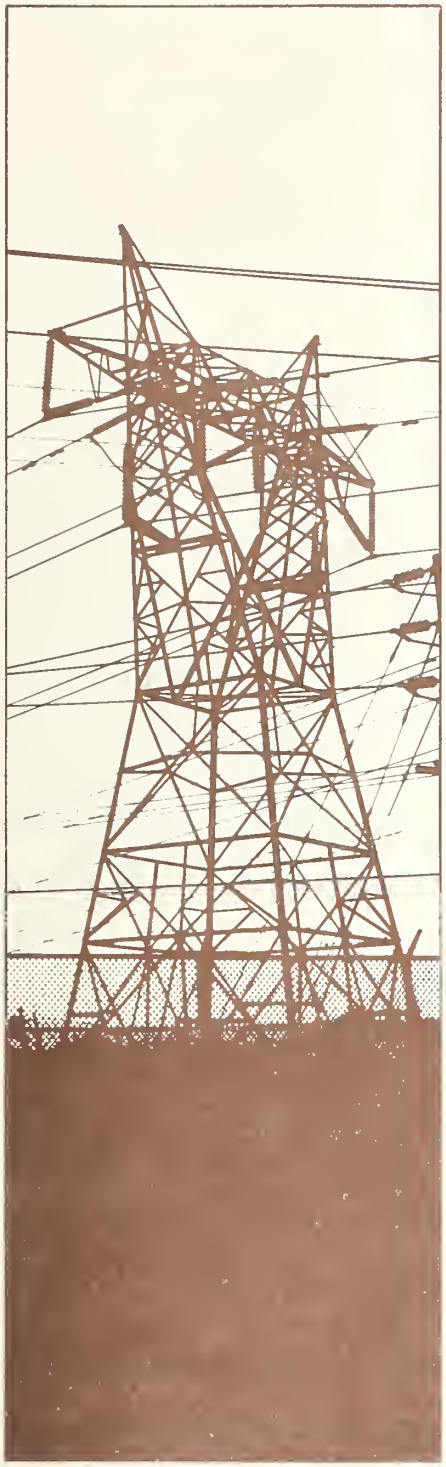
United States
Department of
Agriculture

Agricultural
Marketing
Service

Marketing
Research
Report
Number 1123

Energy Costs for Marketing Fresh Beef



Preface

This report is published as part of a continuing research program designed to reduce the costs of marketing agricultural products from producer to consumer.

The research data upon which this report is based were furnished under contract by Globe Engineering Company, Chicago, Ill.

The author expresses his appreciation to the staff of Globe Engineering Company for their cooperation, and to those firms who assisted by providing necessary data to the contractor. Appreciation also is expressed to the former Transportation and Packaging Laboratory, Agricultural Research Service, USDA, now the Transportation and Packaging Branch, Office of Transportation, USDA, for help in planning and financing the contract study.

Contents

November 1981

Energy Costs for Marketing Fresh Beef

By Charles L. Goulston, Industrial Engineer
Market Research and Development Division
Agricultural Marketing Service, Beltsville, Md. 20705

This publication reports on a study of energy costs for five systems for marketing fresh beef from the packer to the retail display case. In two systems, the packer prefabricated the carcasses into subprimal cuts before shipping. In two systems, the carcasses were shipped intact to the retail stores. In the fifth system, the packer shipped carcasses to a central processor, where they were broken into subprimal cuts, then shipped to the retail stores. This report lists the energy costs for each system; tables show costs by category—that is, packer, central distributor or processor, transportation, or retail store; and also by energy source—electricity, natural gas, or diesel fuel. The amounts of energy used are shown in the same detail as costs.

Results were based on theoretical engineering analyses and numerous calculations involving data collected in the field, as well as several stated assumptions. Taken into account was energy used to run the equipment directly related to preparing, packaging, handling, and refrigerating the beef, and transporting it through the systems.

The two systems where the packer prefabricated the carcasses into subprimal cuts before shipping incurred the lowest energy costs, about $1.50 and $1.54 per 100 pounds of salable retail cuts. The two systems incurring the greatest energy costs were those where the carcasses were shipped intact to the retail stores, the costs being about $1.66 and $1.72 per 100 pounds of salable retail cuts. These cost figures can be expected to fluctuate because of differences in geographical area and the inflationary rise in utility costs.

Introduction

One of the most noticeable changes in the marketing of beef in recent years is the fact that more beef is arriving at the retail store in prefabricated form instead of carcass form. An April 1979 study showed that carcass beef accounted for only 24 percent of fresh beef received at retail, while prefabricated primals and subprimals (also known as boxed beef) accounted for 76 percent of the total.[1] The latter figure is expected to reach 88 percent by 1982. Generally, the prefabricating is done at the packing plant or at a central fabricating facility.

Some benefits of prefabricating beef before its arrival at the retail store are:

1. Cutting operations of beef can be more efficiently done at the packing plant or at a central facility than at the retail store because the beef cutters are more specialized, and operations resemble an assembly line rather than a butcher shop.
2. Transportation costs may be reduced because less fat and bone are shipped to the stores.
3. Moisture loss is reduced when prefabricated beef is stored in vacuum plastic bags instead of exposing it to the air.
4. Sanitation is improved and shelf life is increased because fewer people handle the beef surfaces. Reduced handling impedes some types of bacterial growth in the vacuum plastic bag.
5. Fat and bone are usually more valuable when removed at a central facility than at the retail store.
6. Less floor space is required to store the meat at each retail store.

It is reasonable to assume that most of these benefits, particularly 2 and 6, will result in a reduction in the cost of energy used in marketing fresh beef. Because energy costs have increased more than fivefold in the last 10 years and energy sources are being depleted at an alarming rate, it is important that areas of potential energy savings be identified.

This publication reports on a study of five systems and their associated energy costs for marketing fresh beef from packer to retail display case. In addition to a breakdown of costs by system, tables show costs by category (packer, central distributor or processor, transportation, retail store) and by energy source (electricity, natural gas, diesel fuel). The amounts of energy used are shown in the same detail as costs. Energy is expressed as Btu's[2] per 100 pounds of salable retail beef cuts.

---

[1]Supermarket News, May 14, 1979.
[2]Btu is an abbreviation for British thermal unit. It is defined as the amount of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit.

Procedure

Numerous publications prepared by government agencies, institutions, or trade associations were reviewed for pertinent, current, and reliable research data on energy costs for marketing fresh beef. (See bibliography.) One packer, one central distributor, and two retail stores supplied additional information to provide the basis for the data in this report.

The energy requirements and costs stated in this publication are the result of theoretical engineering analyses and numerous calculations involving the data mentioned above, together with several necessary assumptions which are discussed.

For the purposes of this study, all marketing systems begin at the point the beef carcass enters the packer's chill cooler, and end when the retail cut is removed from the retail store display case. "Retail store" refers to supermarkets and excludes meat markets, delicatessens, and convenience stores as well as firms that cater to the hotel, restaurant, and institutional trade. Processing of ground beef is included in the study, but variety meats and beef byproducts are excluded.

The study takes into account energy used to run the equipment directly related to preparing, packaging, handling, and refrigerating the beef, and transporting it through the systems. The energy required to produce packaging materials is not included.

The five systems considered do not account for all systems currently used for marketing beef, but do account for the vast majority of beef sold in supermarkets throughout the United States.

Throughout this report the five systems are identified by Roman numerals and titles. The description of each *system* and its designated Roman numeral and title is as follows:

System I. Carcasses to Stores:
The packer ships carcasses directly to the retail store.

System II. Boxed Beef to Stores:
The packer breaks carcasses into subprimal cuts, wraps and boxes them, and ships them directly to the retail store.

System III. Carcasses to Distributor to Stores:
The packer ships carcasses to a central distributor who warehouses them, and ships them to the retail store.

System IV. Carcasses to Processor, Boxed Beef to Stores:
The packer ships carcasses to a central processor who breaks them into subprimal cuts, wraps and boxes them, and ships them to the retail store.

System V. Boxed Beef to Distributor to Stores:
The packer breaks carcasses into subprimal cuts, wraps and boxes them, and ships them to a central distributor who warehouses the boxed beef and ships it to the retail store.

Each system was divided into components called *functions*. Energy calculations were made for each function. A list of the functions for each system follows:

System I—Carcasses to Stores

Packer carcass chill cooler
Packer carcass holding cooler
Packer shipping cooler
Transportation of carcasses from packer to stores
Retail store carcass holding cooler
Retail store breaking carcasses and packaging
Retail store display case

System II—Boxed Beef to Stores

Packer carcass chill cooler
Packer carcass holding cooler
Packer boxed beef cutting and packaging
Packer boxed beef holding cooler
Packer boxed beef shipping cooler
Transportation of boxed beef from packer to stores
Retail store boxed beef holding cooler
Retail store breaking boxed beef and packaging
Retail store display case

System III—Carcasses to Distributor to Stores

Packer carcass chill cooler
Packer carcass holding cooler
Packer shipping cooler
Transportation of carcasses from packer to central distributor
Central distributor carcass holding cooler
Central distributor carcass receiving and shipping docks
Transportation of carcasses from central distributor to stores
Retail store carcass holding cooler
Retail store breaking carcasses and packaging
Retail store display case

System IV—Carcasses to Processor, Boxed Beef to Stores

Packer carcass chill cooler
Packer carcass holding cooler
Packer shipping cooler
Transportation of carcasses from packer to central processor
Central processor carcass holding cooler
Central processor boxed beef cutting and packaging
Central processor boxed beef holding cooler
Central processor carcass receiving and boxed beef shipping docks
Transportation of boxed beef from central processor to stores
Retail store boxed beef holding cooler
Retail store breaking boxed beef and packaging
Retail store display case

System V—Boxed Beef to Distributor to Stores

Packer carcass chill cooler
Packer carcass holding cooler
Packer boxed beef cutting and packaging
Packer boxed beef holding cooler
Packer boxed beef shipping cooler
Transportation of boxed beef from packer to central distributor
Central distributor boxed beef receiving and shipping docks
Central distributor boxed beef holding cooler
Transportation of boxed beef from central distributor to stores
Retail store boxed beef holding cooler
Retail store breaking boxed beef and packaging
Retail store display case

For the reader's convenience, data for certain functions were grouped together into four *categories*, as follows:

- Packer
- Central distributor or central processor
- Transportation
- Retail store

Several assumptions were made regarding the transportation functions:

1. The average distance from the packer to the central distributor or central processor is 1,000 miles. (Systems III, IV, and V.)

2. In systems I and II, the average distances are 1,000 miles from the packer to the first store, 5 miles to the second, third, and fourth stores, and a 1,000-mile return trip to the packer.

3. In all systems it was assumed that the trailer returning to the packer was empty 25 percent of the time; revenue-producing payloads were carried 75 percent of the time. Therefore, only 25 percent of the energy consumed in the return trip was charged to the transportation function.

4. In systems III, IV, and V, the average distances are 30 miles from the central distributor or central processor to the first store, 5 miles to the second, third, and fourth stores, and a 30-mile return trip. All energy consumed on return trips was charged to the transportation function.

5. All trailers carried a net weight of 38,000 pounds of carcass beef or 40,000 pounds of boxed beef per load.

Table 1 lists some basic operating conditions and assumptions which were used in the energy calculations. It also shows systems sharing the same functions. It is important to note that the percentages shown for cutting loss can vary substantially from firm to firm, depending on the carcass yield and the firm's specifications.

Table 1.—Basic operating conditions and assumptions

Category	Function	Applicable system[1]	Moisture loss in function[2]	Cutting loss[3]	Average product storage time[4]	Air temperature[5]
		Number	*Percent*	*Percent*	*Hours*	*°F*
Packer	Carcass chill cooler	I, II, III, IV, V	2.0	N.A.	22	32
Packer	Carcass holding cooler	I, II, III, IV, V	.5	N.A.	24	32-34
Packer	Shipping cooler (boxed beef or carcass)	I, II, III, IV, V	0	N.A.	N.A.	28-30
Packer	Boxed beef cutting and packaging	II, V	0	13.0	N.A.	45
Packer	Boxed beef holding cooler	II, V	0	N.A.	72	28-30
Central distributor	Carcass holding cooler	III	.75	N.A.	36	32-34
Central processor	Carcass holding cooler	IV	.5	N.A.	24	32-34
Central processor	Boxed beef cutting and packaging	IV	0	13.0	N.A.	45
Central processor or distributor	Boxed beef holding cooler	IV, V	0	N.A.	72	28-30
Central distributor	Carcass receiving and shipping docks	III	0	N.A.	N.A.	28-30
Central distributor	Boxed beef receiving and shipping docks	V	0	N.A.	N.A.	28-30
Central processor	Carcass receiving and boxed beef shipping docks	IV	0	N.A.	N.A.	28-30
Retail store	Carcass holding cooler	I, III	1.0	N.A.	48	28-30
Retail store	Boxed beef holding cooler	II, IV, V	0	N.A.	36	28-30
Retail store	Breaking carcasses and packaging	I, III	0	28.5	N.A.	55
Retail store	Breaking boxed beef and packaging	II, IV, V	0	17.5	N.A.	55
Retail store	Display case	I, II, III, IV, V	0	N.A.	N.A.	30
Transportation	Packer ships carcasses to stores	I	.5	N.A.	31	32-34
Transportation	Packer ships boxed beef to stores	II	0	N.A.	31	32-34
Transportation	Packer ships carcasses to central distributor or processor	III, IV	.5	N.A.	29	32-34
Transportation	Packer ships boxed beef to central distributor	V	0	N.A.	29	32-34
Transportation	Central distributor ships carcasses to stores	III	.5	N.A.	4	32-34
Transportation	Central distributor or processor ships boxed beef to stores	IV, V	0	N.A.	4	32-34

N.A. = not applicable.
[1]This column shows functions applicable to systems.
[2]Based on cooperating firms' data
[3]Based on cooperating firms' data. Includes removal of fat, bone, and waste.
[4]Based on cooperating firms' data.
[5]Based on assumptions and industry data.

The basis for energy use is the quantity of energy consumed by the function at the point of use. The total energy use for each function was converted to its equivalent energy use per cwt[1] of fresh beef in the display case. The equivalent energy use by energy source was determined separately for each system, based on the assumption that diesel fuel was used for transportation, natural gas was used primarily for heating water, and electricity was used for everything else.

In converting energy use to energy costs, national average unit energy costs for 1978, as supplied by the Federal Energy Administration, were used. It is recognized that these unit costs vary with inflation as well as with the geographical area. However, the reader can easily adjust the cost figures in this report to reflect different unit costs. The unit costs as well as the heating values of each energy source are shown in table 2.

Table 2.—Unit cost and heating value by energy source

Energy source	Unit cost[1]	Heating value[2]	Cost per Btu[3]
	Dollars	*Btu*	*Cents*
Electricity	0.035/kWh	3,420	0.001023
Natural gas	.0014/ft³	1,000	.000140
Diesel fuel	.55/gal	138,800	.000396

[1]Based on Federal Energy Administration data for 1978.
[2]Based on industry data.
[3]Obtained by dividing unit cost by heating value.

[1]Cwt is an abbreviation for hundredweight, a unit equal to 100 pounds.

Results of this study are developed in this section through the use of various tables. Table 1 shows that the product lost varying amounts of moisture depending on the particular system through which it flowed. The product also lost varying amounts of fat and bone. To determine more precisely the equivalent amount of energy used for each function, it was first necessary to determine how much product was handled for each function. Starting with a 650-pound carcass, appendix table 1 illustrates how much weight is lost throughout each system due to moisture and cutting losses. It also shows how many pounds of salable retail cuts remain at the end of each system. The losses are also expressed as percentages of the weight of product which entered the function.

As shown in appendix table 1, the total weight of moisture loss per carcass ranged from 16.3 pounds for systems II and V to 33.5 pounds for system III. In systems II and V the beef was cut into subprimals and wrapped by the packer, thereby eliminating any further moisture loss. On the other hand, in system III the entire carcass was exposed to the air throughout the entire system until it was cut at the retail store, resulting in the greatest moisture loss. These facts help explain the differences in yield between systems as reflected by the bottom line of appendix table 1.

Using the data in appendix table 1, the next step was to convert this data to a common denominator of 100 pounds (cwt) of salable retail cuts in the retail store display case for each of the five systems. Appendix table 2 shows how many pounds of product flow through each function in order to arrive at 100 pounds of salable retail cuts at the end of each system. This is called "function equivalent weight." Moisture and cutting losses are identical to those used in appendix table 1. The weight figures in appendix table 2 were used in table 3 to calculate equivalent energy use for each function.

Table 3, Development of equivalent energy costs by function, shows how equivalent energy cost for each function was developed. The table is divided into five sections representing the five systems. The bottom line of each section shows the total equivalent energy cost for each system—that is, the cost of energy used to yield 100 pounds of salable retail cuts.

Column 1, Energy use (Btu/lb), is the direct result of calculations. It shows the energy required for each pound of product that moves through that particular function. Column 2, Equivalent weight (lb/cwt), shows how many pounds of product move through a particular function in order to yield 100 pounds of salable retail cuts at the end of each system. This data is obtained directly from appendix table 2. Column 3, Equivalent energy use (Btu/cwt), is obtained by multiplying column 1 by column 2. This column represents the total Btu's of energy used in moving

a quantity of product through that function that will yield 100 pounds of salable retail cuts at the end of the system.

Column 4, Electricity, column 6, Natural gas, and column 8, Diesel fuel, were the direct result of the engineering calculations. These columns reflect what percentage of the energy used for each function was furnished by each of the three energy sources. (As stated earlier, the assumption was made that diesel fuel was used for transportation, natural gas was used primarily for heating water, and electricity was used for everything else.)

Column 5, Equivalent energy used from electricity (Btu/cwt), column 7, Equivalent energy used from natural gas (Btu/cwt), and column 9, Equivalent energy used from diesel fuel (Btu/cwt), are also the direct result of the engineering calculations. The total of these three columns will equal the figure in column 3.

Column 10, Average unit energy cost (cents/Btu), indicates the average cost of a Btu of energy for each function. When a function requires more than one energy source, the average unit energy cost as shown in column 10 is computed as a weighted average in which the cost per Btu for each energy source as shown in table 2 is weighted by the percentages shown in table 3, columns 4, 6, and 8.

Column 11, Equivalent energy cost (Dol/cwt), indicates the total cost of energy used in moving a quantity of product through the function that will yield 100 pounds of salable retail cuts at the end of the system. This was obtained by multiplying column 3 by column 10.

The results of this study are presented in tables 4 and 5. Table 4, Equivalent energy use and cost by category, represents a consolidation of table 3. Column 1 is a consolidation of column 3, table 3. Column 3 is a consolidation of column 11, table 3. Columns 2 and 4 present the data from columns 1 and 3 in percentages.

Table 5, Equivalent energy use by source, was derived from the "Total" lines of table 3. It indicates in concise form the equivalent energy use for each system by energy source.

The total equivalent use (Btu/cwt) ranged from a low of 232,807 for system II to a high of 274,952 for system III. Energy use was lowest for the systems where the packer broke the carcass into subprimal cuts before shipping (systems II and V). This was not surprising since transportation energy, which accounted for more than half of the total energy requirements for every system, was greatly reduced because considerable fat and bone were removed before shipment.

The total equivalent energy cost (Dol/cwt) ranged from a low of $1.50 for system II to a high of $1.72 for system III. The relative cost standings could change if unit costs for the various energy sources change at a rate disproportionate to each other. Costs can vary dramatically because of differences in geographical area and inflation. Again, systems II and V were the least expensive because removal of considerable fat and bone prior to transportation reduced the bulk and weight shipped.

The "retail store" category (see table 4) accounted for more than half of the total equivalent energy cost for each system, even though the share of total equivalent energy use was only between 30 and 40 percent. This apparent discrepancy is attributed to the almost exclusive use of electricity for the energy source. The cost per Btu of electricity is more than 2½ times that of diesel fuel and more than seven times that of natural gas (1978 data). Electricity is commonly used because of its availability and convenience, and because nearly all lighting, cutting and packaging equipment, and small refrigeration units are designed to operate with electricity.

Natural gas (see table 5) accounted for 5 percent or less of the total equivalent energy use in each system. Diesel fuel, used exclusively for transportation, accounted for about 53 to 60 percent of each system's total. Electricity accounted for about 36 to 41 percent of the total equivalent energy use for each system.

Figures 1 and 2 graphically illustrate equivalent energy use and equivalent energy cost by category.

Table 3.—Development of equivalent energy costs by function

Category	Function	1 Energy use	2 Equivalent weight	3 Equivalent energy use	4 Electricity
		Btu/lb	*Lb/cwt*	*Btu/cwt*	*Percent*
SYSTEM I — Carcasses to stores:					
Packer	Carcass chill cooler	301.1	145.6	4,382	94.6
Packer	Carcass holding cooler	8.8	142.7	1,256	81.2
Packer	Shipping cooler	6.9	142.0	980	52.4
Transportation	Carcasses from packer to stores	1,083.2	142.0	153,814	0
Retail store	Carcass holding cooler	85.2	141.3	12,039	98.9
Retail store	Breaking carcasses and packaging	330.6	139.9	46,251	89.7
Retail store	Display case	429.7	100.0	42,970	100.0
	Total	N.A.	N.A.	261,692	N.A.
	Percentage of total energy use	N.A.	N.A.	N.A.	39.0
SYSTEM II — Boxed beef to stores:					
Packer	Carcass chill cooler	30.1	142.9	4,301	94.6
Packer	Carcass holding cooler	8.8	140.0	1,232	81.2
Packer	Boxed beef cutting and packaging	83.4	139.3	11,618	45.7
Packer	Boxed beef holding cooler	15.6	121.2	1,891	87.0
Packer	Boxed beef shipping cooler	6.9	121.2	836	52.4
Transportation	Boxed beef from packer to stores	1,029.0	121.2	124,715	0
Retail store	Boxed beef holding cooler	57.4	121.2	6,957	98.9
Retail store	Breaking boxed beef and packaging	315.9	121.2	38,287	89.2
Retail store	Display case	429.7	100.0	42,970	100.0
	Total	N.A.	N.A.	232,807	N.A.
	Percentage of total energy use	N.A.	N.A.	N.A.	41.4
SYSTEM III — Carcasses to distributor to stores:					
Packer	Carcass chill cooler	30.1	147.5	4,440	94.6
Packer	Carcass holding cooler	8.8	144.6	1,272	81.2
Packer	Shipping cooler	6.9	143.8	992	52.4
Transportation	Carcasses from packer to central distributor	1,055.1	143.8	151,723	0
Central distributor	Carcass holding cooler	12.1	143.1	1,732	82.9
Central distributor	Carcasses receiving and shipping docks	3.3	142.0	469	47.2
Transportation	Carcasses from central distributor to stores	92.0	142.0	13,064	0
Retail store	Carcass holding cooler	85.2	141.3	12,039	98.9
Retail store	Breaking carcasses and packaging	330.6	139.9	46,251	89.7
Retail store	Display case	429.7	100.0	42,970	100.0
	Total	N.A.	N.A.	274,952	N.A.
	Percentage of total energy use	N.A.	N.A.	N.A.	37.8

N.A. = not applicable.

5 Equivalent energy used from electricity	6 Natural gas	7 Equivalent energy used from natural gas	8 Diesel fuel	9 Equivalent energy used from diesel fuel	10 Average unit energy cost	11 Equivalent energy cost
Btu/cwt	*Percent*	*Btu/cwt*	*Percent*	*Btu/cwt*	*Cents/Btu*	*Dol/cwt*
4,145	5.4	237	0	0	0.000975	0.043
1,020	18.8	236	0	0	.000857	.011
514	47.6	466	0	0	.000603	.006
0	0	0	100.0	153,814	.000396	.609
11,907	1.1	132	0	0	.001014	.122
41,487	10.3	4,764	0	0	.000932	.431
42,970	0	0	0	0	.001023	.440
102,043	N.A.	5,835	N.A.	153,814	N.A.	1.662
N.A.	2.2	N.A.	58.8	N.A.	N.A.	N.A.
4,069	5.4	232	0	0	.000975	.042
1,000	18.8	232	0	0	.000857	.010
5,309	54.3	6,309	0	0	.000544	.063
1,645	13.0	246	0	0	.000908	.017
438	47.6	398	0	0	.000603	.005
0	0	0	100.0	124,715	.000396	.494
6,880	1.1	77	0	0	.001014	.070
34,152	10.8	4,135	0	0	.000928	.355
42,970	0	0	0	0	.001023	.440
96,463	N.A.	11,629	N.A.	124,715	N.A.	1.496
N.A.	5.0	N.A.	53.6	N.A.	N.A.	N.A.
4,200	5.4	240	0	0	.000975	.043
1,033	18.8	239	0	0	.000857	.011
520	47.6	472	0	0	.000603	.006
0	0	0	100.0	151,723	.000396	.601
1,436	17.1	296	0	0	.000872	.015
221	52.8	248	0	0	.000557	.003
0	0	0	100.0	13,064	.000396	.052
11,907	1.1	132	0	0	.001014	.122
41,487	10.3	4,764	0	0	.000932	.431
42,970	0	0	0	0	.001023	.440
103,774	N.A.	6,391	N.A.	164,787	N.A.	1.724
N.A.	2.3	N.A.	59.9	N.A.	N.A.	N.A.

Category	Function	1 Energy use	2 Equivalent weight	3 Equivalent energy use	4 Electricity
		Btu/lb	*Lb/cwt*	*Btu/cwt*	*Percent*
SYSTEM IV — Carcasses to processor, boxed beef to stores:					
Packer	Carcass chill cooler	30.1	144.3	4,343	94.6
Packer	Carcass holding cooler	8.8	141.4	1,244	81.2
Packer	Shipping cooler	6.9	140.7	971	52.4
Transportation	Carcasses from packer to central processor	1,055.1	140.7	148,452	0
Central processor	Carcass holding cooler	8.8	140.0	1,232	76.4
Central processor	Boxed beef cutting and packaging	84.2	139.3	11,729	45.7
Central processor	Boxed beef holding cooler	15.6	121.2	1,891	87.0
Central processor	Carcass receiving and boxed beef shipping docks	3.7	121.2	448	47.2
Transportation	Boxed beef from central processor to stores	87.4	121.2	10,593	0
Retail store	Boxed beef holding cooler	57.4	121.2	6,957	98.9
Retail store	Breaking boxed beef and packaging	315.9	121.2	38,287	89.2
Retail store	Display case	429.7	100.0	42,970	100.0
	Total	N.A.	N.A.	269,117	N.A.
	Percentage of total energy use	N.A.	N.A.	N.A.	36.3
SYSTEM V — Boxed beef to distributor to stores:					
Packer	Carcass chill cooler	30.1	142.9	4,301	94.6
Packer	Carcass holding cooler	8.8	140.0	1,232	81.2
Packer	Boxed beef cutting and packaging	83.4	139.3	11,618	45.7
Packer	Boxed beef holding cooler	15.6	121.2	1,891	87.0
Packer	Boxed beef shipping cooler	6.9	121.2	836	52.4
Transportation	Boxed beef from packer to central distributor	1,002.3	121.2	121,479	0
Central distributor	Boxed beef holding cooler	15.6	121.2	1,891	87.0
Central distributor	Boxed beef receiving and shipping docks	3.7	121.1	448	47.2
Transportation	Boxed beef from central distributor to stores	87.4	121.2	10,593	0
Retail store	Boxed beef holding cooler	57.4	121.2	6,957	98.9
Retail store	Breaking boxed beef and packaging	315.9	121.2	38,287	89.2
Retail store	Display case	429.7	100.0	42,970	100.0
	Total	N.A.	N.A.	242,503	N.A.
	Percentage of total energy use	N.A.	N.A.	N.A.	40.5

N.A. = not applicable.

5 Equivalent energy used from electricity	6 Natural gas	7 Equivalent energy used from natural gas	8 Diesel fuel	9 Equivalent energy used from diesel fuel	10 Average unit energy cost	11 Equivalent energy cost
Btu/cwt	*Percent*	*Btu/cwt*	*Percent*	*Btu/cwt*	*Cents/Btu*	*Dol/cwt*
4,108	5.4	235	0	0	.000975	.042
1,010	18.8	234	0	0	.000857	.011
509	47.6	462	0	0	.000603	.006
0	0	0	100.0	148,452	.000396	.588
941	23.6	291	0	0	.000815	.010
5,360	54.3	6,369	0	0	.000544	.064
1,645	13.0	246	0	0	.000908	.017
211	52.8	237	0	0	.000557	.002
0	0	0	100.0	10,593	.000396	.042
6,880	1.1	77	0	0	.001014	.070
34,152	10.8	4,135	0	0	.000928	.355
42,970	0	0	0	0	.001023	.440
97,786	N.A.	12,286	N.A.	159,045	N.A.	1.647
N.A.	4.6	N.A.	59.1	N.A.	N.A.	N.A.
4,069	5.4	232	0	0	.000975	.042
1,000	18.8	232	0	0	.000857	.010
5,309	54.3	6,309	0	0	.000544	.063
1,645	13.0	246	0	0	.000908	.017
438	47.6	398	0	0	.000603	.005
0	0	0	100.0	121,479	.000396	.481
1,645	13.0	246	0	0	.000908	.017
211	52.8	237	0	0	.000557	.002
0	0	0	100.0	10,593	.000396	.042
6,880	1.1	77	0	0	.001014	.070
34,152	10.8	4,135	0	0	.000928	.355
42,970	0	0	0	0	.001023	.440
98,319	N.A.	12,112	N.A.	132,072	N.A.	1.544
N.A.	5.0	N.A.	54.5	N.A.	N.A.	N.A.

Table 4.—Equivalent energy use and cost by category

System	Category	1 Equivalent energy use	2 Equivalent energy use	3 Equivalent energy cost	4 Equivalent energy cost
		Btu/cwt	*Percent*	*Dol/cwt*	*Percent*
I - Carcasses to stores	Packer	6,618	2.5	0.060	3.6
	Transportation	153,814	58.8	.609	36.6
	Retail store	101,260	38.7	.993	59.8
	Total	261,692	100.0	1.662	100.0
II - Boxed beef to stores	Packer	19,878	8.5	.137	9.2
	Transportation	124,715	53.6	.494	33.0
	Retail store	88,214	37.9	.865	57.8
	Total	232,807	100.0	1.496	100.0
III - Carcasses to distributor to stores	Packer	6,704	2.5	.060	3.5
	Transportation	164,787	59.9	.653	37.9
	Central distributor	2,201	.8	.018	1.0
	Retail store	101,260	36.8	.993	57.6
	Total	274,952	100.0	1.724	100.0
IV - Carcasses to processor, boxed beef to stores	Packer	6,558	2.4	.059	3.6
	Transportation	159,045	59.1	.630	38.3
	Central processor	15,300	5.7	.093	5.6
	Retail store	88,214	32.8	.865	52.5
	Total	269,117	100.0	1.647	100.0
V - Boxed beef to distributor to stores	Packer	19,878	8.2	.137	8.9
	Transportation	132,072	54.4	.523	33.9
	Central distributor	2,339	1.0	.019	1.2
	Retail store	88,214	36.4	.865	56.0
	Total	242,503	100.0	1.544	100.0

Table 5.—Equivalent energy use by source

System	Source					
	Electricity		Natural gas		Diesel fuel	
	Equivalent energy use	Percent of total	Equivalent energy use	Percent of total	Equivalent energy use	Percent of total
	Btu/cwt		*Btu/cwt*		*Btu/cwt*	
I	102,043	39.0	5,835	2.2	153,814	58.8
II	96,463	41.4	11,629	5.0	124,715	53.6
III	103,774	37.8	6,391	2.3	164,787	59.9
IV	97,786	36.3	12,286	4.6	159,045	59.1
V	98,319	40.5	12,112	5.0	132,072	54.5

Figure 1

Equivalent Energy Use by Category

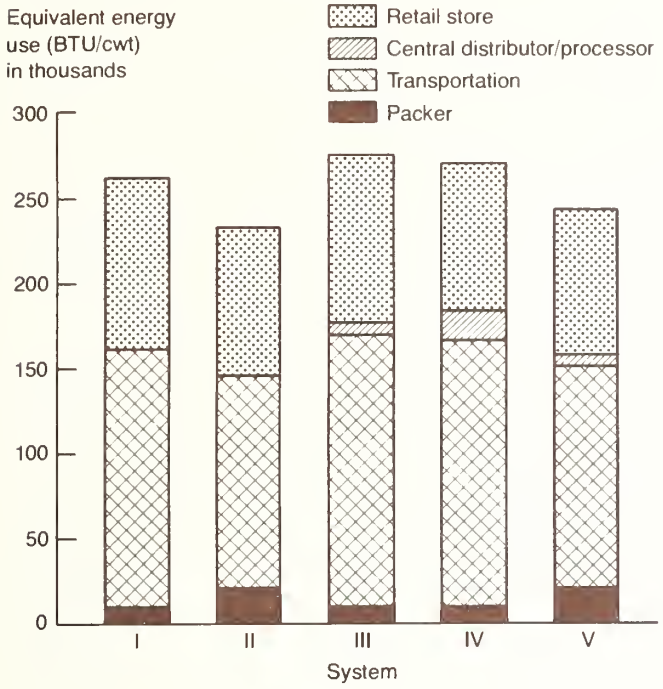
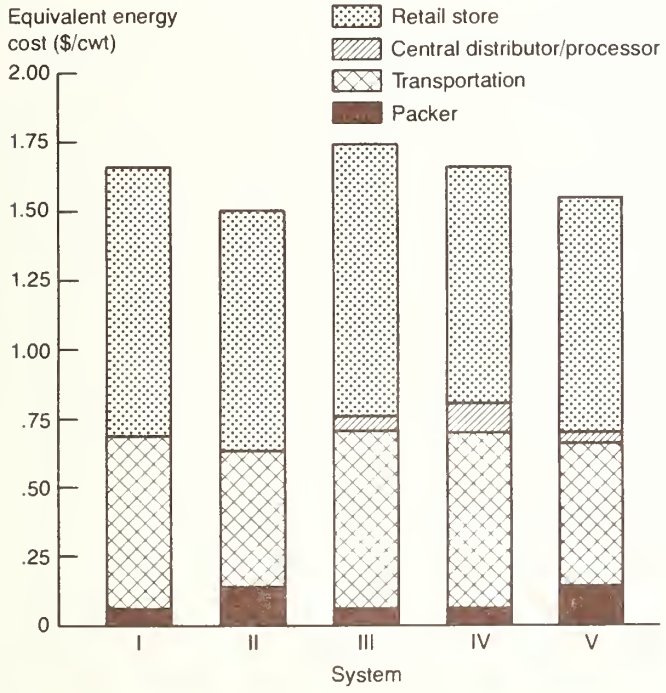


Figure 2

Equivalent Energy Cost by Category



Of the five systems studied, systems II and V had the lowest energy costs. In both of these systems, the packer broke the carcass into subprimal cuts before shipping. The only difference between the two systems was that in system V, the subprimals made an intermediate stop at the central distributor before being shipped to retail stores, while in system II they traveled from the packer directly to the retail stores. Consequently, the energy cost for system V was about $0.05/cwt greater than that of system II.

The two systems with the greatest energy cost were I and III. In both of these systems the beef was shipped in carcass form all the way to the retail stores. In system III, the carcasses were shipped from the packer through a central distributor, then to the retail stores, while in system I, the carcasses were shipped directly from the packer to the retail stores. This was the only difference between the two systems. The energy cost for system III was about $0.06/cwt greater than that of system I.

Based on the utility costs, shipping distances, and other assumptions used in this report, it is concluded that if the packer breaks beef carcasses into subprimal cuts before shipping them to a central processor or distributor or to retail stores, as opposed to shipping entire carcasses, a savings in energy costs of $0.10 to $0.23 per cwt of retail cuts can be achieved.

Appendix table 1.—Weight of 650-lb carcass flowing through system after moisture and cutting losses

Category	Function or description	Type of loss
Packer	Into carcass chill cooler	N.A.
Packer	Carcass chill and hold cooler	Moisture
Packer	Net carcass weight	N.A.
Packer	Boxed beef cutting and packaging	Cutting
Packer	Net weight of product shipped	N.A.
Transportation	Weight loss in transport	Moisture
Central distributor or processor	Net weight into holding cooler	N.A.
Central distributor or processor	Holding cooler	Moisture
Central distributor or processor	Net weight into cutting room	N.A.
Central distributor or processor	Boxed beef cutting and packaging	Cutting
Central distributor or processor	Net weight of product shipped	N.A.
Transportation	Weight loss in transport	Moisture
Retail store	Net weight into holding cooler	N.A.
Retail store	Holding cooler	Moisture
Retail store	Net weight into cutting room	N.A.
Retail store	Cutting into retail cuts and packaging	Cutting
Retail store	Net weight of product into display case	N.A.
Recap	Total moisture loss	—
Recap	Total cutting loss	—
Recap	Total moisture and cutting losses	—
Recap	Yield-retail cuts from 650-lb carcass	—

N.A. = not applicable.

System I		System II		System III		System IV		System V	
Weight	Loss	Weight	Loss	Weight	Loss	Weight	Loss	Weight	Loss
Lb	*Percent*	*Lb*	*Percent*	*Lb*	*Percent*	*Lb*	*Percent*	*Lb*	*Percent*
650.0	—	650.0	—	650.0	—	650.0	—	650.0	—
16.3	2.5	16.3	2.5	16.3	2.5	16.3	2.5	16.3	2.5
633.7	—	633.7	—	633.7	—	633.7	—	633.7	—
N.A.	N.A.	82.4	13.0	N.A.	N.A.	N.A.	N.A.	82.4	13.0
633.7	—	551.3	—	633.7	—	633.7	—	551.3	—
3.2	.5	0	0	3.2	.5	3.2	.5	0	0
N.A.	N.A.	N.A.	N.A.	630.5	—	630.5	—	551.3	—
N.A.	N.A.	N.A.	N.A.	4.7	.75	3.2	.5	0	0
N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	627.3	—	N.A.	N.A.
N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	81.5	13.0	N.A.	N.A.
N.A.	N.A.	N.A.	N.A.	625.8	—	545.8	—	551.3	—
N.A.	N.A.	N.A.	N.A.	3.1	.5	0	0	0	0
630.5	—	551.3	—	622.7	—	545.8	—	551.3	—
6.3	1.0	0	0	6.2	1.0	0	0	0	0
624.2	—	551.3	—	616.5	—	545.8	—	551.3	—
177.9	28.5	96.5	17.5	175.7	28.5	95.5	17.5	96.5	17.5
446.3	—	454.8	—	440.8	—	450.3	—	454.8	—
25.8	—	16.3	—	33.5	—	22.7	—	16.3	—
177.9	—	178.9	—	175.7	—	177.0	—	178.9	—
203.7	31.3	195.2	30.0	209.2	32.2	199.7	30.7	195.2	30.0
446.3	68.7	454.8	70.0	440.8	67.8	450.3	69.3	454.8	70.0

Appendix table 2.—Weight of product flowing through system to yield 100 lb of retail cuts in the display case (function equivalent weight)

Category	Function or description	Type of loss
Packer	Into carcass chill cooler	N.A.
Packer	Carcass chill and hold cooler	Moisture
Packer	Net carcass weight	N.A.
Packer	Boxed beef cutting and packaging	Cutting
Packer	Net weight of product shipped	N.A.
Transportation	Weight loss in transport	Moisture
Central distributor or processor	Net weight into holding cooler	N.A.
Central distributor or processor	Holding cooler	Moisture
Central distributor or processor	Net weight into cutting room	N.A.
Central distributor or processor	Boxed beef cutting and packaging	Cutting
Central distributor or processor	Net weight of product shipped	N.A.
Transportation	Weight loss in transport	Moisture
Retail store	Net weight into holding cooler	N.A.
Retail store	Holding cooler	Moisture
Retail store	Net weight into cutting room	N.A.
Retail store	Cutting into retail cuts and packaging	Cutting
Retail store	Net weight of product into display case	N.A.

N.A. = not applicable.

System I		System II		System III		System IV		System V	
Weight	Loss	Weight	Loss	Weight	Loss	Weight	Loss	Weight	Loss
Lb	*Percent*	*Lb*	*Percent*	*Lb*	*Percent*	*Lb*	*Percent*	*Lb*	*Percent*
145.6	—	142.9	—	147.5	—	144.3	—	142.9	—
3.6	2.5	3.6	2.5	3.7	2.5	3.6	2.5	3.6	2.5
142.0	—	139.3	—	143.8	—	140.7	—	139.3	—
N.A.	N.A.	18.1	13.0	N.A.	N.A.	N.A.	N.A.	18.1	13.0
142.0	—	121.2	—	143.8	—	140.7	—	121.2	—
.7	.5	0	0	.7	.5	.7	.5	0	0
N.A.	N.A.	N.A.	N.A.	143.1	—	140.0	—	121.2	—
N.A.	N.A.	N.A.	N.A.	1.1	.75	.7	.5	0	0
N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	139.3	—	N.A.	N.A.
N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	18.1	13.0	N.A.	N.A.
N.A.	N.A.	N.A.	N.A.	142.0	—	121.2	—	121.2	—
N.A.	N.A.	N.A.	N.A.	.7	.5	0	0	0	0
141.3	—	121.2	—	141.3	—	121.2	—	121.2	—
1.4	1.0	0	0	1.4	1.0	0	0	0	0
139.9	—	121.2	—	139.9	—	121.2	—	121.2	—
39.9	28.5	21.2	17.5	39.9	28.5	21.2	17.5	21.2	17.5
100.0	—	100.0	—	100.0	—	100.0	—	100.0	—

Bibliography

A Dialogue Between Producers and Retailers of Beef. Super Market Institute, August 1975.

A Look at Trends in the Meat Industry . . . 1975. Super Market Institute, May 1975.

A Study of Energy Conservation Potential in the Meat Packing Industry (draft). Johns Manville Corporation. Federal Energy Administration, May 1976.

Development Document for Effluent Limitations, Guidelines and New Source Performance Standards for the Renderer Segment of the Meat Products and Rendering Processing Point Source Category. EPA-440/1-74/031-D, January 1975.

Development Document for Proposal Effluent Limitations, Guidelines and New Source Performance Standards for the Processor Segment of the Meat Products Point Source Category. EPA-440/1-74/031, August 1974.

Energy Conservation in the Food System: A Publications List. Booz, Allen and Hamilton, Federal Energy Administration/76/080-D, May 1976.

Energy Consumption for Transportation in the U.S. Oak Ridge National Laboratory, Oak Ridge, Tenn., ORNL-NSF-EP-15, March 1972.

Energy Usage in Small Meat Plants. Brasington, Clayton F. USDA, Agricultural Research Service, Transportation and Marketing Research, P.O. Box EC, College Station, Tex. 77840.

Energy Usage in Supermarkets. Special Research Report No. 19, Super Market Institute, 1976.

Energy Use in the Food System. Booz, Allen and Hamilton, Federal Energy Administration/76/083-D, May 1976.

Feasibility of a Physical Distribution System Model for Evaluating Improvements in the Cattle and Fresh Beef Industry. Kearney & Co., Inc., A.T. USDA, ARS-52-36, November 1969.

Financial Facts About the Meat Packing Industry. American Meat Institute, 1975.

Frozen Meat—Its Distribution Costs, Acceptance and Cooking and Eating Qualities. Smith, Floyd W., Agricultural Experiment Station, Kansas State University, Manhattan, Kansas, September 1973.

Industrial Energy Study of Selected Food Industries for the Federal Energy Office/U.S. Department of Commerce. Development Planning and Research Associates, #14-01-0001-1652. Federal Energy Administration, July 1974.

Meatfacts—A Statistical Summary About America's Largest Food Industry. American Meat Institute, 1976 Edition.

Method and Costs of Distributing Beef to the Food-Service Industry. Stafford, Thomas F., Cornell University Agricultural Experiment Station, March 1974.

NAFC Report on Meat: The Move to Centralization. National Association of Food Chains, October 1973.

National Energy Outlook. Federal Energy Administration, 1976.

Proceedings of the Meat Industry Research Conference. American Meat Science Association, March 1976.

Recommended Guidelines for Retail Store Energy Conservation. CRMA-EC-1, Commercial Refrigeration Manufacturers Association.

Standard Industrial Classification Manual. Executive Office of the President, Office of Management and Budget, 1972.

Summary Report—Meat Clinic. American Meat Institute, March-April, 1976.

The Supermarket Industry Speaks. Super Market Institute, 1975.

What It Is—How It's Changed. National Livestock and Meat Board, 1976.

U.S. GOVERNMENT PRINTING OFFICE: 1981-360-932:AMS-102

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. 20250

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF
AGRICULTURE
AGR 101
THIRD CLASS