UTILIZATION OF ELECTRICITY ON SELECTED WILLAMETTE VALLEY FARMS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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CHAPTER I

INTRODUCTION

The objective of this thesis is to provide an analysis of the extent and nature of electricity utilization on farms which might be useful to the distributors of power in estimating future power requirements. No prior studies have been made in Oregon on this problem although six similar studies have been completed by the Bureau of Agricultural Economics in cooperation with various power distributors and land grant colleges.

General Economic Scope of the Problem

It is necessary at the beginning to consider the general framework within which this problem exists and has meaning. A tremendous amount of public and private resources are employed in the production and distribution of electric power. It is desirable that only those resources be employed in this use over time which can be operated at an optimum capacity to provide consumers with power at the lowest possible cost. The existence of excess capacity disallows attaining the low cost goal as it implies operation at other than an optimum level. A shortage of productive

capacity forces emergency facilities into use which are more costly than normal methods of power generation. Therefore, estimation of required capacity is the key to the provision of low cost power over time. Electric power companies are public utilities and this fact must be considered as a special criterion in analysis. The peculiarities of the product or service must also be considered, as the production and distribution of a non-storeable product is a unique problem.

Nature and Problems of Public Utilities

The legal and the economic characteristics of a public utility define duties and responsibilities of the utility to the consumers whom they serve. These legalized monopolies are awarded franchises which, in the public interest, require that everyone receive service who applies for service, and that safe and adequate service be provided without discrimination to the maximum of capacity (15, pp. 75-98). Customarily these franchises specifically establish controls on the price of service so that no unjust or unreasonable charge may be forced on the consumer by the monopoly. Control of these service firms is placed in State Public Utility Commissions who function within the framework of the laws which have been established for them. It is obvious that definitions of such vague terms as

adequate service, maximum capacity, discrimination, and reasonable price, for example, have been derived from legal decisions over time and that literary use of the terms must recognize the semantic limitations.

The general public utility responsibility with which this study is concerned is that of providing adequate power on demand. This would obviously be no problem if demands of consumers were not changing over time, and if there were no variation in demands of various consumers. All distributors of electric energy know that demands are changing, and that there is considerable variation in these demands. Within very broad limits, they know the nature of this demand and the changes that are taking place. Particularly, they recognize that a difference exists between demands of urban and rural users of power and that rural uses are changing more rapidly and to a greater extent than urban uses.

The cost of providing service to the rural population is higher than the cost for similar service to urban users of electricity. It is a characteristic of electric power companies that their major costs are fixed or non-variable, and that the greater the number of consumers that can be served per dollar of fixed facility, the lower the cost of the service (15, p.87). A mile of power line in urban areas clearly serves many times the number of households

that a mile of rural line serves. When these lines can adequately serve over an extended period of time without change, the annual cost for amortization of the investment is thereby reduced, and a lower cost service made possible to the consumer. This statement assumes that generating facilities are also not excessive. If the utility is to provide safe and adequate service over time, it is clear that their estimations of future requirements must be accurate or the cost of the service will be higher.

If it were possible to adjust generating or distributing capacity on short notice and in varying proportions, the problem would be simplified. Where total power is generated by hydro-electric plants that require years to plan and build, the inflexibility of productive capacity becomes a limiting factor. Experience in the northwest clearly demonstrates that utilization of emergency generating facilities results in increased costs to the consumer of power. Equally limiting but less obvious are the installations of lines and sub-stations necessary to distribute power and maintain service. This inflexibility in an industry that is required to provide low cost, adequate service in the public interest, further necessitates the increased reliability of future estimations so that adequate service may be provided with safety, but facilities will not be so excessive as to result in increased costs.

The dichotomy presented by the adequate service-reasonable rate responsibilities is not readily solved at any one time much less over changing periods of time.

The uncertainty as to the amount and type of service the consumer demands is confounded by the nature of electricity distribution. The consumer seldom consults the distributor when his demand increases unless the increase is technically impossible, or will make possible a different rate of charge for service. Where adequate wiring and voltage already exist, additional appliances are connected without question, and the consumer assumes the power will be provided. Because of this, the distributor seldom knows exactly how the power is being utilized by a particular consumer even though his demand may have doubled or tripled over a relatively short time. This is not true of only a particular or specific consumer; it is also true of types of consumers such as rural, urban or industrial. In view of this scanty knowledge of the present, the prospects of estimating into the more uncertain future with any reliability seem remote. All available descriptions of present uses must be gathered, and the relevance of the relationships which seem to exist between this utilization and other factors must be ascertained if estimates are to be any more than wild guesses.

The distributor does know how much power is being used

by his customers. This information is maintained in the customer's meter account book in terms of kilowatt hours of electricity. Where special meters are used for specific uses, such as water heaters or irrigation pumps on some farms, the distributor knows something of the nature of utilization. In addition to lighting, which is common to all households, there are literally dozens of electrical appliances which may or may not be in use by a particular consumer or group of consumers. It is immediately obvious that the electricity consumed by any firm or household is a function of the extensity of uses and the intensities of the various uses. It is equally obvious that there is considerable variation among consumers both in extensity and intensity of power consumption. This variation is subject to change over time. There is a peculiar business-household interrelationship on farms that does not exist in urban circumstances. Where power is used in production on the farm, an additional source of variation is introduced. Further, since the production uses are specific and peculiar to a particular type of farm or farm enterprise, this source of variation must also be considered. It seems a logical question to wonder how any distributor of power could hope to maintain an understanding of these varying relationships over time without incurring sizeable costs.

Previous Studies

The previously mentioned six studies by the Bureau of Agricultural Economics were very similar in scope and method. Two researchers were responsible for all of these studies. Where there are regional differences existing that can be clarified by descriptive studies, that clarification is enhanced by the comparability of the individual studies. Bonneville Power Administration, the initiator of this study, and the various public and private utility companies of this area possess and utilize the information contained in these other studies. It becomes a responsibility of this study to remain reasonably comparable to these other studies for this reason. However, if there are shortcomings resulting from method in these studies, there is nothing to be gained from repetition of the method. Therefore, careful examination of these reports is necessary.

The data collected, and the analyses of data in these studies, are so similar that no injustice is done by generalizing them. Each was a study concerned with farms in a specific geographic region. The regions included in the studies are in Georgia (11), Iowa (3), Kansas (2), Tennessee (1), Eastern Washington (13) and Northwest Washington (14). The reports include summaries of annual and seasonal electricity consumption in terms of kilowatt hours and cost

to consumers. These summaries are related to farm size, income, farm practices, and type of farm. In some cases, the length of time power has been available is considered as a significant factor. In each case, a ten year record of power consumption is utilized to indicate the trend and change which has taken place. Correlation analysis was used extensively to indicate the relationship between farm size and income and electricity consumption. In no case was a significantly high coefficient of correlation found to exist. There is no single, clearly defineable relationship between power consumption and any other factor as reported in these studies. Farm type is the only factor which appears relatively significant in all studies.

One methodological concept common to all studies deserves careful consideration. In each case, although a ten year record of power consumption was obtained, only a one year description of the farms and their incomes, size, and existing electrical appliances was used in analysis. A ten year trend, which is related only to conditions prevailing in the last year, is subject to criticism when this trend is to be extrapolated. If the nature of changes over time is important, the technique they used eliminates the possibility of measuring this importance. Where this method indicates the variation of extensity of electricity uses, it disallows analysis of the variation in intensities of these

uses. The problem of change and growth is not a static problem and use of a purely static approach in analysis of these phenomena is a serious shortcoming. It may be that other factors were considered, but that analytical and statistical tools currently available were inadequate to fully measure and report their significance. The realm of economic dynamics is as yet largely unexplored, and no researcher can be criticized for only utilizing that body of knowledge which is available to him.

Except for the above criticism, it would seem that a high degree of comparability can be maintained between this study and previous studies. Ability to contribute beyond this measure will depend on availability of accurate data, and facility for its analysis.

CHAPTER II

SAMPLING PROCEDURE AND COLLECTION OF DATA

The sample for this survey was not drawn solely or specifically for the study of electricity utilization. The electricity study became a part of a broader study initiated by the Department of Agricultural Economics, Oregon State College. This study is concerned with resource utilization, and combinations of crop and livestock enterprises on selected Willamette Valley farms of several types. To reduce variation, the population of farms in three selected counties of the valley were stratified as to farm type, farm size, and soil type. The counties selected were believed to be sufficiently typical of the valley that inference could be made logically from data received in this survey to farms of similar types in all counties of the valley.

The Population Sampled

The counties from which the sample was drawn are: Marion, Polk, and Yamhill. These counties are adjacent to each other, and are located in the central portion of the Willamette Valley. The 1950 Census of Agriculture (18, pp. 231-436) indicates that Marion County had 5013 farms in that year, of which 1925 were miscellaneous, residential,

or part-time, non-commerical farms; Polk County had a total of 1833 farms, of which 810 were similarly classified; Yamhill County had 2808 farms, and 1215 of these were non-commercial. The three counties had a total of 9654 farms, or 27% of all farms in the thirteen Western Oregon counties. Of these 9654 farms, 40.9% or 3950 farms were non-commercial or miscellaneous types of farms. By census definition, a unit of land and buildings, three acres in size, which does not produce and sell a total of $150.00 of agricultural commodities in a year, is classified as non-commercial (18, p.XII). It is obvious that the broader study of farm enterprises combinations could not consider these operations since the objective of the study was to secure information which might help commercial farmers make adjustments in production to meet changing price conditions. Therefore, the sample was concerned with only 59.1% of all farms in these three counties.

The selection of these three counties did not unduly limit variation with respect to distributors of electric energy as farms in this area are served by five distributors. Of these five distributors, two are municipal power and light companies, two are private utility companies, and one is a cooperative REA.

Selection of Farm Types

The selection of farm types was carefully planned to gather information about those types of farms which changing price relationships might force to make adjustments in farm enterprise combinations. The types selected were: First, Field crop farms whose incomes are from the sale of grains, cover crops, and grass seeds. These farms do not have income producing livestock. Second, Crop-Livestock farms with various types of livestock enterprises that produce a substantial portion of the farm income. These farms produce grains, forage crops, and grass seeds, but market a considerable portion of their crops through livestock rather than by cash sale. Third, Grade A and factory milk producing Dairy farms were selected. These farms produce varying proportions of the feed required to maintain their cow herds. It is immediately obvious that the farm types selected for study are interrelated. However, it is possible to classify them as separate types of farms. Table 1 indicates that these types comprise 52.3% of all commercial farms within the three selected counties.

Table 1: Number of farms of selected types as enumerated by county in the 1950 Census of Agriculture (18, pp.231-436).

Type of Farm	Marion	Polk	Yamhill	Total
Cash Grain	198	223	204	625
Dairy	503	160	296	959
General Farms:				
Principally Crop	246	114	160	520
Prin. Livestock	137	15	25	177
Crop-Livestock	361	140	204	705
Totals	1445	652	889	2986
Total Commercial Farms	3088	1023	1593	5704
Percent of Commercial:	46.7	63.6	55.2	52.3

Stratification of Farms by Soil Type

Because enterprise combinations on farms are limited by the adaptability of the soil to various alternatives, the stratification of this population by soil type is a logical corollary to the selection of farm types. Since farms with the alternative of producing intensive cash crops were eliminated from the sample, it became necessary to eliminate those farms that had a substantial portion of either Chehalis or Newberg soil. The specific soil types selected were divided into hill and valley floor groups. The hill soil group included the Aiken, Carlton, Melbourne, and Olympic Series. The Willamette and Amity Series made up the other group of soils included in the sample.

Stratification of Farms by Size

The size stratification was not possible until a list of farms by acreage was available. To obtain this information, a list of farms was made from the records of the county Production and Marketing Administration offices. Although this is not a perfect source, there are very few farms which are not listed in these records. Because of differences in definitions of farms, it is impossible to tell whether the records are complete, but it was estimated at the outset that over 95% of all farms in the counties were included in these office records.

The list of farms contained all farms with forty or more acres of cropland that did not have more than one acre of orchard. The lower limit of forty acres was used to eliminate many of the non-commercial farms. The restriction on orchard acreage is arbitrary, but one acre of orchard is generally a household orchard and non-commercial in nature. The list made in this way contained approximately 3000 farms.

Stratification of Farms by Type

To classify the 3000 listed farms by type, where the type was not indicated on PMA records, the lists were completely checked with the respective county agents. The

County Agents were able to classify approximately 70% by type, and to identify the kind of livestock on the farms. The final list contained 830 farms of the selected types. Of this total, 128 were Crop Farms, 610 were Crop-Livestock Farms, and 92 were Dairy Farms. The 830 farms represent 27.9% of the total of farms of these types in the three counties as indicated in the 1950 Census of Agriculture. However, 65.1% of all farms reporting cropland harvested in these three counties had less than 40 acres of cropland, and it is not possible to tell from the census how many of these were of the types selected for the study. If a proportionate percentage of these types of farms had less than 40 acres of cropland, then the 830 farms represent 79.9% of these types of farms in the three counties. The restriction placed on orchard acreage is a further limiting factor in making comparisons as is the elimination of farms with either Chehalis or Newberg soils. It is felt that the list in this final form was quite complete.

Permanent Pasture Acreage Limitations

Having reduced the list to 830 farms of specific types, the acreage of permanent pasture had to be controlled to eliminate this as a source of variation. Four hundred thirty of the eight hundred thirty farms had less than 10 acres of permanent pasture land recorded on PMA records.

These were retained as the group from which sizes were selected according to acres of cropland. As expected, the distribution of farms by type and size was not symmetrical. Thirty one of fifty nine Dairy Farms with less than ten acres of pasture also had less than sixty acres of cropland. The distribution of farms with from forty to two hundred forty acres of cropland was more symmetrical in the other types of farms.

The original survey list, or sample, included all farms with less than ten acres of pasture whose cropland acreage was within the following size groups: 40-49 acres, 70-89 acres, 140-179 acres, 220-260 acres. This list contained a total of 216 farms. It is difficult to imagine how more care could be exerted toward selecting a sample of farms stratified to eliminate confounding variation, which would exist in any random sample of farms.

The Field Work and Collection of Data

In spite of the caution used in preparing the original list of farms, it was found that less than one third of the selected farms were accurately classified as to size, 60% of the farmers were operating other farmland on lease, or other land which they owned, and of which there had been no record. Because of this, and the inaccuracy of the pasture acreage as contained in the farm list, it was

necessary to add forty farms within the cropland acreage groups that were listed as having from ten to nineteen acres of permanent pasture. By adding these farms, the sample was expanded from 216 to 256 farms. It was possible to complete eighty-five questionnaires from this group of farms.

A much less refined technique was employed to select a group of poultry farms. This list was made by the respective county agents in response to a request for a list that would include various types and sizes of poultry operations in the counties.

Since there were essentially two studies to be completed in one questionnaire, it was necessary to adjust the extent of detail to be included in order to make possible the completion of a questionnaire, with a cooperator, in a reasonable time period. This did not directly reduce the information gathered with respect to electricity utilization. There was, however, an indirect effect resulting from this compromise. The more lengthy and detailed double questionnaire increased the time necessary for completion, tended to tire the cooperator, and generally reduce his interest and accuracy in responding to questions.

Obtaining answers to the questions concerning income proved to be unsatisfactory, and the questions were altered in order to obtain this type of information. It was felt

that the best estimate of disposable income on farms could be ascertained by adding depreciation allowances to the taxable income reported on the Federal Income Tax forms. Because of a natural reluctance of some cooperators to divulge this personal information, and because the exact figures were not available for more than the most recent years in many cases, the decision was made to make use of income groups. Placement within groups was based on the same concept of disposable income, including off-farm income and the estimated value of farm-produced subsistence. Three groups were used: The lower income group included incomes of less than two thousand dollars per year. The middle income group included those incomes between two thousand and five thousand dollars per year. The high income group included incomes in excess of five thousand dollars per year.

Use of the income groups resulted in more willing cooperation. Since they are rather broad groups, the placement of an individual within groups could be expected to be reasonably accurate. Many cooperators produced income tax forms, records of farm produced subsistence, and other data from which placement was made into groups. Income groups are unquestionably less desirable data for analysis than exact income figures, but the compromise was forced on the study.

In addition to supplying answers to the questionnaire, each cooperator signed a form letter which requested the power distributor to release the customer's monthly account to an enumerator. The final phase of the field work was the copying of these accounts of kilowatt hours per month, and cost when available, from the meter books to office analysis sheets. Power companies seldom refer to these old accounts. Consequently they do not incur special cost to maintain them in particularly usable form. Because of this, complete records of electricity use were not always available.

Limitations of the Sample

The technique used for this tudy was a thorough attempt to secure a stratified random sample of farms in a typical portion of the Willamette Valley. In order to stratify farms by type, it was necessary to seek the aid of county agents in classifying farms. This influence qualifies the completeness of the list from which the sample was drawn. It is possible that the county agents knew only the better, upper-strata farms and farmers within each of the selected types of farms. This could induce a bias toward higher incomes and more progressive farm practices. However, it is felt that the list in final form was quite complete.

There was no random selection of farms within strata as it was necessary to call on every farm which finally remained within these classified groups.

With the qualification of the possible bias induced by the county agent's role in preparing the list for this study, this writer believes inference can be logically made from this survey to all farms in the Willamette Valley of similar types and sizes.

CHAPTER III

PRESENTATION AND ANALYSIS OF DATA

The data are arranged and presented to indicate relationships between several general characteristics of farms, and the amount of electricity used by these farms. Where possible, significance of these relationships is tested statistically and the result of the test is presented. It is necessary to examine these relationships critically and to approach the question: How can these data aid in predicting the future power requirements of farms? To do this, each phase of the study must be examined in order after briefly reviewing the general economic conditions of the years studied.

The Time Period Studied

It would be extremely difficult to select a less normal ten year period than that covered by this study, 1943-1952. The first three years are war years with critical shortages of materials and labor, with price controls, rationing, relatively high incomes and readily available off-farm work. Many of the farmers in this study were operating their farms on a reduced scale and working off the farm during these years. The four years following the war saw personal incomes in the United States rise to

unprecedented heights. With the removal of price controls in 1946, prices of agricultural commodities advanced sharply. As a result, the years 1947 and 1948 were particularly favorable to the farmer. His prices received were high compared to prices which he paid, and farm output jumped to a previously unattained level in 1948. Therefore, farmers experienced particularly high gross and net incomes in those years.

The backlog of wartime savings created a tremendously effective demand for durable appliances which had not been available for several years. Although 1949 introduced a slow-down in the inflationary trend of these years, it was abruptly changed in 1950 by events which led into the Korean War.

The ten year period is generally one of full employment, rising price levels, increasing incomes, and economic optimism. Agriculture made a phenomenal 40% increase in its production in the United States during this time. Farmers were guaranteed prices for much of this production by federal programs. Farm mechanization in the United States advanced rapidly: Number of tractors increased by 150%, trucks by 120%, and grain combines by 300%. The total machinery on farms increased by 60% in this ten year period. This mechanization is undoubtedly very largely responsible for the increase in output per man hour, and

is an important part of the increase in total production. Electricity used in production is part of this mechanization. (16, pp.6-21)

Although it is extremely difficult to define normal as it pertains to economic activity, it is quite certain that these ten years would be classified as non-normal in terms of any definition based on past experience. Whether they might appear much more normal ten years from now is unknown, but they are unusual years in light of the past.

This study is concerned with the trend of increase in use of electricity in production and in durable household appliances during this period of years. The general economic conditions of the time period are extremely important in the total analysis, and limit the validity of any attempted extrapolation of a trend. This summary is presented as part of the general framework of criteria in which the electricity problem exists.

The General Trend in Use of Electricity

Electricity utilization records were obtained for 103 farms. Of these, 18 were Dairy farms, 16 were Poultry farms, 32 were Crop farms (farms with no income producing livestock), and 37 were Crop-Livestock farms. The availability of a complete ten year record of electricity use for each farm varied because of the length of time farmers

had resided on their present farm and because distributors of power do not maintain a complete record for this period of time. Table 2 indicates the variation of these factors and the analytical limitations imposed. Sixty five of the one hundred three farmers had resided on the sampled farm since 1943, but it was possible to attain complete records of electricity consumption on only 20% of these for the year 1943. From 1946 to 1952, the number of complete records is sufficient to reduce the distortion caused by extremes in the total group of farms. The changing number of farms by type for these years, however, remains a limiting factor.

Table 2: Number of farms by type from which information was obtained.

	No. Residing on Farm Sampled					No. for which electricity history is complete.					
Year	P	D	C	C&L	Total	P	D	C	C&L	Total	%
1943	13	15	16	21	65	2	3	4	4	13	20
1944	14	16	16	22	68	6	5	7	10	28	41
1945	15	16	17	22	70	7	9	10	10	36	51
1946	16	17	20	25	78	13	12	16	17	58	74
1947	16	16	23	26	81	14	13	17	22	66	81
1948	16	17	28	29	90	16	13	19	22	70	78
1949	16	17	30	34	97	16	17	23	28	84	87
1950	16	17	31	37	101	16	17	27	33	93	96
1951	16	18	32	37	103	16	18	29	36	99	98
1952	16	18	32	37	103	15	18	32	36	101	98

Abbreviations: P for Poultry, D for Dairy, C for Crop, C&L for Crop-Livestock.

The general trend for all farms in this study which is shown in Figure 1 indicates a tremendous increase in the use of electricity by these farms. The thirteen farms for which complete data were available in 1943 averaged using 4848 kilowatt hours of electricity that year. The average for the one hundred one farms for 1952 was 14,062 kilowatt hours. The mean deviation in 1943 was 3551 kilowatt hours, and in 1952, the mean deviation was 7665 kilowatt hours. The range in 1943 was from 712 to 10,946 KWH, and in 1952 the range was from 569 to 62,348 KWH. These figures are totals per farm for all uses; household, production, and irrigation. The number of farms by type changes each year, so this trend is confounded by all sources of variation and must be regarded with caution.

The average annual kilowatt hour use of electricity by farms of all types in the Willamette Valley as provided by Bonneville Power Administration from reports submitted to them by the power distributors included in this study is shown in Table 3.

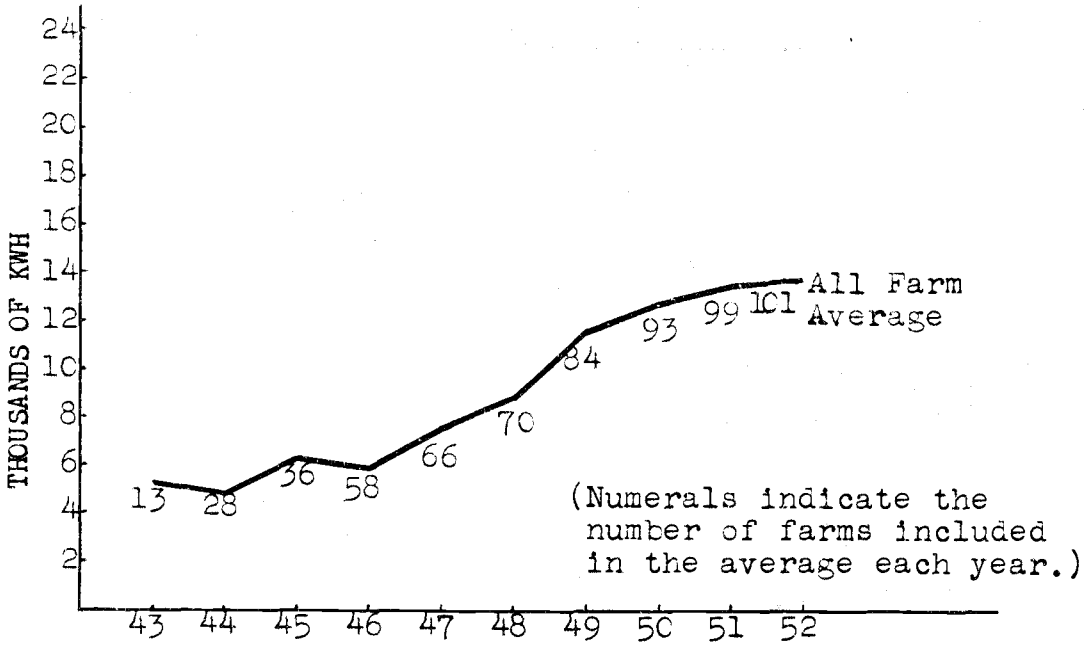


FIGURE 1. AVERAGE ANNUAL USE OF ELECTRICITY BY ALL FARMS IN SAMPLE FROM 1943-1952.

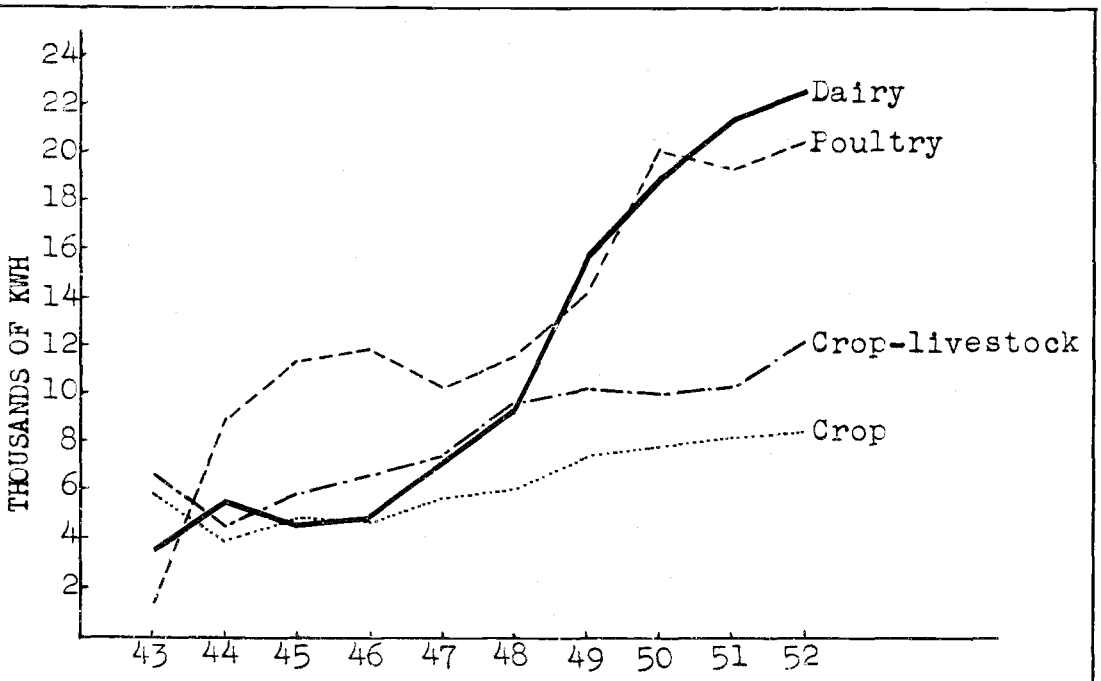


FIGURE 2. AVERAGE ANNUAL USE OF ELECTRICITY BY TYPE OF FARM FROM 1943-1952.

Table 3: Average annual KWH per farm in the Willamette Valley, as reported by four Power Distributors.[1]

Year	Power Distributor A	B	C	D
1943		2245	961	2218
1944		2656	1090	2373
1945		3056	1376	2633
1946		4292	1715	3197
1947		5375	2184	3804
1948		6595	2714	4553
1949		7203	3210	4990
1950	4168	7898	3755	5344
1951	4459	8519	4179	5543
1952	4988	9175	4899	5893

Entries in Table 3 of Distributors A, B, and C should be generally comparable as they were submitted as averages of rural customers only. The entries under Distributor D probably contain urban and rural averages and are not comparable to the other three. It is not certain whether irrigation is included in these averages as submitted, but it is believed that all special irrigation accounts have been excluded.

It is obvious that the farms of this study do not compare with the averages contained in Table 3. This cannot be wholly rationalized, and there are several questions which would need answering before comparison could be accurately made. First, it is not known how the distributors defined account, or rural account. If each meter

1. John H. Davidson, Industrial Analyst, Bonneville Power Administration, Portland, Oregon. Personal letter to Dr. G. E. Blanch, dated January 19, 1954.

were treated as an account, lower averages should be expected as many farms have several meters. If every account outside the city limits of urban areas was included in the rural accounts, then far more than farm accounts might be included in the averages shown.

Relationship between Type of Farm and Use of Electricity

Figure 2 indicates the composition of the general trend shown in Figure 1 by separating the farms into the four types sampled. It is clearly obvious that the proportion of farms of the different types included in the all farm average is of considerable importance. Analysis of variance was used to test the hypothesis that the means of the different types of farms are equal with respect to annual use of electricity. The F-value resulting from this test is 11.77 with three and ninety-six degrees of freedom. This value is significant at the one percent level, and it is concluded that the means of the different types are not equal. Six t-tests were made to test the equality of the individual farm type means. Results are: The mean of Poultry farms equals the mean of Crop farms; t equals 3.9 with 44 degrees of freedom. The mean of Poultry farms equals the mean of Crop-Livestock farms; t equals 2.9 with 50 degrees of freedom. The mean of Dairy farms equals the mean of Crop farms; t equals 5.4 with 46

degrees of freedom. The mean of Dairy farms equals the mean of Crop-Livestock farms; t equals 4.2 with 52 degrees of freedom. The mean of Poultry farms equals the mean of Dairy farms; t equals .49 with 32 degrees of freedom. The mean of Crop farms equals the mean of Crop-Livestock farms; t equals 2.18 with 64 degrees of freedom. Each of these t values is significant at the 5% level except the Poultry-Dairy test. Type of farm is not an isolated variable in these tests as income variation remains in the data. Because of the unequal numbers of observations in the groups, this variable could not be separated.

It is obvious in Figure 2 that the average annual use of electricity for poultry and dairy farms is greater than the other two types of farms in this study. Table 4 indicates the extent of the variation within the type of farm groups for the years 1951 and 1952.

Table 4: Mean, standard deviation, and range, of annual KWH electricity use by type of farm. The 1951 and 1952 totals were averaged for each farm in this analysis.

	Dairy	Poultry	Crop	Crop-Livestock
Mean	21,977	19,650	8313	11,192
s.d.	12,960	14,580	4370	6040
Range:				
High	46,200	62,348	23,200	22,200
Low	1600	1200	569	2100

Previous to 1948, the relationship between these types of farms was quite different, but since 1948, with the exception of the crossing of averages for poultry and dairy farms, the relationship has been consistent. If this study had been made in 1948, and similar data had been obtained, this relationship between type of farm and average annual use of electricity would have appeared to be of little or no importance.

Since the variation in electricity use on farms must be dependent upon the number and type of appliances, both for household and production uses, and the intensity to which they are used, an analysis of appliance density is desirable. Nineteen major appliances or types of appliances were enumerated in this study. Twelve of these were household appliances and seven were production appliances. The water pump is probably both a household and a production appliance in most cases, but it is included in the household group.

Tables 5 and 6 present the actual number of the individual appliances which were enumerated in this study. This information is presented graphically in Figure 3 to indicate the percent of all appliances found on the various types of farms. The relationship of the types of farms in this analysis is very similar to the relationship noted in the graph showing average annual use of electricity.

Table 5: Appliance density by type of farm for each year from 1943-1952.

Type of Farm	Number of Farms	Refrig.	Range	Deep Freeze	Water Heater	Space Heat	Wash. Mach.	Auto. Wash.	Cloth. Dryer	Dish Wash.	Roaster	T.V.	Water Pump
Dairy	15	9	4	-	3	-	14	-	-	-	1	-	14
Poultry	13	11	8	-	6	-	12	-	-	-	1	-	12
Crop-Livestock	21	19	12	1	13	-	20	-	-	-	-	-	18
Crop	16	15	8	1	9	1	13	1	-	-	-	-	16
1943 Total	65	54	32	2	31	1	59	1	0	0	2	0	60
Dairy	16	10	6	-	3	-	16	-	-	-	1	-	15
Poultry	14	12	9	-	6	-	13	-	-	-	1	-	13
Crop-Livestock	22	20	13	2	13	-	21	-	-	-	-	-	18
Crop	16	15	10	1	9	1	13	1	-	-	-	-	16
1944 Total	68	57	38	3	31	1	63	1	0	0	2	0	61
Dairy	16	11	7	-	4	-	15	1	-	-	1	-	15
Poultry	15	13	9	-	7	-	13	1	-	-	1	-	13
Crop-Livestock	22	21	14	2	15	-	20	1	-	-	-	-	19
Crop	17	16	11	2	11	1	13	2	-	-	1	-	17
1945 Total	70	61	41	4	37	1	61	5	0	0	3	0	64
Dairy	17	11	8	1	7	1	16	1	-	-	1	-	16
Poultry	16	15	12	-	10	-	14	1	-	-	1	-	15
Crop-Livestock	25	24	16	2	18	-	22	1	-	-	-	-	23
Crop	20	19	13	3	14	1	15	2	-	-	1	-	19
1946 Total	78	69	49	6	49	2	67	5	0	0	3	0	73
Dairy	16	13	10	1	8	1	15	1	-	-	1	-	15
Poultry	16	15	12	-	12	-	14	2	-	-	1	-	15
Crop-Livestock	26	24	17	5	18	1	23	2	-	-	-	-	24
Crop	23	22	16	5	18	1	15	3	-	-	1	-	21
1947 Total	81	74	55	11	56	3	67	8	0	0	3	0	75
Dairy	17	14	12	4	8	1	13	4	1	-	1	-	16
Poultry	16	15	13	1	12	-	14	3	-	-	1	-	15
Crop-Livestock	29	28	19	8	23	1	25	2	-	2	-	-	27
Crop	28	25	19	5	23	2	18	4	1	-	2	-	26
1948 Total	90	82	63	18	66	4	70	13	2	2	4	0	84
Dairy	17	17	13	5	11	2	12	5	2	-	1	-	17
Poultry	16	15	13	1	12	-	14	3	-	-	1	-	15
Crop-Livestock	34	34	27	11	29	2	27	6	1	2	-	-	32
Crop	30	26	22	9	25	3	22	4	1	-	2	-	29
1949 Total	97	92	75	26	77	7	75	18	4	2	4	0	93
Dairy	17	17	14	6	15	3	11	6	3	1	-	-	17
Poultry	16	15	13	3	12	-	13	4	-	-	1	-	15
Crop-Livestock	37	37	32	13	35	3	25	10	2	2	-	-	35
Crop	31	30	26	11	29	4	22	6	4	-	2	-	30
1950 Total	101	99	85	33	91	10	71	26	9	3	3	0	97
Dairy	18	18	17	7	16	3	12	6	4	1	-	-	18
Poultry	16	16	13	3	14	-	12	4	2	-	1	-	15
Crop-Livestock	37	37	33	16	35	3	25	12	2	3	-	1	35
Crop	32	31	28	13	31	4	18	12	7	1	2	-	31
1951 Total	103	102	91	39	96	10	67	34	15	5	3	1	99
Dairy	18	18	18	10	16	4	10	8	6	1	-	-	18
Poultry	16	16	14	4	14	-	12	4	3	-	1	2	15
Crop-Livestock	37	37	32	17	35	3	23	12	5	3	-	2	35
Crop	32	31	28	17	32	4	15	16	9	2	2	3	31
1952 Total	103	102	92	48	97	11	60	40	23	6	3	7	99

Table 6: Production Appliance density by type of farm. 1943-1952.

Type of Farm	No. of Farms	Motors	Irriga-tion	Farm Shop	Welder	Dairy Equip.	Prod. Wtr.Htr.	Poultry Equip.
Dairy	15	2	2	-	-	10	3	1
Poultry	13	1	-	1	-	2	-	11
Crop-Livestock	21	3	2	1	1	5	1	2
Crop	16	3	2	-	-	2	-	-
1943 Total	65	9	6	2	1	19	4	14
Dairy	16	2	3	-	1	10	3	4
Poultry	14	3	1	2	1	2	-	13
Crop-Livestock	22	4	2	1	1	5	1	2
Crop	16	3	2	-	-	2	-	-
1944 Total	68	12	8	3	3	19	4	19
Dairy	16	2	3	-	1	10	4	3
Poultry	15	3	1	2	1	2	-	13
Crop-Livestock	22	4	2	1	1	6	1	2
Crop	17	3	2	-	-	2	-	-
1945 Total	70	12	8	3	3	20	5	18
Dairy	17	2	3	-	2	13	4	3
Poultry	16	3	1	2	1	2	-	13
Crop-Livestock	25	4	2	2	2	9	1	2
Crop	20	3	2	-	-	2	-	-
1946 Total	78	12	8	4	5	26	5	18
Dairy	16	1	3	-	2	12	6	2
Poultry	16	3	1	2	1	2	1	15
Crop-Livestock	26	4	2	2	3	9	1	2
Crop	23	3	2	-	-	3	-	-
1947 Total	81	11	8	4	6	26	8	19
Dairy	17	2	6	2	2	15	10	3
Poultry	16	3	1	2	2	2	1	15
Crop-Livestock	29	5	2	2	3	10	1	3
Crop	28	3	2	-	1	3	-	-
1948 Total	90	13	11	6	8	30	12	21
Dairy	17	2	6	2	3	16	12	4
Poultry	16	3	1	2	3	2	1	15
Crop-Livestock	34	5	5	2	3	9	1	4
Crop	30	3	2	1	2	2	-	-
1949 Total	97	13	14	7	11	29	14	23
Dairy	17	3	7	2	3	16	12	7
Poultry	16	3	2	3	3	2	1	16
Crop-Livestock	37	5	5	2	5	12	1	4
Crop	31	4	2	1	2	2	-	1
1950 Total	101	15	16	8	13	32	14	28
Dairy	18	3	10	2	3	18	12	7
Poultry	16	3	2	3	3	2	1	16
Crop-Livestock	37	5	5	2	7	14	1	5
Crop	32	4	2	1	2	2	-	2
1951 Total	103	15	19	8	15	36	14	30
Dairy	18	4	11	2	3	18	12	7
Poultry	16	3	3	3	3	2	1	16
Crop-Livestock	37	5	8	2	7	15	1	5
Crop	32	4	2	1	2	2	-	2
1952 Total	103	16	24	8	15	37	14	30

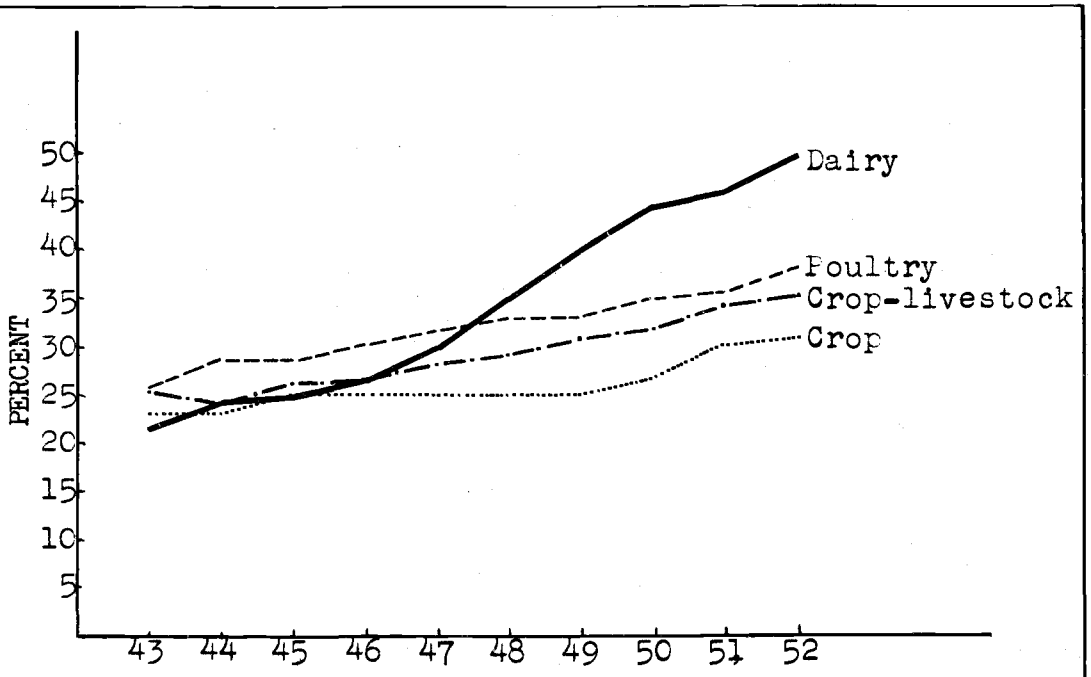


FIGURE 3. YEARLY DENSITY OF ALL APPLIANCES ENUMERATED FROM 1943-1952. BY TYPE OF FARM.

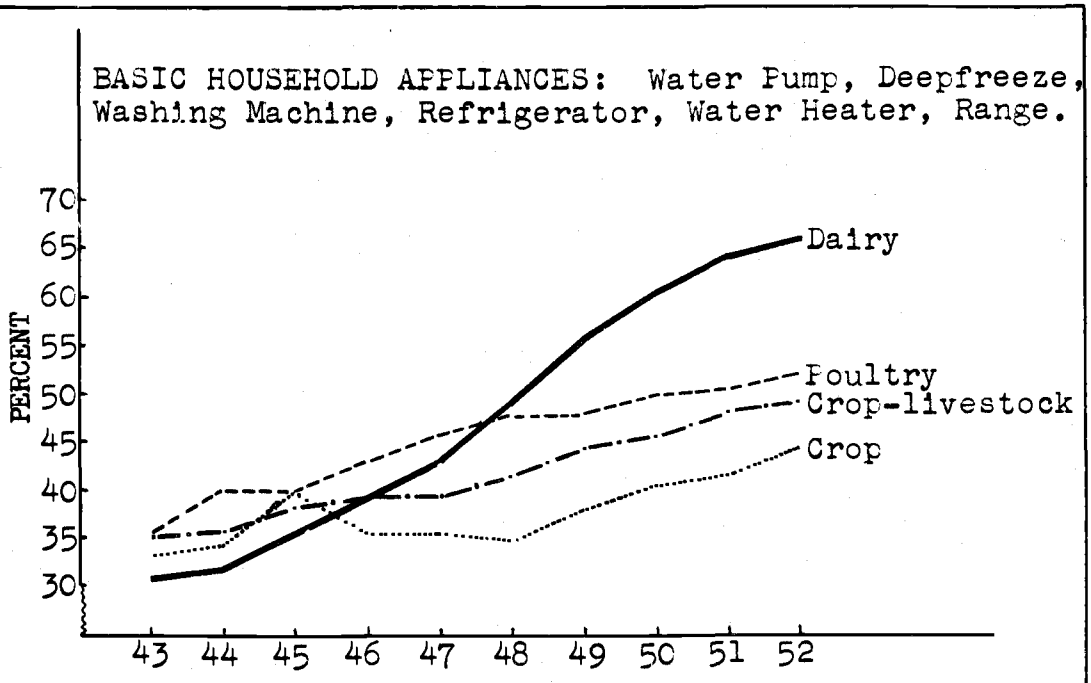


FIGURE 4. YEARLY DENSITY OF BASIC HOUSEHOLD AND ALL PRODUCTION APPLIANCES FROM 1943-1952. BY TYPE OF FARM.

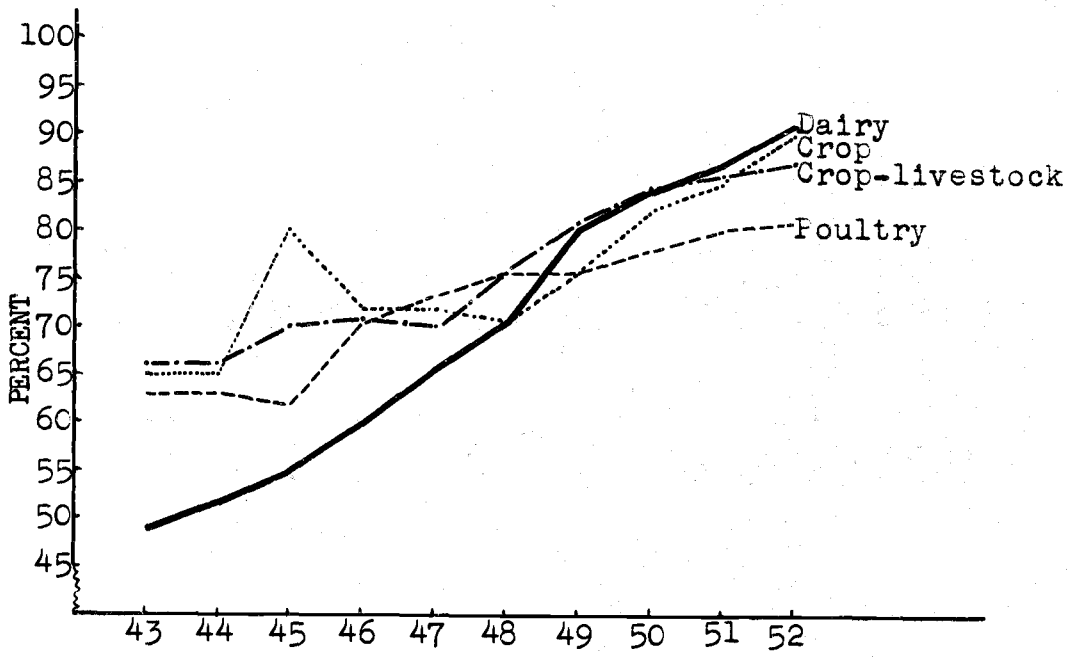


FIGURE 5. YEARLY DENSITY OF BASIC HOUSEHOLD APPLIANCES FROM 1943-1952. BY TYPE OF FARM.

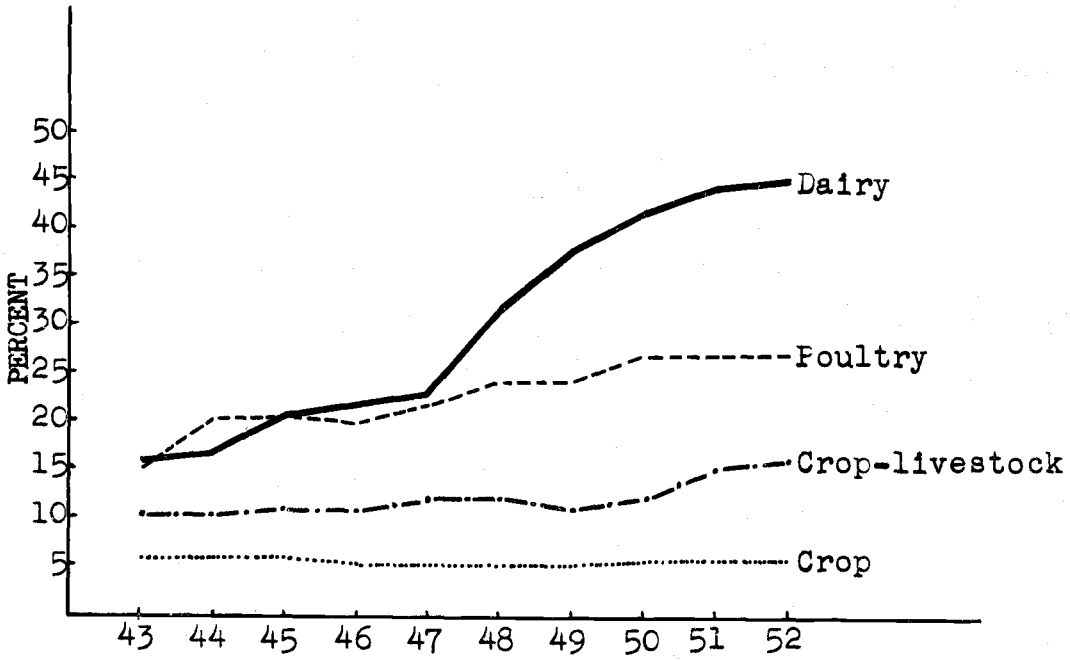


FIGURE 6. YEARLY DENSITY OF ALL PRODUCTION APPLIANCES FROM 1943-1952. BY TYPE OF FARM.

There is a general relationship between annual use of electricity and total number of appliances on the different types of farms.

Figures 4, 5, and 6 are presented to illustrate the nature of the appliance density within and between the types of farms. Several household appliances are classified as basic because of their high saturation on farms and because their function is essentially a necessity in any household. These appliances are: Refrigerator, range, washing machine, water heater, and water pump. The deep-freeze was added to these because of its rapid adoption and present popularity, although it probably cannot be regarded as a necessary appliance.

The relationship between types of farms in Figure 4 which indicates the percentage of all possible production appliances and basic consumer appliances found in the study is essentially the same as that presented in Figure 3 which is the density of all appliances. The percentage saturation is higher in Figure 4 because of the fewer consumer appliances included in the density figure. The density of basic consumer appliances in Figure 5 presents a very different relationship between the types of farms. It clearly indicates that although the crop farms use less electricity than the other types studied, it is not because they do not have these basic household appliances.

Production appliances enumerated were: Irrigation motors, other electric motors of one horsepower or more, welders, farm shop, dairy production equipment, poultry production equipment, and production water heaters. The annual density of these for the different types of farms is presented separately in Figure 6. Again, the alignment of the types of farms is similar to that noted in the graph of annual electricity use (Figure 2), and the graph of total appliance density (Figure 3). It becomes obvious when this graph is compared to the graph presenting density of basic consumer appliances, that the extreme difference in number of production appliances on the farms of the different types is very directly related to the extreme difference in annual use of electricity by these types of farms.

The difference in the comparative densities of production and household appliances on the farms is only part of the explanation of the difference in total use of electricity. The variation in intensity of use of the different appliances is the other part of the explanation. This factor is extremely difficult to measure as most farms have but one meter which measures the total kilowatt hours of electricity used on the farm. Therefore, a process of estimation was necessarily used to facilitate a separation of total electricity used for the household and for production purposes. The individual farm records of the study contain

the date that major appliances were added to the farm. They also include the number of persons living on the farm each year, number and type of livestock, number of buildings and dates new buildings were wired for electricity, and changes in the types of crops raised on the farm. These intensity factors were used in conjunction with the Bonneville Power Administration Load Estimating Manual to estimate the total electricity used each year by each farm for consumption and for production. The result of this analysis is presented in Figures 7, 8, 9, and 10.

The alignment of the types of farms in these graphs is very similar to that noted in previous graphs related to appliance density and annual use of electricity. Poultry farms had fewer household appliances than the other types. They use less electricity in the household, but more for production than any of the other types. This is a necessary residual as they used the most total electricity. Dairy farms have the highest density of household appliances, and use the most electricity in the household. Dairy farms also have the highest density of production appliances, but seem to use less electricity for production than the poultry farms. This results from the different appliances and the intensity to which they are used. It is logical that variations of considerable magnitude are caused by production uses of electricity, as the power

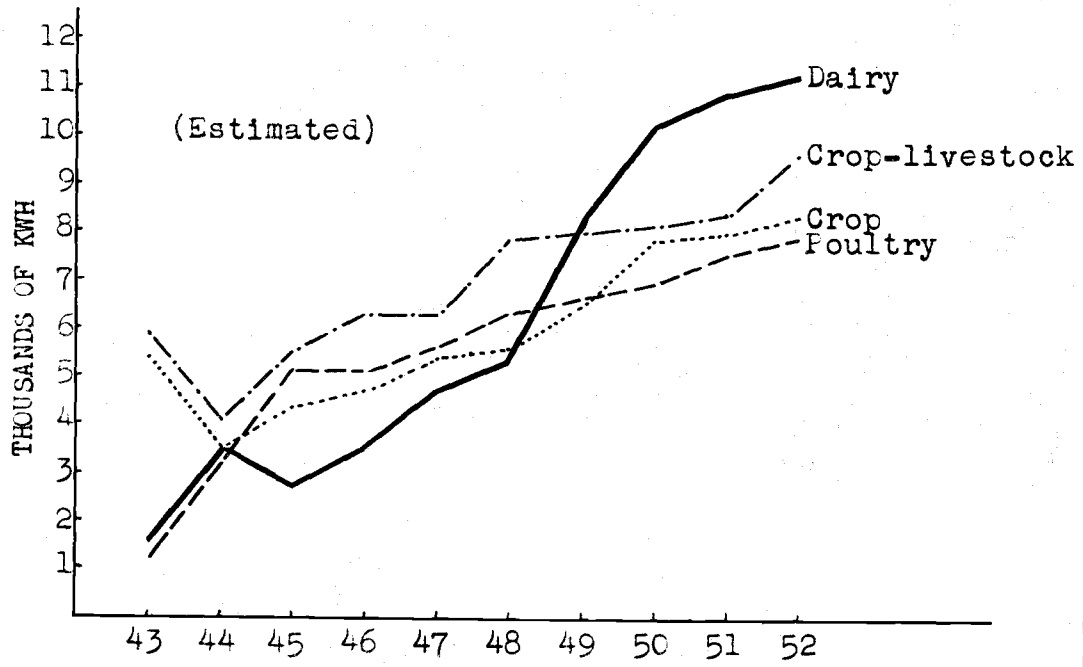


FIGURE 7. AVERAGE ANNUAL USE OF ELECTRICITY IN THE HOUSEHOLD FROM 1943-1952. BY TYPE OF FARM.

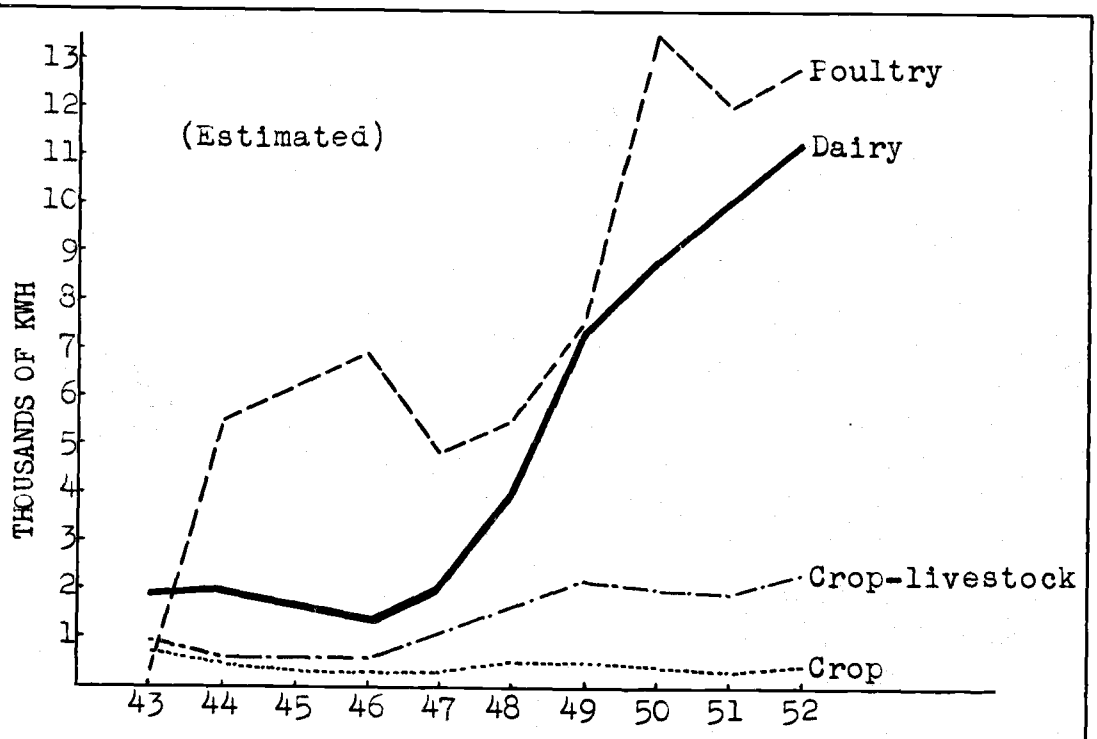


FIGURE 8. AVERAGE ANNUAL USE OF ELECTRICITY FOR PRODUCTION FROM 1943-1952. BY TYPE OF FARM.

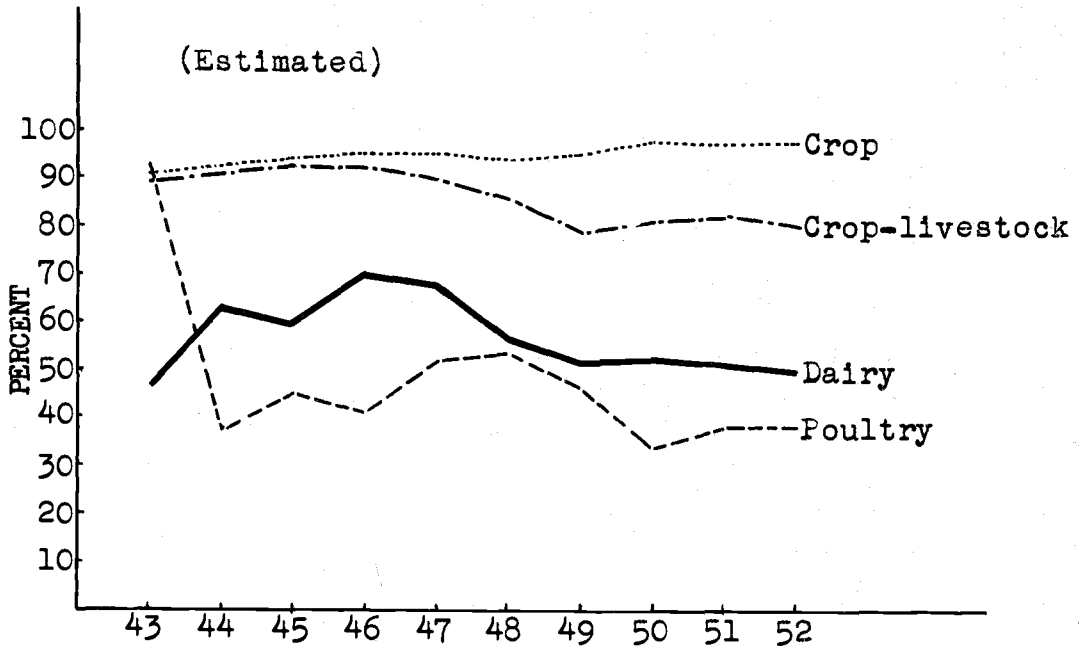


FIGURE 9. PERCENTAGE OF AVERAGE ANNUAL ELECTRICITY USED BY HOUSEHOLD FROM 1943-1952. BY TYPE OF FARM

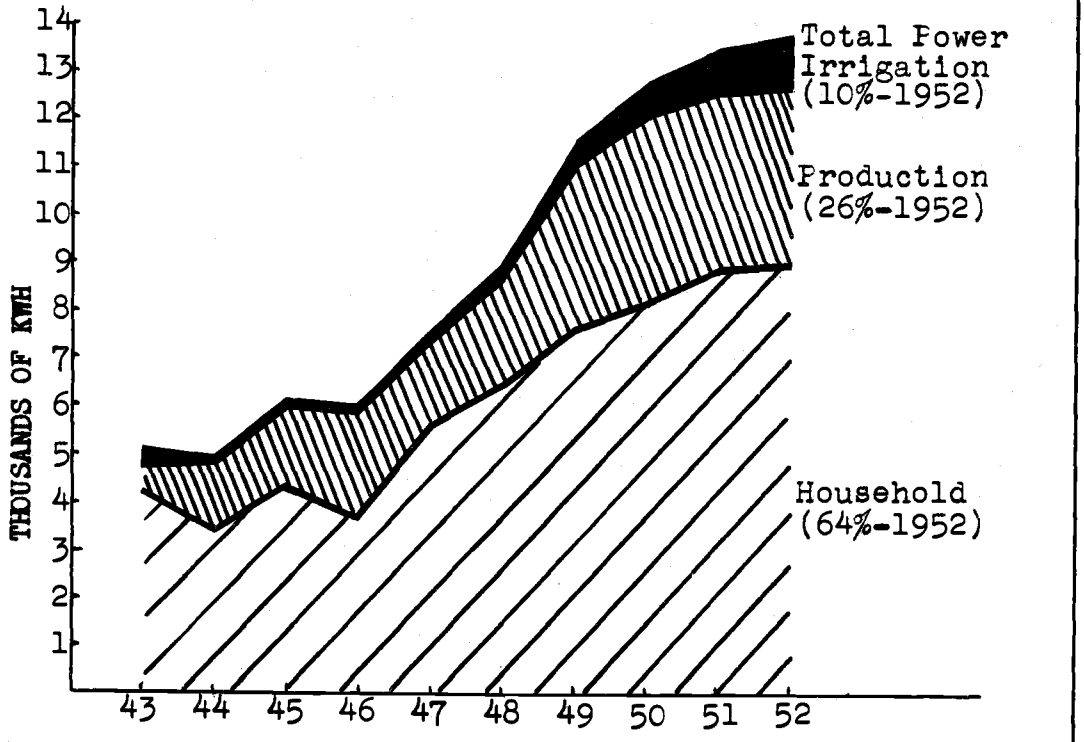


FIGURE 10. ESTIMATE OF FARM USE OF POWER, 1943-1952.

consumption by production appliances is essentially without limit. Figure 8 clearly shows that it is the production use of electricity that causes most of the variation among farms. Although it is not shown, a similar analysis within types of farms results in and supports the same conclusion.

There is an apparent inter-relationship indicated between production and household use of electricity on the dairy and the crop-livestock farms. This is partially explained by the non-existence of production water heaters on some of these farms and the common use of water pumps for the household and for livestock. There is possibly an income effect resulting from the presence of livestock which has some bearing on this relationship, but isolating and measuring this effect was not possible.

Figure 10 indicates the total electricity consumed in the different uses of power by the average farm for each year of the study. It presents a very important aspect of the power use and estimation problem. In 1943, households used 83% of the electricity on these farms, irrigation used 7%, and production uses accounted for the other 10%. In 1952, the households used only 64% of the total, irrigation used 10%, but production uses were consuming 26% of the total.

Conclusions of Farm Type Influence on Electricity Use

Type of farm, due to its relationship to farm practices which utilize electricity and because of its influence on income, is a source of considerable variation in electricity use on farms. If it were possible to isolate the sources of variation in this study, it is believed farm type would be the source of greatest variation in electricity use.

Production uses of electric power found in this sample were related to dairy enterprises, poultry enterprises, irrigation, and various miscellaneous uses. The presence of these enterprises determines farm type and affects farm income. The capital capacity of the farmer partially determines the existence of these enterprises on the farm. Separation of these factors is essentially impossible.

The data clearly indicate that production appliances and uses cause the extreme magnitudes of variation in electricity use on the sampled farms. The crop farms are the lowest users of electricity in this sample. They have a high saturation of household appliances, and a low saturation of production appliances. Both poultry and crop-livestock farms have a lower saturation of consumer appliances, but they use more total electricity than crop farms. Production appliances have a power-use potential which is

many times that of all household appliances with the exception of electric heat, and they cause the great difference between these types of farms.

This sample includes only four types of farms, and is useful for describing the characteristics of only these types. However, questions arise which invite speculation: Wouldn't it seem that farms of all types, with similar incomes tend to use comparable amounts of electricity in their households? Couldn't extreme variation in annual use of electric power be expected to arise because of production uses related to farm enterprises and practices as noted in this study?

Relationship of Income to Use of Electricity

The distribution of the 103 farms for whom questionnaires were completed is very asymmetrical with respect to income. As shown in Table 7, the proportion of farms in this sample with a calculated disposable income of less than two thousand dollars per year is small.

Table 7: Number of farms by income group from which information was obtained.

	No. completing questionnaire.				No. for which electricity history is complete			
Year	High	Medium	Low	Total	High	Medium	Low	Total
1943	21	30	14	65	7	5	1	13
1944	24	32	12	68	12	14	2	28
1945	26	34	10	70	13	20	3	36
1946	32	35	11	78	24	28	6	58
1947	37	37	7	81	28	34	4	66
1948	41	37	12	90	30	33	7	70
1949	47	40	10	97	37	37	10	84
1950	54	37	10	101	46	37	10	93
1951	53	44	6	103	48	45	6	99
1952	57	37	9	103	55	37	9	101

The concentration in the higher income groups was noted in doing the field work. An effort was made to find farms that would bolster the number in the lower income group. This effort was unsuccessful. Part of the explanation of this lies in the incidence of off-farm income. Only fifty of the one hundred three farms report the farm as the sole source of income. Due to the reluctance of many farmers to admit to other sources of income, this figure is probably too high if it is not correct. The magnitude of this off-farm income varies considerably, but in many cases it exceeds the farm income. In many cases, it is enough to place the particular farmer in the next higher income group. Table 8 indicates the extent of off-farm work as reported by type of farm.

Table 8: Number of farms by type reporting off-farm income.

Type of Farm	Total in sample	No. reporting off-farm income	Percent with off-farm income
Dairy	18	5	27.7
Poultry	16	7	43.7
Crop-livestock	37	20	54.05
Crop	32	21	65.6
Total	103	53	51.5

It is logical that the crop farmers report the highest percentage incidence of off-farm work, because characteristically they have farm operations that require the least labor. It is equally logical that the dairy farmers should report a relatively small percentage for the same general reason. Among all types of farms, those reporting off-farm income were found to be in all income brackets, and it is not just the lower income group that seeks additional income.

Figure 11 shows the relationship found between income groups of farms in the study and the annual use of electricity. The amounts shown for the low income group in 1943, 1944, and 1945 are based one one, two and three observations respectively and consequently are of no significance. An analysis of variance test was made to test the hypothesis that the mean annual use of electricity by the higher income group is equal to the mean annual use of the other groups combined. The two low groups were combined because

of the few observations in the lower group. The F-value resulting from this test is 6.27 with one and seventy-eight degrees of freedom. This is significant at the five percent level, but is not significant at the one percent level. Income is not an isolated variable in this test as variation due to farm type remains in the data. The analysis was limited to this test because of the unequal numbers of observations within the groups. The kilowatt hours per farm used for this test were the averages of the last two years, and only those farms who were in the same income group for both years were included in the test.

Figures 12, 13, 14, and 15 are a refinement of the all farm graph to show relationship between income and use of electricity for each of the four types of farms sampled. Similarly as the relationship of farm type to electricity use was shown, Tables 9 and 10 list the number of appliances found on the farms within each income group. This density is shown graphically in Figures 16 and 17. A rather constant relationship is noted in all of these graphs and tables which clearly indicate that the higher income groups own more appliances and use more electricity than the lower income groups. The higher income groups are the first to adopt the innovations, and the lower income groups are the last to adopt them.

The actual density of appliances is not the total

picture of income effect on electricity use. During the period covered by this study many appliances were added or replaced on the farms, and this information was obtained. Table 11 shows the nature of this total addition from 1944 to 1952. Of the 479 appliances purchased, 435 were new and 44 were replacements. Quite often the replacement appliances were larger appliances than were previously in use, and this may have an influence on the increase in use of electricity. The result of these additions is that almost five major appliances were added per farm over the time studied. For all the years included in Table 11, forty-six point nine percent of the farms were in the high income group. They added forty-seven point six percent of the new appliances. Forty-two point one percent of all farms were in the medium income group, and they added forty-four point four percent of the new appliances. Eleven percent of the farms were in the low income group, and they added eight percent of the new appliances.

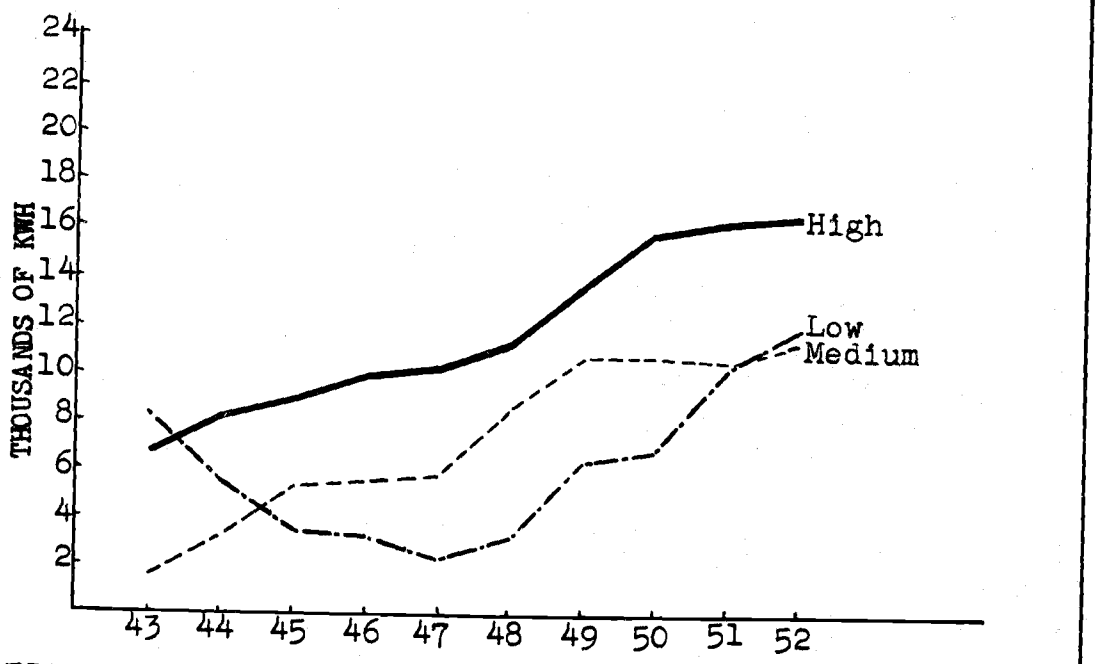


FIGURE 11. AVERAGE ANNUAL USE OF ELECTRICITY OF ALL FARMS FROM 1943-1952. BY INCOME GROUP.

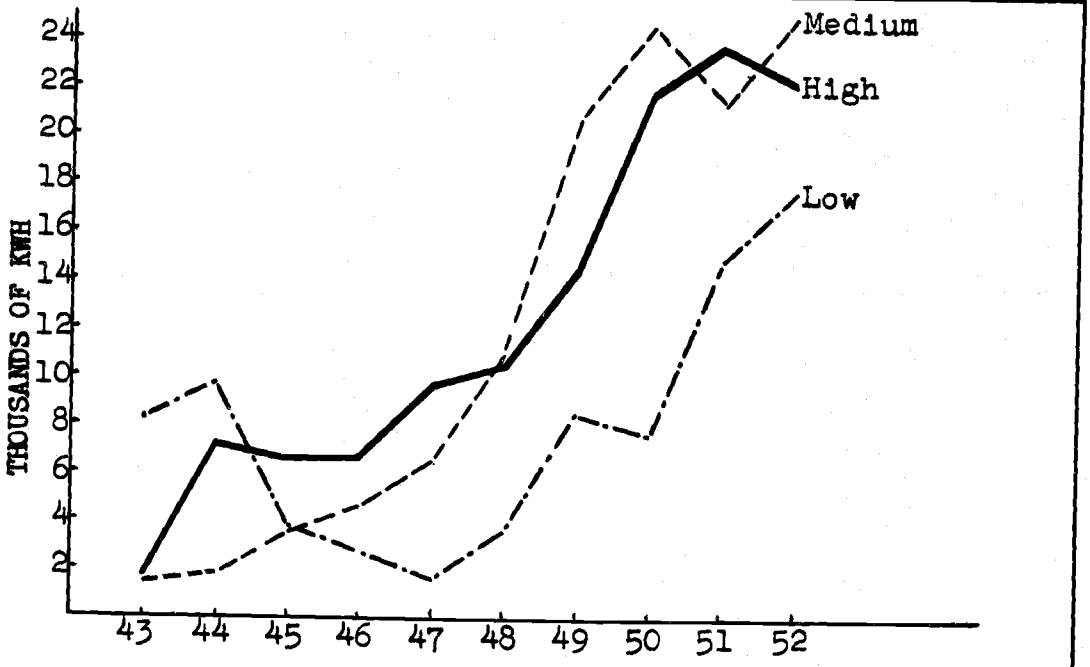


FIGURE 12. AVERAGE ANNUAL USE OF ELECTRICITY OF DAIRY FARMS FROM 1943-1952. BY INCOME GROUP.

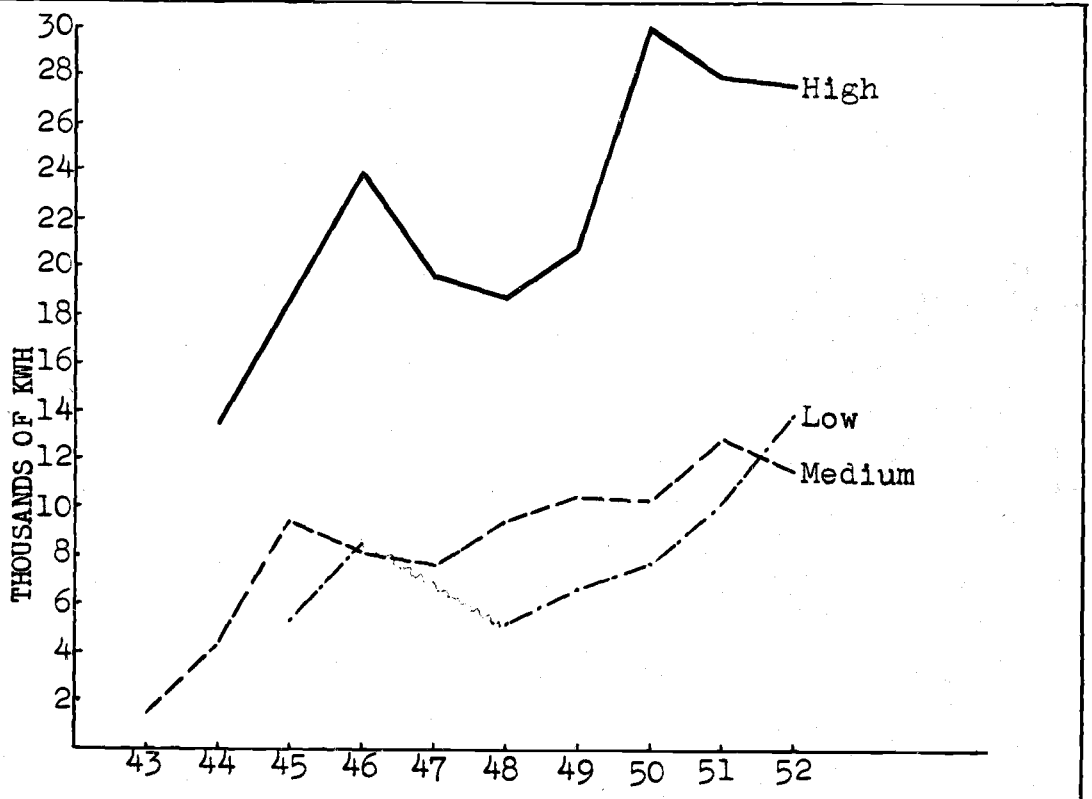


FIGURE 13. AVERAGE ANNUAL USE OF ELECTRICITY BY POULTRY FARMS, 1943-1952. BY INCOME GROUP.

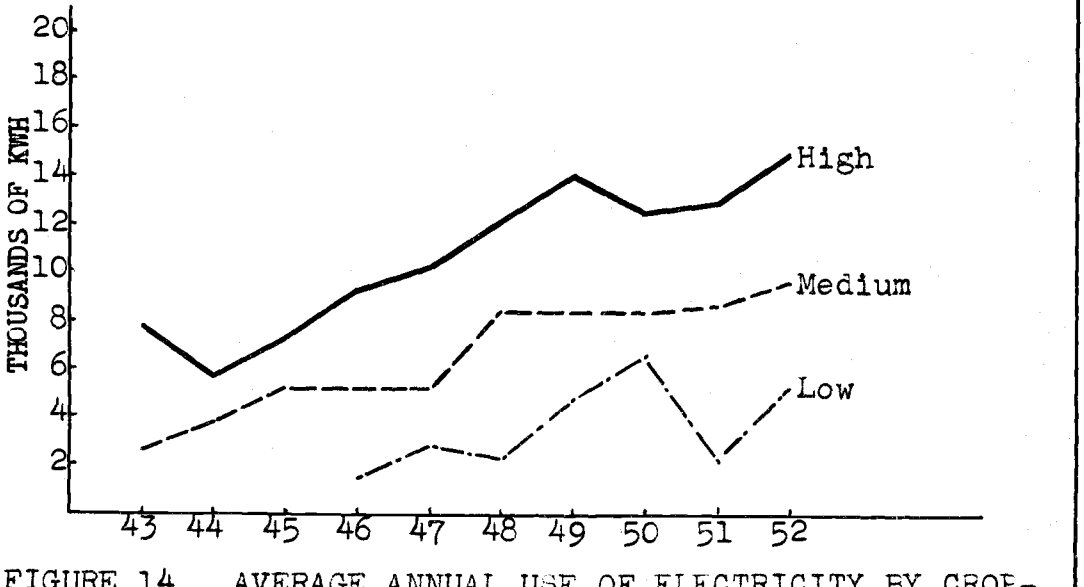


FIGURE 14. AVERAGE ANNUAL USE OF ELECTRICITY BY CROP-LIVESTOCK FARMS, 1943-1952. BY INCOME GROUP.

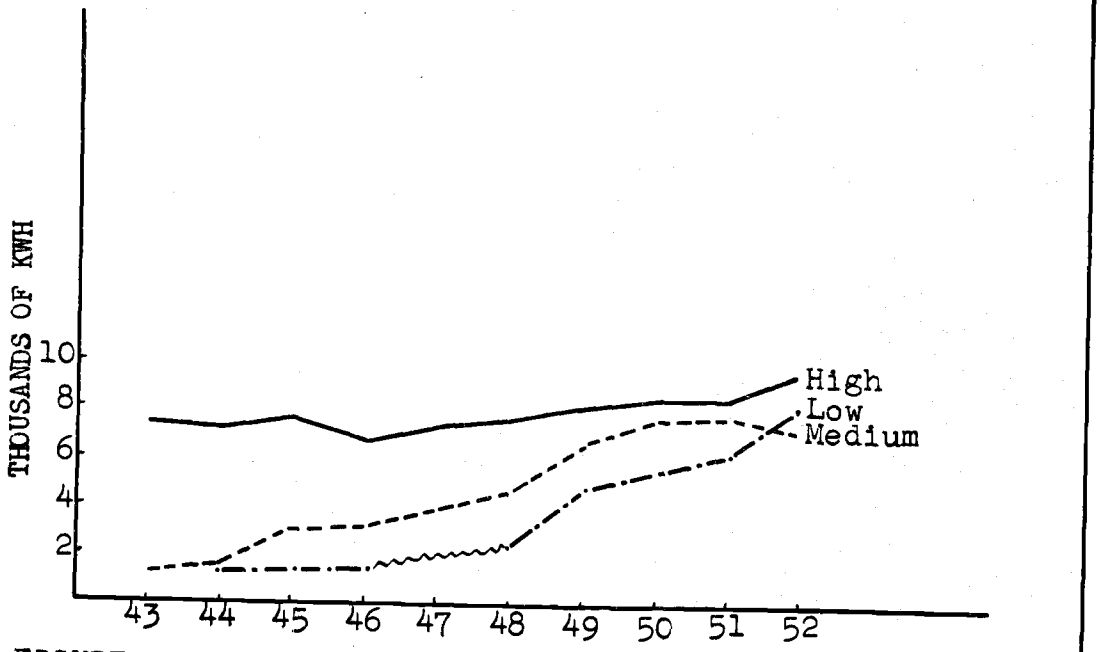


FIGURE 15. AVERAGE ANNUAL USE OF ELECTRICITY FOR CROP FARMS, 1943-1952. BY INCOME GROUP.

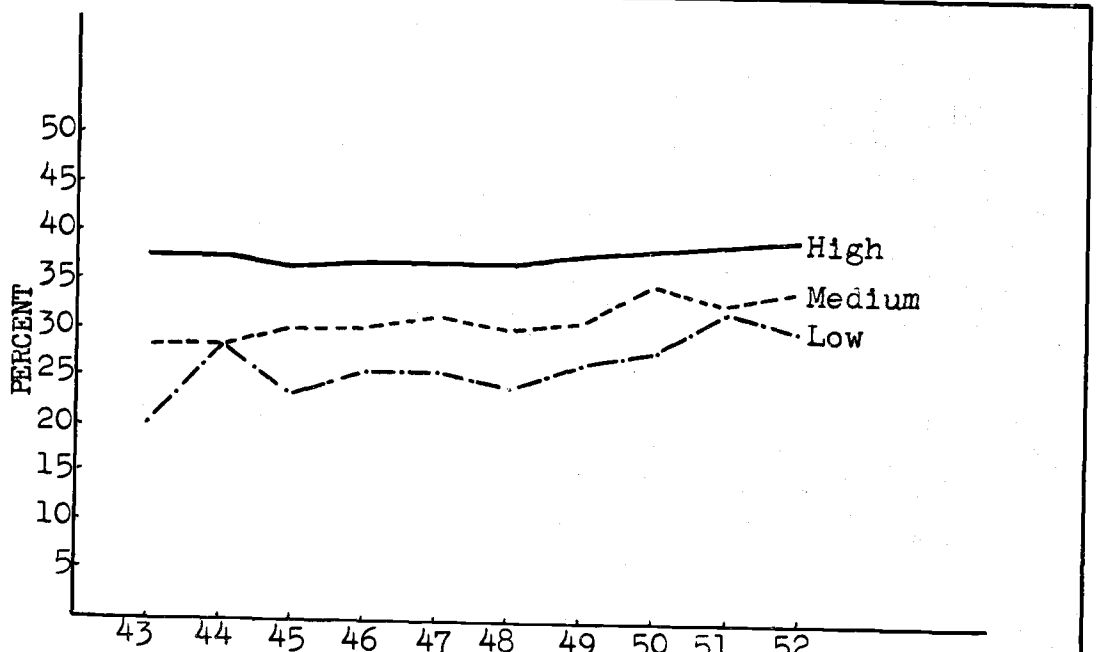


FIGURE 16. YEARLY DENSITY OF ALL APPLIANCES ENUMERATED FOR ALL FARMS, 1943-1952. BY INCOME GROUP.

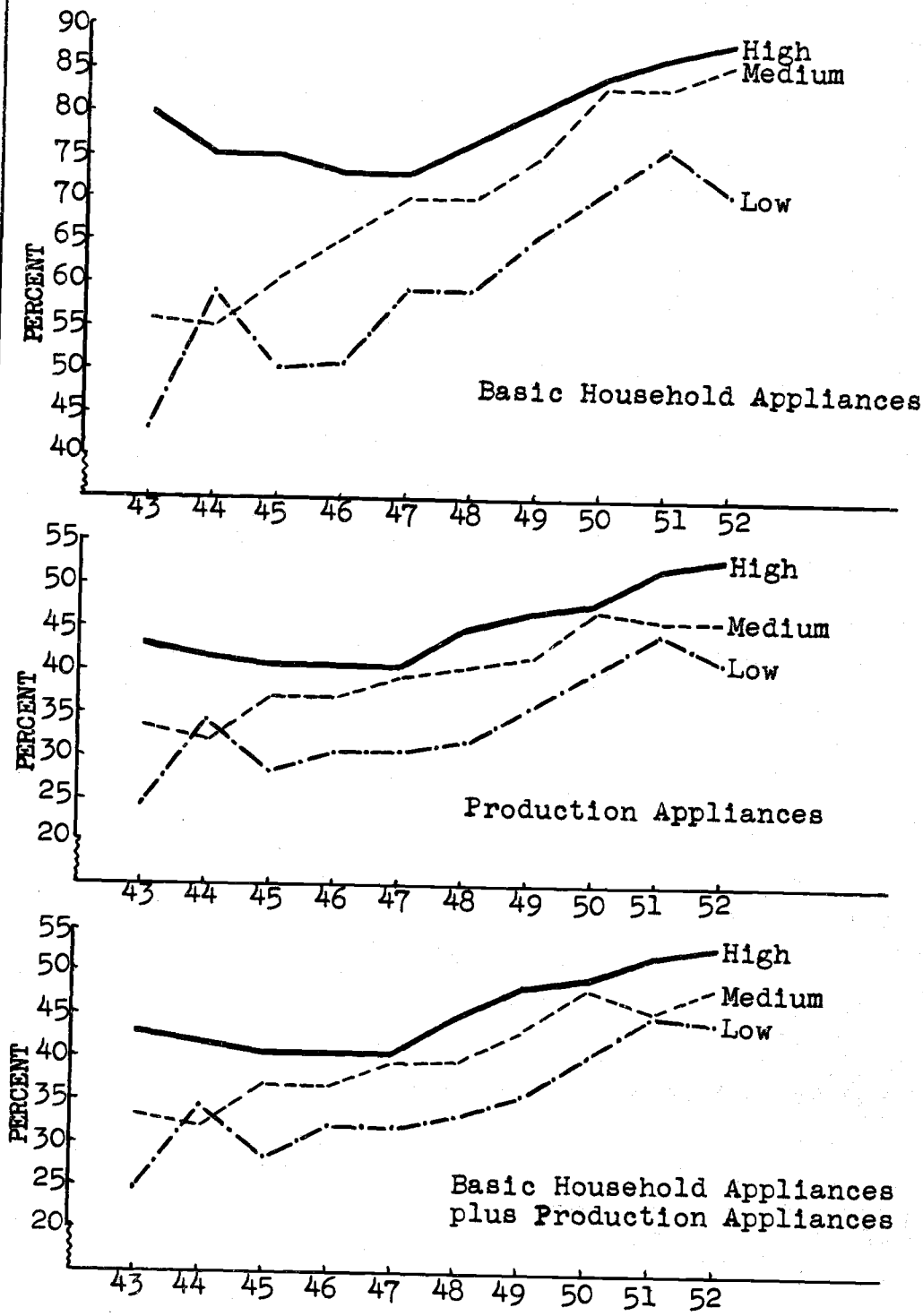


FIGURE 17. YEARLY DENSITY OF BASIC HOUSEHOLD APPLIANCES AND PRODUCTION APPLIANCES FROM 1943-1952. BY INCOME GROUP.

Table 9: Consumer appliances enumerated by income group. 1943-1952.

Income Group	Number of Farms	Refrig.	Range	Deep Freeze	Water Heater	Space Heat	Wash. Mach.	Auto. Wash.	Cloth. Dryer	Dish Wash.	Roaster	T.V.	Water Pump
High	21	20	18	2	17	1	20	1	-	-	-	-	23
Medium	30	25	10	-	13	-	29	-	-	-	2	-	25
Low	14	9	4	-	1	-	10	-	-	-	-	-	12
1943 Total	65	54	32	2	31	1	59	1	0	0	2	0	60
High	24	22	22	2	17	1	23	1	-	-	-	-	21
Medium	32	25	12	-	12	-	29	-	-	-	2	-	28
Low	12	10	4	1	2	-	11	-	-	-	-	-	12
1944 Total	68	57	38	3	31	1	63	1	0	0	2	0	61
High	26	24	22	2	21	1	22	3	-	-	1	-	23
Medium	34	30	16	1	15	-	30	2	-	-	2	-	32
Low	10	7	3	1	1	-	9	-	-	-	-	-	9
1945 Total	70	61	41	4	37	1	61	5	0	0	3	0	64
High	32	30	28	3	27	1	25	3	-	-	1	-	29
Medium	35	31	18	3	19	1	32	2	-	-	2	-	34
Low	11	8	3	-	3	-	10	-	-	-	-	-	10
1946 Total	78	69	49	6	49	2	67	5	0	0	3	0	73
High	37	35	30	7	29	2	27	5	-	-	1	-	33
Medium	37	33	23	4	23	1	33	3	-	-	2	-	36
Low	7	6	2	-	4	-	7	-	-	-	-	-	6
1947 Total	81	74	55	11	56	3	67	8	0	0	3	0	75
High	41	40	36	12	33	3	29	8	1	2	2	-	37
Medium	37	33	24	6	26	1	28	5	1	-	2	-	36
Low	12	9	3	-	7	-	13	-	-	-	-	-	11
1948 Total	90	82	63	18	66	4	70	13	2	2	4	0	84
High	47	47	40	19	38	4	33	10	3	2	2	0	43
Medium	40	36	30	7	33	2	32	8	1	-	2	-	40
Low	10	9	5	-	6	1	10	-	-	-	-	-	10
1949 Total	97	92	75	26	76	7	75	18	4	2	4	0	93
High	54	52	48	23	50	7	31	19	6	3	2	-	50
Medium	37	37	31	10	34	3	30	7	3	-	1	-	37
Low	10	10	6	-	7	-	10	-	-	-	-	-	10
1950 Total	101	99	85	33	91	10	71	26	9	3	3	0	97
High	53	53	50	24	51	8	28	23	9	5	2	1	49
Medium	44	43	36	15	40	2	33	11	5	-	1	-	44
Low	6	6	5	-	5	-	6	-	1	-	-	-	6
1951 Total	103	102	91	39	96	10	67	34	15	5	3	1	99
High	57	57	57	29	58	10	25	32	14	6	3	5	56
Medium	37	37	29	17	33	1	29	8	8	-	-	2	35
Low	9	8	6	2	6	-	6	-	1	-	-	-	8
1952 Total	103	102	92	48	97	11	60	40	23	6	3	7	99

Table 10: Production appliances enumerated by income group. 1943-1952.

Income Group	No. of Farms	Motors	Irriga-tion	Farm Shop	Welder	Dairy Equip.	Prod. Wtr.Htr.	Poultry Equip.
High	21	4	2	1	1	7	1	2
Medium	30	5	2	1	-	8	2	10
Low	14	-	2	-	-	4	1	2
1943 Total	65	9	6	2	1	19	4	14
High	24	8	2	2	1	8	2	3
Medium	32	3	4	1	1	7	1	14
Low	12	1	2	-	1	4	1	2
1944 Total	68	12	8	3	3	19	4	19
High	26	7	2	1	1	7	1	3
Medium	34	5	4	2	2	11	3	13
Low	10	-	2	-	-	2	1	2
1945 Total	70	12	8	3	3	20	5	18
High	32	8	3	2	3	10	2	4
Medium	35	3	3	2	2	12	1	10
Low	11	1	2	-	-	4	2	4
1946 Total	78	12	8	4	5	26	5	18
High	37	7	3	2	4	11	4	5
Medium	37	4	5	2	2	12	4	13
Low	7	-	-	-	-	3	-	1
1947 Total	81	11	8	4	6	26	8	19
High	41	8	6	4	5	14	8	7
Medium	37	3	5	2	3	11	4	12
Low	12	2	-	-	-	5	-	2
1948 Total	90	13	11	6	8	30	12	21
High	47	9	8	6	6	14	8	9
Medium	40	3	6	1	4	12	5	12
Low	10	1	-	-	1	3	1	2
1949 Total	97	13	14	7	11	29	14	23
High	54	12	8	8	9	15	9	11
Medium	37	2	7	-	4	13	4	15
Low	10	1	1	-	-	4	1	2
1950 Total	101	15	16	8	13	32	14	28
High	53	10	11	7	10	20	10	16
Medium	44	4	7	1	5	12	4	12
Low	6	1	1	-	-	4	-	2
1951 Total	103	15	19	8	15	36	14	30
High	57	12	15	7	11	24	12	16
Medium	37	3	6	1	4	9	2	11
Low	9	1	3	-	-	4	-	3
1952 Total	103	16	24	8	15	37	14	30

Table 11: Appliances added yearly by type of farm, and income group. 1944-1952.

Type of Farm	1944	1945	1946	1947	1948	1949	1950	1951	1952	Total	Cumulative Total
Poultry:											
High	-	1	-	6	-	-	10	12	1	30	
Medium	4	3	4	6	8	-	4	5	3	37	
Low	-	1	4	1	-	-	-	-	1	7	
Total	4	5	8	13	8	0	14	17	5	74	
Dairy:											
High	-	2	2	2	14	4	12	3	4	43	73
Medium	3	4	8	6	14	18	5	4	5	67	104
Low	1	-	2	1	-	1	1	11	3	20	27
Total	4	6	12	9	28	23	18	18	12	130	204
Crop:											
High	-	4	5	5	8	5	17	15	13	72	145
Medium	-	2	-	9	3	5	6	11	9	45	149
Low	-	-	-	-	-	1	-	1	-	2	29
Total	-	6	5	14	11	11	23	27	22	119	323
Crop-Livestock											
High	-	7	4	10	8	14	15	12	13	83	228
Medium	2	6	3	3	9	12	15	8	6	64	213
Low	3	-	-	-	2	2	2	-	-	9	38
Total	5	13	7	13	19	28	32	20	19	156	479
Yearly Total:	13	30	32	49	66	62	87	82	58	479	

The analysis of income effect on use of electricity has evolved around the placement of the farms into income groups based on a calculated disposable income. There are several important questions unanswered by the location of an individual in an income group. These questions have considerable bearing on how a given disposable income is spent.

Annual income does not depict net worth or the extent of credit demands on the income. Certainly a farmer who is not in debt could spend a given disposable income differently than one who is heavily indebted. Past incomes, future expectations, a person's "level of aspiration" as Katona phrases it (7, pp.91-93), his personal values, his desire for accumulation of liquid assets, his cultural background, and many other factors will influence the effect of income on expenditures. Stigler points out that people may not necessarily live within their incomes, but that they do live within their average incomes (12, p.50). This is undoubtedly true for aggregate expenditures, but is not necessarily an applicable concept as related to a part of their expenditures. The income effect in this study can be expected to exert its greatest infuence on the purchase of major appliances, and these are probably a minor portion of total expenditure from most given incomes. Even if this study were to use average income of all

cooperators, only a limited correlation could be expected between this and the use of electricity.

It became apparent during the field work of this study that the alternative of purchasing used appliances introduced further confounding variation into this question. Farmers will not readily admit purchase of used or second-hand household appliances, but several additions were noted which were obviously not new. Thus the initial cost of many appliances can be quite high or quite low depending on the buyer's tastes and desires. Where electricity rates are low and alternative sources of power are absent, it is not surprising to find low income farmers in possession of appliances that have been in popular use for many years. Also, it is not always the low income farmer that buys the used appliances.

The data indicate that higher income farmers own more appliances than lower income farmers, and that they buy the innovations first. Therefore, they also show a faster rate of growth in electricity use. This logically leads to the hypothesis that higher levels of income for all farmers would lead to a faster rate of growth in their use of electricity. Although measurement of this phenomenon has not been accomplished in this study, it certainly must explain much of the change noted in the ten year period studied. The higher income farms appeared to

own larger and better appliances on the average. For example, larger deepfreezes, larger water heaters, double-oven ranges, and fancier automatic appliances. This factor cannot be directly associated with greater power use. Engineers are reluctant to conclude whether the relative inefficiency of some older appliances might not result in greater power use than some of the newer and bigger replacements.

A characteristic of consumers that Katona describes and which seems evident in this study, is that people who own the new appliances and innovations are more apt to buy more appliances than those who own relatively few or old appliances (7, p.106). This presents an effect that can almost be described as cumulative and which might well reduce the effect of income on the possession of appliances. It infers that once consumers become appliance or gadget conscious, this consciousness becomes an impelling or generating force in itself which accelerates the purchase of appliances in the future. This also results in a greatly increased rate of adaptation for innovations, and an accelerated rate of growth in electricity use. The phenomenal growth of the television industry in the last few years is an example of this characteristic.

The limiting significance of income in face of this accelerated willingness to buy becomes very obvious,

especially when credit is lightly restricted or not restricted at all. If this is coupled with a generally rising income level, rapid growth should be expected.

It is certain that level of income is an important factor to consider in making estimations of future power requirements. This study has embraced a period marked by increasing levels of income, but there are other possibilities that need consideration. What if the level were to stay the same or decline? Would the use of power and the adaptation of innovations continue to expand? Would the rate of change be slower than that induced by higher income levels? Although the overall level of income in this study was rising, there were several farmers in the sample whose incomes did not change or that decreased in the time covered. With one exception, their electricity use increased, and this farm showed a steady annual decrease in power consumption. During the period covered by the study, however, the size of this family decreased from seven to two persons, and this could well account for the decrease in use of electricity.

Household use of electricity seems to be a rather fixed amount which would not be quickly affected by change in income. However, a lower level of income, and a pessimistic outlook for the future would undoubtedly curtail the rate of increase in power used in the household over

time. Over quite a broad range of prices and conditions, the demand for electric power for household purposes, and the income elasticity of demand for power, seem to be inelastic. Production uses of power are an entirely different question and their response to changing income levels is not readily estimated. If farmers faced decreasing price levels, and if off-farm work were not readily available, use of power in production could decrease as it might be possible to substitute labor for electric power economically. It is possible, however, that farmers would tend to enter into more intensive types of production to more fully utilize the available labor on the farm. In so doing they could adopt such enterprises as poultry or dairy which could readily account for an increase in use of power. There are other enterprises and practices which might evolve from a similar situation that could produce an increase in production power use. Some farmers try to increase their total volume of production in times of low prices to maintain a relatively stable gross income. When expansion of existing enterprises seems undesirable, dairy and poultry enterprises have frequently been substituted. It is understood that at the present time an unusual number of Willamette Valley farmers are making inquiry about these enterprises at Oregon State College. The field questionnaire related to farm organization which was

accomplished in conjunction with this study brought out statements from farmers which substantiate this point.

Relationship of Farm Size to Use of Electricity

There is possibly no concept in Agricultural Economics which is as evasive as the definition of farm size. Because of this lack of specific definition and measurement, it is customary to speak of size in terms of the extensity of the three measureable factors of production, land, labor, and capital. As yet, management has not lent itself to specific measurement, but is evaluated in terms of the efficiency of the other factors. In this study, the farm size was determined in acres of land. The poultry farms were an exception to this classification. Table 12 contains the summary data of kilowatt hour use per farm by acre size groups. The poultry farms are excluded from this table.

Table 12: Electricity use of farms by acreage groups.

Size	Average KWH per farm	Range
Small: (40-100 Acres)	15,236	1,600-50,800
Medium: (140-180 Acres)	12,550	500-40,100
Large: (220-260 Acres)	10,350	2,100-23,200

The inverse nature of the relationship between acreage and electricity use is obvious. The kilowatt hour usage in Table 12 includes variation due to type of farm, farm income, and other factors. This measurement of farm size leaves much to be desired in terms of explaining electricity use, but the inverse relationship is a useful fact to consider. The smaller acreage farms are forced to intensive production to attain an economic unit, and the availability of power is a determining factor in this type of organization. The small farms in this sample are largely dairy farms which have been noted as comparatively heavy users of electricity.

The total value of capital invested in a firm is another estimate of size usable in comparing farms. In this study an estimate was made of current market value of land, buildings and equipment on all but the poultry farms. A correlation between this estimated value and the average of the last two year's kilowatt hour usage on the farms results in a coefficient of correlation of .22, and an r-square value of .044.

The productive man work unit is a universally employed method of comparing the extent of labor required to operate farms. Table 13 shows the relationship between this measure, and the annual use of electric power found in this study. It should be noted that 57% of all farms

have less than three hundred productive man work units, which is normally considered an economic unit, or a full years work for one man. All of the crop farms are below this standard, 65% of the crop-livestock farms, 12% of the poultry farms, and 16% of the dairy farms. This helps to explain the high incidence of off-farm work found in this study. The farms with the higher labor requirement are generally larger users of electric power. Electric power substitutes for labor through many devices on these farms. On many of the crop and crop-livestock farms, the labor requirement is not existent on the farm for which electric power can be substituted.

Table 13: Productive Man Work Units per farm related to annual kilowatt hour use of electricity.

Type of Farm	Number of Productive Man Work Units				
	0-150	151-299	300-450	451-599	600-
Poultry					
Number	1	1	5	2	7
KWH	13,744	1240	12,568	44,572	22,892
Dairy					
Number		3	4	6	5
KWH	none	15,750	11,760	27,696	30,729
Crop-livestock					
Number	4	18	5	5	2
KWH	8981	9509	13,677	18,103	23,277
Crop					
Number	18	10			
KWH	7861	9219	none	none	none
Total Number	23	32	14	13	14

Conclusions Regarding Influence of Size on Electricity Use

Two size relationships seem quite positive: First, the inverse relationship between number of acres and electricity used and second, the direct relationship between the extent of labor required to operate a farm and use of electricity. These relationships are peculiarly interrelated. The small farms are forced to intensive types of production, and in this study, that was dairy and poultry farming. These enterprises require relatively large amounts of labor, and are the enterprises for which electrically powered, labor-saving devices have been introduced. If these devices are not used, then more labor is used, which increases the number of persons on a farm, and this intensity factor tends to increase electricity use.

The inverse relationship between acreage and kilowatt hours of power used in this study logically leads to a further question: Does this same relationship continue to exist on farms with less than forty acres of cropland? 65% of all farms reporting cropland harvested in the 1950 Census of Agriculture, in the counties included in this study, reported less than forty acres of cropland. A substantial percentage of these are the miscellaneous, unclassified, or part-time farms. Many are fruit, nut, berry, and vegetable farms, and other types not included

in this study (18,pp.231-436). Many are on soil types not included in this study. There is reason to believe that the household use of electricity on these farms, provided there is similar income, would be similar to that found on the farms in this study. The extent of production uses of power on them would vary with farm type as was found in this study.

In the Willamette Valley, which has so many types of farms, and combinations of farm enterprises, size of farm seems to be of minor importance as a single factor effecting use of electricity. Only as this size is related to farm type, and to farm practices, and income, does it exert an important influence on the use of electricity.

Seasonality of Electricity Use

Because of the influence of peak demands, or loads, placed on existing facilities for distribution of power, it is desirable to know whether the seasonal pattern of use changes. It was possible to make an anlysis of this characteristic from data available to this study.

The seasonal variation for the years 1946-1952 is pictured in Figure 18 for the all-farm average, and in Figures 19, 20, 21, and 22 for each of the types of farms sampled. The differences are extremely obvious. Electricity used for irrigation has been removed from these

averages. The farms that use power for production, other than irrigation, show a greater seasonal variation than those which use power for the household only.

The farms included in Figure 18 were selected to test the change in seasonality of electricity use. Fifty-four farms are included in this analysis. Of these fifty-four farms, 12 are poultry farms, 12 are dairy farms, 14 are crop farms, and 16 are crop-livestock farms. They are the farms for which seven years of complete data were available. They were divided into two random groups for an analysis of variance test of interaction. An F-value of 2.54 with 66 and 66 degrees of freedom resulted when the month by year mean square was divided by the month by year by groups mean square. This is significant at the one percent level.

The utilities companies use the ratio of the high month of each year to the low month of the year as the measure of seasonality. The ratios for the seven years of this fifty-four farm analysis are as follows: 1946, 1.46 to 1; 1947, 1.34 to 1; 1948, 1.43 to 1; 1949, 1.54 to 1; 1950, 1.66 to 1; 1951, 1.44 to 1; 1952, 1.60 to 1. The changes in these ratios seem to substantiate the findings of the statistical test.

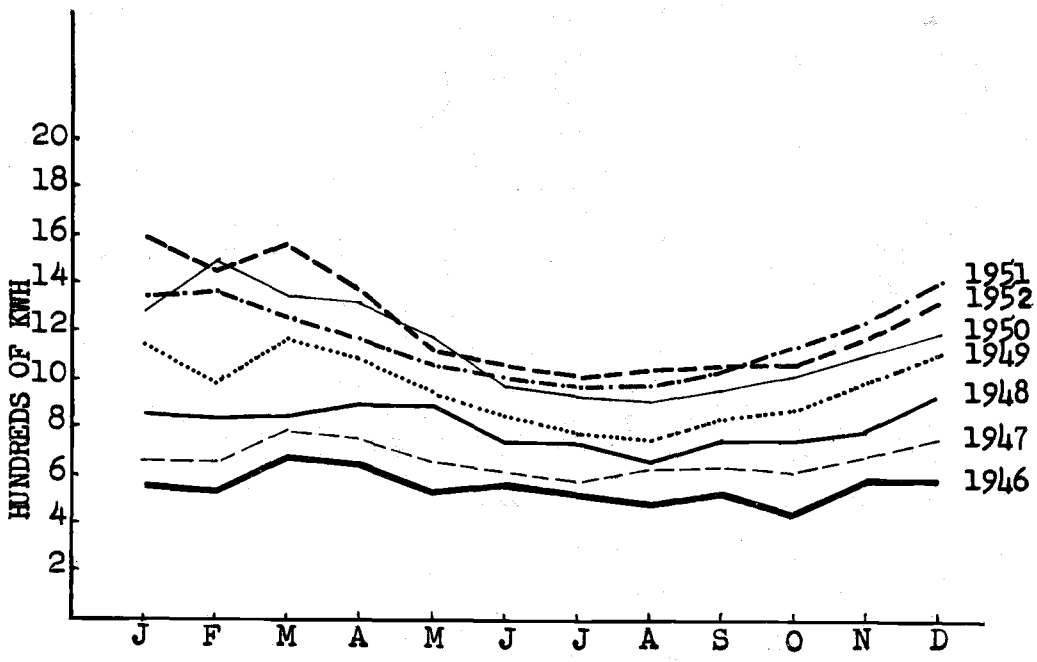


FIGURE 18. AVERAGE MONTHLY ELECTRICITY USE BY 54 FARMS FROM 1946-1952. (IRRIGATION EXCLUDED)

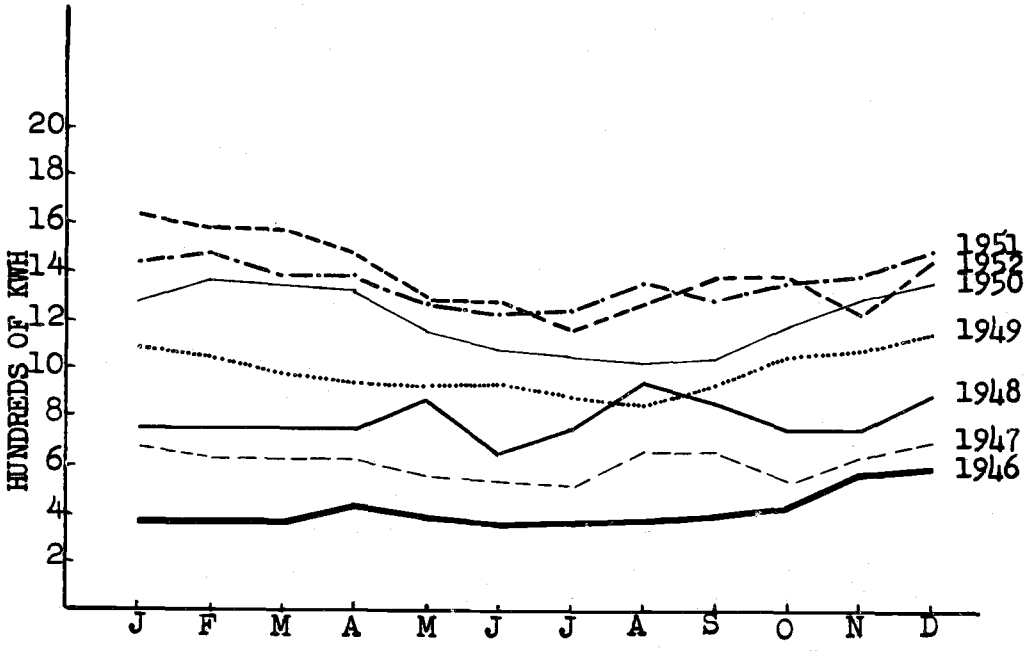


FIGURE 19. AVERAGE MONTHLY ELECTRICITY USE BY 12 DAIRY FARMS FROM 1946-1952. (IRRIGATION EXCLUDED)

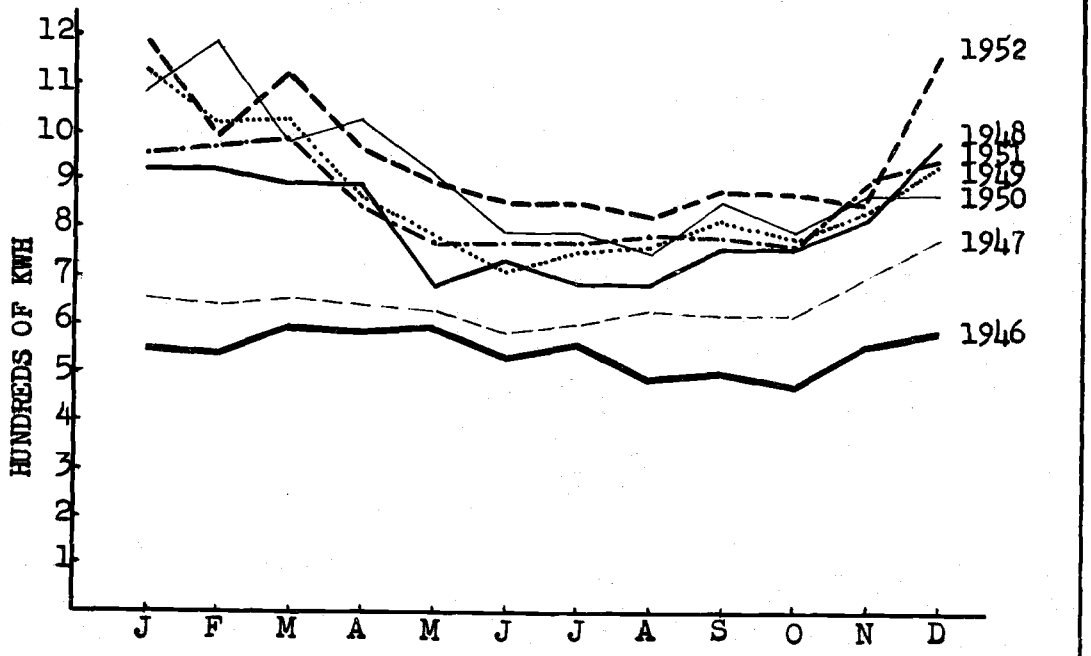


FIGURE 20. AVERAGE MONTHLY ELECTRICITY USE BY 16 CROP-LIVESTOCK FARMS FROM 1946-1952.

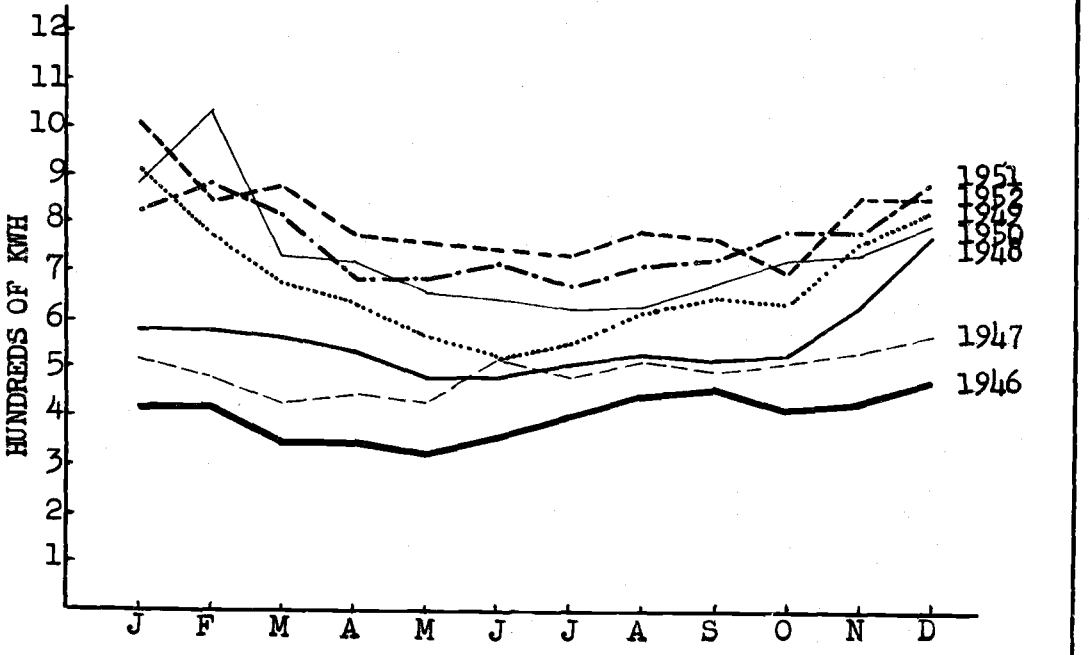


FIGURE 21. AVERAGE MONTHLY ELECTRICITY USE BY 14 CROP FARMS FROM 1946-1952.

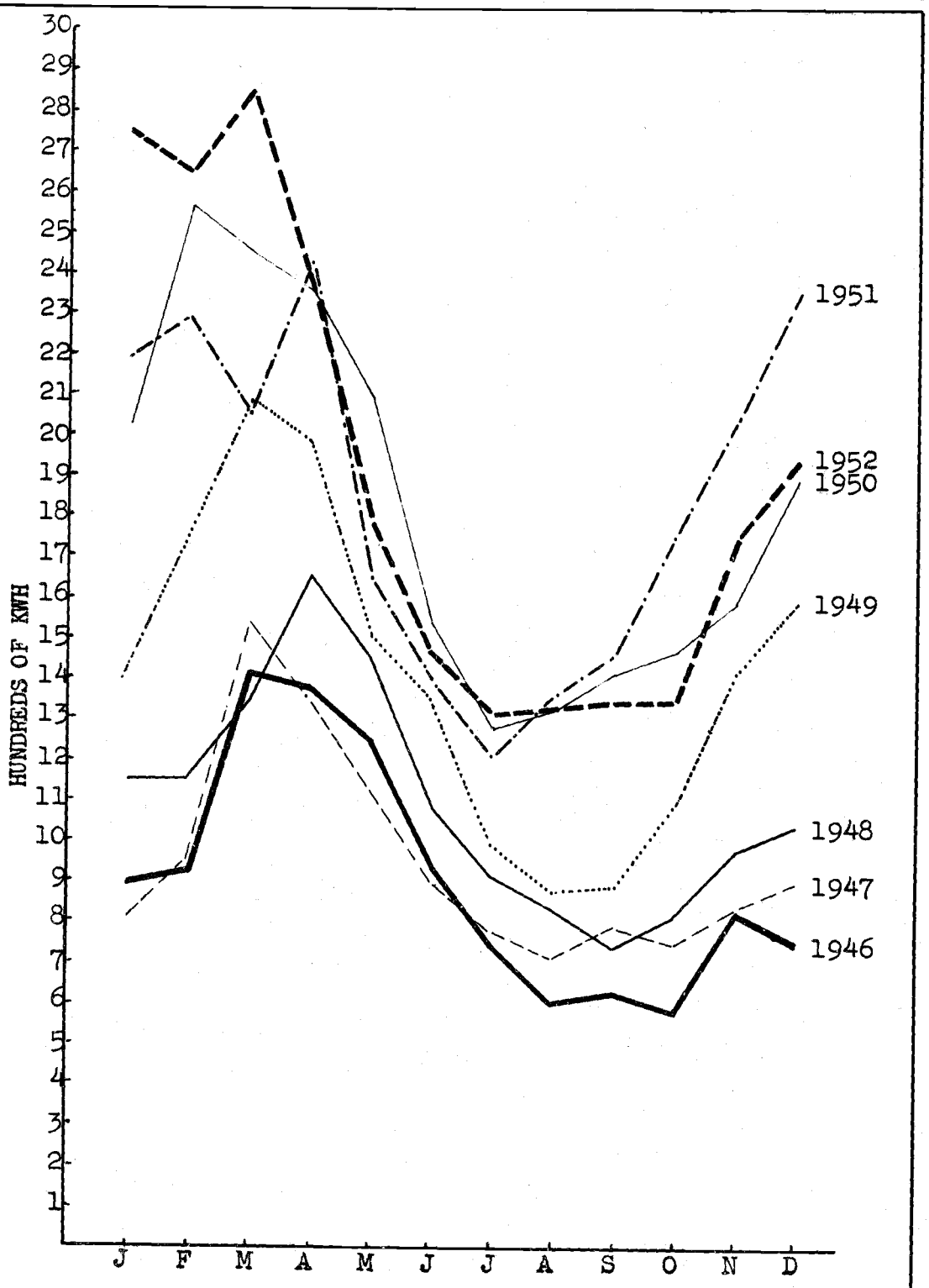


FIGURE 22. AVERAGE MONTHLY USE OF ELECTRICITY BY 12 POULTRY FARMS FROM 1946 to 1952.

Effect of Length of Time the Farm Has Been Connected to a Power Line on Electricity Use.

Essentially no meaningful analysis can be made from this sample regarding length of time a farm has been connected to a power line. However, it is desirable to point out why this is true.

Of the one hundred three farms in the sample, only five had been connected to a power line less than ten years. These five farms are located in the Camp Adair area which was returned, by the Federal Government, to agricultural production in 1948. They are the only farms in this study which are served by one of the five power distributors. Three are crop farms and average using 4320 kilowatt hours of power per year. Two are crop-livestock farms and average using 7236 kilowatt hours of power per year. The smallest user of the entire sample is one of the three crop farms in this group.

The comparatively low usage of these farms might seem to support the suspicion that newly connected farms would be lower users of electric power. This must be observed with caution. The lowest income farms of these five is the highest user of the five farms. The lowest user of the five is a medium income farm. Both of these farms are crop farms. Ten of the other ninety six farms in the study use less electricity than the average of

5486 kilowatt hours per year of these five farms, and they have all been connected over ten years. If the low user is eliminated from the five, the other four average 6716 kilowatt hours per year, and twenty-two of the other farms use less electricity than this amount. Therefore, because of the few observations, and the other sources of variation which need consideration, no statements can be made regarding this characteristic.

Cost of Electricity to the Consumer

Each of the power companies has several rates in effect as found in this study. The rates are quite similar, and all recognize the decreasing cost of increased demand (15, pp.383-406). Each of the rates is of the Block type (15, p.394), and the special rates used are either Wright Demand rates of Hopkinson Two-part rates (15, pp.395-399), so that all farmers are faced with similar methods of charging for electric service. The existence of several rates, and on some farms, as many as three different rates are in effect, makes analysis of this factor extremely difficult, especially since the difference between rates is slight.

Sixty-six of the farms are served by one utility company, twenty farms are served by another, nine farms by another, five farms by one of the companies, and only one

farm by the fifth distributor. Because of this uneven number, the cost data in Table 14 is presented in aggregate without any attempt to separate by distributors.

Table 14: Average annual cost of electricity per farm from 1943 to 1952.

Year	Average annual electricity cost per farm	Average cost per KWH
1943	$ 74.26	$ .0153
1944	64.83	.0166
1945	91.39	.0105
1946	100.13	.0139
1947	87.06	.0117
1948	101.34	.0111
1949	122.86	.0109
1950	138.63	.0107
1951	148.85	.0110
1952	156.98	.0111

Approximately sixty-four percent of the 1952 average cost, or $100.46 represents household electricity on the average farm, and is therefore a relatively fixed cost. It represents a considerable increase over the $63.73 which is eighty-three percent, the household portion, of the 1943 average cost in Table 14. This represents a substantial cost for the farmer which helps to reduce his flexibility. Several farmers in the group have annual electricity costs in excess of five hundred dollars, and although much of this is production power, and is somewhat variable, it cannot be regarded as a minor item on these farms.

Influence of Cost on Use of Electricity

Farmers in this sample have paid little, if any, attention to the cost of electricity. Gas and oil, the principle alternative sources of power, are expensive in this region. In this sample, only one farmer was served by piped gas, and only one had a gas water heater (Propane), or used gas for production, other than for irrigation. The average cost per kilowatt hour of electricity in this region was so low, even in 1943, compared to the 2.8 cent U.S. average of July, 1952 (17, p.3), that it is no wonder these farmers have not regarded their rates too seriously.

The only farmers who seem at all conscious of rates are those who either irrigate or heat with electricity. It is obvious that alternatives exist for both of these jobs. Electricity used for heating is relatively inefficient, and expensive, and the farmers know this. It is clean, safe, convenient, and entails apparently low maintenance and repair costs. The value of these considerations is immeasureable. Eleven farmers in this sample are now heating with electricity, and ten more plan to install electric heat in their homes.

Many farmers commented that electricity is the cheapest and most dependable labor they have on the farm. This power is fundamental to their present organization of farm

enterprises. Alternatives to electricity are either non-existent, unknown, or undesired. These farmers are not electricity cost conscious.

One hundred of one hundred three farmers indicated strong preferences for using electricity rather than other fuels, whenever possible. Also, initial cost of electric motors is lower than the cost of either gasoline or diesel engines of similar horsepower. These are important factors in determining what kind of power a farmer will use.

The cost of installing poles and lines for electric service at special locations on farms, especially for irrigation, is an important item. These costs are proportionate to the distance which must be covered by the installation. Eight of one hundred three farmers mentioned this as a cost which restricts their expansion of power use. Their estimates of this cost varied from $150.00 to $600.00. In some cases the cost can be spread over several years, but it is a relatively high fixed cost to accept. All of them plan to irrigate, and must have three-phase power to operate their pumps. Two of these farmers already own sprinkler systems, but are delaying irrigation because of this cost of installation.

Miscellaneous Factors Related to Electricity Use

Five questions were included on the questionnaire, which was completed on one hundred three farms. The questions and a summary of the replies are as follows:

1. Q. Would you add any new appliances if electricity rates were lowered? Which ones?

   A. 17 Yes, 86 No. Of the affirmative responses, ten would heat with electricity, and seven would add irrigation.

2. Q. Would you alter your use of electricity if rates were increased? How?

   A. 5 Yes, 98 No. Of the affirmative responses, four would reduce heating, and one would curtail irrigation. Many negative responses were, "How could I?"

3. Q. What would an increase in your income do to your electricity bill? Would you add any new appliances?

   A. Fifty-four would add appliances, and forty-nine would not add appliances.

4. Q. If the price of appliances decreased, by twenty percent, would you buy any new appliances?

   A. 23 Yes, 80 No. All of the affirmative answers came from low and medium income farmers.

5. Q. Do you have any preference for electricity for production uses, such as irrigation, grinding, poultry or similar farm jobs?

   A. 100 Yes, 3 No. All of the affirmative responders mentioned the convenience factor of electricity as compared to other types of power. Many mentioned the low maintenance and repair costs of electric motors, and the reliability of the motors. Of the negative

responders, one is served by a piped gas line, and has an alternative peculiar to him in this sample. The other two stated a preference for using diesel motors wherever possible.

In answering question numbers three and four, the co-operators indicated a desire to add appliances. Largely, the appliances are those desired which the question merely prompted mentioning. In many cases, the desire or intent to add the appliance had been previously mentioned, and was recalled in connection with this question. In relatively few cases was it felt that the question prompted the desire. In most cases the responses were such that they indicated real desire that had received considerable previous discussion in the families. This, of course, is opinion based on observation. Table 15 contains the summary of these answers. Thirty one farmers plan to add one appliance, and thirty-seven plan to add more than one appliance.

Table 15: Appliances farmers indicated a desire, or plan to add to their farms.

Appliance	Type of Farm D	P	C	C-L	Total Planned	Present Number	Potential New Density
Deepfreeze	5	5	7	11	28	48	76
Range	-	-	2	3	5	92	97
Water Htr.	-	-	1	1	2	97	99
Clothes Dryer	1	2	8	11	22	23	45
Television	4	2	2	7	15	7	22
Dishwasher	1	-	-	3	4	6	10
Auto-Wash. Machine	-	1	4	7	12	40	52
Electric Heat	-	-	7	3	10	11	21
Production Uses	5	1	7	9	22	144	166

Total new appliances planned or desired: 120

Innovations:

Several of the appliances enumerated were non-existent ten years ago, and are innovations in terms of this study. The rate at which these are adopted by farms has considerable influence on the annual KWH used by the farm, and any estimation of the future power requirements of farms must consider this factor.

Two farmers reported having deepfreezes in 1943. Both of these were converted milk coolers, and not commercially produced units. Deepfreezes did not become readily available until after 1945, and had not been produced commercially previous to the war. In 1952, there were 48

farmers of 103, who possessed a deepfreeze, and 28 more indicated a desire to add this appliance to their household. The Load Estimating Manual of Bonneville Power Administration allows from 1000-1500 KWH per year for a deepfreeze (19, p.21). This single appliance has accounted for tremendous increase in power use, and will account for more in the future.

Clothes dryers did not appear on the consumer market until 1948. In 1952, twenty-three farmers had the appliance, and twenty-eight indicated a desire to own one. Dishwashers also came on the market in 1948, but only six of the one hundred three farmers had one in 1952, and four indicated a desire to own one.

Television sets were not available in this area until 1951, but in 1952, seven of the farmers had a set, and fifteen said they planned to get one in the near future.

In the ten year period studied, the deepfreeze has become essentially a basic farm household necessity, similar to the range and the refrigerator. The clothes dryer seems destined to become almost as common; the climate of the area has a great deal to do with this. The dishwasher has not grown in popularity comparably, and there is much reason to believe that its adoption will not compare to deepfreezes and clothes dryers in the future. The dishwasher must overcome a barrier of custom, in addition to

being a desired labor-saver, so its adoption will be slower than the other types of appliances that perform unique service. Was the popularity of these appliances estimated accurately ten years ago? There is no record to check this question against, but it would seem probable that because of the high initial cost of them, that their popularity was underestimated.

The propensity for television noted in this survey is surprisingly low when one realizes the very rapid adoption of this appliance in other regions of the country. Many farmers had never seen television at the time of this study, and the quality of reception in this area has not been too satisfactory for those who have sets. It is suspected that once reception has been improved, and television's adoption gets started in these rural communities, that its growth will exceed the farmer's present expectations.

The Rate of Growth in Use of Electricity

Growth is a process of change, and in this study the growth is a question of change in kilowatt hour demand for electricity. Since 1943 is the initial year of the study, it cannot indicate any change, and there are nine years remaining in which this can be analyzed. The changing numbers of farms each year is a definite impediment to

analysis of this factor. It is necessary, however, to analyze the intensity and extensity factors in the year-to-year growth found in this study. Summarizing the change in total demand of the average farm each year makes this possible. This change is expressed as a percent of the previous year demand, and the average per farm is shown in Figures 23, 24, 25, 26, and 27. Only those farms are included each year for whom a complete previous year's electricity record is available. The stipulated allowances of the Load Estimating Manual are used to account for the changes due to addition of a new appliance (19, p.21).

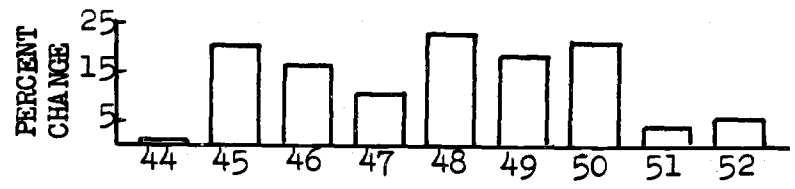
There were no years in which there was a net decrease in number of appliances, and there were no years in which there was a net decrease in demand for all farms. There are years of decrease for the individual farm types even though there were new appliances added during those years on those farms. The poultry farms show two years of net decrease in demand, and this is due to variation in intensity of use of given appliances. Each of the other types of farms shows one year of similar change.

The crop farms show an average change of 12.2% per year or 703 KWH per year. 39% of this is attributable to new uses, while 61% is due to variation in intensity of existing uses. These relationships are very similar in

the crop-livestock farms, except that the average change in kilowatt hours per year is almost double, or 1363 KWH per year per farm. The years of extreme change for these two types of farms are not comparable to the extreme years of the other two types of farms.

Poultry farms show an average change of 20.3% per year, or 1871 KWH per farm, and the dairy farms show an average change of 16.9% per year, or 1561 KWH per farm. In both of these, over half of the change seems to be due to variation in intensity of uses. It is logical that as more productive power is consumed, the potential variation in number of kilowatt hours would increase, but it is not obviously logical that the percentage of change would also increase. Much of this cannot be rationalized by consideration of known intensity factors on the farms.

The average annual change of 1148 kilowatt hours per farm is only slightly similar to the approximate 900 kilowatt hours shown in Figure 1, which is the average based on changing numbers of farms.



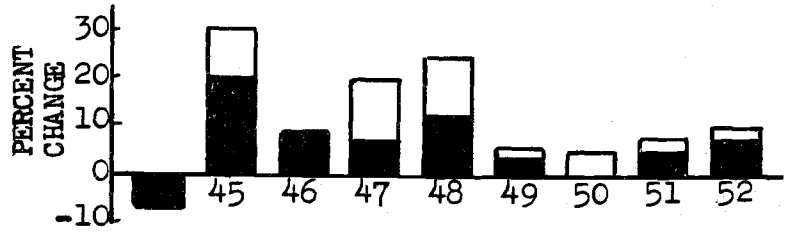
Average Annual Change: 13.7%

Average KWH Change	14	1060	1080	806	1797	1702	2524	522	827
Appliances Added	13	30	32	49	66	62	87	82	58
No. of Farms	14	27	36	57	65	69	83	91	98

9yr. Avg. KWH Change: 1148

Appliances Added Per Farm Per Year: .887

FIGURE 23. AVERAGE YEARLY CHANGE IN ELECTRICITY USE PER FARM: AS PERCENT OF PREVIOUS YEAR'S TOTAL, IN KWH, AS RELATED TO NEW APPLIANCES.



(Unshaded area is change due to new appliances)

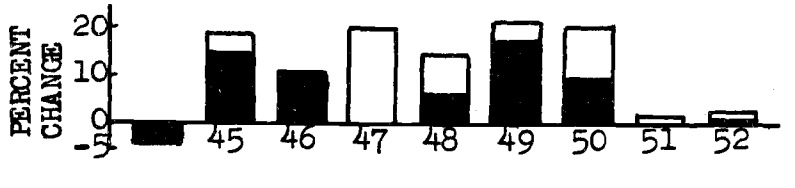
Average Annual Change: 11.5%

Average KWH Change	-47	1399	475	1392	1840	593	511	727	1096
Appliances Added	5	13	7	13	19	28	32	20	19
No. of Farms	4	10	10	16	21	22	28	33	35

9yr. Avg. KWH Change: 1363

Appliances Added Per Farm Per Year: .87

FIGURE 24. AVERAGE YEARLY CHANGE BY CROP-LIVESTOCK GP.



(Unshaded area is change due to new appliances)

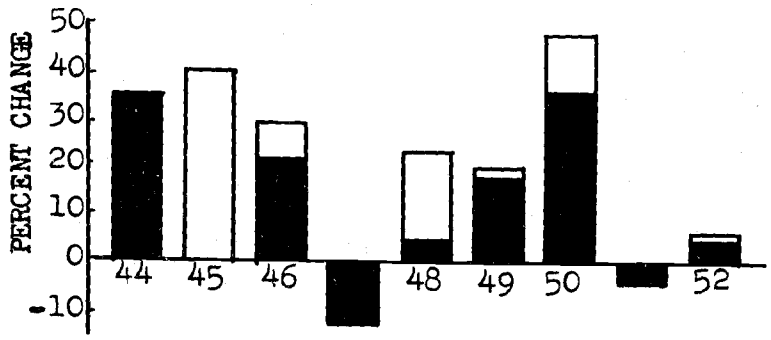
Average Annual Change: 12.2%

Average KWH Change	-236	720	528	1010	830	1446	1601	153	278
Appliances Added	0	6	5	14	11	11	23	27	22
No. of Farms	5	8	10	16	17	18	22	25	28

9yr. Avg. KWH Change: 703

Appliances Added Per Farm Per Year: .79

FIGURE 25. AVERAGE YEARLY CHANGE BY CROP FARMS.



(Unshaded area is change due to new appliances)

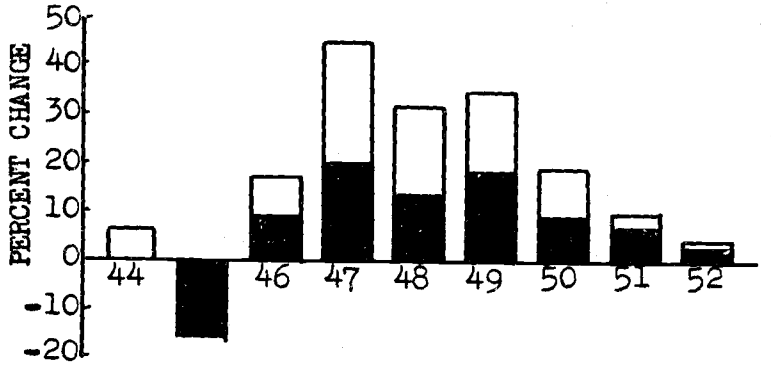
Average Annual Change : 20.3%

	44	45	46	48	49	50	52
Average KWH Change	457	3309	3084	-1508	2439	2260	6455	-787	1129
Appliances Added	4	5	8	13	8	0	14	17	5
No. of Farms	2	4	7	13	14	16	16	16	16

9 yr. Avg. KWH Change: 1871

Appliances Added Per Farm Per Year: .71

FIGURE 26. AVERAGE YEARLY CHANGE BY POULTRY FARMS.



(Unshaded area is change due to new appliances)

Average Annual Change: 16.9%

	44	46	47	48	49	50	51	52
Average KWH Change	214	-888	807	2262	2303	3247	3336	1897	875
Appliances Added	4	6	12	9	28	23	18	18	12
No. of Farms	3	5	9	12	13	13	17	17	18

9 yr. Avg. KWH Change: 1561

Appliances Added Per Farm Per Year: 1.22

FIGURE 27. AVERAGE YEARLY CHANGE BY DAIRY FARMS.

An Analysis of the Growth in Use of Electricity

The average annual use of electricity in this study almost doubled in the three year period, 1948-1950. It increased from about six to over thirteen thousand KWH per year per farm. This is a tremendous increase, both in percentage and in kilowatt hours of electric power. In 1952, the average farm in the United States was using only about 3600 kilowatt hours of electricity per year (17, p.3). The 1948 average of this study is almost double this amount, and the three year change noted above is also almost double the current U.S. average.

Much of this increase is due to the addition of consumer durable appliances. The shortage of these which resulted during the second World War had been largely overcome by 1948, and the appliances were available for immediate purchase with some selection possible between brands and types. 1948 was another very favorable year for agriculture. These farmers also undoubtedly had a larger than normal backlog of savings which was characteristic at the close of the war, and their credit capacity was enhanced by this, by guaranteed prices, and a generally optimistic outlook for the future.

The war years had taken many members of farm families into urban situations for the first time. Having

experienced the generally better living conditions of the city, these folks returned to the farm with a desire to duplicate these advantages. They wanted better lighting and better homes with the convenient appliances they knew were available to them. There was also an unusual shifting of population throughout the country during these years. The impact of new residents in a community, who have come from different environments can be great, and this is undoubtedly an accelerating factor in this total situation.

The combination of these socio-economic factors could certainly be expected to induce change in the use of electricity. In addition, these farmers seem to have participated in the scare buying of durable appliances in 1950 that was prompted by the Korean outbreak. This is evidenced by their change in annual use of electricity that year. The years 1948 to 1950 include data for an aggregate of 217 farms who added a total of 215 major appliances during those years. This is essentially one major appliance per farm per year. More appliances were added in 1950 than any other year.

The year of greatest change in electricity use was 1950 when the average per farm increased by 2500 kilowatt hours. The number of appliances added does not necessarily explain much of this as the relationship between

electricity use and addition of appliances is not consistent. In 1951, ninety-one farms added eighty-two appliances, only five fewer than 1950, but the annual use of power increased by only 522 KWH per farm.

The change varied a great deal more for farms of the different types than it did for the aggregate of farms. The crop and the crop-livestock farms do not show the extreme annual fluctuations of the other types of farms. The poultry farms are particularly variable from year to year. In 1950, they increased 47.2% or 6455 kilowatt hours per farm over the 1949 average. Much of this is attributable to three farms and variations in their intensities of installed uses. For example, one had prune dryers that used 25,000 KWH more in 1950 than in 1949; another added broilers to a layer enterprise and increased his annual use of power by 36,000 kilowatt hours. The dairy farms had their greatest percentage increase, 46%, in 1947, but their greatest change in kilowatt hours in 1950 which was an average increase of 3300 KWH per farm. On dairy farms, the change is general, and no few farms show spectacular changes as noted on poultry farms.

This growth analysis strongly supports the hypothesis that type of farm is the most important source of variation in use of electricity. It points out that production uses of power induce extreme variation and that

this can be in terms of an increase, or it can also be in terms of a decrease in use of power. Because of the tremendous change which took place from 1948 to 1950 in this group, it is also possible to see why some studies which ended in 1948 were unable to indicate the nature of change in demand which might be expected on farms.

CHAPTER IV

SOME ASPECTS OF THE PROBLEM OF ESTIMATING FUTURE POWER REQUIREMENTS

The trend of annual electricity use found in this study could be mathematically projected to estimate future requirements for the farms in the sample. The value of such extrapolations increases with higher confidence limits and a small standard error of estimate. Reduction in the number and type of assumptions upon which the extrapolation is based also enhances the usefulness of the estimate. The characteristics of the phenomena contained in the data of this study force limitations on the projection of this trend.

Two broad assumptions are implicit in any similar extrapolation. They are: First, that some sort of routine exists in the data and is reflected by the data, and second, that this routine can be approximated empirically from the data. These assumptions were outlined by Schultz in his attempt to measure demand for several agricultural commodities from historical data (10, p.65).

Additional assumptions depend upon the logical considerations indigenous to the problem. The electricity trend problem fits into the general setting of economic demand. Demand is a willingness to buy given amounts of

a specific good or service at specific prices, and under given conditions. The electricity records of the farms in this study indicate the amount of electricity purchased and the price paid. There are conceptual difficulties brought out by this, and by the nature of the electric service, or product, which qualify the applicability of demand theory.

Electricity is of no value to the consumer except as it can be used by him with other factors to produce goods, service, or utility. Electricity alone can provide no direct service or utility to the consumer. Although its availability may affect property value, it is generally non-storeable and non-negotiable so that no speculative possibilities exist to stimulate demand for it. The demand for electricity is derived, because of its use in other agents, through the demand for these other agents. It is a joint factor, or co-factor, in all its uses.

Economic demand theory has largely evolved from considerations of product demand, or those goods and services that can directly satisfy some want of consumers. The basic tenet of this theory is the principle of diminishing marginal utility. The logic of factor demand theory is similarly based on the principle of diminishing marginal productivity.

Measurement of demand is a problem which has met

with slight success, especially when it has been based on construction of historical-statistical demand curves. As stated in Black and Mighell, "Attempts to deal with this situation by A. C. Pigou, Wassily Leontief, Henry Schultz, and others did not give encouraging results."(8, p.77) These problems, and electricity is one of them, face the necessity of interpreting intersections of various supply and demand curves under a host of changing conditions. The routine, if existent, is not readily approximated from the data. The analysis of time-series in these problems has been very difficult. The result has been that demand curves simply do not take logical shape in these studies. Attempts to measure demand under semi-controlled conditions, such as Godwin's Florida orange study, are a more satisfactory approach to the problem. "Our knowledge of behavior patterns for individual consumers is sufficiently limited that much probably can be learned by the further use of designed experiments in retail stores." (5, p.76) Extrapolations and estimates made from such studies are limited by their assumptions.

Since electricity is not a simple product, or factor, and its demand is derived through the demand for a wide variety of consumption and production agents, the demand for electricity becomes a completely indefineable concept. The marginal utility of a kilowatt hour of

electricity would be a futile consideration, and the marginal productivity of a kilowatt hour of electricity is essentially immeasureable. It is difficult to see how this can be classified as a measureable-demand problem. However, the basic logic and assumptions related to demand theory can aid in defining the problem of extrapolating the apparent demand for electricity.

Several assumptions are essential to the construction of a demand schedule (4, pp.84-118) and 9, pp.60-112) and 10, pp.39-75):

1. General economic conditions remain the same.
2. Level and distribution of income remain the same.
3. Preferences of consumers remain the same.
4. Price, quality, and types of substitutes remain the same.
5. Buyer expectations remain unchanged.
6. Uses for the product and technologies do not change.

Estimates based on extrapolations of trends must logically make similar assumptions. It becomes immediately obvious that estimates based on these ceteris paribus conditions provide little useful information because change over time is largely due to the alteration of one or more of these assumptions. Useful estimation information is that which indicates the change in demand which can be associated with these alterations. The data of this study

certainly indicate that there is considerable change in total demand for electricity and describes the relationship of this change to several factors. Measurement of the comparative influence of these factors on demand is not readily accomplished from historical data.

A brief examination of changes related to these assumptions, which have occurred in the time period covered by this study, is desireable.

1. General economic conditions changed tremendously from a war economy with rationing and shortages to a post-war economy of inflation, more than full employment, and unprecedented levels of income and production. The last three years of the study are a peculiar mixture of war and peace economy. There is certainly nothing constant about this assumption in the period studied.

2. Whether the distribution of income changed is not known, but the entire period is marked by a rising level of income for the farm population of the nation, and for the farms sampled by this study.

3. There is little doubt that preferences of these farmers changed; this is exhibited by their propensity to purchase household appliances and production equipment. The cumulative effect of this descussed on page 56 seems to indicate an effective change in preferences.

4. The influence of substitutes on use of

electricity among farms sampled is imperceptible.

5. The buying surge of 1950 is a specific instance of change in buyer expectations, and its effect on use of electricity was great. Equally important, but less defineable, is the aspect of optimism which pervades the time-period studied. Expectations for secure and increasing incomes for the farmers have possibly never been higher or more justified than they were during this period of time.

6. New uses and technologies made tremendous impact on use of electricity. Sprinkler irrigation, infrared brooders, milking equipment, deepfreezes, clothes-dryers, dishwashers, television, and numerous other innovations and improvements occurred in this period of time.

A problem which utility companies must face, which this study eliminated in its design, is the problem of changing numbers of farms in a geographic area. Utility Companies serve geographic areas; the changing population, and the changing composition of their accounts is a big factor. As this study recognizes large differences in electricity use due to farm type, the proportion of farms of the various types in a given area will very largely influence the amount of electricity used in the aggregate.

Although it was not determined in this study, there

may be a definite rate (cost) effect related to electricity use. This could only be determined by studies of accounts of customers whose rates are sufficiently different to justify conclusion. Rates in this study are too similar to analyze their effect on electricity use.

It seems quite certain that estimations of the future power requirements of farms must be based on a larger standard error of estimate than estimates which were made ten years ago. This is partially due to the extent of increase in use, but more particularly to the noted increase in variation of intensity of uses, especially for production.

The 1943 average annual total KWH per farm was composed of 83% household uses, 10% production uses, and 7% irrigation. The 1952 average is composed of 64% household uses, 26% production uses, and 10% irrigation. In this time, the average household total has increased 208%, the average production total has increased 700%, and the irrigation total has increased 411%.

Total household use varies, but tends to be relatively stable compared to production use totals. For reasons that are not wholly rationalized, there appears to be a tendency for this to fluctuate widely from year to year, and a new possibility is introduced: That total electricity used by a group of farms can either decrease or increase from year to year where the past has indicated only

constant increase in total electricity use. These variations can be of considerable magnitude. If the present trend continues, the average farm of the type studied will soon use more power for production than in the household. This source of extreme variation (production) will necessarily require that estimates include very broad allowances for error.

A utility company executive told this writer that the lowest possible cost had been reached in providing electric service, and that future rates will be higher than current rates. If the findings of this survey are applicable, they would seem to partially substantiate his statement. Seasonality has changed in the last ten years; the ratio of the peak demand period within a year to the low demand period in the same year has increased. The increase in peak demand requires additional facilities for providing service. The greater actual and potential magnitude of variation in demand on the farms also will require facility expansion. The result could well be that this facility cost will be transferred to the customer in the form of higher service charges.

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