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REQUIREMENTS FOR CONTRIBUTIONS

Articles in the field of agricultural economics, suitable for publication in the journal, will be welcomed.

Articles should have a maximum length of 10 folio pages (including tables, graphs, etc.), typed in double spacing. Contributions, in the language preferred by the writer, should be submitted in triplicate to the Editor, c/o Department of Agricultural Economics and Marketing, Pretoria, and should reach him at least one month prior to date of publication.

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Economic Aspects of the Use of Electricity on farms

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INTRODUCTION

Since Escom (Electricity Supply Commission) commenced to make electric power available on farms, the use of electrical machines and equipment by farmers has increased steadily. As far back as 1959[2)], the S.A. Agricultural Union adopted a resolution requesting the Government to make more Escom power available to farmers.

Because of the growing importance of electric power in agriculture in the future the Division of Agricultural Economic Research made a study during 1965 with the object of:

1. Determining the cost of Escom power in areas containing large and small farms on which a limited amount of electricity is used and on others using it extensively;
2. determining the extent to which various types of farms could utilize Escom power economically; and
3. studying the cost of generating power on the farm.

The results of the investigation summarised in this article, and which could serve as a guide in the provision of electric power on farms, were calculated from data provided by Escom and the determination of costs when generating power privately.

To understand the economics of electrification attention should be paid to:

1. What the cost of electricity would be when it is supplied by Escom or when it is generated on the farm;
2. the extent to which electric power can be utilized on the farm;
3. the amount of electric power which could be used on different types of farms.

1) Summary of a report prepared by G.P. Niewoudt, 1966.

2) Steyn, A.L.: The economics of electrification in the mechanization of Agriculture in the R.S.A. Agricultural Economic Seminar, University of Pretoria.

THE INTRODUCTION OF ELECTRIC POWER

The introduction of electric power is closely associated with the type of farming and the extent to which it can be utilized. This involves the question whether the farmer, in his special circumstances, can use electric power economically. By the nature of things the answer will depend upon a whole range of factors which may differ from farm to farm and from area to area. A few of these factors will be considered to establish whether a method can be found whereby the introduction of electric power on the farm can be evaluated and thus lend guidance to individual farmers.

The amount of electric power required, that is in terms of kilowatt hours will determine which source of power, namely Escom or locally generated, should be used.

FACTORS WHICH DETERMINE THE AMOUNT OF ELECTRICITY REQUIRED ON THE FARM

1. Power requirements according to uses

The power required for certain appliances and the time they will be used, will naturally determine the amount of electricity (in units) which will be consumed. To illustrate this the amount of electricity required for various appliances is given in Table 1.

From Table 1 it can be established, depending upon the time each appliance will be used, what the power requirements per unit of time will be.

2. Type of produce

The various products produced will also have a bearing on the economic aspects of providing electricity on the farm. A product with a high unit value could make the introduction of electricity economical if the product can be handled or treated in less time (perishability) or if some of the post-harvest processes could be mechanized and the costs per unit reduced.

TABLE 1 - Power required for various electrical appliances

Item	Period in use	Horse-power or kilowatt	Units-kilowatt hours
Electric light (100 Watts)	4 hours a night	0.1 kW	12 a month
Radio	8 hours a day	0.06 kW	14 a month
Stove	Family of 5	3 to 10 kW	200 to 300 a month
Electric iron	4 hours a week	1 kW	16 a month
Silage cutter	6 to 10 tons an hour	5 h.p. and over	1 a ton
Cream Separator	1,400 lb. an hour	1/8 h.p. and over	1 per 2,000 lb.
Milk Cooler	50 to 400 gal. a day	½ to 3 h.p.	1.3 per 10 gal.
Incubator	50 to 7,500 eggs	0.5 watts a chick	180 per 200 eggs
Welding apparatus		150 to 200 amps	75 a year
5 h.p. motor (for water pumping)		4.8 kW	5 an hour at full load
25 h.p. motor (for water pumping)		23.1 kW	22 an hour at full load

SOURCE: ibid.

3. Degree of intensity of farming

The intensity of farming will also be an important factor. Because of the time factor it may be to the advantage of one farmer to mechanize and use electric power, while another may derive little or no benefit from it.

It has been estimated[1] that the American agricultural labourer is at present able to undertake the work of 200 men. This increase in work capacity is the result of mechanization and in particular the use of electricity on the farm. Whether mechanization with electricity will pay or not depends upon the circumstances of each farmer.

4. Management by the entrepreneur

Finally we may briefly consider the farmer's needs. The provision of light in the home serves as an illustration. Lights can be provided in various ways, of which candles and oil lamps would probably cost least. The concept of utility plays a part here, however, and oil lamps are considered to be more efficient than candles; gas lamps more than oil lamps and electric lights the best of all. Can the cost of providing electricity actually be determined theoretically or practically? Can the entrepreneur be taken to task for an uneconomic act in providing electric lighting in his house?

This example can be extended to a variety of tasks on the farm. It also depends on the farmer whether he will use this power or production factor in farming in such a manner that it will prove profitable. A high degree of management ability is essential to organise the work in such manner that the lowest amount of current is used.

1) Steyn, A.L., ibid

SOURCES OF ELECTRIC POWER

A. ESCOM

Since Escom is a utility enterprise and receives no subsidies from the State, the expenses arising from any service must be covered by revenue. It is not possible to deal in one article with all the different rural schemes of Escom. It was therefore decided to use the Rand and Orange Free State Undertaking which supplies power to areas in the Transvaal and Orange Free State south of a line joining Standerton and Koppies as a basis for calculating rural rates.

(a) Cost structure of Escom power

The cost of Escom power is determined by five separate cost items, namely:

(i) connection charge
(ii) demand charge
(iii) unit tariffs
(iv) extension charge and
(v) the cost of wiring and the purchase of electrical appliances.

(i) Connection charge. - Escom provides the capital to lay on transmission lines to the farm, but each consumer pays a connection charge. This charge varies and amounts to R60 for a single-phase connection and R100 for a three-phase connection. It is paid only once and over time it is not an important cost and will not be taken into account.

(ii) A demand charge of R30 a month is imposed and must be paid regardless of the amount of power used. In addition there is a further surcharge of 10 cents for each full amp of the maximum demand which the consumer uses in excess of 30 amps a month. In the calculations this item is taken as a fixed cost.

(iii) Unit tariff (variable cost). - A unit tariff of 0.675c per unit must be paid for the first 1,000 units and 0.5c for each additional unit in excess of 1,000. In the area under consideration a further surcharge of 20 per cent on the demand charge plus the unit tariff is paid. This is done to keep the extension charge as low as possible and thus encourage small consumers to buy electricity and support the rural schemes.

(iv) Extension charge (fixed costs). - The revenue derived from the sale of electricity under a particular scheme does not cover all expenditure. Escom must therefore collect an additional amount from all users under a scheme to cover the deficit. This is known as the extension charge and in the area under consideration it amounts to R11 a month for a single-phase and R14 for a three-phase connection.

(v) Wiring and purchase of appliances. - This item of costs is independent of the method by which electricity is provided and will not be taken into account in the comparisons of costs. Wiring is necessary and appliances must be purchased whether power is provided by Escom or generated privately.

B. GENERATING POWER PRIVATELY

The calculation of costs when power is generated privately raises numerous problems, since costs vary depending upon the purchase price of the engine, consumption of fuel, the amount of power used etc. In comparing costs, the cost per kilowatt[1] hour at different levels of amps used and unit use of Escom supplies, will be compared with corresponding costs of engines obtainable in the trade.

The purchase prices, maintenance costs and fuel consumption were obtained from specifications of power generators available in the trade. The rate of depreciation was taken at 10 per cent of the original cost which means the engine is written off over a period of 10 years. An interest charge of 5 per cent a year on the value of the engine was calculated. The maintenance costs were calculated at 8 per cent a year on the purchase price. Fuel costs were calculated on a specific fuel consumption of 0.5 lb per brake horse-power hour. The fixed costs consist of interest, depreciation and maintenance and the variable cost is represented by fuel costs depending upon the number of hours the engine runs.

1) The units of measurement of electricity are -
(i) Volts, which express the tension,
(ii) Amps, which express the current,
(iii) Ohms, which express the resistance between two points in the circuit, and
(iv) Watts, which express the work of a specific current according to the formula: Volts x Amps = Watts. A kilowatt therefore equals, 1,000 watts, and a kilowatt hour equals work of a kilowatt operating for 1 hour.

COST CALCULATIONS AND COMPARISONS BETWEEN ESCOM POWER AND PRIVATELY GENERATED POWER

A. COSTS AT A MAXIMUM CURRENT OF 30 AMPS

(a) Escom power

The monthly cost of electricity supplied by Escom to a maximum of 30 amps and at various extension charges are given in Tables 2 and 3. The extension charge was estimated theoretically at different levels so as to establish how high it could be at a point of intersection in costs of the two sources namely Escom and private power. These costs will then be compared with those of private generators of 8 and 30 amps respectively. These particular generators were selected because of their universal popularity.

TABLE 2 - Monthly costs of electric power provided by Escom to a maximum of 30 amps at an extension charge of R5.00

Kilowatt hours a month	Cost per month			Cost per unit
	Fixed	Variable	Total	
	R	R	R	cent
87	8.00	1.31	9.31	10.70
175	8.00	2.02	10.02	5.72
262	8.00	2.72	10.72	4.09
350	8.00	3.43	11.43	3.26
438	8.00	4.14	12.14	2.77
525	8.00	4.85	12.85	2.45
612	8.00	5.56	13.56	2.21
700	8.00	6.26	14.26	2.04
800	8.00	7.08	15.08	1.88
1,000	8.00	8.70	16.70	1.67
1,250	8.00	10.20	18.20	1.46
1,500	8.00	11.70	19.70	1.31
1,750	8.00	13.20	21.20	1.21
2,000	8.00	14.70	22.70	1.13
2,400	8.00	17.10	25.10	1.04
2,700	8.00	18.90	26.90	1.00
3,000	8.00	20.70	28.70	0.96

(b) Generators on farms

1. Monthly costs of 3.5 h.p. engine. - The cost per month to provide electric power with a 3.5 horse-power diesel engine, developing 8 amps (1.75 kilowatt) is shown in Table 4. This engine costs R650 retail. The cost of fuel is 4.17c an hour in accordance with the standard previously established.

TABLE 3 - Cost per unit of power provided by Escom to a maximum of 30 amps at various extension charges

Kilowatt hours a month	Cost per unit extension charges of:						
	R5	R7.50	R10	R12.50	R15	R17.50	R20
87	10.70	13.57	16.44	19.32	22.20	25.07	27.94
161	-	-	9.27	-	-	-	-
175	5.72	7.15	8.58	10.01	11.44	12.87	14.30
262	4.09	5.04	6.00	6.95	7.92	8.86	9.82
322	-	-	-	5.82	-	-	-
350	3.26	3.98	4.69	5.41	6.12	6.84	7.55
438	2.77	3.34	3.91	4.48	5.05	5.62	6.20
480	-	-	-	-	4.69	-	-
525	2.45	2.92	3.40	3.88	4.35	4.83	5.30
612	2.21	2.62	3.03	3.44	3.85	4.26	4.67
700	2.04	2.39	2.75	3.11	3.46	3.82	4.18
800	1.88	2.20	2.51	2.82	3.14	3.45	3.76
1,000	1.67	1.92	2.17	2.42	2.67	2.92	3.17
1,200	1.46	1.70	1.86	2.12	2.32	2.53	2.66
1,500	1.31	1.47	1.65	1.81	1.97	2.14	2.31
1,800	1.21	1.33	1.50	1.61	1.75	1.89	2.07
2,100	1.13	1.23	1.38	1.47	1.58	1.70	1.88
2,400	1.04	1.15	1.25	1.36	1.46	1.57	1.67
2,700	1.00	1.09	1.18	1.27	1.37	1.46	1.55
3,000	0.96	1.04	1.12	1.21	1.29	1.37	1.46

TABLE 4 - Cost per month when generating power on the farm to a maximum of 8 amps

Generator hours a month	Kilowatt hours a month	Cost per month			Cost per unit
		Fixed	Variable	Total	
		R	R	R	cents
50	87	11.08	2.09	13.17	15.05
57	100	11.08	2.38	13.46	13.46
86	150	11.08	3.59	14.67	9.78
93	161	11.08	3.84	14.92	9.27
100	175	11.08	4.17	15.25	8.71
150	262	11.08	6.26	17.34	6.62
185	322	11.08	7.66	18.74	5.82
200	350	11.08	8.35	19.43	5.52
250	438	11.08	10.44	21.52	4.91
276	480	11.08	11.43	21.51	4.69
300	525	11.08	12.52	23.60	4.50
350	612	11.08	14.61	25.69	4.20
400	700	11.08	16.70	27.78	3.97

From a comparison of Tables 2, 3 and 4 it can be deduced that -

(i) Should power be generated privately, it will still be more advantageous for the farmer if he uses less than 161 kilowatt hours a month. If he uses more, power supplied by Escom will be cheaper at an extension charge of R10. At 161 kilowatt hours the cost will be 9.27c a unit.

(ii) Power supplied by Escom will cost less than a private supply if, at an extension charge of R12.50 more than 322 units a month are used. At 322 kilowatt hours the unit will cost 5.82c.

(iii) Power supplied by Escom at an extension charge of R15 will cost less than private power if more than 480 units a month are used. At 480 kilowatt hours the cost per unit will be 4.69c.

(iv) The amount of the extension charge is decisive in determining whether private power should be replaced with Escom power. The higher the extension charge the more kilowatt hours must be used to make Escom power more economical than private power. With a low extension charge the number of kilowatt hours used increases to a point where the alternative sources of supply are equal.

2. Monthly costs of a 13 h.p. engine. - The second generator with which Escom power is compared is a 13 horse-power diesel engine which developes 6.2 kilowatts (30 amps maximum). This engine costs R950 and the cost of fuel used is 15.51c an hour. The cost of producing power with this engine are shown in Table 5.

The results in Table 5 are compared with those in Tables 2 and 3. From these it can be deduced that the cost of Escom power is equal to that of private power at extension charges of R12.50, R15, R17.50, R20 at 90, 135, 300 and 435 units at a unit charge of 19.00, 14.50, 7.99 and 6.23 cents respectively.

It thus appears that Escom power is more economical over the greater part of the range of kilowatt hours used. Only at a very low rate of consumption is private power cheaper. At an extension charge of R20 a month private power is for example slightly cheaper if the consumption is less than 435 kilowatt hours a month.

Additional calculations were also made for cost comparisons with maximum amperage at 45, 60 and 115 amps. In all instances the same conclusion applies, namely that only at a low rate of consumption (comparatively small number of kilowatt hours) is it economically justified to use private power. The unit rates of Escom for higher amperages are generally lower than those of private power even when the extension charges are very high.

PRACTICAL EXAMPLES OF THE INTRODUCTION OF ELECTRIC POWER

In Table 6 the costs of own generators developing a maximum of 8 and 30 amps for certain uses are compared with the costs of power supplied by Escom for the same purposes.

According to these examples Escom power is cheaper per unit at full and half load than power generated privately with large generators (30 amps). Private generators with limited use (8 amps) are however cheaper per unit at full or half load.

Many farmers purchase expensive engines to provide electric power and consider that their costs are low, because -

(i) they compare the cost of power provided by Escom which includes running as well as fixed costs with the running costs of their own generators; and
(ii) they have to pay Escom monthly for running as well as fixed costs, while they only pay running costs monthly on their own generators.

As stated the provision of private power is cheaper than Escom power where use is limited. This is, however, very important on the average farm since in most instances only a limited amount of electricity is required.

CONCLUSION

1. The two most important factors which influence the inclusive cost per unit of power supplied by Escom is the amount of the extension charge and the amount of electricity used. The farmer's managerial ability and knowledge will also influence his account to the extent to which he succeeds in keeping the consumption low. The question arises whether he can organise his activities in such a manner that a single-phase connection can be used instead of a three-

TABLE 5 - Monthly costs of generating electricity to a maximum of 30 amps

Engine hours a month	Kilowatt hours a month	Costs a month			Cost per unit
		Fixed	Variable	Total	
		R	R	R	cents
10	62	16.25	1.55	17.80	28.71
25	155	16.25	3.88	20.13	12.99
50	310	16.25	7.75	24.00	7.74
100	620	16.25	15.51	31.76	5.12
150	930	16.25	23.26	39.51	4.25
200	1,240	16.25	31.07	47.27	3.81
250	1,550	16.25	38.78	55.03	3.55
300	1,860	16.25	46.53	62.78	3.38
350	2,170	16.25	54.25	70.53	3.25
400	2,480	16.25	62.04	78.29	3.16
450	2,790	16.25	69.80	86.05	3.08
480	2,976	16.25	74.45	90.70	3.05

phase connection with corresponding higher extension and demand charges.

2. As stated, it is in most instances not economical to generate power privately, except in small amounts and low amp use. With higher amp use there are still instances where private power is cheaper than Escom power, that is where the kilowatt use is low. The lower the extension charge of Escom, however, the more advantageous it becomes to use Escom power.

3. The system of farming and the farm layout determine whether it is economical to use power supplied by Escom. These factors cover so many variables that it is impossible to determine according to a standardised prescription to what extent electric power can be used economically. A final decision whether electricity will be employed must therefore be preceded by a detailed study of all the factors which could influence costs.

TABLE 6 - Practical examples of the use of electricity on the farm: Comparison of costs between Escom power and private power, with different capacities for various combinations of use

Item	Large private generator		Private generator with limited use	
Type of installation: Kilowatt	6.2		1.8	
Volt	220		220	
Maximum current (amps)	30.0		-	
Purchase price	R950		R650	
Fixed monthly costs	R 16.25		R 11.08	
Running costs an hour	15.51 cents		4.17 cents	
Capacity rate	Full	Half	Full	Half
Uses (in amps)				
4 100 watt lamps (4 hours a night)	1.80	1.80	1.80	1.80
Radio, 8 hours a day	0.27	0.27	0.27	0.27
Vacuum cleaner	2.27	2.27	2.27	2.27
Battery charger	3.41	-	3.41	-
Silage cutter	3.06	-	-	-
Saw (10" wheel)	3.06	-	-	-
Drill (1/4" bit)	3.06	-	-	-
Grindstone	0.87	-	-	-
2.2 kw. pump	10.00	10.00	-	-
Total amps	27.80	14.34	7.75	2.07
Total kilowatt hours a month	1,088	1,069	72	62
Cost a month	R43.55	R43.08	R12.75	R12.54
Cost a unit	4.00c	4.03c	17.71c	20.22c
Escom: Cost a month[1)]	R20.23	R20.11	R15.19	R15.10
Cost a unit	1.86c	1.88c	21.10c	24.35c
Difference a unit, Escom to private	- 2.14c	- 2.15c	3.39c	4.13c

1) With R11 or R14 extension charges as applicable in the particular area.