ERS-138

Costs of Electric Power and Fuel

FOR DRIERS IN COTTON GINS, ARKANSAS AND MISSOURI

U.S. DEPARTMENT OF AGRICULTURE ■ Economic Research Service ■ Agricultural Research Service

ACKNOWLEDGMENTS

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SUMMARY AND CONCLUSIONS

Currently, nearly three-fifths of the approximately 5,400 cotton gins in the United States are powered by electricity, a proportion about double that of 20 years ago. The proportion of gins having seed cotton drying equipment also has grown rapidly during the past 20 years, increasing from about 10 percent in 1940 to 96 percent by 1962. Thus, electric power and fuel for driers are now important operating items of expense in a majority of the Nation's cotton gins.

Average power cost per bale for all gins studied in the northern Delta area in 1960-61 was $1.69. Cost of individual gins ranged from less than $1 to over $3 per bale. The 5/80 plants (gin plants with 5 stands of 80 saws each) with elaborate overhead cleaning equipment, generally accompanied by more extensive materials handling equipment, had the highest group average power cost at $1.83 per bale. Generally, plants with elaborate overhead equipment had higher average power costs per bale than gins of similar size with either moderate or simple overhead equipment.

Nearly two-thirds of the variation in power costs per bale was accounted for by differences in kilowatt-hours of energy consumed per bale ginned. Cost variation not explained by differences in electrical energy consumed can be attributed to variation in cost per kilowatt-hour. Average power costs per kilowatt-hour ranged from 2 to 6 cents, and averaged 3.7 cents for all gins. The differences in cost per kilowatt-hour among gins are closely associated with methods used in assessing charges. Power companies in the survey area generally varied rates with variations in number of bales ginned, or in total kilowatt-hours used. Total kilowatt-hours of energy used per season accounted for 48 percent of the variation in average power costs per kilowatt-hour.

The elaborate overhead 5/80 and 5/90 plants used the greatest number of kilowatt-hours per bale ginned, with group averages of approximately 52 and 51, respectively. Power used per bale by individual gins varied from about 28 kilowatt-hours for one of the simple 3/80 plants to almost 72 kilowatt-hours for one of the elaborate 4/80 plants. Fifty-four percent of the variation in kilowatt-hours used per bale was accounted for by: (1) connected horsepower (the sum of rated horsepower of all motors used in a plant), (2) number and size of fans, and (3) bales ginned per year. Although numbers of overhead cleaners, gin saws, and lint cleaners individually did not have a statistically significant effect on kilowatt-hours of energy used, they had an indirect influence on power use through their effects on connected horsepower.

Average connected horsepower for all gins was 344. The highest for any group of gins was 479 horsepower for 5/80 plants equipped with elaborate overhead, and the lowest was 185 horsepower for 3/80 plants using simple overhead setups. However, gins within the same overhead cleaning group varied by as much as 300 in their connected horsepower. Seventy-three percent of the variation in horsepower was explained by: (1) number and size of fans, (2) number of gin saws, (3) number of lint cleaners, and (4) overhead cleaning equipment.

The average number of fans for each gin was 9 and varied from 4 to 20. Gins equipped with elaborate overhead averaged 9.8 fans per gin, compared to an average of 6.7 fans for gins with simple overhead. The size 35 fan was observed most often, with nearly one-third of all fans being this size. Fan sizes 35 and 40 accounted for over one-half of all fans used. Fans require about two-thirds of total power used in ginning. Any improvement in plant layout or design that will reduce the number or size of fans can mean considerably lower power costs per bale. Fans consume substantially more power when moving air than when moving cotton or trash. Therefore, it is generally economical to close a plant down if it is without cotton for 10 minutes or more. Use of automatic throttling valves on fans moving cotton intermittently, and use of a fan of the proper size for the job to be done can also aid in lowering power costs.

An additional important area for possible improvement in use of power is increased efficiency at gin stands. Since volume of cotton reaching the stands is one of the biggest factors influencing the level of efficiency at gin stands, it is essential that plant design provide for adequate volumes of cotton at the stand at all times. Past studies, as well as recent observations, indicate that gin stands frequently run idle for extended periods and that often moderate changes in organization of the plant can keep all gin saws at all stands ginning at or near capacity. This, in turn, means more ginned lint per kilowatt-hour of energy consumed and lower power costs per bale ginned.

Based on data from Arkansas and Missouri gins, natural gas, when available, is the most economical type of drying fuel. Gins using this fuel had average drying costs of 22 cents per bale ginned. Average drying cost per bale for gins using propane-butane was 54 cents. However, there was considerable variation among gins using each type of fuel. A portion of the variation around these averages doubtlessly can be traced to differences in average moisture content of cotton ginned. But a portion is undoubtedly due also to drying below optimum levels and inefficient operation of driers.

COST OF ELECTRIC POWER AND FUEL FOR DRIERS IN COTTON GINS, ARKANSAS AND MISSOURI

By Shelby H. Holder and Oliver L. McCaskill 1/

INTRODUCTION

Increased costs of constructing new cotton gins or modifying existing ones to keep them abreast of the rapid technological advances in equipment have made ginners acutely aware of the need to operate efficiently. Ginner groups have requested the development of information on operating costs for various types of gins as a basis for evaluating their relative operating efficiency and indicating potential reductions in costs.

The shift to mechanized cotton harvesting has been the most important factor behind the pronounced changes in ginning during the past two decades. The first result of the shift was to increase the amount of conditioning and cleaning equipment needed in gins. Shortened harvesting periods and the potential reduction of averaged fixed costs through increased volumes have brought about the development and installation of high capacity gin stands.

Marked shifts in the type and amount of fuel utilized by gins have accompanied the changes in gin equipment. From 1940 to 1957 the proportion of electrically powered gins doubled in the United States, increasing from 28 percent of the total in 1940 to 56 percent in 1957 (fig. 1). 2/ Steampowered gins are now virtually nonexistent, and there has been a marked decline in gasoline-powered gins.

The increase in the importance of fuel for driers is even more pronounced than changes in the number of electrically powered gins. Only one-tenth of the gins in the United States had driers in 1940, whereas by 1962, almost 96 percent had such equipment. In 1962, approximately one-half of these gins had two stages of drying and about 10 percent had three or more stages.

PURPOSE AND METHOD OF STUDY

The purpose of this study was to determine: (1) power costs for specified types of gins and factors affecting these costs, and (2) consumption of fuel for driers and its cost per bale ginned.

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2/ Cotton Division, Agricultural Marketing Service. Cotton Ginning Machinery and Equipment in the United States. U. S. Dept. Agr. (Previously published by U. S. Dept. of Commerce, Bur. of Census.)

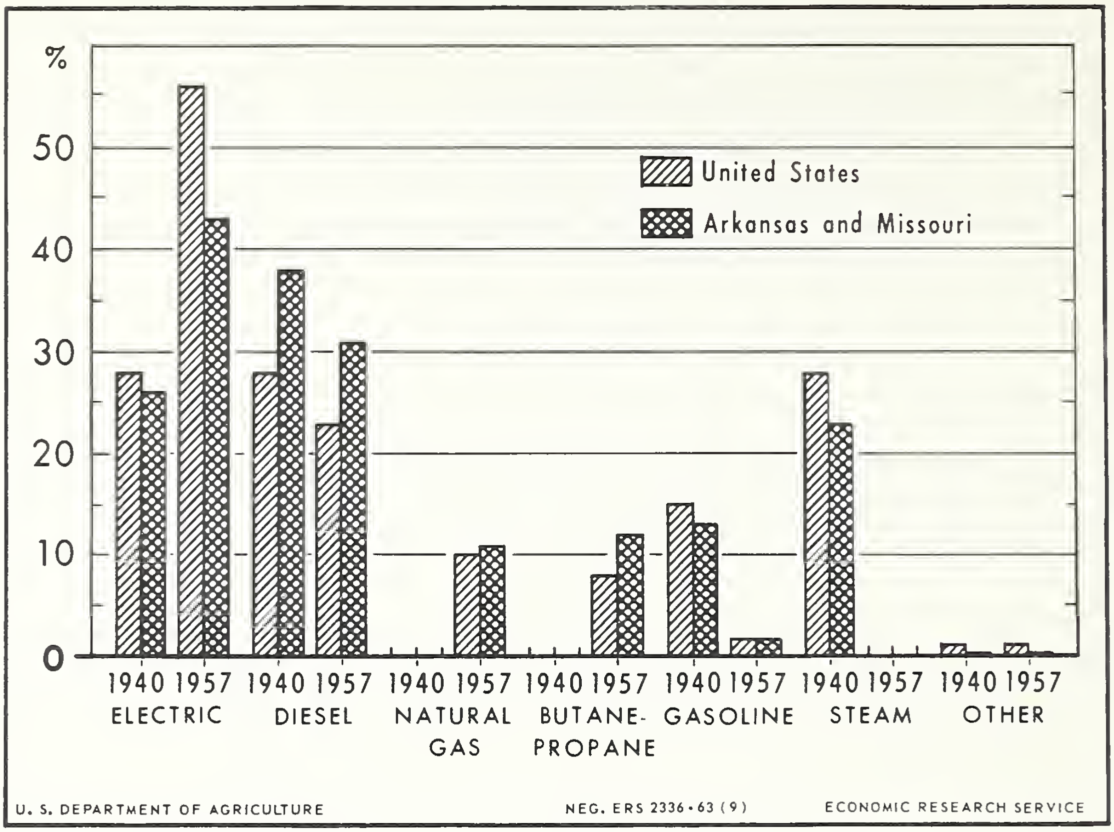

Figure 1.--Distribution of cotton gins, by type of motive power, 1940 and 1957.

Data were obtained during the 1960-61 season from 90 all-electric gins located in Arkansas and Missouri. Plants ranged in size from 3/80-saw gin stands to 5/90-saw stands. 3/ Data on quantity and cost of electricity used were collected from all gins, and data on quantity and cost of fuel for driers were collected from 49 of these gins.

ELECTRIC POWER REQUIREMENTS AND COST

Power is one of the most important variable costs in a ginning operation. This item alone costs the Nation's ginners millions of dollars each year. As horsepower requirements have increased in response to changes in harvesting methods and gin machinery technology, total power bills have increased. Faced with larger total power bills, ginners have become more aware of the need for increasing power efficiency. The wide variation in power requirements and costs revealed by this study indicates that substantial improvement is possible in many gins.

3/ Because of the few number of high-capacity gins in commercial operation at the time this study was initiated, none of these gins was included.

Power Costs Per Bale

The average power cost per bale for the 90 gins was $1.69, with individual costs ranging from less than $1 to over $3 per bale. Based on actual cost to ginners, there was wide variation in per bale costs between gins of similar size and equipment. The highest group average power cost was $1.83 per bale for plants with 5/80-saw gin stands and elaborate overhead cleaning equipment (table 1). Individual plants within this group had costs ranging from $1.37 to $2.39 per bale. Gins with simple overhead equipment had the lowest group average power costs per bale, with the exception of the 3/80 plants. One reason for the higher average power costs for this group of gins may be low-volume ginning. Three of the plants in this group ginned less than 1,000 bales and 2 of the 3 ginned less than 700 bales.

Table 1.--Power cost: Average, low, and high in electric power costs per bale ginned, by number and size of stands and by overhead setup, Arkansas and Missouri, 1960-61

Number and size of stands	Type of overhead machinery	Gins	Cost per bale 1/		
			Average	Low	High
		Number	Dollars	Dollars	Dollars
5/90..........	Elaborate	5	1.78	1.18	1.98
4/90..........	Elaborate	19	1.60	.88	2.28
3/90..........	Elaborate	7	1.63	1.34	2.13
5/80..........	Elaborate	5	1.83	1.37	2.39
4/80..........	Elaborate	14	1.70	1.25	2/ 3.10
3/80..........	Elaborate	3	1.61	1.58	1.67
4/90..........	Moderate	3	1.63	1.34	1.94
3/90..........	Moderate	4	1.55	1.44	2.03
4/80..........	Moderate	11	1.52	1.11	2.17
3/80..........	Moderate	9	1.57	1.02	2.56
4/90..........	Simple	2	1.44	1.10	2.09
3/90..........	Simple	1	1.33	--	--
4/80..........	Simple	2	1.18	1.15	1.26
3/80..........	Simple	5	1.70	1.19	2.09
All gins....		90	1.69	.88	3.10

1/ These bale costs are based on actual power costs of individual gins.
2/ This gin had seasonal ginnings of only 600 bales.

Generally, plants with elaborate overhead equipment had higher average power costs per bale than similar sized gins equipped with moderate or simple overhead. Average power costs for all gins with elaborate overhead was $1.67 per bale. Gins having moderate and simple overhead setups had average power costs of $1.55 and $1.45, respectively.

Almost two-thirds of the variation in power costs per bale was due to differences in kilowatt-hours of energy consumed per bale ginned (appendix table 7). Variation in cost per bale not explained by differences in kilowatt-hours can be attributed to variation in cost per kilowatt-hour.

Cost Per Kilowatt-Hour

Average costs per kilowatt-hour ranged from 2 to 6 cents and averaged 3.7 cents for all gins. Over two-thirds of the gins had average kilowatt-hour costs of 3 to 4 cents. Less than 5 percent had kilowatt-hour costs below 3 cents and fewer than 2 percent had costs exceeding 5 cents.

The differences in cost per kilowatt-hour among gins may be associated with several factors. One of the most obvious is the basic rate charged by the power company. Gins studied in northeastern Arkansas and the Missouri Boot-heel, all served by the same power company, had some of the lowest average costs per kilowatt-hour. Of the 90 gins surveyed, those with average kilowatt-hour cost below 3 cents were all located in the Missouri Boot-heel. Nearly one-half the gins that had kilowatt-hour costs below 3.5 cents were located either in extreme northeastern Arkansas or the Missouri Boot-heel.

A second factor affecting the actual cost per kilowatt-hour is the practice of power companies to adjust the basic rate according to the volume of power used. Power companies in the survey area generally varied charges based on number of bales ginned, or on total kilowatt-hours used. Thus, as total kilowatt-hours consumed or bales ginned increases, the charge per kilowatt-hour decreases until it reaches the minimum rate. Because of the sliding scale arrangement of assessing rate charges, total kilowatt-hours used per season or total bales ginned have an important influence on average cost per kilowatt-hour. Total kilowatt-hours of energy used per season accounted for 48 percent of the variation in average power cost per kilowatt-hour (appendix table 7). An increase of 10,000 kilowatt-hours consumed per year was associated, on the average, with a decline of four one-hundredths of a cent per kilowatt-hour in cost of power.

Power Requirements Per Bale

Size of gin and quantity of equipment had some effect on kilowatt-hours of energy used per bale ginned, but other factors also had major effects. Plants with elaborate overhead equipment and with 5/80- and 5/90-saw gin stands used the greatest number of kilowatt-hours per bale ginned, with group averages of approximately 52 and 51, respectively (table 2). Individual gins within each of these groups varied by as much as 25 or more kilowatt-hours in their power consumption per bale ginned. Gins that had simple overhead

Table 2.--Power consumption: Average, low, and high in kilowatt-hours used per bale ginned, by number and size of stands, and by overhead setup, Arkansas and Missouri, 1960-61

Number and size of stands	Type of overhead machinery	Gins	Kilowatt-hours used		
			Average	Low	High
		Number	Number	Number	Number
5/90	Elaborate	5	51.10	32.14	59.61
4/90	Elaborate	19	47.32	28.97	67.17
3/90	Elaborate	7	44.84	33.76	53.98
5/80	Elaborate	5	51.92	40.18	65.43
4/80	Elaborate	14	47.85	40.58	1/ 71.94
3/80	Elaborate	3	42.24	40.58	42.73
4/90	Moderate	3	43.88	37.97	52.40
3/90	Moderate	4	45.79	41.24	51.42
4/80	Moderate	11	41.06	28.21	52.39
3/80	Moderate	9	44.64	32.69	61.19
4/90	Simple	2	37.86	30.80	51.57
3/90	Simple	1	35.12	--	--
4/80	Simple	2	35.22	30.35	37.50
3/80	Simple	5	39.49	28.11	44.51
All gins		90	46.08	28.11	71.94

1/ This gin had seasonal ginnings of only slightly over 600 bales.

equipment used the least power per bale ginned, with group averages of approximately 35 kilowatt-hours to slightly over 39. Power used by individual gins varied from a low of approximately 28 kilowatt-hours per bale for one of the simple 3/80 plants to almost 72 kilowatt-hours per bale for one of the elaborate 4/80's.

Fifty-four percent of the variation in kilowatt-hours used per bale was accounted for by (1) connected horsepower, (2) number and size of fans, and (3) bales ginned per year (appendix table 7). Number of cylinders of overhead cleaning, number of gin saws, and number of lint cleaners also were considered but were not found to have a statistically significant effect. However, these factors have an indirect influence on power use through their effects on connected horsepower.

Since gins of the same type often consume greatly different amounts of power, it would appear that savings can be made by more efficient operation and better plant design. An important area for improvement in this respect is gin stand efficiency, which refers to the proportion of time gin stands are in operation while the plant is running. Some gins operate at little more than two-thirds efficiency and a few have efficiency levels even below this. 4/ One of the biggest factors influencing level of gin stand efficiency is volume of cotton reaching the stands. This has been known for years, yet gin plants are still being designed or operated in such a manner that they do not provide adequate volumes of cotton at the stand. Keeping all gin stands operating at full capacity, or as nearly so as possible, means more ginned lint per kilowatt-hour of energy consumed. This, in turn, means lower costs per bale for power.

Connected Horsepower

Over the past several years, horsepower requirements for gins have grown substantially because of increased use of supplemental equipment. Average horsepower available at gins is more than twice that of 15 to 20 years ago.

The average connected horsepower for all gins in the study was 344. The 5/80 and 5/90 plants equipped with elaborate overhead machinery had the highest average connected horsepower. The horsepower of the 5/80 plants that had elaborate overhead equipment averaged 479, and the 5/90 plants with similar overhead averaged 471 horsepower (table 3). Some plants within these groups operated with as little as 300 connected horsepower; others had over 600. The 3/80 plants with simple overhead machinery had the least connected horsepower, with a group average of 185. The 3/80 and 3/90 plants had the least range in connection horsepower, regardless of overhead equipment.

Seventy-three percent of the variation in connected horsepower was explained by (1) number and size of fans, (2) number of gin saws, (3) number of lint cleaners, and (4) overhead cleaning equipment (appendix table 7). Number and size of fans was the largest contributor to variation, followed closely by number of saws. Overhead cleaning equipment had the least effect on this horsepower. The apparent importance of the effects of overhead equipment on connected horsepower, when looking at group averages, merely reflects those factors that do significantly change the needs for available horsepower. For instance, as more gin machinery is added to increase capacity, overhead cleaning equipment must be capable of handling the extra cotton without choke-ups. Thus, additional gin saws and fans are the factors having the significant effect on changes in requirements for more potential horsepower, and not the quantity of overhead equipment.

4/ Weaver, Otis T., and McVey, Daniel H. Using Gin Machinery More Effectively. U. S. Dept. Agr., FCS Bul. 7, Sept. 1955. Wash., D. C.
Griffin, Clyde A., and McCaskill, Oliver L. Cotton Ginning Power Requirements and Efficiency. U. S. Dept. Agr. Cotton Ginning Research Laboratory, Agricultural Engineering Research Division, Agricultural Research Service, Stoneville, Miss.

Table 3.--Connected horsepower: Average, low, and high, in connected horsepower, by number and size of stands and by overhead setup, Arkansas and Missouri, 1960-61

Number and size of stands	Type of overhead machinery	Gins	Connected horsepower		
			Average	Low	High
		Number	Number	Number	Number
5/90..........	Elaborate	5	471	300	605
4/90..........	Elaborate	19	405	299	557
3/90..........	Elaborate	7	317	245	381
5/80..........	Elaborate	5	479	289	605
4/80..........	Elaborate	14	362	265	495
3/80..........	Elaborate	3	260	178	335
4/90..........	Moderate	3	333	305	370
3/90..........	Moderate	4	319	272	395
4/80..........	Moderate	11	305	216	512
3/80..........	Moderate	9	275	204	369
4/90..........	Simple	2	288	255	321
3/90..........	Simple	1	241	--	--
4/80..........	Simple	2	265	250	280
3/80..........	Simple	5	185	140	233
All gins....		90	344	140	605

Fans and Their Effects on Power Requirements

As a group, gins that had elaborate overhead equipment averaged 9.8 fans per gin, compared to a group average of 6.7 fans for gins with simple overhead equipment. Viewed individually, however, the relationship between size of gin and number of fans is not always consistent. Some 5/90 plants equipped with elaborate overhead had as few fans as some 3/80's with simple overhead setups, and vice versa. Gins averaged 9 fans, each, with the number varying from 4 to 20 (table 4). Such wide variation in number of fans, even among the same type gins, indicates that substantial increases in efficiency can be attained in many gins.

The size 35 fan was most popular, with nearly one-third of all fans being this size. Fan sizes 35 and 40 accounted for over one-half of all fans used. About 15 percent of the fans were size 45 and larger, and less than 5 percent were size 20 or smaller.

Table 4.--Number and distribution of fans, by gin size and overhead setup, Arkansas and Missouri, 1960-61

Number and size of stands	Type of overhead machinery	Gins	Fans per gin			Distribution of fans by size group							Proportion of fans by size group					
			Average	Low	High	45 and above	40	35	30	25	20 and below	Total	45 and above	40	35	30	25	20 and below
		No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
5/90.....	Elaborate	5	12.4	7	20	8	18	15	5	13	3	62	12.9	29.0	24.2	8.1	21.0	4.8
4/90.....	Elaborate	19	10.3	6	18	31	43	50	34	24	13	195	15.9	22.1	25.6	17.4	12.3	6.7
3/90.....	Elaborate	7	8.7	4	14	12	9	14	7	16	3	61	19.7	14.8	23.0	11.5	26.2	4.8
5/80.....	Elaborate	5	9.8	6	13	11	15	17	4	1	1	49	22.5	30.6	34.7	8.2	2.0	2.0
4/80.....	Elaborate	14	9.0	6	12	14	30	48	19	15	--	126	11.1	23.8	38.1	15.1	11.9	--
3/80.....	Elaborate	3	8.0	6	18	1	2	14	3	4	--	24	4.2	8.3	58.3	12.5	16.7	--
4/90.....	Moderate	3	8.0	8	9	5	7	8	2	2	--	24	20.9	29.2	33.3	8.3	8.3	--
3/90.....	Moderate	4	10.8	9	14	6	6	15	12	2	2	43	14.0	14.0	34.9	27.9	4.6	4.6
4/80.....	Moderate	11	7.5	4	11	11	16	29	11	12	4	83	13.2	19.3	34.9	13.3	14.5	4.8
3/80.....	Moderate	9	9.0	6	13	13	6	32	15	13	2	81	16.1	7.1	39.5	18.6	16.1	2.6
4/90.....	Simple	2	8.5	8	9	1	6	3	3	3	1	17	5.9	35.4	17.6	17.6	17.6	5.9
3/90.....	Simple	1	6.0	--	--	2	--	2	2	--	--	6	33.3	--	33.3	33.4	--	--
4/80.....	Simple	2	6.5	6	7	1	6	2	2	2	--	13	7.6	46.2	15.4	15.4	15.4	--
3/80.....	Simple	5	6.2	4	9	2	7	9	6	6	1	31	6.4	22.6	29.0	19.4	19.4	3.2
All gins..		90	9.1	4	20	118	171	258	125	113	30	815	14.5	21.0	31.6	15.3	13.9	3.7

As indicated in earlier sections, number and size of fans are among the most important contributors to explained variation in number of kilowatt-hours used per bale ginned and variation in connected horsepower. Thus, any method of reducing number and size of fans can lower power costs.

A high proportion of a gin's total connected horsepower is required to operate fans. An approximation of connected horsepower required by fans was calculated by multiplying the average number and size of fans by measured power requirements of these fans when cotton was being moved. Based on these calculations, from one-half to two-thirds of total connected horsepower in the gins surveyed was required to operate the fans (table 5). Therefore, any improvement in plant design or piping layout that will reduce number of fans can mean lower power bills. Since fans consume substantially more power when moving air than when moving cotton or trash, it is generally considered economical to close a gin down if it is without cotton for 10 minutes or more. Installation of automatic throttling valves on fans that move cotton intermittently can also result in more economical operation. It is also important that a fan of the proper size be used for the job to be performed.

Table 5.--Proportion of total horsepower required by fans, by number and size of stands and by overhead setup, Arkansas and Missouri, 1960-61

Number and size of stands	Type of overhead machinery	Average connected horsepower: Gin plant	Required by fans 1/: Total	Required by fans 1/: Proportion
		Number	Number	Percent
5/90	Elaborate	471	257	55
4/90	Elaborate	405	213	53
3/90	Elaborate	317	184	58
5/80	Elaborate	479	241	50
4/80	Elaborate	362	192	53
3/80	Elaborate	260	157	60
4/90	Moderate	333	191	57
3/90	Moderate	319	219	69
4/80	Moderate	305	155	51
3/80	Moderate	275	181	66
4/90	Simple	288	165	57
3/90	Simple	241	136	56
4/80	Simple	265	139	52
3/80	Simple	185	118	64

1/ Estimates of connected horsepower required by fans were obtained by multiplying average horsepower requirements of specified sizes of fans (based on actual power readings) by number of fans. Number of specified sizes of fans applied to average horsepower requirements was determined by distributing average number of fans for various gin groupings according to proportional distributions from table 4.

COSTS OF FUEL FOR DRIERS

Propane-butane and natural gas are the most popular fuels for driers in the United States. In 1957 approximately 48 percent of the gins used propane-butane for drying seed cotton; 41 percent used natural gas; with most of the remainder using oil (fig. 2). In the south central Cotton Belt, over 95 percent of all gins used propane-butane or natural gas as a fuel in driers.

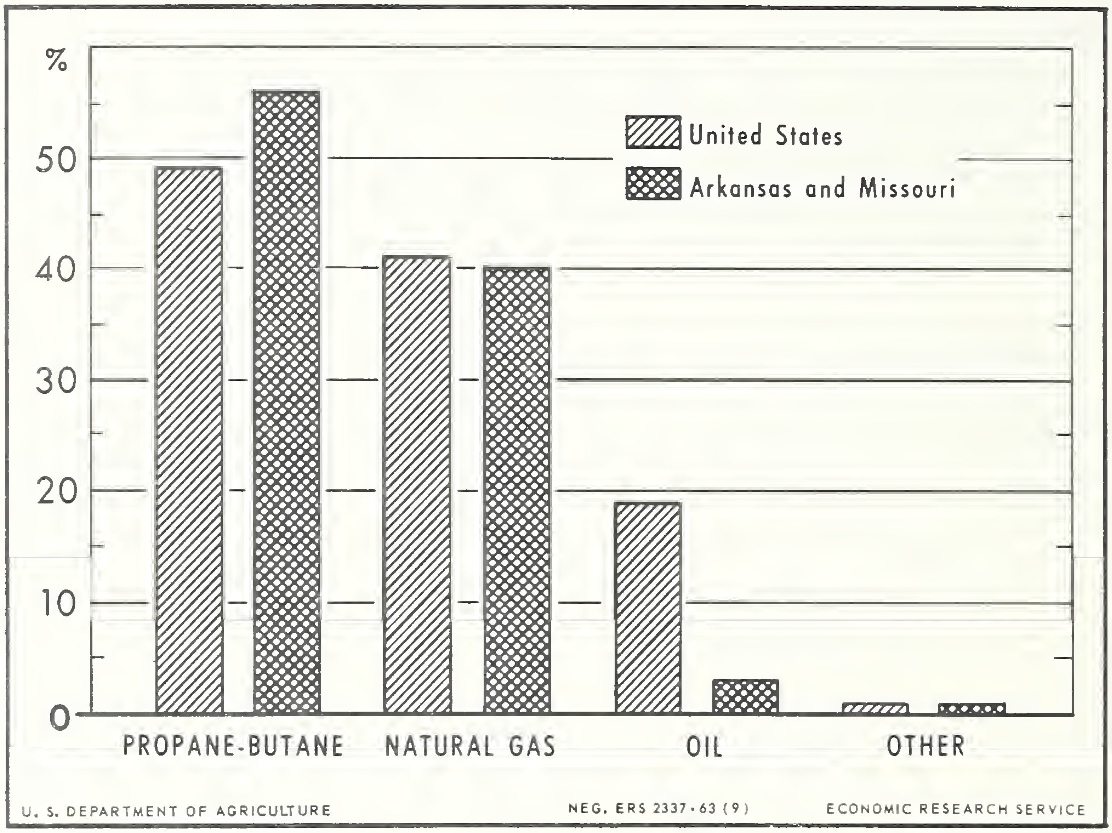

Figure 2.--Distribution of cotton gins by type of fuel used in driers, 1957.

Gins that used natural gas had an average drying fuel cost of 22 cents per bale, which was less than one-half the average cost of 54 cents per bale for propane-butane (table 6). Approximately one-fourth of the gins using propane-butane had drying costs exceeding 75 cents per bale, whereas none of the gins using natural gas had a cost greater than 43 cents per bale. The difference in cost of propane-butane and of natural gas is due mostly to difference in fuel cost per unit. 5/

5/ When cubic feet of natural gas and gallons of propane-butane consumed per bale ginned are compared in terms of British thermal units, they are nearly identical. Based on high heat value, 381 cubic feet of natural gas is equivalent to approximately 430,000 B.t.u.'s and 4.4 gallons of propane-butane is equivalent to about 429,000 B.t.u.'s.

Table 6.--Fuel in driers: Cost and consumption of fuel in driers, per bale ginned, Arkansas and Missouri, 1960-61

Type of fuel	Gins reporting	Fuel cost			Average units consumed 1/	Average cost per unit
		Average	Low	High		
	Number	Cents	Cents	Cents		Cents
Natural gas..	28	22	10	43	380.8 cu. ft.	5.8 per 100 cu. ft.
Propane-butane......	20	54	22	101	4.4 gal.	12.2 per gal.

1/ When cubic feet of natural gas and gallons of propane-butane consumed per bale ginned are compared in terms of British thermal units, they are nearly identical. Based on high heat value, 381 cubic feet of natural gas is equivalent to approximately 430,000 B.t.u.'s and 4.4 gallons of propane-butane is equivalent to about 429,000 B.t.u.'s.

The range in costs of fuel in driers among gins using the same fuel was partially accounted for by differences in drying temperatures. The higher the temperature per given volume of air, the more fuel required to heat it. Ginners consistently maintaining higher temperatures than necessary to obtain recommended moisture levels are "taking money out of their pockets" in terms of costs of fuel for driers. Length and layout of hot air line and moisture content of seed cotton are other factors that affect drying costs. Moisture content of seed cotton varies from season to season, from day to day, and even during the day, depending upon weather and other conditions at harvest time. Devices measuring moisture content of seed cotton or ginned lint can help ginners cope with such conditions and enable them to more accurately regulate drying temperatures. This would not only help prevent any overdrying of cotton in the gin, but would also avoid excess use of fuel associated with overdrying.

APPENDIX

Table 7.--Multiple correlation of specified dependent and independent variables and the resulting statistical values

Dependent variable	Independent variables				Coeff. of determination	Coeff. of multiple correlation	Partial regression coefficients			
Y	X_1	X_2	X_3	X_4	R^2	R	b_1	b_2	b_3	b_4
Power cost per bale ginned	Kw.-hr. 1/	---	---	---	.63	.80	.034001 (**)	---	---	---
Power cost per Kw.-hr.	Total Kw.-hr. per season	---	---	---	.48	.69	-.000000044 (**)	---	---	---
Kw.-hr. used per bale ginned	Connected Hp. 2/	Fans 3/	Bales ginned per yr.	---	.54	.73	.049676 (**)	.034907 (**)	-.002243 (**)	---
Connected Hp.	Fans 3/	Cyl. of overhead 4/	No. of lint cleaners	No. of gin saws	.73	.85	.499685 (**)	.029575 (*)	23.629313 (**)	.626684 (**)

1/ Kilowatt-hours of energy used per bale ginned.
2/ The rated horsepower according to the manufacturer.
3/ Number of specified fans, times their size.
4/ Number of cylinders of overhead, times length in inches.

** Statistically significant at the 1 percent level.
* Statistically significant at the 5 percent level.