. Because of small sample size and diversity of firms it is inadvisable to attempt to make any generalizations concerning SIC 514 firms.

Total energy seasonality. This group used considerably more energy in winter months than during the rest of the year. (See Table 22.) Much of the increased use was likely for space heating, as firms in the group were mostly involved in non-frozen food warehousing.

Natural gas and fuel oil again appeared to have some substitutability, with the highest proportions of fuel oil being used in winter. Together, these fuels supplied nearly half of the group's energy. (See Table 23.)

The firm size/fuel type relationship noted above does not appear applicable here. SIC 514 was third among the eight groups in terms of gross sales, yet used relatively small proportions of natural gas and fuel oil, and higher proportions of transportation fuels and electricity. However, gross sales from warehousing firms is a poor indicator of physical activity (to which energy use is more related). Though large dollar volumes of goods may pass through a warehouse, the physical activity involved is small. Hence, the firm size/fuel type relationship might have held if "total value added" or "physical activity" was the criteria used in measuring firm size.

Table 22

S.I.C. 514 - GROCERIES AND RELATED PRODUCTS (WHOLESALE)
INDEX OF MONTHLY ENERGY USE (BTUs), BY FUEL TYPE
(April 1977 through March 1978)

FUEL	No. of Observations[1]	APR '77	MAY '77	JUN '77	JUL '77	AUG '77	SEP '77	OCT '77	NOV '77	DEC '77	JAN '78	FEB '78	MAR '78
Natural Gas	6	1.11	0.76	0.63	0.61	0.43	0.36	0.63	1.01	1.35	1.86	1.78	1.41
Fuel Oil	2	0.23	0.18	0.11	0.22	0.16	0.27	0.37	0.36	0.70	2.28	3.65	3.41
Electricity	8	0.96	0.89	1.03	1.10	1.11	1.13	0.99	0.97	0.94	0.95	0.96	0.91
LP Gas	1	0.98	0.58	0.71	0.80	1.44	1.10	0.83	1.06	0.45	1.60	1.05	1.34
Coal	0	--	--	--	--	--	--	--	--	--	--	--	--
PROCESSING FUELS	N/A	1.04	0.79	0.75	0.76	0.65	0.61	0.74	0.99	1.20	1.59	1.57	1.31
Diesel	5	0.97	0.91	0.92	1.06	0.80	0.87	1.02	0.96	1.05	0.95	1.09	1.33
Gasoline	6	1.08	0.94	0.96	1.03	0.92	0.99	0.99	0.90	1.04	0.96	1.03	1.08
TRANSPORTATION FUELS	N/A	1.04	0.94	0.95	0.99	0.93	0.94	1.01	0.93	1.05	0.96	1.06	1.19
ALL FUELS	N/A	1.04	0.84	0.81	0.84	0.74	0.72	0.83	0.97	1.15	1.39	1.40	1.27

[1]Some firms supplied only annual or partial year (i.e., quarterly) data. Seasonality indexes were computed using only observations reporting monthly data.

Table 23

S.I.C. 514 - GROCERIES AND RELATED PRODUCTS (WHOLESALE)

PERCENTAGE OF TOTAL ENERGY OBTAINED FROM SPECIFIC FUELS

(April 1977 through March 1978)

	GROCERIES AND RELATED PRODUCTS Avg. Gross Sales = $14.3 million		
FUEL	No. of Observations	% of Processing Energy	% of Total Energy
Natural Gas	6	58.7	41.0
Fuel Oil	4	10.8	7.5
Electricity	8	28.4	19.8
LP Gas	3	2.0	1.4
Coal	0	0.0	0.0
PROCESSING FUELS	8	100.0	69.7
Diesel	6	--	13.1
Gasoline	6	--	17.2
TRANSPORTATION FUELS	8	--	30.3
ALL FUELS	8	--	100.0

Electricity supplied about one-fifth of the group's energy, and was used most heavily during the summer. This may imply that refrigeration needs were increased during hot summer months, for those firms handling frozen or refrigerated products.

LP gas was fairly insignificant for the group as a whole. Since monthly use data were reported by only one firm, seasonality patterns cannot be considered representative.

Transportation fuels. Gasoline and diesel together supplied one-third of the group's energy needs. Most firms in the sample performed some amount of either delivery of in-shipment of food products. No seasonal pattern was evident for either fuel.

Meat and Fish (Seafood) Markets, Including Freezer Provisioners (SIC 542)

Discussion of this group will be limited to the ten freezer provisioners who responded. They may be characterized as small, independent freezer provisioners and custom meat processors. At $0.3 million, their average gross sales figure is the lowest of any group.

Total energy seasonality. As in the previous group, SIC 542 experienced its greatest energy consumption during winter. (See Table 24.) Consumption was above average from December through March. Energy for processing operations and heating office space was a considerable portion of the total energy consumed, and cold winter temperatures probably made heating requirements greater in both areas.

Natural gas and fuel oil combined, provided only about 20 percent of the energy used by these firms. (See Table 25.) Fuel oil was used by only two firms, and natural gas by only five--less than half the group. These results agree with the hypothesized fuel type/firm size relationship: small firms tended to use less natural gas and fuel oil vis-a-vis other energy sources.

A linkage between use of these two fuels was not determinable from the data. Only two firms reported using fuel oil and, though both used it only in

Table 24

FREEZER PROVISIONERS OF S.I.C. 542
INDEX OF MONTHLY ENERGY USE (BTUs), BY FUEL TYPE
(April 1977 through March 1978)

FUEL	No. of Obser-vations[1]	APR '77	MAY '77	JUN '77	JUL '77	AUG '77	SEP '77	OCT '77	NOV '77	DEC '77	JAN '78	FEB '78	MAR '78
Natural Gas	3	0.86	0.47	0.51	0.56	0.47	0.46	0.61	1.01	1.63	2.10	2.01	1.32
Fuel Oil	2	0.00	0.00	0.00	0.00	0.00	0.00	0.80	1.00	5.32	1.20	0.80	2.86
Electricity	7	0.84	1.03	1.16	1.20	1.19	1.11	1.07	0.91	0.95	0.88	0.82	0.84
LP Gas	1	0.38	0.00	0.00	0.00	0.00	0.00	0.77	0.57	1.82	2.81	2.42	3.24
Coal	0	--	--	--	--	--	--	--	--	--	--	--	--
PROCESSING FUELS	N/A	0.77	0.84	0.94	0.98	0.96	0.90	0.98	0.89	1.26	1.20	1.10	1.18
Diesel	0	--	--	--	--	--	--	--	--	--	--	--	--
Gasoline	3	0.98	0.98	0.97	0.94	1.12	0.94	1.07	0.98	1.02	1.11	0.99	0.91
TRANSPORTATION FUELS	N/A	0.98	0.98	0.97	0.94	1.12	0.94	1.07	0.98	1.02	1.11	0.99	0.91
ALL FUELS	N/A	0.78	0.85	0.94	0.98	0.97	0.90	0.98	0.90	1.24	1.20	1.10	1.16

[1]Some firms supplied only annual or partial year (i.e., quarterly) data. Seasonality indexes were computed using only observations reporting monthly data.

Table 25

FREEZER PROVISIONERS OF S.I.C. 542

PERCENTAGE OF TOTAL ENERGY OBTAINED FROM SPECIFIC FUELS

(April 1977 through March 1978)

	FREEZER PROVISIONERS Avg. Gross Sales = $0.3 million		
FUEL	No. of Observations	% of Processing Energy	% of Total Energy
Natural Gas	4	21.7	20.7
Fuel Oil	2	2.2	2.1
Electricity	9	67.6	64.5
LP Gas	2	8.5	8.1
Coal	0	0.0	0.0
PROCESSING FUELS	10	100.0	95.4
Diesel	0	--	0.0
Gasoline	4	--	4.5
TRANSPORTATION FUELS	4	--	4.5
ALL FUELS	10	--	100.0

fall and winter months, fuel oil consumption did not appear directly related to natural gas availability.

Electricity supplied almost two-thirds of the group's total energy. Its paramount role in refrigeration is attested to by the seasonality indexes. Electricity consumption during spring and summer was as much as 19 percent above average. Winter consumption went down to 18 percent below average.

LP gas was reported by two firms, and may have been used only for heating during winter.

Transportation fuels. No diesel fuel was reported. However, gasoline supplied 23 percent of the group's energy and was reported by nearly half the group (five firms). Although nearly half the firms indicated they made product deliveries, the largest part of total gasoline consumption was by two firms delivering 100 percent of their product. Gasoline consumption exhibited little seasonality.