use of Electricity on farms

a summary report of ten area studies

by Joe F. Davis

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PREFACE

This report brings together and relates some of the more important findings from farm electrification studies made in 10 of the major type-of-farming areas of the country. These studies were made by what is now the Production Economics Research Branch, Agricultural Research Service, U. S. Department of Agriculture, in cooperation with the agricultural experiment stations concerned. The list of studies follows:

Bonser, Howard J., and Davis, Joe F. Electricity on Farms and in Rural Homes in the East Tennessee Valley. Tenn. Agr. Expt. Sta. Bul. 221, 63 pp., illus. 1951. (U. S. Dept. Agr. cooperating.)

Bortfeld, C. F. and Davis, Joe F. Electricity on Farms in Southwestern Kansas. Kans. Agr. Expt. Sta. Bul. 351, 62 pp., illus. 1951. (U. S. Dept. Agr. cooperating.)

Davis, Joe F., and Staniforth, Sydney D. Electricity on Farms in the Eastern Dairy Area of Wisconsin. U. S. Dept. Agr., Agr. Inform. Bul. 143, 31 pp., illus. 1955. (Wis. Agr. Expt. Sta. cooperating.)

Davis, Joe F., and Strickler, Paul E. Electricity on Farms in the Eastern Livestock Area of Iowa. U. S. Dept. Agr. Cir. 852, 88 pp., illus. 1950. (Iowa Agr. Expt. Sta. cooperating.)

Davis, Joe F. Electricity on Farms in New York and New England. U. S. Dept. Agr., Agr. Inform. Bul. 124, 42 pp., illus. 1954.

Gaines, J. P., and Davis, Joe F. Electricity on Farms in the Clay Hills Area of Mississippi. Miss. Agr. Expt. Sta. Bul. 493, 42 pp., illus. 1952. (U. S. Dept. Agr. cooperating.)

Gilcreast, Roy M. Electricity—How Much? What For? On Farms in North-Central North Dakota. N. Dak. Agr. Expt. Sta. Bul. 379, 50 pp., illus. 1952. (U. S. Dept. Agr. cooperating.)

Steanson, Oscar, and Davis, Joe F. Electricity on Farms in the Upper Piedmont of Georgia. Ga. Agr. Expt. Sta. Bul. 263, 62 pp., illus. 1950. (U. S. Dept. Agr. cooperating.)

Stippler, Henry H. Electricity on Farms in Eastern Washington. Wash. Agr. Expt. Sta. Cir. 149, 77 pp., illus. 1951. (U. S. Dept. Agr. cooperating.)

Stippler, Henry H., and Peterson, A. W. Electricity on Farms in Northwestern Washington. U. S. Bur. Agr. Econ. FM 77, 105 pp., illus. 1950. (Wash. Agr. Expt. Sta. cooperating.)

Woodworth, R. C., and Beneke, R. R. Electricity in Farm Production, Eastern Livestock Area of Iowa. U. S. Dept. Agr., Agr. Inform. Bul. 100, 51 pp., illus. 1953. (Iowa Agr. Expt. Sta. cooperating.)

This series of studies was carried on under the guidance and general supervision of M. R. Cooper, Production Economics Research Branch, but many organizations and individuals made valuable contributions to the work. Truman E. Hienton, Agricultural Engineering Research Branch, Agricultural Research Service, U. S. Department of Agriculture, gave valuable advice and consultation at all stages in the development of the series of studies. A number of persons in the Rural Electrification Administration, U. S. Department of Agriculture, especially J. P. Schaenzer, R. D. Partridge, and E. C. Weitzell, were helpful. Special credit is also due those who prepared, or helped prepare, the individual reports: Oscar Steanson, Georgia Agricultural Experiment Station; A. W. Peterson, Washington Agricultural Experiment Station; R. C. Woodworth and R. R. Beneke of the Iowa Agricultural Experiment Station; Howard J. Bonser, Tennessee Agricultural Experiment Station; C. F. Bortfeld, Kansas Agricultural Experiment Station; J. P. Gaines, Mississippi Agricultural Experiment Station; Sydney D. Staniforth, Wisconsin Agricultural Experiment Station; and H. H. Stippler, Paul E. Strickler, and the late Roy M. Gilcreast of the Production Economics Research Branch. Suppliers of electricity in each study area provided records of kilowatt-hour consumption and cost for each of the farms studied. Finally, the splendid cooperation of farmers interviewed is gratefully acknowledged.

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By JOE F. DAVIS, *agricultural economist, Production Economics Research Branch, Agricultural Research Service, United States Department of Agriculture*

HIGHLIGHTS

This report was written to summarize some of the more significant results of studies on the use of electricity in 10 major type-of-farming areas of the country. These studies had two primary objectives: (1) To establish criteria that would be useful in estimating future consumption of electricity on farms of different types and in different situations, and (2) to develop information that would be useful to farmers—to appraise some of the ways in which electricity and electrical equipment can be used to further the goals of farmers and their families.

Records of consumption of electricity and costs to farmers in each of the studies were obtained for the 10 years immediately preceding the enumeration, or for the part of the decade in which the farm was electrified and the records were available. In these study areas, average consumption of electricity per farm in the decades of study increased at geometric rates, which ranged from 7 percent per year in southwestern Kansas to 21 percent in eastern Washington. In 5 of the 10 areas, average annual consumption of electricity per farm increased at rates that ranged from 13 to 16 percent a year.

Many factors contributed to the increased use of electricity during the study periods. Among these were technological developments of electrical equipment of various kinds, the fact that time is necessary for farmers to become aware of the potentialities of electrical equipment and to buy and install the kinds they want, the generally rising farm incomes during the period of study, the increasing sizes of commercial farms, the rising standards of living, and the shortages of labor.

In the three areas in which dairying and poultry production were the chief farming enterprises, the consumption patterns showed substantial similarity during the periods studied. The average rate of increase in use of electricity for farms in the New York-New England area was 13.3 percent a year, in eastern Wisconsin 13.6 percent, and in northwestern Washington 16.3 percent. Kilowatt-hour consumption records for wheat farms in southwestern Kansas and in north-central North Dakota were similar in many respects. Uses of electricity were similar also in the Upper Piedmont of Georgia and the Clay Hills of Mississippi. Farms are generally small in both these areas. Average consumption per farm in the Georgia area increased from 668 kilowatt-hours in 1943 to 1,050 in 1947, whereas the average for farms in the Mississippi area increased from 675 to 961 kilowatt-hours.

Significant differences were found among some of the areas in use of

electricity. Several factors contributed to these differences. Three of those identified were prevailing type of farming, size of farm or disposable income of the operators, and competition from other fuels and sources of power.

Many rate schedules were encountered in these studies. Most were of the block rate type, which provides for decreasing costs per kilowatt-hour after a specified minimum has been passed. Many suppliers had special rates for special uses.

The cost of electricity to farmers varied widely among the study areas. It ranged from 1.54 to 4 cents per kilowatt-hour. The average annual cost in the last year of record ranged from $36.37 to $157.52 per farm.

More than 400 different applications of electricity on farms and in farm homes have been identified. Before electricity can be used, it must be converted into light, heat, or motive power. Thus equipment of some kind is necessary to make the application. Of the electrical equipment used in farming operations, shop tools were most numerous. Dairy and poultry equipment, however, required much more electricity. Pieces of equipment for household operations were more numerous than for farm operations.

Costs of electrical equipment, installations, and wiring vary greatly among farms. Based on 1955 retail prices, a well-equipped, 1-man, 30-cow dairy farm in the northern part of the country can easily have an investment of $8,900 in electrically operated equipment. Of this, $3,200 would be for household operations, and $5,700 for use in service buildings and service areas. To this should be added the cost of farmstead wiring, which at 1955 prices probably would amount to between $1,500 and $2,500.

Electricity used in household operations ranged from 58 to 87 percent of the total used in each study area. Equipment used in farming operations required from 3 to 30 percent of the total, the lighting of homes and service buildings from 5 to 26 percent, and pumping water from 2 to 7 percent.

Of the types of farms studied, poultry farms had the most pronounced seasonal pattern of consumption. For these farms, consumption was high in winter and early spring and low in summer and early fall. Dairy farms used about as much electricity in one season as another, when allowance is made for new equipment added during the year. In most of the study areas, the seasons of high and low consumption by farms of different types were largely offsetting.

Many considerations may enter into the decision of a farmer to buy or not to buy a particular piece of equipment. These may be classified into three broad categories of considerations: (1) Those in which anticipated money returns are compared with money costs; (2) those that deal primarily with the management and allocation of labor resources; and (3) those in which anticipated returns are largely in personal satisfactions and services rather than in money. Still other considerations modify or limit the extent to which individual farmers can buy new equipment. Among these are alternative uses of limited capital resources, amount of power available to the farm, and the psychological makeup of the farmer himself.

Apparently, farmers will continue to use more and more electricity in the foreseeable future. Farmers want equipment to make farm life more desirable and farming more efficient. The need for additional equipment for use in farming operations is not equal on all farms. More than half the farms are so small that their operators have little opportunity to use electrical equipment outside their homes. Of 5.4 million farms reported by the 1950 Census of Agriculture, only 64,000 had 30 or

more milk cows and only 3,000 had as many as 3,200 chickens 4 months old or over.

Average consumption of electricity per electrified farm has increased at geometric rates since about 1940. The average increase per farm in the New York-New England area was 13.3 percent a year from 1942 through 1951. For the United States as a whole, average consumption per farm increased at the rate of 7.5 percent a year. Obviously, these rates of increase cannot continue indefinitely. There must come a time when the rate of increase will slow down. Some slowing down may be expected within the next 10 years. The actual level that will be attained will be determined in part by general economic conditions, technological developments, and the scope and effectiveness of educational programs.

WHY THE STUDIES WERE MADE

About 4.5 million of the 4.8 million farms in the United States had central-station electric service on June 30, 1955. This is 6 times the number of farms that had the service only 2 decades earlier. Powerlines now extend to almost all farming communities. More than 95 percent of the farms in 20 States had the service on June 30, 1955. Only 5 States—Montana, Nevada, New Mexico, North Dakota, and Wyoming—had less than 85 percent of their farms electrified at that time (table 1).

TABLE 1.—*Percentage of electrified farms in specified years, by State and area, United States*

State and area	Farms electrified—					All farms, November 1954
	December 31, 1934	April 1, 1940	January 1, 1945	April 1, 1950	June 30, 1955	
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Number*
Maine	33.3	51.9	63.5	85.6	94.0	23,368
New Hampshire	53.7	65.5	80.9	94.7	97.6	10,411
Vermont	29.4	51.8	67.7	91.7	97.5	15,981
Massachusetts	41.3	82.2	88.9	91.2	98.3	17,361
Rhode Island	45.6	81.5	86.3	92.8	97.5	2,004
Connecticut	31.5	80.3	87.9	92.2	98.8	12,753
New York	32.7	66.7	80.9	93.5	97.9	105,714
New Jersey	51.6	82.4	89.5	93.3	99.1	22,686
Pennsylvania	23.6	55.7	71.5	90.9	96.5	128,876
Delaware	17.3	39.4	59.7	81.8	95.2	6,297
Maryland	15.3	40.7	57.4	83.5	93.4	32,500
Northeast	30.2	61.2	75.1	90.9	96.8	377,951
Ohio	18.8	58.9	73.7	92.9	97.1	177,074
Indiana	11.7	49.4	69.0	91.5	97.7	153,593
Illinois	12.3	37.5	57.3	86.4	96.9	175,543
Iowa	14.4	34.4	59.0	90.3	97.6	192,933
Missouri	6.4	15.3	30.1	68.7	94.8	201,614
Corn Belt	12.6	38.3	56.8	85.3	96.8	900,757
Michigan	21.4	69.9	81.8	94.2	97.9	138,922
Wisconsin	19.6	46.9	67.3	92.3	96.7	153,558
Minnesota	6.8	25.4	46.3	82.8	94.5	165,225
Lake States	15.9	47.0	64.7	89.5	96.3	457,705

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TABLE 1.—*Percentage of electrified farms in specified years, by State and area, United States*—Continued

State and area	Farms electrified—					All farms, November 1954
	December 31, 1934	April 1, 1940	January 1, 1945	April 1, 1950	June 30, 1955	
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Number*
Virginia	7.6	24.1	35.8	75.5	92.3	136,416
West Virginia	3.5	25.4	38.7	72.2	92.9	68,583
North Carolina	3.2	24.3	37.5	75.9	94.8	267,906
Kentucky	3.0	15.3	28.9	66.3	91.4	193,487
Tennessee	3.6	15.7	29.7	71.2	92.7	203,149
Appalachian	4.0	20.2	33.5	72.2	95.7	869,541
South Carolina	2.3	20.0	35.2	68.1	89.1	124,203
Georgia	2.8	19.6	33.7	75.2	92.7	165,524
Florida	7.8	24.9	39.6	70.8	88.0	57,543
Alabama	4.0	14.6	29.0	68.2	90.0	176,956
Southeast	3.6	18.4	33.0	70.7	90.4	524,226
Mississippi	.9	9.0	18.6	55.8	86.1	215,915
Arkansas	1.7	10.7	24.2	66.8	93.5	111,127
Louisiana	1.2	9.8	21.2	66.6	92.8	145,075
Delta States	1.2	9.6	20.7	61.8	89.9	472,117
Oklahoma	2.6	11.2	27.1	64.7	90.8	118,979
Texas	2.3	18.9	39.5	78.1	92.4	292,946
Southern States	2.4	16.6	35.8	74.1	91.9	411,925
North Dakota	2.3	4.4	10.3	54.5	84.4	61,939
South Dakota	3.5	5.5	12.5	56.4	86.6	62,520
Nebraska	7.1	18.9	33.8	72.2	92.6	100,846
Kansas	7.6	17.9	31.6	69.8	90.7	120,167
Northern Plains	5.8	13.7	25.1	65.4	89.4	345,472
Montana	5.5	19.0	28.9	65.3	84.7	33,059
Idaho	29.8	58.3	74.8	91.6	96.9	38,735
Wyoming	3.0	23.1	36.6	62.9	84.6	11,392
Colorado	11.2	28.8	48.6	72.0	87.0	40,749
New Mexico	3.3	13.1	23.9	55.1	80.5	21,070
Arizona	29.6	30.4	65.5	72.4	86.6	9,321
Utah	52.5	68.5	75.3	88.6	96.9	22,285
Nevada	25.6	43.5	52.2	58.2	72.0	2,857
Mountain	17.6	34.6	50.4	74.1	88.8	180,008
Washington	47.5	71.4	83.2	91.9	98.3	65,175
Oregon	27.5	58.8	73.9	89.3	97.2	54,442
California	53.9	81.3	85.3	90.0	95.9	123,074
Pacific	46.4	73.3	82.2	90.3	96.9	242,691
United States	10.9	30.4	45.7	77.2	93.4	4,782,393

Not only has the number of farms that use this invisible source of power increased, but average use per farm also has expanded. In 1935, electrified farms used an average of 2,200 kilowatt-hours per farm. By 1954, the average had increased to 4,100 kilowatt-hours. Thus the 20.8 billion kilowatt-hours of electricity used on farms in 1954 was more than 12 times the 1.7 billion used in 1935.[1]

Little is known of the impact of electrification on American agriculture. That the effect has been profound is obvious. But the extent to which farmers now depend on electricity for the operation of their farms is seldom appreciated until there is an interruption in the service. Some farmers are unwilling to assume the risk of loss and inconvenience that may result from a power failure. They install auxiliary generating equipment of sufficient capacity to operate their most essential pieces of equipment for a few hours or days.

The extension of electric distribution systems to so many farms has created many new and perplexing problems. Some are of primary concern to farmers, others to those who manufacture and distribute equipment, and some to those who generate and distribute the power. The community of interests may be illustrated by crop driers that use electric power.

To use a crop drier effectively, a farmer must have a suitable building in which to house it and adequate farmstead wiring to carry power to the motors. Probably he will need to acquire new skills in order to operate the equipment and handle the crops that are dried. The supplier of electricity will need information as to the number of driers that may be installed, as this could affect the power requirements of the system. He will want to know who has the driers, as this may affect the size of transformer needed at the farm. Manufacturers and distributors of the basic equipment will want to know about the functional specifications of the equipment individual farmers need and the probable number of driers that may be sold in any one season.

Soon after 1940, it became evident that the amount of electricity used by farmers exceeded the estimates that in earlier years had been considered "liberal." Distribution systems in some areas were overloaded. Many farmers in unserved areas were asking for the service. As a consequence, the Rural Electrification Administration and other groups concerned with rural electrification expressed a need for a clearer understanding of the factors that affect consumption of electricity on farms.

In 1948, studies of some economic aspects of farm electrification were begun by what is now the Production Economics Research Branch, Agricultural Research Service. Two primary objectives were set forth at the beginning: (1) To establish criteria that would be useful in making estimates of future power requirements by farms of different types and sizes, and (2) to develop information that would be of primary use to farmers in operating their farms—to appraise the usefulness of electrical equipment in reducing costs and increasing efficiency in farm production.

Selection of Study Areas

Because little was known of the problems that might be encountered in the work, the first studies were designed to restrict the universe to electrified farms within a type-of-farming area of an individual State. This would keep to a minimum the types and sizes of farms to be studied. It would also limit the number of suppliers of electricity to contact.

[1] Edison Electric Institute. ELECTRIC UTILITY INDUSTRY IN THE UNITED STATES. Edison Electric Inst. Statis. Bul. for . . . 1954. No. 22 (Pub. 55-2), 64 pp. 1955.

It was considered desirable, however, that the farms in the study be fairly representative of those in a larger region.

An additional consideration restricted to some degree the possible locations for the studies. The act that authorized the funds stipulated the cooperation of the State agricultural experiment stations. Thus it was necessary that the surveys be made in cooperation with State agricultural experiment stations that were interested in the line of work and had some resources to put into it.

Surveys on which this summary is based were made in 10 areas as follows: A dairy-poultry area of western Washington, a wheat-producing area of eastern Washington, a spring wheat area of north-central North Dakota, a red winter wheat area of southern Kansas, the eastern livestock area of Iowa, the eastern dairy area of Wisconsin, the Clay Hills of Mississippi, the Upper Piedmont of Georgia, the East Tennessee Valley of Tennessee, and all of New York and New England. In addition to these, a study primarily concerned with the use of electricity and electrical equipment in increasing the efficiency of farm production was made in the eastern livestock area of Iowa. Thus, 11 studies have been made in 10 study areas (fig. 1).

The sample of farms for enumeration in each study area was intended to be representative of all electrified farms in that area. The random-block system of sampling was used in seven of the studies. In the remaining surveys, the sample farms were scattered throughout the respective areas. Most of the enumerators were students from the State colleges of agriculture.

Records of consumption of electricity and of costs to farmers were provided by the suppliers of power.

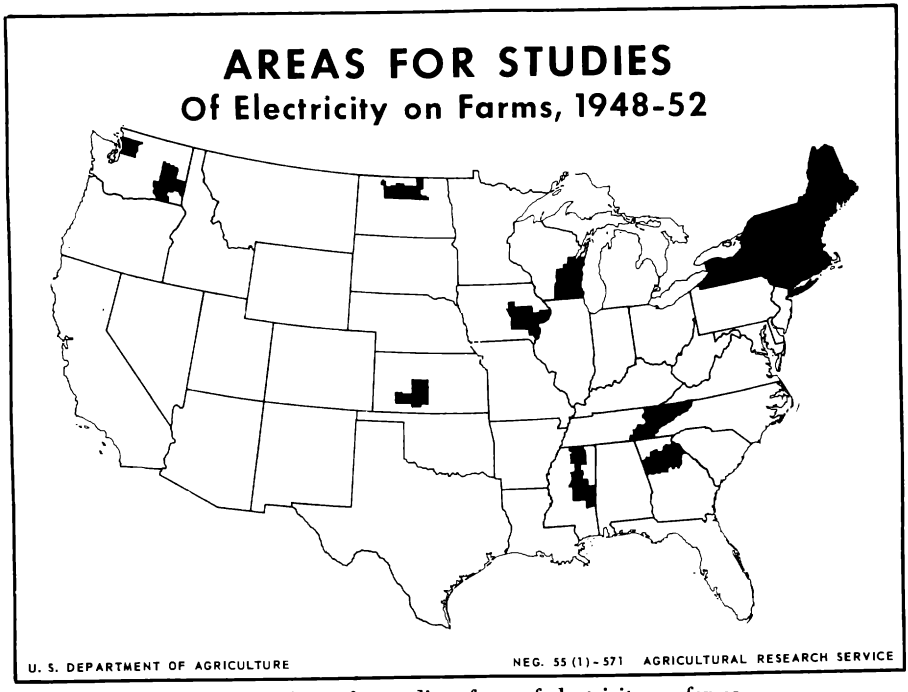

Figure 1.—Areas for studies of use of electricity on farms.

These records covered the 10 years immediately preceding the enumerations. Records of consumption for the first studies were for 1938 to 1947, inclusive; records for the last study were for 1942 to 1951, inclusive.

AVERAGE CONSUMPTION INCREASING

In each study area, average consumption of electricity per farm was considerably higher at the end of the decade of study than at the beginning. The increases were achieved even though many farms that had previously been without electric service were connected to distribution systems during those years. These newly electrified farms tended to pull down the average consumption of electricity. Farmers with only brief experience with central-station electric service tend to use less electricity than similar farmers who have used electricity for a number of years.

The rate of increase in each study area was geometric. The most rapid rate—21 percent annually—was found in eastern Washington. The lowest rate of increase—7 percent a year—was found in southwestern Kansas, where gas was a strong competitor with electricity for some major household uses. In 5 of the 10 areas, average annual consumption per farm increased at rates that ranged from 13 to 16 percent a year. In 3 of these 5 areas, dairying and poultry production were important farm enterprises. These areas were in western Washington, Wisconsin, and New York and New England. The remaining 2 of the modal 5 were areas of small farms of various types in Mississippi and Tennessee. The increase for each area, in terms of magnitude during the period of study, and the annual rate of increase are presented in table 2.

TABLE 2.—*Electricity used per farm in designated years and increase in use during period of record, designated study areas*

Study area	Consumption of electricity per farm				Increase	
	Year	Amount	Year	Amount	Amount	Annual rate [1]
		Kwh		*Kwh*	*Kwh*	*Percent*
Upper Piedmont of Georgia	1940	549	1947	1,050	501	[2] 8.3
Northwestern Washington	1938	1,080	1947	4,240	3,160	16.3
Eastern livestock area of Iowa	1938	812	1947	2,174	1,362	10.5
East Tennessee Valley	1939	654	1948	2,139	1,485	14.7
Eastern Washington	1939	1,534	1948	9,845	8,311	20.9
Southwestern Kansas	1939	1,315	1948	2,428	1,113	7.2
Clay Hills of Mississippi	1941	452	1949	1,494	1,042	[3] 14.6
North-central North Dakota	1942	1,442	1949	3,276	1,834	[2] 10.8
New England and New York	1942	1,657	1951	5,057	3,400	13.3
Eastern dairy area of Wisconsin	1940	1,252	1949	4,233	2,981	13.6

[1] Regression equations of $Y=ab^x$ form.
[2] 8 years only.
[3] 9 years only.

Causes of Increases

A part of the increase in average consumption was due to technological developments. These developments included both the improvement of conventional kinds of electrical equipment and the creation and perfection of new kinds. Transformation in conventional equipment becomes obvious when advertisements with pictures of ranges, lighting fixtures, and other kinds of equipment available today are contrasted with comparable advertisements of 25 years ago. Among new kinds of equipment now readily available are electric blankets, television sets, bulk milk-handling facilities, and hay-drying equipment.

Another part of the increase was due to the fact that farmers must have time to become acquainted with the potentialities of electrical equipment and to buy and install the kinds they want. Few farmers equip their farms completely immediately on receiving electric service. The delay on some farms may be caused by lack of money with which to buy the desired equipment. On these farms, the purchases may be postponed until money is accumulated or borrowed. On other farms, the delay may be due to the physical difficulty of making the installations at one time. But in many instances, farmers do not realize what the equipment can do for them. There is a substantial time-lag between the time research establishes the worth of a machine or farm practice and the time it is generally adopted by farmers. In all study areas, farmers were buying and installing electrical equipment even though their experience with power-line electricity extended for 25 years or more.

Contributing to the increase also was the generally rising farm income during the periods of study. The studies have demonstrated that, as a rule, there is a direct relationship between the income of the operator and the use of electricity on farms of similar type. Comparable data for periods of stable or declining farm incomes are not available.

The generally increasing size of enterprise on commercial farms also helped to increase the use of electricity on the farms during the periods of study. As enterprises become larger, the need for equipment used in farming operations becomes greater. For example, a farm with 30 milk cows uses more electricity for pumping water, milking, and cooling milk than a similar farm with 20 cows. A complex of other factors also contributed to the increased usage. The rapid mechanization of farms increased the need for repairs to be made quickly and on the farm. Labor shortages, especially during the war years, increased the need for equipment to save farm labor and to make labor more productive. Finally, the generally rising standards of living changed our concepts of "necessities" and "luxuries." The effects of none of these factors can be isolated or measured, but there can be no doubt that each had an influence.

THE AREAS COMPARED

The last year for which consumption records were obtained in all study areas was 1947. In that year, average consumption per farm ranged from less than 1,000 kilowatt-hours in the Clay Hills of Mississippi to more than 8,000 in eastern Washington. There is little similarity in farming in these two areas. Farms in eastern Washington produced wheat and cattle primarily and farms in Mississippi produced cotton and feed crops. Farms in eastern Washington had 12 times as many acres per farm as Mississippi farms, whereas the average total income of the operator (including farm and nonfarm sources) was almost 10 times as large. In eastern Washington, less

than 1 percent of the total income of operators came from nonfarm sources, compared with 37 percent in Mississippi.

Consumption patterns among areas of similar types of farms, however, showed considerable similarity. The study areas of northwestern Washington, eastern dairy area of Wisconsin, and New York-New England—the three areas in which dairying and poultry production were the principal farming enterprises—may be used for illustration (fig. 2). The average rate

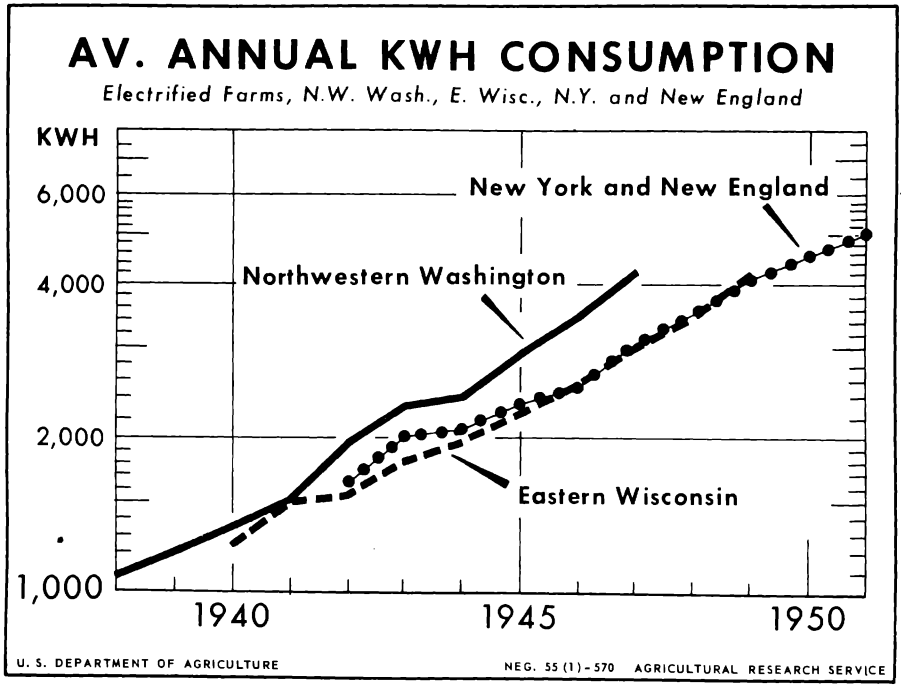

FIGURE 2.—The consumption patterns showed considerable similarity in the northwestern Washington, eastern Wisconsin, and New York-New England areas.

of increase among farms in the New York-New England study was 13.3 percent a year. In Wisconsin, it was 13.6 percent and in Washington 16.3 percent. For the years 1942–49, averages of consumption in the Wisconsin and New York-New England areas were almost identical. In 1947, farms in northwestern Washington used somewhat more electricity than farms in either of the other two areas—an average of 4,240 kilowatt-hours per farm in northwestern Washington compared with 3,109 in New York-New England and 3,042 in Wisconsin.

Although other factors may have contributed to the more rapid rate of increase in consumption in northwestern Washington, the lower cost of the electricity appears to have been a contributing factor also. Farmers in the Washington area paid 1.54 cents per kilowatt-hour for the electricity they used in 1947, whereas farmers in New York-New England paid 2.73 cents and farmers in Wisconsin paid 3.23 cents. Thus, farmers in the Washington area paid an average of $65 for the electricity they used in 1947, compared with an average of $85 spent by farmers in

New York-New England and $98 spent by farmers in Wisconsin.

Consumption records of farms in the winter wheat-producing areas of southwestern Kansas and in the spring wheat-producing area of north-central North Dakota also showed similarity. Average consumption per farm in the Kansas area increased at the rate of 7 percent a year from 1939 to 1948. The comparable rate in the North Dakota area was 10.8 percent annually from 1942 through 1949. In 1948, average consumption per farm in the Kansas study was 2,428 kilowatt-hours compared with 3,021 in North Dakota. The cost per kilowatt-hour was similar in the two areas—4 cents in Kansas and 3.9 cents in North Dakota.

Two additional areas that used similar amounts of electricity were the Upper Piedmont of Georgia and the Clay Hills of Mississippi. In 1947, average consumption per farm in the Georgia area was 1,050 kilowatt-hours compared with 961 in the Mississippi area. For 1943, the average in the Georgia area was 668 kilowatt-hours; in the Mississippi area, it was 675 kilowatt-hours. In both these areas, production of cotton has long been the principal farming enterprise. But cotton is gradually being supplemented by grass, small grains, and mixed farming. In the Georgia area at the time of the survey, production of poultry, and especially of broilers, was expanding rapidly. In both areas, off-farm employment was becoming increasingly important as a source of revenue for many farm people.

Causes of Differences

The preceding discussion has suggested some of the reasons for variations among the study areas in the amount of electricity used per farm. Three of these—type of farm, size of farm or income of operator, and competition from other fuels or sources of power—are discussed more fully in the pages that follow.

Type of Farm.—Among commercial farms, type of farm has been shown to affect greatly the use of electricity and electrical equipment in farming operations. Most kinds of equipment are designed for specific farming enterprises. They are used only on farms having these enterprises.

As a rule, dairy and poultry farms have more electrical equipment than farms of other types. Much of the work on dairy and poultry farms is repetitious and is done in the service buildings and service areas, where electricity from powerlines can be used effectively. Wheat farmers in the Great Plains have little need for specialized dairy or poultry equipment, but they do need shop equipment to keep their field machines running in the busy season. Less electricity is required to operate farm shop equipment than the equipment ordinarily used for dairy or poultry operations. Livestock farmers need equipment with which to provide fresh water at suitable temperatures, to process and handle feed, and for other purposes. These farms usually fall between dairy and grain farms in number of kilowatt-hours used. The small cotton farmers have few farm animals or chickens and few tractor-driven field tools. Thus their need for electricity outside their homes is relatively small.

In 1951, in the New York-New England area, dairy farms used an average of 7,001 kilowatt-hours, poultry farms 6,538, other commercial farms 4,768, and noncommercial farms 2,572.

Size of Farm and Income.—On most commercial farms, there is a direct relationship between the size of the farm business and the income of the operator. Within broad limits, large farms are those with high operator incomes and small farms those with

low operator incomes. Consequently it was difficult, if not impossible, with data developed in these studies, to isolate and measure separately the individual effects of income and size of farm as they relate to the use of electricity. Thus, they are classed together here.

On most commercial farms, electricity is used in both household and farming operations. In farming operations, its use depends a great deal on the size of the farm business. Obviously, more electricity is needed to pump water for 40 cows than for 10 or to brood 1,000 chicks than 100. In household operations, its use depends on the income of the operator, custom, habit, level of living prevailing in the community, and other factors, much as does use of other consumptive goods.

It is not surprising, therefore, that in areas with large farms and relatively high farm incomes—eastern Washington, for example—more electricity was used per farm than in areas of small farms and relatively low farm incomes, as in the Upper Piedmont of Georgia or the Clay Hills of Mississippi. However, the influence of size of farm and income was more readily seen within each study area than among them. When data from two areas are compared, this influence may be obscured by other factors, such as predominant types of farming or competition from petroleum products.

In each study area, average consumption for large farms was considerably higher than for small farms (table 3). In northwestern Washington, for example, average consumption on large farms in 1947 was 10,549 kilowatt-hours; on medium-sized farms, 5,817; and on small farms, 2,982.

Competition.—On the farms studied, electricity had little competition for some of its uses. For example, most of the artificial lighting was provided by electricity. Most homes had one or more electric irons, and only a few had refrigerators that used ice or a source of power other than electricity. For some other uses, for example home heating, competition was so strong that few farmers used electricity.

Between these limits was a broad field in which competition was keen. In most of the study areas, competition in providing heat for kitchen ranges and water heaters was sharp although it varied considerably between areas. Densities of electric and competing kinds of ranges, water heaters, and refrigerators in each study area are shown in table 4. Data from the studies in Iowa and Tennessee illustrate the results of differing competitive situations.

Taking into account solely the physical characteristics of the farms, one might expect that consumption of electricity per farm in the Iowa area would be substantially greater than in Tennessee. The average farm in the Iowa study had 2½ times as many acres, kept 4 times as much livestock, and had a total income 2½ times as great as the average farm in the Tennessee study. Some comparative data for the 2 areas are given in table 5.

The studies reveal that Iowa farmers used twice as much electricity per farm in farming operations as Tennessee farmers used. Iowa farmers had more milking machines, pig brooders, chick brooders, and other electrical equipment for use in service buildings and service areas. On the other hand, Iowa farm families used less electricity in household operations than farmers in the Tennessee area. As a result, the averages of consumption for the 2 areas were almost identical from 1943 to 1947 (fig. 3). An important difference in household equipment reported in these areas was in the densities of gas ranges and water heaters. Only 2 pieces of equipment that used gas for fuel were reported

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TABLE 3.—*Electricity used per electrified farm, by income groups, designated study areas and years*

Study area	Year	Income group			All farms
		Low	Medium	High	
		Kwh	*Kwh*	*Kwh*	*Kwh*
Upper Piedmont of Georgia [1]	1947	660	780	1,977	1,050
Northwestern Washington [2]	1947	2,982	5,817	10,549	4,240
Eastern livestock area of Iowa [3]	1947	1,295	2,170	3,491	2,174
East Tennessee Valley [4]	1948	1,048	1,404	4,971	2,139
Eastern Washington [2]	1948	6,720	10,292	15,147	9,845
Southwestern Kansas [3]	1948	1,658	2,414	3,349	2,428
Clay Hills of Mississippi [1]	1949	869	1,287	2,918	1,494
North-central North Dakota [3]	1949	2,350	3,094	5,543	3,276
New England and New York [5]	1951	1,777	3,846	11,672	5,057
Eastern dairy area of Wisconsin [6]	1949	2,542	4,326	7,396	4,233

[1] Income group: Less than $2,000, $2,000 to $3,999, and $4,000 and over.
[2] Small, medium-sized, and large farm classifications closely approximate low, medium-sized, and high income groupings for these areas.
[3] Income group: Less than $6,000, $6,000 to $14,999, and $15,000 and over.
[4] Income group: Less than $1,500, $1,500 to $4,999, and $5,000 and over.
[5] Income group: Less than $2,500, $2,500 to $9,999, and $10,000 and over.
[6] Income group: Less than $6,000, $6,000 to $9,999, and $10,000 and over.

in the Tennessee study—1 kitchen range and 1 water heater. But 42 percent of the Iowa farms had gas ranges and 5 percent had gas-burning water heaters for household use.

Although the reasons why Iowa farmers had more gas equipment were not fully explored, the relative cost of electricity and liquefied petroleum gas probably was one of them. In 1947, the cost of electricity to an Iowa farmer was 3.63 cents per kilowatt-hour, compared with 1.94 cents to a Tennessee farmer. Consequently, the average Iowa farmer paid $78.81 for the electricity he used in 1947, whereas the Tennessee farmer paid only $41.96.

Rate Schedules in Effect

The cost of electricity to farmers varied widely among the study areas. The range was from 4 cents per kilowatt-hour in southwestern Kansas to 1.54 cents in northwestern Washington. The total cost to the farmer ranged from an average of $157.52 per farm in eastern Washington in 1948 to $36.37 in the Upper Piedmont of Georgia in 1947 (table 6). The bill for an individual farmer is determined by two criteria: (1) Kilowatt-hours used, and (2) rate schedule in effect at the time of use.

Many different rate schedules were encountered in these studies. Adjoining suppliers frequently had schedules that were dissimilar in many respects. Some suppliers had special rates for special uses. Some, for example, had special rates for homes with both an electric range and a water heater. Others had special rates for electricity used during off-peak hours. Some had special rates for certain specified power uses.

Most suppliers had schedules of the block rate type. These schedules provide for lower costs per kilowatt-hour as additional amounts or blocks of electricity above a designated minimum are used. A sched-

TABLE 4.—*Pieces of electric, gas, and other household equipment per 100 electrified farms, designated study areas and years*

Study area	Year	Range			Refrigerator			Water heater		
		Electric	Gas	Other	Electric	Gas	Other	Electric	Gas	Other
		Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Upper Piedmont of Georgia	1948	17	4	114	68	(1)	16	11	2	5
Northwestern Washington	1948	43	(2)	67	87	(2)	2	44	(2)	32
Eastern livestock area of Iowa	1948	28	44	41	85	2	3	24	5	12
East Tennessee Valley	1949	33	(3)	72	83	(1)	8	18	(3)	(3)
Eastern Washington	1949	89	9	34	112	4	(3)	98	3	9
Southwestern Kansas	1949	26	69	11	78	23	2	25	25	5
Clay Hills of Mississippi	1950	22	21	67	97	1	13	7	4	4
North-central North Dakota	1950	59	27	27	91	1	(3)	33	(3)	1
New England and New York	1952	42	41	44	109	2	2	34	12	26
Eastern dairy area of Wisconsin	1950	37	53	27	100	(1)	(1)	38	6	11

[1] None reported on sample farms.
[2] "Other" includes gas.
[3] Less than 1.

TABLE 5.—*Selected characteristics of electrified farms, Eastern livestock area of Iowa and East Tennessee Valley of Tennessee, 1947* [1]

Item	Eastern livestock area, Iowa	East Tennessee Valley, Tennessee
Farms represented.....number..	461	492
Average per farm:		
Electricity used:		
Amount.....kilowatt-hours..	2,174	2,165
Cost.....dollars..	78.81	41.96
Size of farm.....acres..	165	65
Land in crops.....do....	109	29
Animal units.....number..	41	10
Income per farm:		
Gross farm.....dollars..	9,977	2,454
Off farm.....do....	732	1,734
Total.....do....	10,709	4,188

[1] Tennessee data on acreage, animal units, and income are for 1948.

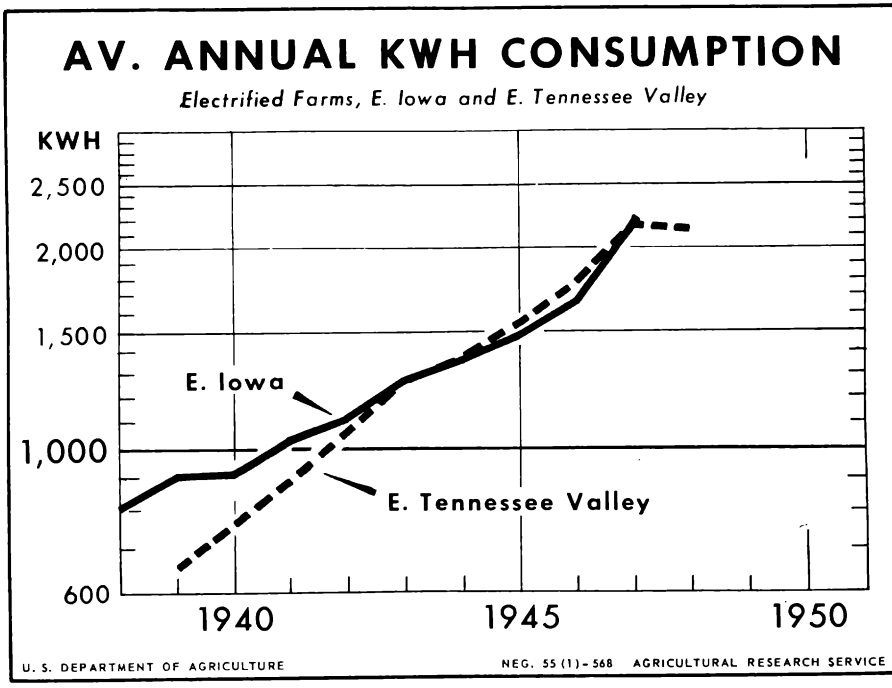

FIGURE 3.—From 1943 to 1945, average consumption per farm in the East Tennessee Valley was equal to that in the eastern livestock area of Iowa.

ule used by one supplier illustrates this type of schedule. This supplier was on a monthly billing basis.

First 15 kwh..... 75 cents.
Next 45 kwh..... 3.75 cents per kwh.
Next 140 kwh..... 2.5 cents per kwh.
Over 200 kwh..... 1.5 cents per kwh.
Minimum charge... 75 cents.

Some suppliers had schedules that provided for decreasing cost blocks up to some designated quantity (say 1,400 kilowatt-hours in any one month) and increasing costs above that quantity. Most suppliers were on a monthly billing basis but others sent bills to their customers at 2-month intervals. Most suppliers had an established minimum monthly bill for a specified type of service; others based the minimum bill on the size of the transformer needed at the farm; the larger the transformer, the larger the minimum bill.

Some suppliers had an "amortization" or "service" charge, in addition to a charge for the electricity used. This was adopted to provide revenue for the system and, at the same time, to make the use of electricity and electrical equipment attractive to consumers.

This is only a partial listing of the different types of rate schedules found in the study areas. However, it gives some idea of the diversity of types in effect.

The studies indicate that there is an inverse relationship between the cost of electricity to a farmer and the amount he uses. A precise measurement, however, could not be made because of the limitations of the samples used for study, the diversity of rate schedules in effect, and the complexity of other factors that affect use of electricity.

EQUIPMENT IN USE

Among the sources of power available to farmers, electricity is unique. It is readily available at the flick of a switch at any hour of the day or night. Limited only by the capacity of the distribution system, it may be used at any rate desired, from the amount necessary to ring the doorbell to enough to operate a 5- or 7½-horsepower motor. It is not readily storable, so a reserve supply for contingencies cannot be maintained on the farm.

TABLE 6.—*Annual use, cost per farm, and cost per kilowatt-hour of electricity, specified study areas and years*

Study area	Year	Electricity used per farm	Cost—		
			Per farm	Per $1,000 income	Per kwh
		Kwh	*Dollars*	*Dollars*	*Cents*
Upper Piedmont of Georgia	1947	1,050	36.37	10.22	3.46
Northwestern Washington	1947	4,240	65.19	6.16	1.54
Eastern livestock area of Iowa	1947	2,174	78.81	7.36	3.63
East Tennessee Valley	1948	2,139	42.63	16.34	1.99
Eastern Washington	1948	9,845	157.52	4.98	1.60
Southwestern Kansas	1948	2,428	97.48	8.21	4.01
Clay Hills of Mississippi	1949	1,494	46.96	14.09	3.15
North-central North Dakota	1949	3,276	126.99	12.71	3.88
New England and New York	1951	5,057	123.29	15.25	2.44
Eastern dairy area of Wisconsin	1949	4,233	122.09	16.31	2.88

More than 400 different applications of electricity on farms and in farm homes have been identified. To be utilized in any of these 400 ways, however, the electricity must first be converted into light, heat, or motive power. In the form of light, it is used in buildings and service areas; as black light, it is used to attract and trap insects. When converted into heat, it heats farm homes and water, warms the baby's milk, broods chicks or pigs, cooks food, welds metal, heats the soil in hotbeds, and performs other functions that require heat. In the form of power, it has even wider application. For example, it is used to pump water, milk cows, polish floors, freeze and refrigerate food, ventilate or cool buildings, and saw wood or mix concrete. A piece of equipment is necessary to apply electricity to each task. An inventory of electrical equipment in use, therefore, provides an indication of the extent to which electricity is used on a farm or in an area. Densities of the different kinds of equipment in each area are given in table 7.

Farming Operations

The use of electrical equipment in farming operations varied widely among the study areas. The greatest density of such equipment, almost 6 pieces per farm, was found in the eastern Washington area. The lowest, less than 1 per farm, was found in the Georgia, Mississippi, and Tennessee areas.

Densities of electrical equipment on electrified farms in each study area are given in table 8. In this tabulation, farm equipment is grouped in five general categories. Farm-shop equipment includes saws, drills, welders, air compressors, lathes, and other kinds generally used in shops. Dairy, livestock, and poultry equipment includes the kinds specifically associated with these enterprises, such as milking machines, pig brooders, and egg cleaners. The "general" group includes equipment not otherwise classified, such as elevators, ventilator fans, corn shellers, potato graders, and hay hoists.

Of these general categories, farm-shop equipment was most numerous. Shop work in which electrical equipment can be used needs to be done on almost all farms, regardless of type. Some of this work is new construction and some is repair work. Many part-time farmers, and operators of residential farms also, have a considerable number of electrical tools. Advancing farm mechanization increases the importance of making repairs to machines quickly and on the farm. Timeliness of operation is important to modern commercial farmers. A breakdown of a machine is frequently more costly in terms of work not done and hired labor idle than in the actual repairs to the machine itself. Furthermore, a well-equipped farm shop helps to equalize the labor load on farms. Field machines can often be repaired and reconditioned at times when work cannot be done in the fields.

Of the major farm enterprises, dairying and poultry production made the greatest application of electricity and electrical equipment. Much of the demand for milk and eggs is for high-quality products. Many farmers would find it difficult to produce for this market without mechanical refrigeration and other facilities made possible by electricity. Furthermore, as noted previously, much of the work in these two enterprises is repetitive and is done near the powerline, in the service buildings and service areas. Means are not yet available to make efficient and satisfactory use of powerline electricity in field operations.

For handling such materials as grains, roughages, fertilizers, and potatoes, electrical equipment was used to only a limited extent on the farms studied. Some farmers had elevators

TABLE 7.—*Electrical equipment: Specified kinds per 100 electrified farms, designated study areas and years*

Equipment	1948			1949			1950			1952
	Georgia Piedmont	Northwestern Washington	Eastern Iowa	East Tennessee Valley	Eastern Washington	Southwestern Kansas	Mississippi Clay Hills	North Central North Dakota	Eastern Wisconsin	New York-New England [1]
Household:	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Radio	126	155	146	114	212	138	117	161	177	.....
Refrigerator	68	87	85	83	112	78	97	91	100	109
Range	17	32	28	33	88	26	22	59	37	42
Water heater	11	33	25	22	98	25	7	33	38	34
Home freezer	1	4	10	5	48	17	5	30	37	41
Washing machine	34	96	99	82	117	99	60	100	106	.....
Iron	112	103	108	108	127	107	112	99	115	.....
Ironer	[2]	9	5	2	27	8	[3]	6	3	.....
Hot plate	29	71	39	43	60	23	29	39	33	.....
Toaster	12	77	83	24	107	87	8	91	96	.....
Space heater	3	22	20	18	95	25	4	16	24	.....
Waffle iron	6	76	39	11	101	58	3	62	34	.....
Percolator	9	41	11	18	58	28	4	31	23	.....
Food mixer	3	45	38	9	87	56	3	60	56	.....
Clock	18	97	96	28	173	92	14	102	122	.....
Vacuum cleaner	8	67	72	26	95	82	5	67	84	.....
Sewing machine	4	19	14	5	38	30	3	21	31	.....
Household fan	23	[3]	60	34	54	87	51	40	36	.....
Heat pad	7	42	34	17	49	39	6	35	36	.....
Oil furnace	[3]	10	6	[2]	24	9	[3]	9	15	.....
Coal stoker	1	[3]	6	1	12	[3]	[3]	5	5	.....
Other	61	40	32	51	269	86	22	111	119	.....
Water supply:										
Pressure system	45	75	59	18	51	71	36	40	80	92
Gravity system	[3]	[3]	11	[3]	23	1	[3]	1	38	[2]
Pump jack	[3]	[3]	38	[3]	10	6	[3]	54	9	1

See footnotes at end of table.

TABLE 7.—*Electrical equipment: Specified kinds per 100 electrified farms, designated study areas and years*—Continued

Equipment	1948			1949			1950			1952
	Georgia Piedmont	Northwestern Washington	Eastern Iowa	East Tennessee Valley	Eastern Washington	Southwestern Kansas	Mississippi Clay Hills	North Central North Dakota	Eastern Wisconsin	New York-New England [1]
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Dairy and livestock:										
Cream separator	(3)	(3)	60	1	44	42	(2)	65	2	6
Milking machine	3	54	21	6	4	18	2	28	71	42
Milk cooler	2	2	(3)	6	(2)	1	2	1	18	42
Water heater	2	35	5	5	1	1	2	7	27	15
Ventilator fan	(3)	(3)	(2)	(2)	.....	(3)	(3)	(3)	7	12
Milkhouse heater	.....	(3)	(3)	.....	.....	.....	.....	.....	2	2
Stock clipper	1	(3)	2	1	3	1	(3)	(3)	36	28
Fence controller	1	60	9	9	9	5	2	8	46	27
Pig brooder	(3)	37	70	(3)	2	1	(3)	9	11	1
Stock-tank heater	(3)	(3)	14	(3)	4	2	(3)	4	(3)	(3)
Other	2	.....	2	1	8	3	.....	.....	3	8
Poultry:										
Brooder hover [4]	7	26	43	24	36	17	9	26	42	40
Brooder battery	(2)	2	(2)	4	1	(3)	(3)	(3)	(3)	3
Water warmer	(3)	(3)	25	(2)	4	5	(3)	11	(3)	15
Incubator	1	0	(3)	1	(3)	(3)	(3)	(3)	(3)	4
Other	(2)	.....	(2)	.....	1	.....	.....	.....	.....	11
General farm:										
Elevator [5]	(3)	(2)	10	(3)	17	16	(3)	15	29	8
Seed cleaner	(3)	(2)	7	(2)	11	7	(3)	32	19	1
Corn sheller	(3)	.....	7	(2)	.....	(3)	(3)	(3)	12	(3)
Feed grinder or chopper	(3)	2	1	(3)	2	1	(3)	9	2	1
Hay hoist	(3)	2	(2)	(3)	.....	1	(3)	(3)	3	3
Other	(3)	2	(2)	(2)	2	.....	1	52	6	15

Farm shop:											
Air compressor	(2)		4	14	1	40	32	(2)	29	18	11
Drill press	(2)		9	14	1	36	19	1	12	9	8
Portable drill		3	3	10	3	82	41	1	49	28	29
Tool grinder		1	31	39	9	64	42	3	48	47	34
Power saw		2	14	11	4	33	12	3	13	17	24
Battery charger	(3)		2	5	1	28	14	(3)	30	5	9
Welder	(2)		3	9	(3)	38	27	(2)	25	5	4
Soldering iron		2	8	25	3	51	24	(2)	35	0	21
Other		1	11	7	6	51	11	3	62	29	20

[1] Only 4 pieces of household equipment included in survey.
[2] Less than 1.
[3] None reported on sample farms.
[4] Including heat lamps.
[5] Including roughage and grain.

TABLE 8.—*Electrical equipment: Pieces in use per 100 electrified farms, designated study areas and years*

Equipment	1948			1949			1950			1952
	Georgia Piedmont	Northwestern Washington	Eastern Iowa	East Tennessee Valley	Eastern Washington	Southwestern Kansas	Mississippi Clay Hills	North-central North Dakota	Eastern Wisconsin	New York-New England
Household operations:	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Heavy consumers [1]	30	69	64	61	250	76	36	124	114	[2] 117
Light consumers [3]	522	1,058	992	673	1,801	1,123	538	1,145	1,213	[4]
Total	552	1,127	1,056	734	2,051	1,199	574	1,269	1,327	[4]
Water supply:										
Water system	45	75	70	34	74	72	36	40	118	93
Pump jack	[5]	[5]	38	[5]	10	6	[5]	54	9	1
Total	45	75	108	34	84	78	36	94	127	94
Farm operations:										
Farm shops	9	85	133	27	438	221	12	303	158	160
Dairy	9	91	90	19	57	65	6	101	165	154
Other livestock	2	97	95	10	16	9	2	21	58	29
Poultry	8	28	68	29	43	22	9	37	42	73
General	[5]	6	25	1	32	25	1	108	71	28
Total	28	307	411	86	586	342	30	570	494	444
Total, all uses	625	1,509	1,575	854	2,720	1,619	640	1,933	1,948	[4]

[1] Ranges, water heaters, home freezers, clothes driers, and air-conditioning units.
[2] Clothes driers and air-conditioning units not reported.
[3] All other equipment for household use.
[4] Data not available.
[5] None reported on sample farms.

and hoists to take some of the backache out of farmwork but most of them relied on pitchforks, scoop shovels, bushel baskets, and manpower for much of the handling of materials in service buildings.

Farm Water Supply

One of the most highly valued uses of electricity on farms is for pumping water. Hot and cold running water is a requirement for a "modern" home. Running water in service buildings and service areas is almost indispensable on many farms.

It is true that some farmers had water systems before they had electric service. Most of these systems were of the gravity type. Windmills or gasoline engines provided power with which to pump water to reservoirs. Some systems were fed by springs on a hillside above the house or barn. In some thickly populated areas, many farmers had water from city systems. For example, 10 percent of the farmers in the New York-New England study had city water. But for most farmers, running water became a reality only after electricity from a powerline became available.

According to the Census of Agriculture, the number of farms with running water in the operator's dwelling increased from 1.7 million in 1945 to 2.3 million in 1950, or 36 percent. The Census of 1955 reports 2.8 million farms with piped running water. This expansion could not have been achieved without central-station electric power on the farms.

Among the study areas, electrical equipment for pumping and distributing water was most numerous in areas where dairy, poultry, and livestock systems of farming prevailed. They were least numerous in the Tennessee, Georgia, and Mississippi areas, where crop production and off-farm employment were relatively important sources of income and where total incomes were relatively low.

Household Operations

Electricity has contributed greatly to farming operations, but it has contributed even more to household operations. Between 65 and 90 percent of all pieces of electrical equipment reported in the study areas was for use in the farm homes.

From the viewpoint of electricity used, most important pieces of equipment used in homes are kitchen ranges, water heaters, and food freezers. In the New York-New England, Tennessee, and Kansas studies, these 3 kinds of equipment accounted for about 40 percent of the electricity used in the last year of record. Recently, air-conditioning units, clothes driers, and equipment for heating homes have become increasingly important items in some localities.

In most of the study areas, kinds of household equipment that were light consumers of electricity were 10 or more times as numerous as the kinds that were heavy consumers. Most farms had one or more radios and irons. There were few farms that did not have an electric refrigerator or an electrically operated washing machine.

Lighting of Farm Buildings

Lighting was the only application of electricity made on all electrified farms in all the surveys. Some farms used electricity very little for other purposes. Most of the occupied and some of the unoccupied dwellings on the farms studied were wired for electricity. Among service buildings, dairy barns, milkhouses, general barns, brooder houses, and garages were most likely to be wired. Many corncribs, granaries, hog houses, and machine sheds remained unwired "because they were not

used much at night." The number of wired buildings per 100 farms in each study area is given in table 9.

To determine the adequacy of the wiring on farmsteads was outside the scope of the studies. Nonetheless, it was apparent to the enumerators that by present standards many farm buildings were inadequately wired. This was especially true of farms wired a number of years ago when there was little expectation that the farmload would be as heavy as it now is. A few fires caused by overloaded circuits were reported. More commonly, some equipment gave unsatisfactory performance, apparently because of low voltage. It was not unusual for a farmer to say that he had not installed certain electrical equipment because of the cost of the additional wiring necessary for its use.

Inadequate wiring on farms is of concern to farmers and to the industry as well. Some authorities consider it to be the most pressing problem in the field of electrification today.

EQUIPPING A FARM

The process of installing electrically operated equipment is a continuing one, which begins at the time the farm receives central-station electric service. First, the farmstead must be wired. Then, on most farms, a few basic pieces of equipment are bought, such as radio, iron, refrigerator, and washing machine. Gradually, other kinds of equipment, such as water systems, portable drills, tool grinders, milking machines, and vacuum cleaners, are installed. On most farms, original wiring becomes inadequate for the increasing demands on it and a major rewiring job is necessary. When the rewiring is done, still more equipment is bought and installed.

Costs of equipment and installations vary widely among farms. Some farmers buy the "de luxe" models, others the "economy" kinds. Some buy new equipment; others improvise when possible and build their own equipment from available materials. Some farmers hire the wiring and equipment installed, whereas others do much of the work themselves or with family labor. Costs vary also because of changes in price levels over time. But even though all possible economies in purchasing are followed, a well-electrified farm has a substantial investment in electrically operated equipment and electrical fixtures.

Cost of Household Equipment

A well-electrified farm home may have at least one each of the following kinds of equipment—radio, television set, refrigerator, range, home freezer, washing machine, iron, toaster, food mixer, clock, vacuum cleaner, heat pad, household fans, and other small appliances. At 1955 retail prices, the value, new, of these items is more than $1,700. If some other kinds of equipment, such as dishwashers and clothes driers, are added, the estimated cost is increased accordingly.

Some equipment that is attached to the dwelling is considered part of the real estate. Included in this category are water systems (many farms have 2 systems, 1 for hard water and 1 for soft), water heaters, and ventilating fans. Many farm homes with central heat have oil-burning furnaces with two or more electric motors and electric controls. The retail cost of all this equipment, exclusive of plumbing and fixtures, probably is $1,500 or more. Thus the farm home alone may have electrically operated equipment with a present retail value of at least $3,200. If the water supply should be a deep well or if, in addition to the equipment listed above, the dwelling should have an air-conditioning unit, a heat pump, or a garbage-disposal unit, the cost would be greater than the indicated amount.

TABLE 9.—*Farm buildings: Number wired per 100 electrified farms, designated study areas and years*

Buildings	1948			1949			1950			1952
	Eastern Iowa	Northwestern Washington	Georgia Piedmont	East Tennessee Valley	Southwestern Kansas	Eastern Washington	North-central North Dakota	Mississippi Clay Hills	Eastern Wisconsin	New York-New England
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Dwelling	111	121	118	109	106	127	106	132	109	115
Service buildings:										
General barn	95	45	14	27	79	86	90	17	25	45
Garage	49	57	4	9	48	53	62	4	49	36
Poultry house	60	81	5	12	49	51	55	9	68	45
Brooder house	52	24	15	6	40	33	22	7	38	21
Hog house	46	1	[1]	0	4	7	13	[2]	33	[2]
Shop	37	35	1	5	21	62	32	2	28	11
Dairy barn	8	67	3	6	6	6	6	2	85	49
Milkhouse	24	56	2	5	12	5	29	[2]	62	36
Crib and granary	48	13	[2]	3	23	31	56	[1]	43	3
Machine shed	[2]	.....	[1]	2	17	32	20	2	43	11
Other buildings	25	18	5	16	32	38	24	9	6	19
Total	444	397	50	91	331	404	409	52	480	276

[1] Less than 1.
[2] None reported on sample farms.

The cost of the electrical components—motors and heating elements—is often insignificant compared with the cost of equipment necessary to make the power effective. The retail price of the motor on a shallow-well water system, for example, probably is about $70. This is a small amount compared with the cost of the well, pipe, plumbing, fixtures, and sewage-disposal facilities necessary to make the water system complete.

The cost of the electricity necessary to operate the motor for the water system is also insignificant; it amounts to about 50 cents a month for the average home. Yet this small expenditure makes possible water as desired and at the turn of a faucet. Some farms, as noted previously, had running water before electrification. For most farmers, however, the ambition to have running water could not be realized until the farm was electrified.

Cost of Farm Equipment

If the farm home just described were in the northern part of the country and on a 1-man dairy farm with 30 cows, the farmer might have electrically operated farm equipment somewhat as follows: Milking machine, milk cooler (immersion type), pressure water system (for dairy barn and milkhouse), water heater, milkhouse heater, barn cleaner, ventilating fan, silo unloader, fence controller, and stock clipper. At 1955 prices, the cost of this equipment, installed, would be about $4,400, exclusive of plumbing and drinking cups for the water system. A bulk tank for handling milk would add about $2,000 to this cost; a pipeline milker (for milking parlor), perhaps $400; a hay drier, about $700. Many farms have equipment for other farming enterprises, such as poultry or hogs, but none is listed here.

In his farm shop, this dairyman probably would have several electrically operated tools. The kinds most commonly found include air compressor, drill press, portable drill, tool grinder, welder, and bench saw. The combined retail value of these at 1955 prices is $600 or more. Other electrical equipment on the farm might include a portable elevator, wagon unloader, seed cleaner, and one or more portable motors. Their combined retail value would be $700 or more.

As with household equipment, the cost of the electrical components of the farm equipment listed frequently is only a small part of the total installed cost. For example, the cost of the electric motors used to operate milking machines, bulk milk coolers, barn cleaners, and silo unloaders, may be between 10 and 15 percent of the installed cost. Some of the equipment listed can be operated with gasoline engines but most farmers have adopted electric power for these purposes. All the milking machines reported were electrically operated. In the New York-New England area, portable elevators with electric motors outnumbered other kinds 8 to 1.

The mechanization of choring on farms has been largely a process of adapting electric power and electrical equipment to specific tasks. Dairy farmers quickly installed electric lights, milking machines, immersion-type milk coolers, and water systems in their barns and milkhouses. Water heaters, milkhouse heaters, and ventilating fans came more slowly. Recently, many dairymen have installed gutter cleaners in their stanchion barns and silo unloaders in upright silos. Many are shifting from conventional milk cans and immersion coolers to bulk tanks. Adoption of bulk tanks appears to encourage further change to milking parlors, pipeline milkers, and loose housing. Although its cost is relatively small, electricity is an essential element in each of these stages of mechanization.

Summary of Equipment Costs

At 1955 retail prices, the combined cost of the equipment listed is almost $9,000, which is distributed as follows:

Item	*Dollars*
Household appliances	1,700
Equipment for dwelling	1,500
All household operations	3,200
Dairy equipment	4,400
Shop tools	600
General farm equipment	700
All farm operations	5,700
Total operations	8,900

This inventory, although not taken from an actual farm, is presented to indicate the size of the investment that the operator of a well-electrified farm can have in electrically operated equipment. In contrast, the comparable figure for the average dairy farmer in the eastern dairy area of Wisconsin in 1955 is estimated to be about $3,400. This estimate is based on the equipment reported by the farmers in the survey made in August 1950 and the rapidity with which farmers added new equipment.

To the cost of the equipment must be added the cost of farmstead wiring. This cost varies greatly among farms, depending on the number of circuits and voltages provided for, distances between buildings, number of outlets, number of 2- and 3-way switches, local wiring codes, amount of work done by the farmer, and other factors. To wire a farmstead completely and adequately to handle the equipment listed and provide for some future expansion probably would cost between $1,500 and $2,500 at 1955 prices. Few farmers, however, are wiring their farmsteads so completely at this time. More commonly, the rewiring made necessary by increasing demands on the existing farm system is done. The cost of rewiring a farmstead when maximum use is made of the old wiring probably would cost at least $400. More complete rewiring could cost 3 or 4 times this amount.

It is evident that central-station electric service has made possible a completely new working environment in farm homes and service buildings. In the farm home, modern facilities for lighting, heating, cooking, refrigeration, and laundering are now feasible. Hot and cold running water in the home and in service buildings may be provided. For use in service buildings and service areas, there are many kinds of equipment for both crop and livestock production and for farm repair work. All these things cost money but they make farm homes comparable to city homes. They also make it possible to apply new techniques and practices to chore operations.

ELECTRICITY CONSUMED FOR FARM AND FOR HOUSEHOLD USES

In preceding sections, various applications of electricity on farms have been discussed. There remains, however, the question of the amount of electricity used in each of the broad classifications listed. Most farms had only one meter. It recorded the total number of kilowatt-hours used, whether for farm or for household operations. As a rule, farms with two or more dwellings had a meter for each dwelling. However, individual pieces of equipment were metered separately on only a few of the farms studied.

In each study area, estimates were made of the number of kilowatt-hours used for the major classifications. These estimates were based on four criteria: (1) Actual total consumption in kilowatt-hours, as reported by the suppliers; (2) numbers of the various kinds of equipment reported by farmers; (3) amount of use made of certain kinds of farm

equipment, for example, milking machines, brooders, and elevators, as reported by farmers; and (4) estimates of average number of kilowatt-hours used by each piece of equipment, as made by the Rural Electrification Administration (table 10) and adjusted to local situations. The percentage distribution of number of kilowatt-hours used among five broad categories, as derived from these estimates, is given in table 11.

Although lighting was the most highly valued single use of electricity, it required only from 4 to 25 percent of the total number of kilowatt-hours used in the study areas. Lighting represented a larger percentage of the total in areas with low average consumption than in areas with high consumption. As farmers install more electrical equipment, the percentage used for lighting will continue to decline.

Another highly valued use of electricity was for pumping water; yet this required only 2 to 7 percent of the total consumption. Around 20 kilowatt-hours of electricity per month are needed for an electrically operated pressure system to provide water for an average farm home water system. This is about a fifth as much as is used by an electric range and less than a tenth as much as is used by an electric water heater. Few farmers in any of the areas studied used electric motors to pump irrigation water. This is a growing practice, however, and it may be expected to change consumption patterns in some localities.

Operation of household equipment required from 58 to 87 percent of all electricity used on the farms when the surveys were made. Equipment for use in farming operations required from 3 to 30 percent of the total. This percentage was highest in areas of dairying and poultry production.

Seasonality of Use

The amount of electricity used by farms often varies considerably from hour to hour, from day to day, and from month to month. The variations in rates of use are of concern to suppliers, who must be prepared to satisfy maximum demands on their systems. It was outside the scope of this study to determine peak demands [2] but records provided by suppliers permitted a study of consumption by months in eight areas. Summary data for the last year of record in each of these areas are given in table 12.

Differences in consumption from month to month are due primarily to the amount of use made of lights and other electrical equipment, and to the installation and use of new kinds of equipment. Effects of both these factors are clearly discernible in the data. In the Iowa area, for example, there was a peak in consumption in February, March, and April, when pig and chick brooders were used extensively. A second peak came in November and December when 50 kilowatt-hours above the average of the preceding January was reached. The higher consumption in December can be accounted for largely by the new equipment installed during the year. In 7 of the 8 areas, average consumption for both November and December was higher than for the preceding January.

[2] Studies for this purpose have been made. For example, Altman, Landy B., Jr., Philson, Kathryn, and Buresh, Ernest J. DEMAND AND DIVERSITY OF USE OF ELECTRICITY ON 16 FARMS IN THE EASTERN LIVESTOCK AREA OF IOWA. Iowa Agr. Expt. Sta. Res. Bul. 387, pp. 689–745, illus. 1952. (U. S. Dept. Agr. cooperating); Altman, Landy B., and Jebe, Emil H. LOAD CHARACTERISTICS OF SOUTHEASTERN IOWA FARMS USING ELECTRIC RANGES. Iowa Agr. Expt. Sta. Res. Bul. 420, pp. 211–224, illus. 1955. (U. S. Dept. Agr. cooperating.)

TABLE 10.—*Estimated average amount of electricity used annually for specified applications on farms* [1]

Equipment	Estimated annual amount of electricity used	Equipment	Estimated annual amount of electricity used
	Kwh		*Kwh*
Household:		Poultry—Continued	
Radio	100	Chicken scalder (per 25 chickens)	1
Television receiver	360	Mechanical feeder	240
Refrigerator	360	Egg cooler, farm size, mechanical	300
Range	1,200	General farm:	
Water heater (with bath)	3,000	Grain elevator (per 1,000 bushels)	3
Home freezer	900	Roughage elevator (per 100 tons)	10
Washing machine	35	Hay drier (per ton)	50
Dishwasher	30	Grain drier, with heat (per 100 bushels)	20
Iron	100	Grain drier, without heat (per 100 bushels)	100
Ironer	120	Feed grinder (per ton)	20
Hot plate	70	Feed mixer (per ton)	1
Toaster	35	Corn sheller (per 100 bushels)	5
Space heater	70	Seed cleaner (per 100 bushels)	1
Blanket	120	Potato grader (per 100 bushels)	1
Waffle iron	25	Farm shop:	
Percolator	60	Air compressor	35
Food mixer	25	Drill press	12
Clock	18	Portable drill	24
Vacuum cleaner	20	Tool grinder	25
Sewing machine	10	Power saw	12
Household fan	15	Battery charger	12
Oil furnace	300	Welder	75
Coal stoker	240	Lathe	12
Ventilator fan (window)	50	Forge	12
Ventilator fan (attic)	100	Soldering iron	15
Air-conditioning unit	2,000	Water supply:	
Dairy and livestock:		Pressure system (shallow well)	180
Milking machine (per cow)	27	Pressure system (deep well)	240
Milk cooler (per gallon per day)	40	Gravity system	180
Water heater (pressure type)	2,000	Pump jack	180
Water heater (pour-in type)	1,500	Lighting:	
Cream separator	35	Dwelling (Northern States)	300
Ventilator fan	240	Dwelling (Southern States)	240
Milkhouse heater	800	General barn	24
Barn cleaner	120	Dairy barn	80
Silage unloader	300	Milkhouse	35
Stock-tank heater	150	Poultry house	35
Pig brooder (per spring litter)	25	Brooder house	5
Fence controller	50	Hog house	5
Poultry:		Garage	8
Chick brooder (per 100 chicks)	75	Farm shop	12
Incubator, small (per 1,000 eggs)	180	Yard light	18
Water warmer	60		
Ventilator fan	200		
Egg cleaner (per 2,000 eggs)	1		
Chicken picker (per 250 chickens)	1		

[1] Unpublished estimates of Rural Electrification Administration.

TABLE 11.—*Percentage distribution of electric energy consumed for specified uses, specified study areas and years*

Study area	Year	Household use			Water supply	Farm use			All uses
		Lighting	Equipment	Total		Lighting	Equipment	Total	
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Upper Piedmont of Georgia	1947	24.7	59.0	83.7	6.5	1.0	8.8	9.8	100.0
Northwestern Washington	1947	7.8	[1] 61.0	[1] 68.8	[1]	[2]	[2]	31.2	100.0
Eastern livestock area of Iowa	1947	14.5	62.7	77.2	4.4	3.8	14.6	18.4	100.0
East Tennessee Valley	1948	13.8	73.8	87.6	2.7	.9	8.8	9.7	100.0
Eastern Washington	1948	3.6	87.1	90.7	1.6	.9	6.8	7.7	100.0
Southwestern Kansas	1948	13.0	72.3	85.3	5.7	2.4	6.6	9.0	100.0
Clay Hills of Mississippi	1949	20.6	70.6	91.2	4.8	.8	3.2	4.0	100.0
North-central North Dakota	1949	8.9	73.6	82.5	7.0	2.0	8.5	10.5	100.0
New England and New York	1951	6.9	57.5	64.4	3.8	2.0	29.8	31.9	100.0
Eastern dairy area of Wisconsin	1949	7.7	59.3	67.0	4.8	2.5	25.7	28.2	100.0

[1] Water pumping included in household usage.
[2] Not differentiated.

TABLE 12.—*Average consumption of electricity per farm, by months, specified study areas and years*

Month	1947			1948		1949		1951
	Georgia Piedmont	Northwestern Washington	Eastern Iowa	Eastern Washington	Southwestern Kansas	Mississippi Clay Hills	Eastern Wisconsin	New England
	Kwh	*Kwh*	*Kwh*	*Kwh*	*Kwh*	*Kwh*	*Kwh*	*Kwh*
January	82	370	182	766	204	117	345	372
February	79	370	190	807	213	117	331	349
March	73	345	191	784	200	115	328	330
April	79	337	206	832	199	117	350	344
May	80	337	176	809	196	113	341	319
June	83	327	177	741	203	115	352	354
July	87	333	161	779	205	131	334	344
August	92	338	170	888	198	128	333	348
September	97	339	172	830	205	127	333	371
October	95	347	172	825	195	123	325	354
November	101	382	199	844	222	128	336	390
December	102	415	232	941	223	139	371	390
Average	87	353	186	821	205	122	340	355

Among the types of farms studied, poultry farms had the most pronounced seasonal pattern of consumption (fig. 4 and table 13). Brooders, incubators, water warmers, and ventilator fans use considerable amounts of electricity and are in operation largely in winter and spring. Dairy farms showed less seasonality of use. Milking machines, water heaters, and milk coolers are the chief kinds of electrical equipment used in a dairy enterprise and they are used each day of the year.

With a peak coming in June, July, August, and September, New England dairy farms had a seasonal pattern of consumption that differed from that of dairy farms in Wisconsin or northwestern Washington. One reason for this may be that in winter many New England dairy farmers used their mechanical milk coolers and electric ranges very little. The summer peak came when electricity was more fully utilized for cooling milk and for preparing food.

In most of the study areas, the seasons of high and low consumption of electricity by farms of different types were largely offsetting. Thus, with allowance made for year-to-year changes, the farms as a whole used about as much electricity in one season as in another. These averages include data from many farms of various sizes and types and from a number of distribution systems. They are not necessarily representative of any one system.

BASIS FOR FARMERS' DECISIONS CONCERNING ELECTRICAL EQUIPMENT

A farmer's decision to buy a particular piece of equipment involves many considerations. Although he may not state them definitely, a dozen or more probably enter into most of his decisions. One consideration may be most influential in one decision. At another time, this consideration may be overshadowed by some other factor. We cannot now identify all the motives that may be involved or measure the relative importance of those that can be identified. We can, however, list and illustrate some of the more conspicuous factors that influence farmers' decisions when they buy electrical equipment for use in farming operations. As a matter of convenience, these factors are here classified arbitrarily into three broad categories of considerations—money, labor, and personal.

Money Considerations

In this category are situations in which the money returns from the use of the equipment are compared with the money costs. Following are a few examples.

Increasing Production.—A farmer may install an air-conditioning unit in his poultry house to induce the hens to lay more eggs. The possibilities of cooling poultry houses and dairy barns in summer have aroused interest. In northern States more problems arise in winter. Many farmers install ventilating fans in dairy barns to maintain the health of the cows and thus increase their production.

Improving Quality of Product.—The farmer may install a milk or egg cooler so that he can market a high-quality product. Many farmers who produce Grade A milk said that it would be difficult to produce for that market without electrical equipment.

Meeting Market Requirements.—He may install bulk milk-handling equipment because there is no satisfactory market outlet for milk in the more conventional cans. This consideration is similar to "improving quality of product" but with one important difference—there is a satisfactory market for the product in only one form rather than in two or more.

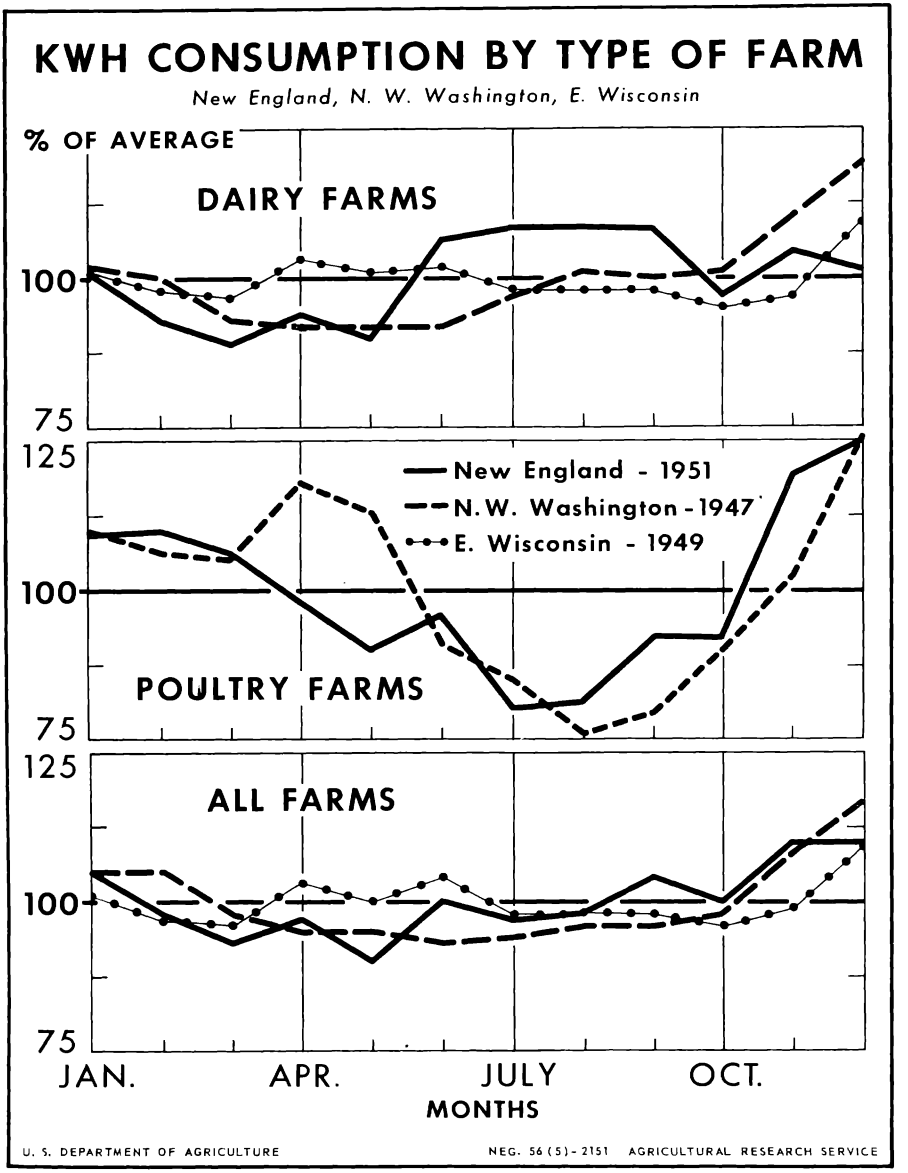

FIGURE 4.—Among the types of farms studied, poultry farms had the most pronounced seasonal pattern of consumption.

TABLE 13.—*Indexes of consumption, by type of farm, specified study areas, by months*

(Average for year=100)

Month	Dairy farms			Poultry farms		All farms		
	Northwestern Washington	Eastern Wisconsin	New England	Northwestern Washington	New England	Northwestern Washington	Eastern Wisconsin	New England
January	102	101	101	110	109	105	101	105
February	100	98	93	106	110	105	97	98
March	93	97	89	105	106	98	96	93
April	92	103	94	118	98	95	103	97
May	92	101	90	113	90	95	100	90
June	92	102	106	91	96	93	104	100
July	97	98	108	85	80	94	98	97
August	101	98	108	76	81	96	98	98
September	100	98	108	79	92	96	98	104
October	101	95	97	90	92	98	96	100
November	110	97	104	102	119	108	99	110
December	119	109	101	126	125	117	109	110

Assuring Timeliness of Operations.—He may buy expensive shop equipment so that he can keep his field machines running in critical seasons. Among farms in these studies, there was a direct relationship between the number of tractors and complementary field machines on the farms and the size and completeness of the farm shops. Many farmers use night lights on laying flocks to increase production of eggs in months when prices of eggs are high.

Avoiding Losses.—He may install a hay or a grain drier to prevent the spoilage and loss of some of the products of the farm. Ventilating fans in potato and apple storage houses are installed for the same reason.

Reducing Risks.—Two kinds of risks are noted here—weather and accidents. A sprinkler irrigation system may be installed to assure normal production in years with inadequate rainfall. Or electrical equipment may be installed in service buildings because of the fire hazard created by the use of fuel-burning equipment.

Labor Considerations

In this category are considerations that deal primarily with the management and allocation of labor resources. The following examples come to mind.

Increasing Productivity of Labor.—A milking machine may be installed to reduce the number of man-hours required for milking. The time saved may be used in caring for additional cows or in expanding some other farm enterprise. In the studies, most farmers with 12 or more cows had milking machines.

Reducing Exertion.—A farmer may buy an elevator with which to put baled hay in the barn, thus making it easier to do the job, although the man-hours required may not be changed. The saving in energy may make him feel able to do additional farmwork, or it may merely enable him to enjoy life more. The reduction in requirements for exertion may make it possible for elderly or physically handicapped persons to do the work.

Increasing Leisure Time.—He may install a water system to save the time and labor of pumping, carrying, or hauling water to livestock or poultry. The time saved may be used for recreation, community improvement, or in some other way usually considered as a leisure occupation.

Reducing Dependence on Hired Labor.—He may install an automatic feeder for his poultry flock to replace disinterested, undependable, or costly hired labor. Scarcity of labor was frequently given as a reason for buying milking machines, elevators, gutter cleaners, and certain other types of equipment.

Personal Considerations

This category includes considerations in which anticipated returns are largely in personal satisfactions or services instead of money. Five types are listed here.

Increasing Prestige.—A farmer may buy a machine that he does not particularly need, or he may buy a more elaborate and costly model than is necessary. He may reason that the possession of it will increase his prestige in the neighborhood or his own sense of importance. Advertising and sales campaigns frequently appeal to this motive.

Complying With Standards of the Community.—He may buy a machine or tool because, "Everybody that is anybody has one." Social pressures exist in rural as well as in urban areas. Farm children often demand television sets, for example, just as their city cousins do.

Habit.—He may buy, or rebuy, some particular kind of equipment because he has had no firsthand ex-

perience with any other kind. Many young men who enter farming today have been trained to use mechanical devices of various kinds. They accept as necessities many things that older people might consider luxuries.

Improving Health.—He may install a complete water system, including sewage-disposal facilities, because he feels that the health of his family will be improved thereby.

Convenience.—Electrically operated water systems, brooders, and some other kinds of equipment are almost fully automatic and require little care. Farmers frequently said they bought them because they required so little attention.

Limitations on Purchases

Clearly, the considerations listed above are not the only ones that enter into farmers' decisions. There are some that modify or limit the extent to which farmers can go in buying new equipment. For example, there is the financial limitation. A farmer cannot buy a piece of equipment no matter how much he may need it if he lacks the necessary money or credit. If the money available to him is limited, he must decide how to use it. He may feel that he can use the money in some other way and get greater returns from it.

For most farmers, there is a limitation on the supply of power available. Many farmers are not permitted to install electric motors larger than 5 or 7½ horsepower; existing distribution systems frequently are not adequate for heavier individual loads. In some areas, farmers are permitted to operate certain kinds of equipment only in off-peak hours.

A personal or psychological limitation also exists. Equipment is bought with the expectation that returns will be realized over a period of time, which usually extends a number of years into the future. Thus the "optimism" or "pessimism" of individual farmers becomes an important factor in the decision. One farmer may look into the future and decide that the price of milk will be relatively high and that he can operate his farm intensively enough to maintain a 30-cow dairy herd. Another may analyze the same information and decide that he should liquidate his dairy herd and shift production to hogs or poultry. Furthermore, some farmers are reluctant to go into debt; they like to operate on a cash basis. Others are willing to take greater risks and have less fear of debt.

Many other factors enter into the decision-making process. It is outside the scope of this work to list or to discuss all of them. The few discussed were noted to illustrate the fact that decision-making is a complicated process and that the answer to the simple question "Will it pay?" may involve considerations that are difficult to identify or measure.

A LOOK AHEAD

For the last 20 years, much attention has been given by government agencies and by the electric industry to making central-station electric service available to farmers. For the most part, effort has been concentrated on extending distribution systems to unserved areas. Except for a few localities, this work is about completed. Emphasis now is being shifted to: (1) Encouraging the farmer to make effective use of this new source of power; (2) developing new uses for it; and (3) improving the service available to farmers.

Comments made by farmers indicate that they appreciate the value of electric service. "Greatest thing that ever happened for the farmer;" "Wouldn't be without it;" "It adds $10 an acre to the value of my farm," and similar remarks were made frequently. Other sections of this report

show that farmers have gone a long way in a short time in making use of electricity and electrical equipment in their homes, service buildings, and service areas. It should be pointed out, however, that the period covered by these studies was one of generally high employment, rising incomes, and farm prosperity. Labor shortages and a favorable income situation no doubt stimulated the installation of electrical equipment of various kinds during the period.

The process of shifting the work of farming and homemaking to electrical equipment is by no means completed. Giant strides have been made in the last 20 years in increasing the efficiency of farm production; but the need for even greater improvement is apparent. Electricity has helped to increase the productivity of farm labor in chore operations in recent years, and it seems destined to play an even more important role in the future. Greater use in farm homes also is as certain as anything can be in an unpredictable world.

Production Pattern Changing

It is obvious that farmers will be called on to produce more food and fiber for domestic consumption in the future than they have produced in the past. The rapidly expanding population means more people to feed. Rising levels of living mean a growing demand for health foods, such as milk, eggs, fruits, and vegetables. This report points out that dairy and poultry farmers, as a rule, use more electricity than farmers on other types of farms similarly situated. Thus greater production of dairy and poultry products will mean greater use of electricity.

A development that is becoming apparent is the decreasing number but the increasing size of commercial farms. Between 1940 and 1950, the number of milking herds of less than 10 cows decreased 26 percent whereas herds of 20 or more cows increased 46 percent. Production of poultry and poultry products also is gradually shifting to farms with larger flocks. In 1940, 42 percent of all chickens 4 months old or over on farms were in flocks of less than 100 birds and 8 percent were in flocks of 800 or more. By 1950, the distribution had changed to 30 percent in flocks of less than 100 and to 16 percent in flocks of 800 or more. These shifts notwithstanding, there are few large, highly specialized dairy or poultry farms. In 1950, there were only 2,886 farms with 3,200 or more chickens 4 months old or over. There were only 63,755 farms with 30 or more milk cows (table 14).

This report indicates that greater opportunity exists for effective use of mechanical devices in farm production on a few farms with large herds or flocks than on a greater number of farms with small enterprises. Thus the shift to larger dairy and poultry enterprises no doubt will encourage greater use of electricity and use of more electrical equipment.

New Kinds of Equipment in Prospect

Other signs also point to greater use of electricity on farms. Engineers continue to develop and perfect equipment for use on farms and in farm homes. Home air conditioning, for example, is spreading rapidly and, in some areas, electricity competes with conventional fuels for home heating. Interest is growing in equipment for curing and processing farm products, especially feed, on farms. Destruction of certain kinds of insects with electricity is a possibility. Attention is also being given to developing equipment for handling of materials on farms, thus taking more of the backbreaking labor out of farming. If the past is a guide to the future, we can be confident that much of the equipment that will be com-

TABLE 14.—*Farms reporting milk cows and chickens, by size of herd and flock, United States, 1940 and 1950*

Item	Farms reporting		Percentage of total reporting	
	1940	1950	1940	1950
	Thousands	*Thousands*	*Percent*	*Percent*
Cows milked:				
1–2	2,359	1,705	51	46
3–9	1,712	1,321	37	36
10–19	467	473	10	13
20–29	85	119	2	3
30 or more	41	64	(1)	2
Total	[2] 4,663	3,682	100	100
Chickens on hand: [3]				
Under 25	1,631	1,313	32	31
25–49	1,385	1,103	27	26
50–99	1,101	802	21	19
100–199	736	651	14	15
200–399	237	286	5	7
400–799	43	59	1	2
800–1,599	13	19	(1)	(1)
1,600–3,199	4	8	(1)	(1)
3,200 and over	1	3	(1)	(1)
Total	[2] 5,150	[2] 4,243	100	100

[1] Less than 1 percent.
[2] Totals not exact because of rounding.
[3] 4 months old and over.

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monplace tomorrow is only in the idea stage today.

An additional possibility that is not to be underestimated is the harnessing of atomic power for civilian use. Some of the breathtaking potentialities of this are now evident, even though many problems remain to be overcome before atomic power is in general commercial use.

Potentialities for greater use of electricity for purposes now generally adopted must not be overlooked. Lighting, for example, was the first widely adopted application of electricity. Yet it appears that much more electricity will be used for this purpose in the years immediately ahead than in the past. In farm service buildings, a 25-watt light was a vast improvement over the kerosene lantern. The 25-watt light was replaced by a 40-watt one, and that by one using 75 watts. But most work areas and farm homes still are inadequately lighted according to standards set up by experts. Efforts are being made to advise farmers of the advantages of adequate lighting and to help them design the lighting suited to their needs.

Farmers Will Use More Electricity

Thus we come to the obvious conclusion that farmers will use more electricity in the foreseeable future than they have used in the past. How far they will go in this direction and how fast is another matter.

As noted previously, average consumption has increased at geometric rates. If these rates continue, average consumption in some areas will soon reach enormous proportions. Obviously, geometric rates of increase cannot continue indefinitely. A point will eventually be reached at which consumption will increase more slowly, and perhaps level off. In fact, there is now some indication of a slowing down in the rates of increase in some areas that were electrified a number of years ago.

If the trend established in 1942–51 in New York and New England (13.3 percent annual increase in average consumption) continues until 1965, average annual consumption per farm there will be almost 30,000 kilowatt-hours, instead of the 5,057 kilowatt-hours used in 1951. Before this level of consumption can be reached, most farms will need to be rewired and the distribution systems serving them will need to be rebuilt. Furthermore, the farms themselves would need to undergo some revolutionary changes. The difficulty of reaching a level of consumption of 30,000 kilowatt-hours may be appreciated when this level is compared with the level on a farm that is well electrified by present standards.

In the New York-New England area, a typical 1-family dairy farm with 30 cows might now use in the neighborhood of 17,000 kilowatt-hours a year. Of this, the home with an electric range, water heater, refrigerator, home freezer, laundry facilities, and other equipment now found in large numbers in farmhouses could use about 7,500 kilowatt-hours. Lighting the buildings and service areas might require 600 kilowatt-hours and pumping water another 400. The remaining 8,500 kilowatt-hours might be used to operate farm equipment—milking machine, milk cooler, water heater, hay drier, grain and roughage elevator, gutter cleaner, farm shop tools, and other equipment. The cost of the electricity would vary from region to region; at 3 cents per kilowatt-hour, the annual bill for the 17,000 kilowatt-hours would be $510.

The farm just described is hypothetical. It should be remembered that in 1951 dairy farms in the New York-New England study kept an average of 23 cows and used an average of 7,001 kilowatt-hours. Furthermore, dairy farms in the study used almost three times as much electricity per farm as did the noncommercial farms and there were almost as many noncommercial as dairy farms in the area.

Total consumption on this hypothetical dairy farm—17,000 kilowatt-hours—is still far from the projected average consumption of 30,000 kilowatt-hours. The question then becomes, "Is it possible to attain the higher level?" The answer is, "Yes, if—."

If a heat-pump were installed to heat the home in winter and cool it in summer, this one piece of equipment would require possibly 15,000 kilowatt-hours a year and perhaps more. There is considerable interest in heat pumps, especially in areas where winters are relatively mild. However, there is nothing to indicate that they will be generally used in the farmhouses of New York and New England within the next 10 years.

If supplemental irrigation, with electric motors to pump the water, should become general, the use of electricity would be materially increased. There is now considerable interest in supplemental irrigation, but relatively few farmers have adopted the practice and few of those who have adopted it use electric motors for pumping.

The conclusion must be reached, therefore, that with the present stage of technological development, the average rate of increase in consumption

on farms in New York and New England will not be continued until 1965. Sometime before then, the rate of increase is likely to slow down, although probably it will not be completely stabilized.

For the United States as a whole, average annual consumption per farm would reach 9,300 kilowatt-hours by 1965, if the past rate of increase—7.5 percent a year—should continue.[3] There are opportunities for increasing the use of electricity in almost all farm homes, but more than half of the farms are so small that they have little opportunity to use electricity in their farming operations. Of the 5.4 million farms reported by the 1950 Census, only 2.1 million were commercial farms with sales of farm products amounting to $2,500 or more in 1949.

The consumption levels that farms will reach will be conditioned partly by the economic climate in which they operate. War or a severe depression could alter, temporarily at least, the material progress of our society. Technological developments—the perfection of equipment and appliances suitable for farms of various types and sizes—will be influential. Much will also depend on the scope and effectiveness of educational programs. Thus, the combined efforts of research workers, the electrical industry, financial institutions, engineers, home economists, and farm-management experts are necessary if farmers are to make full use of their new source of power.

[3] Based on data for 1941–53 by Edison Electric Institute. (See footnote 1, p. 5.)

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