Vol XXIV
No. 4

ISSN 0019-5014

CONFERENCE NUMBER

OCTOBER-DECEMBER 1969

INDIAN JOURNAL OF AGRICULTURAL ECONOMICS

INDIAN SOCIETY OF AGRICULTURAL ECONOMICS, BOMBAY

COST ANALYSIS OF ELECTRIFIED PUMPS AND DIESELISED PUMPS USED FOR LIFT IRRIGATION

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Introduction

It is an established fact that irrigation is the master-key for increasing agricultural production and productivity through the increased use of interdependent inputs like seeds of high-yielding varieties, fertilizers, pesticides, etc. In India, the area under irrigation at the end of the Third Five-Year Plan was only 88 million acres for the gross cultivated area of 387 million acres. This indicated that much work needs to be done on this front. The minor irrigation projects—especially the lift irrigation projects—contribute substantially through quick and efficient utilization of the resources invested, as the farmers are free to use the irrigation water according to the needs of their irrigated crops.

In areas where canal irrigation is not provided, lift irrigation plays a vital role in the enhancement of agricultural production. The farmers use different sources of power for lifting water. The age-old animal power is replaced by mechanical power, as the farmers have learnt that mechanization of lift irrigation is more convenient and economical as compared to the use of animal power for lifting water. Mechanical power is supplied by two types of machines, *viz.*, (1) oil engines and (2) electric motors. The oil engines consume light diesel oil (LDO)/high speed diesel (HSD)/power kerosene/petrol, as fuel and supply power to the pumps, whereas the electric motors convert electricity into mechanical energy to operate the pumps for lifting water. Out of all the different types of fuels for oil engines, the light diesel oil (popularly known as crude oil) is the cheapest per HP hour operation, and hence the farmers who go in for lift irrigation plants for large scale operation adopt light diesel engines in preference to the other types of oil engines. Using such light diesel engines as prime-movers of the pumps is termed as *dieselisation* and the use of electric motors as prime-movers of pumps is termed *electrification* of the wells.

Situation of Lift Irrigation in Gujarat

Out of all the States in India, Gujarat State is more dependent on lift irrigation as source of irrigation, on account of paucity of canal irrigation. The share of lift irrigation in total irrigation potentials is about 75 per cent which is the maximum in India. The farmers of Gujarat have invested about Rs. 200 crores in power operated pumps which discharge about 75,000 cusecs of water. But, this is not sufficient to cover the area under cultivation as hardly 12 per cent of cultivable land is covered with irrigation facilities in Gujarat. At present, there are about 5.34 lakh wells and tube-wells in Gujarat State. Out of these existing wells, about 1,50,000 wells are equipped with dieselised pumps and about 50,000 wells are equipped with electrified pumps for lift irrigation. The rate of growth of lift irrigation is enhanced recently to about 30,000 power operated pumps per year. It is estimated that about 12 lakh HP from oil engines and 3 lakh HP from electric motors supply energy to the pumps for lifting water from irrigation. These prime-movers annually consume about 2.4 lakh tonnes of crude oil (worth Rs. 1,200 lakh) and 250 million kWh of electricity (worth Rs. 350 lakh) for lifting water from the wells. The energy cost per acre under irrigation in Gujarat comes to about Rs. 60 per acre under irrigation.

Gujarat is one of the few States where the cost of irrigation water is very high as the irrigation water is to be lifted by application of costly power. The lift irrigation activity is capital intensive. It has many managerial problems which need to be answered properly. The main problems faced by the farmers and the managers of organizations serving the farmers are: Which source of power should be used for operating the pumps? How can the farmer minimize the cost of producing agricultural goods by reducing the cost of irrigation water? What is the minimum scale of operation, *i.e.*, period for which the power operated pumps should be operated? What should be the future investment policies with regard to dieselisation versus electrification of wells? Should electricity be subsidized or not? Should farm fuel be taxed?

All these questions can be answered through systematic cost analysis of the two alternative processes, *viz.*, dieselisation and electrification. For some of the questions, the farmers/policy makers of the organizations concerned do have answers but they are not able to quantify them. For example, the farmers with experience in operating both the types of power operated pumps give the following points in favour of electrification:

(*a*) low fuel and labour cost;
(*b*) low repair and maintenance cost;
(*c*) less wastage of power leading to increased output of water for same HP, and
(*d*) low initial investment.

But when they are asked to give comparative and factual information in the form of figures, they sometimes fumble, as do many others concerned with the supply of inputs for lift irrigation. Through a systematic case study, we have tried to verify the trends and quantify the differences between the two alternative methods of operating the pumps for lift irrigation.

Empirical Study of Cost Analysis of Dieselised and Electrified Pumps

In order to compare cost of operation of dieselised and electrified pumps, an empirical study was undertaken in four selected villages of two sub-divisions of the Gujarat Electricity Board. From each of the four selected villages, five farmers, owning and operating dieselised pumps and five farmers owning and operating electrified pumps were selected randomly from the group of farmers with the pump sets of desired characteristics (7.5 to 15 HP prime-movers and 0.3—0.5 cusec discharge).

The capital investment and operating cost of the pumpset for one year (1968-69) were calculated for each of the 40 sample farmers. The capital investment included cost of mechanical units; cost of civil structures and working capital required by the farmers. The operating cost included depreciation of mechanical units and civil structures; interest on capital invested; repairs and maintenance expenses; labour cost; and fuel and lubricant expenses.

Operating Cost of the Power Operated Pumps

The operating cost of the power operated pumps can be calculated with respect to different units or indicators of performance, *viz.*, (1) hours of operation (time unit), (2) horse power hours of operation (energy input unit) and (3) acre-inches of water lifted (energy output unit). In this study, all the three units are used for general comparison but the last indicator has been used for detailed analysis for it takes care of variations in the size of prime-mover, overall efficiency of the system, rate of discharge, operating hours/year and actual/useful work done. The data on investment and operating cost of the power operated pumps owned by the sample farmers are summarised in Table I.

TABLE I—OPERATING COST OF POWER OPERATED PUMP IN SELECTED VILLAGES OF GUJARAT

Item	Dieselised pump		Electrified pump	
	Total	Average	Total	Average
1. Number of sample farmers/pump sets studied	20	—	20	—
2. HP of prime-movers	216	10·8	210	10·5
3. Investment (Rs.) for				
(*a*) Equipment	1,28,525	6,426	86,580	4,329
(*b*) Well, boring, foundation and delivery tank	1,59,223	7,961	1,54,000	7,700
(*c*) Working capital	30,000	1,500	25,000	1,250
Total ..	3,17,750	15,887	2,65,580	13,279
4. Operating cost (Rs./year)				
(*a*) Annual depreciation, interest on investment and repairs	59,619	2,981	44,081	2,204
(*b*) Cost of labour	12,765	638	11,140	557
(*c*) Cost of fuel and lubricants ..	61,940	3,097	52,850	2,642
Total ..	1,34,324	6,716	1,08,071	5,403
5. Performance in				
(*a*) Hours per year	40,565	2,028	44,578	2,227
(*b*) HP hours per year..	4,33,710	21,685	4,75,090	23,755
(*c*) Acre-inches per year	13,999	700	18,398	920
6. Average operating cost in				
(*a*) Rs. per hour	—	3·31	—	2·40
(*b*) Rs. per HP hour	—	0·31	—	0·23
(*c*) Rs. per acre-inch	—	9·60	—	5·87
7. Average cost of fuel (Rs. per acre-inch of water)	—	4·42	—	2·87

It can be observed from Table I that the average cost of operation is lower with electrified pumps than with dieselised pumps for the same performance. These observations however give only a general idea of total operating cost, *i.e.*, at particular level of operation. They do not indicate how the cost components behave in different operating levels, *i.e.*, for a given range of operation. For finer comparison the relationship between (1) the total operating cost in Rs./ year and (2) and performance in acre-inches/year has to be established for each type of the pump sets.

The total operating cost is the sum of cost components which are (*a*) fixed, (*b*) variable and (*c*) partly fixed and partly variable for a given period of time. To understand the nature of all these three types of cost components, the total operating costs observed in different cases were plotted as dependent variable (Y) against the unit of performance (acre-inches of water lifted/year) as independent variable (X) on graphs (Figure 1). The regressions observed in both the types of pump sets were as shown in Table II.

TABLE II—REGRESSION (RELATIONSHIP) BETWEEN TOTAL OPERATING COST (Y) AND UNITS OF PERFORMANCE (X)

Type of pump set	Regression (relationship) between Y = Total operating cost in Rs./year X = Acre-inches of water lifted/year	Tested range	Value of (r) for regression
Dieselised pump (d)	$Y_d = 3400 + 4{\cdot}74X_1$	$X_d = 150$ to 1200	$r = 0{\cdot}887$
Electrified pump (e)	$Y_e = 2300 + 3{\cdot}37X_2$	$X_e = 300$ to 2000	$r = 0{\cdot}962$

Note : (1) The above relationships are statistically significant.
(2) The relationships were tested for a particular range of observation and hence the same should be considered valid only for the tested range. The relationships may or may not be valid beyond the tested range.

The data presented in Table II also indicate the superiority of electric motors over the diesel engines from the operating cost point of view. For the range of HP (7.5 to 15 HP) and discharge (0.3 to 0.5 cusec) under test, on an average, the electrified pumps cost Rs. 1,100/year less in fixed cost and Rs. 1.37 less per acre-inch of irrigation (*i.e.*, in variable cost) that the dieselised pumps. For average performance of 600 acre-inches per year, the difference in operating cost will be Rs. 1,922 in favour of electrified pumps.

The data also indicate that if a farmer invests in suitable electrified pump instead of dieselised pump for lift irrigation and has potentials to operate it for more than 300 acre-inches or cusec hours per year, he will annually save Rs. 1,100 in fixed cost component and Rs. 1.37 per acre-inch of performance.[1]

1. This observation is applicable to the prime-movers of 7·5 to 15 HP having 0·3 to 0·5 cusec discharge and normal overall efficiency. For performance of minimum 300 acre-inches per year, the pumps of 0·3, 0·4 and 0·5 cusec discharge will have to be operated for 1,000, 750 and 600 hours per year respectively.

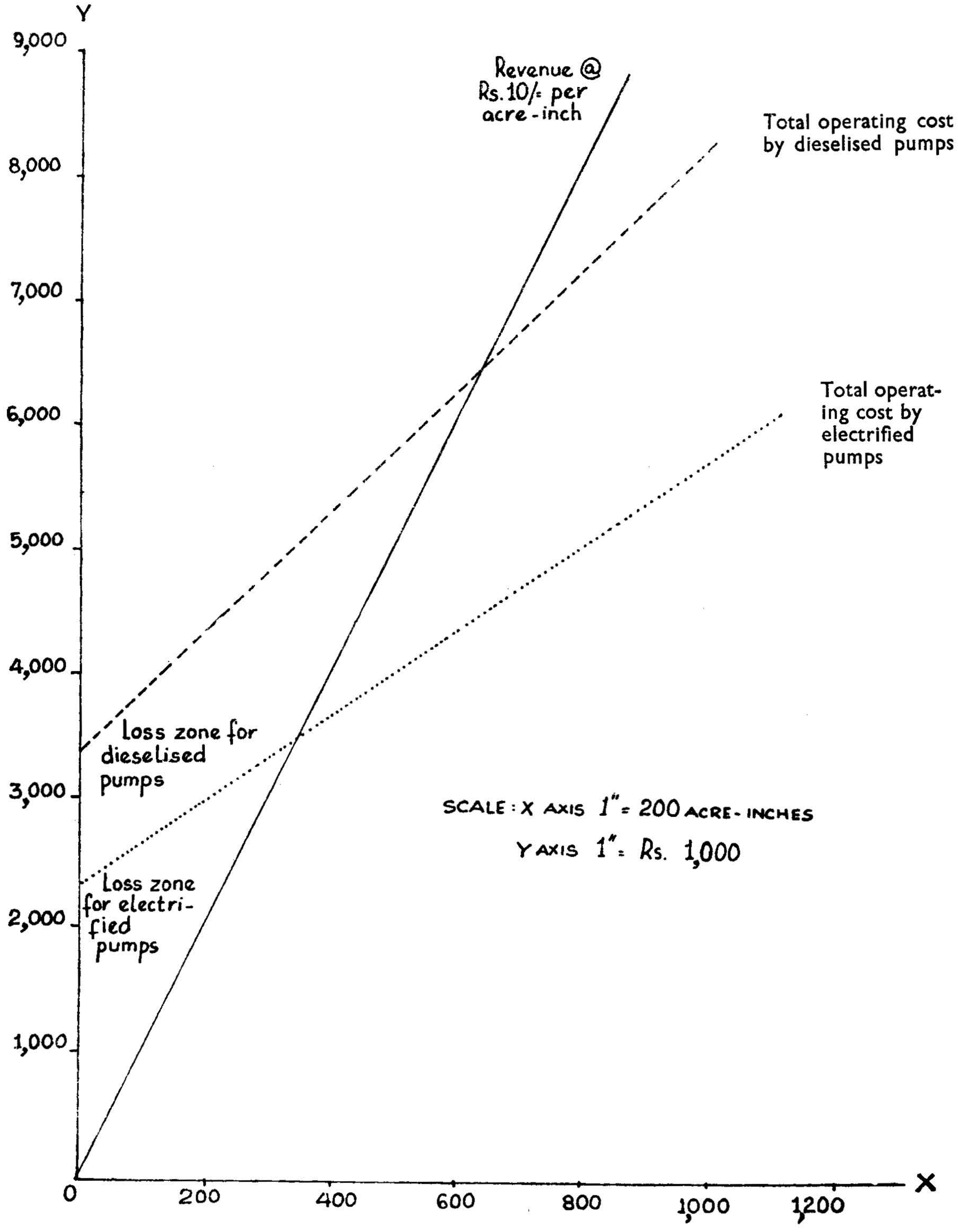

Figure 1—Break-even Chart for Dieselised and Electrified Pumps

Gains to the Farmers Who can Electrify their Wells

The farmers who tend to gain (or save) through electrification can be classified into two categories:

1. The farmers who wish to electrify their wells which are not yet tapped for lift irrigation by power operated pumps. They have not invested in diesel engines for such wells and are free to opt for electric motor.
2. The farmers who wish to electrify their wells which are used for lifting water by dieselised pumps. They have already invested in lift irrigation machinery including diesel engines. They can substitute or replace the diesel engine by electric motor of equivalent performance.

The farmers of the first category can take full advantage of electrification through (*a*) saving in initial investment and (*b*) saving in annual cost of operation. The farmers in the second category can have some of the advantages of electrification as they have already invested in dieselisation, and a part of it would be sunk cost to them if and when they replace the diesel engines by electric motors. They would save in operating cost as the direct costs of fuel, labour and repairs would be reduced as a result of substitution. Both the situations are considered separately below.

The gain to the farmers of category 1 (with investment option) can be illustrated with certain specific situation as shown in Table III.

TABLE III—GAIN TO THE FARMERS THROUGH ELECTRIFICATION OF WELLS (CATEGORY 1)

Item	Pump sets with equal performance and varying HP of prime-movers		Pump sets with equal size of prime-movers and varying performance	
	Dieselised	Electrified	Dieselised	Electrified
1. Discharge available from the well (developed and tested) cusec	0·3	0·3	0·3	0·4
2. Size of the prime-mover	10 HP	7·5 HP	10 HP	10 HP
3. Cost of lift irrigation equipment excluding the cost of civil structures which are common in all the cases (Rs.) ..	6,370	3,824	6,370	4,315
	(These values were obtained from the sample farmers)			
4. Utilization of the plant (assumed feasible range in hours per year) ..	500 to 2,000	500 to 2,000	500 to 2,000	500 to 2,000
5. Output/quantity of water lifted (acre-inches per year)	150-600	150-600	150-600	200-800
6. Annual saving in operating cost for the electrified pump (Rs.) .. .. @ Rs. 1,100 — 484* + 1·37x	—	821-1,438	—	—
@ Rs. 1,100 — 390* + 1·37x	—	—	—	915-1,532
7. Contribution from extra performance of electrified pump 50 to 200 acre-inches which cost Rs. 3·37 acre-inches and can be sold at Rs. 10 per acre-inch (Rs.)	—	—	—	331-1,326
8. Total annual saving in operating cost in the case of electrified pump (Rs.)	—	821-1,438	—	1,224-2,458
9. Saving in initial capital investment in the case of electrified pump (Rs.) ..	—	2,546	—	2,053

* Saving in fixed cost component is reduced by Rs. 484 and Rs. 390 as contribution on the investment saved (*i.e.*, 9 per cent interest and 10 per cent depreciation on the differences in investment, *e.g.*, Rs. 2,546 and Rs. 2,055 in both the cases).

As indicated in Table III, the farmers gain at both the ends (initial investment and annual operating cost) if they opt for electrification of their wells under different operating conditions.

The farmers who, instead of waiting for electricity, have installed diesel engines to operate their pumps are apparently at lesser advantage than those of the first category. In the case of such farmers (category 2) the gains of electrification are to be measured by considering the relevant costs only. This can be explained through an illustrative example. Consider a farmer substituting his 10 HP diesel engine with 7½ HP electric motor with the following conditions:

1.	Discharge of the pump ..	0.3 cusec (limited)
2.	Condition of pipes and pipe fittings ..	Usable with electric motor.
3.	Condition of the diesel engine of good quality ..	Used for 3 years; in perfect working condition; can be sold out with counter shaft, belts and pump @ Rs. 3,500.
4.	New purchase ..	Electric motors with pumps, (7½ HP) starters, wiring, installation, etc., costing Rs. 3,500. (Incremental investment: Nil)

The gain from substituting electricity for diesel can be worked out as indicated in Table IV.

TABLE IV—GAINS TO THE FARMER WHO SUBSTITUTES HIS DIESEL ENGINE WITH ELECTRIC MOTOR OF EQUAL PERFORMANCE

Item	Diesel engine set to be substituted	Electrified pump to be installed
1. Size of prime-mover	10 HP	7 HP
2. Quantity of water lifted (rate)	0·3 cusec	0·3 cusec
3. Incremental cost of irrigation equipment ..	—	Nil
4. Utilization of pump set in hours per year (assumed range)	500 to 2000	500 to 2000
5. Quantity of water lifted in acre-inches per year	150 to 600	150 to 600
6. Saving in operating cost @ Rs. 1·37 per acre-inch	—	206 to 822
7. Contribution from extra performance	—	Nil

Here, the relevant costs must be compared. The incremental investment is nil (3500—3500=0). The incremental gain is Rs. 206 to 822 per year (if he operates for 500 to 2000 hours/year) plus some gain through reduction in the cost of repairs and maintenance. Thus, the gain from electrification to the farmer who has to substitute the prime-mover is a little less than the gain to the farmer who has yet to install a power operated pump. Anyway, the proposal of substitution is acceptable as it does not involve any additional investment and brings some additional gain per year besides a lot of convenience in operation.

Average Unit Cost of Lift Irrigation

The average unit cost of operation at different levels of pump operation was worked out for both the types of pump sets from the relationship established earlier. These data are presented in Table V for easy comparison.

TABLE V—AVERAGE UNIT COST OF OPERATION OF DIFFERENT TYPES OF PUMP SETS

Level of operation (acre-inches/year)	Average unit cost in Rs./acre-inch			Remarks
	Dieselised pump (Ud)	Electrified pump (Ue)	Difference between (Ud) and (Ue)	
200	21·74	14·87	6·87	
300	16·07	11·04	5·03	* A dieselised pump of 0·3 to 0·4 cusec discharge would not operate beyond 1000 acre-inches/year under normal conditions of cropping and irrigation.
400	13·24	9·12	4·12	
500	11·54	7·97	3·57	
600	10·41	7·20	3·21	
700	9·40	6·66	2·74	
800	8·99	6·24	2·75	
900	8·52	5·92	2·60	
1000	8·14	5·67	2·47	
1100	*	5·46	*	
1200	*	5·28	*	

It is quite clear from the data given in the above table that the cost of lifting water can be minimized through (*a*) operating the pump set for the maximum possible performance, and (*b*) selection of electric motor in place of diesel engine as prime-mover of the pumps.

Break-even Point

The next point of importance in cost analysis is the minimum operating level which the farmer must attain so as not to lose in the deal of lift irrigation. This is called the break-even point (BEP) which can be derived from the cost and revenue functions. During our study, the farmers were asked about the rate at which they sold water to the other farmers. It was observed that the water rates varied as follows:

Discharge		Rs./hour
0·5 cusec	..	4 to 6
0·4 cusec	..	3 to 5
0·3 cusec	..	2½ to 3½

Thus, the average selling rate was about Rs. 10 per cusec hour or per acre-inch. The farmers, besides using the lift irrigation plant to irrigate their own land, shared the spare capacity with others, either on crop-share basis or on actual sale of water. The ratio of own land: others' land under irrigation in different seasons was observed to be quite significant. It was learnt that even on crop-share basis, the farmers got returns at the rate of Rs. 8—12 per cusec hour or acre-inch. Thus, the gross revenue from irrigation water can be taken at Rs. 10 per acre-inch of irrigation water. Any gain besides the above rate in the case of self-use can be attributed to actual farming.

A break-even chart or profitograph is drawn with selling rate @ Rs. 10 per acre-inch and other cost functions observed for dieselised and electrified wells (Figure 1). The following conclusions can be drawn from the break-even chart.

(a) Cost-line of a dieselised pump does not cross the cost-line of an electrified pump at any level of operation which indicates that the electrified pumps are cheaper than the dieselised pumps for operation at any level.

(*b*) The break-even point (at which the revenue line crosses the cost-line) for an electric motor is 350 acre-inches of water/year, whereas the same for a dieselised pump is 650 acre-inches of water/year.

(*c*) If the pumps are operated at below BEP level, the owners of such pumps would lose in irrigation activity and get less contribution towards overhead (fixed) expenses.

(*d*) If an electrified pump is chosen instead of a dieselised pump (at investment stage), the farmer would tend to gain Rs. 2,059 in operating cost at the average output of 700 acre-inches per year. This saving will go down as the performance deteriorates, and rise if the performance improves.

Which Fuel Deserves Subsidy

It can be seen from Table I that the overall operating cost per acre-inch of water is Rs. 9.60 in the case of dieselised pumps and Rs. 5.87 in the case of electrified pump sets. Such difference is partly because of high fuel cost as diesel fuel is costlier than the electrical energy. Besides such differences in fuel cost, the revenue functions. During our study, the farmers were asked about the rate at which they sold water to the other farmers. It was observed that the water rates varied as follows:

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Many persons feel that the difference in cost of crude oil (LDO) and electricity is artificially created by taxing the crude oil and subsidizing electricity. Some privileged farmers who were located in the villages nearer the power lines got their wells electrified earlier and obtained the advantage of cheap fuel for lift irrigation. The others who were located in the villages away from the power lines were left without any alternative but to pay heavy price for the fuel required to operate their dieselised pumps. In fact, both the types of farmers are practising the same type of agriculture and there should not be any discrimination as they deserve identical treatment from the government. How far taxation of diesel (LDO) and subsidizing electricity widens the gap between the privileged farmers and the unprivileged farmers, is worth consideration by the policy makers of the State departments/organizations, which help the farmers in enhancing agricultural production.

A CASE STUDY ON THE FINANCIAL FEASIBILITY OF ELECTRICALLY OPERATED DEEP TUBE-WELL IN ILLAMBAZAR DEVELOPMENT BLOCK IN WEST BENGAL

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INTRODUCTION

Rural electrification has opened a wide vista for agricultural development of our country. The demand for electricity in the rural areas is on the increase. Irrigation which is so essential for successful farming has become easier and perhaps cheaper with rural electrification. It is a common belief of the farmers that

2. Duty on light diesel oil is about 18 paise per litre which is about 36 per cent of the retail price of light diesel oil. Besides duty, there are local taxes also. All these taxes work up to four paise per HP hour of operation.

* The authors express their thanks to Dr. L. S. Venkataramanan, Head of the Division of Agricultural Economics, Indian Agricultural Research Institute, for help and suggestions. They are indebted to Shri S. K. Aditya, Joint Block Development Officer, Suri I Development Block, who rendered valuable assistance in data collection. The views expressed in this paper are strictly the personal views of the authors.