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taken back to the farmstead after the irrigation work is over. (3) The fixed energy charges in the case of electric tube-wells (Rs. 15 per H.P. per month) were so high that the farmers were not using any electricity beyond the fixed charges. (4) The running hours for diesel tube-wells were nearly half of that of the electric tube-wells mainly because the diesel pumping sets were owned by the small farmers (size of farm 7.5 acres). (5) There were no significant differences in the delivery rates of the tube-wells. It was around 0.71 cusecs for all the wells in the sample. (6) Due to greater quantity of water pumped out by the electric tube-wells, there was no substantial difference in the cost of water. It may be said that the cost of water from the diesel tube-wells was only about 10 per cent greater than the cost of water from the electric tube-wells.

INVESTMENT PATTERN AND COST ANALYSIS OF ELECTRICAL AND DIESELISED PUMPS USED FOR LIFT IRRIGATION IN MEHSANA DISTRICT (GUJARAT)

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About 98 per cent of the irrigated area is under well irrigation in Mehsana district in Gujarat, where different types of devices, namely electrical tube-well (ETW), electrified dug-cum-bore-well (EDBW) and dieselised dug-cum-bore-well (DDBW) are used for lift irrigation. In the absence of comparative information on investment and cost aspect of different types of pumps in the district, the farmers find it difficult to select the right type of device for irrigation according to their needs and resources. It also creates problems for the financing institutions while sanctioning loans for such purposes. Hence, an attempt has been made in the present paper to study the investment pattern and cost of water lifted by electrical and dieselised pumps in the district.

METHODOLOGY

The specific methodology adopted for the selection of different sampling units, *viz.*, talukas, villages and pumpsets are discussed below.

Talukas

A list of all the talukas in Mehsana district was prepared and a taluka having fewer number of pumpsets and irrigated area was discarded from the list. The remaining ten talukas were arranged in ascending order of the area per pumpset and they were divided into two equal strata. One taluka was then selected at random from each stratum. Thus, two talukas, namely, Sidhpur and Patan were selected.

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Villages

A list of all the villages in each selected taluka was prepared and the villages which were not electrified and having less than five pumpsets were discarded from the list. Further, the villages were arranged in ascending order on the basis of number of pumpsets and were classified into three strata, *viz.*, stratum one with villages having 5 to 15 pumpsets, stratum two with villages having 16 to 30 pumpsets and stratum three with more than 30 pumpsets. Then, one village from each stratum was selected at random. Thus, 6 villages in all (3 villages from each taluka) were selected.

Pumpsets

All the pumpset owners of the sample villages were selected for detailed study. In the case of joint ownership of pumpsets, only the major partner was considered as respondent. Thus, finally 111 pumpsets (24 ETW, 31 EDBW and 56 DDBW) were selected for detailed study. The data were collected by survey method for the year 1973-74.

RESULTS AND DISCUSSION

The pattern of capital investment, sources for capital investment, performance and operating cost of pumpsets according to the type of well are presented below.

Pattern of Investment

There is considerable variation in the intensity and pattern of investment among different types of pumps, as can be seen from Table I.

TABLE I—PATTERN OF CAPITAL INVESTMENT IN IRRIGATION

Particulars	ETW		EDBW		DDBW	
	Total	Per pump	Total	Per pump	Total	Per pump
Pumpsets	24	—	31	—	56	—
Horse power	883	36·79	332	10·70	485	8·66
Investment (Rs.)						
(1) For creation of water ..	12,48,000	52,000 (50·36)	1,26,952	4,095 (28·07)	2,07,621	3,708 (32·66)
(2) For lifting the water ..	7,61,700 863*	31,737 (30·74)	1,87,333 564*	6,043 (41·42)	3,16,533 653*	5,652 (49·79)
(3) Transmission of water and other civil works..	4,68,550	19,552 (18·90)	1,37,965	4,450 (30·51)	1,11,575	1,992 (17·55)
Total investment	24,78,250	1,03,259 (100·00)	4,52,250	14,588 (100·00)	6,35,729	11,352 (100·00)
Investment/H.P.	2,807		1,362		1,311	

Note :—Figures in parentheses indicate the percentages to the total investment.
* Investment per horse power.
(1) It includes cost of digging charges, pipes, compressor, etc.
(2) It includes cost of pump, pipe fitting, pullies, belts, prime movers, cost of electrification, etc.
(3) It includes underground pipelines, *pucca* channel, water tank, room, etc.

Table I reveals that the average investment per pumpset was Rs. 1,03,259 for electrical tube-well, Rs. 14,588 for electrified dug-cum-bore-well and Rs. 11,352 for dieselised dug-cum-bore-well. In ETW, half of the total cost was invested for creation of water while this cost was only 28.07 per cent in the case of EDBW and 32.66 per cent in DDBW. The proportion of total investment for lifting the water was highest (49.79 per cent) in DDBW and lowest (30.74 per cent) in ETW, while the proportion of total investment for transmission of water and other civil works was highest (30.51 per cent) in EDBW, followed by ETW (18.90 per cent) and DDBW (17.55 per cent). Since the investment for lifting the water depends on the size of prime mover, therefore, for better comparison of different devices used for lifting the water, investment per horse power was calculated. The investment per horse power was Rs. 863 in ETW, Rs. 564 in EDBW and Rs. 653 in DDBW, which indicates that EDBW is the cheapest among all the three devices used for lifting the water. Further, the total investment per h.p. in ETW, EDBW and DDBW was Rs. 2,807, Rs. 1,362 and Rs. 1,311 respectively.

Sources of Investment

The amount and sources of fund raised for capital investment for creating lift irrigation facilitity according to the type of pump is given in Table II. It

TABLE II—SOURCES OF FUND FOR CAPITAL INVESTMENT IN IRRIGATION

(*thousand rupees*)

Sources of fund	ETW			EDBW			DDBW		
	Borrowed/ owned	Paid back	Per cent of borrowed money paid back	Borrowed/ owned	Paid back	Per cent of borrowed money paid back	Borrowed/ owned	Paid back	Per cent of borrowed money paid back
A. Institutional									
Land development bank	286 (11.54)	180	62.94	74.0 (16.38)	48.6	65.68	142.8 (22.46)	86.7	60.71
District co-operative bank	80 (3.23)	80	100.00	—	—	—	2.2 (0.35)	2.2	100.00
Commercial bank ..	404 (16.30)	129	31.93	6.0 (1.33)	3.2	53.33	11.0 (1.73)	9.9	81.82
Total (A) ..	770 (31.07)	389	50.51	80.0 (17.71)	51.8	64.75	156.0 (20 54)	97.9	62.75
B. Non-institutional									
Friends and relatives	159 (6.42)	55	34 59	16.0 (3.54)	4.5	28.13	5.0 (0.79)	5.0	100.00
Moneylender* ..	305 (12.31)	—	—	15.8 (3.49)	7.3	69.89	64.0 (10.06)	12.5	19.53
Total (B)	464 (18.73)	55	11.85	31.8 (7.03)	11.8	37.10	69.0 (10.85)	17.5	25.36
C. Total borrowed (A+B)	1,234 (49.80)	444	35.98	111.8 (24.72)	63.2	56.53	225.0 (35.39)	115.4	51.29
D. Own fund ..	1,244 (50.20)	—	—	34 05 (75.28)	—	—	410.7 (64.61)	—	—
E. Total investment	2,478 (100.00)	—	—	452.3 (100.00)	—	—	635 7 (100.09)	—	—

Note :—Figures in parentheses indicate the percentages to the total investment.
* This also includes commission agents and traders.

can be observed from the table that the proportion of total investment borrowed from institutional sources for ETW, EDBW and DDBW was about 31 per cent, 18 per cent and 25 per cent respectively. Among institutional agencies, the land development bank gave proportionately more finance to EDBW and DDBW which require lower investment per pumpset, while it was just the reverse in the case of the commercial bank which financed more to ETW. It shows the lesser risk bearing capacity of the land development bank than the commercial bank. Non-institutional finance to ETW, EDBW and DDBW was about 19 per cent, 7 per cent and 11 per cent of the total investment respectively. Own fund was more than half in ETW, three-fourth in EDBW and about two-thirds of the total investment in the case of DDBW. The proportion of borrowed money paid back was about 36 per cent in ETW, 57 per cent in EDBW and 51 per cent in DDBW.

Operating Cost

The total operating cost and its factorwise distribution according to the type of pump is presented in Table III.

TABLE III—FACTORWISE DISTRIBUTION OF OPERATING COST

(*Rs./year*)

Particulars	ETW		EDBW		DDBW	
	Total	Per pump	Total	Per pump	Total	Per pump
A. *Fixed cost*						
Depreciation	1,51,175	6,298	32,580	1,051	48,794	871
Interest	2,97,390	12,391	54,270	1,750	72,288	1,290
Others	20,512	854	10,540	340	—	—
Total (A)	4,69,077 (62.62)	19,543	97,390 (56.66)	3,141	1 25,082 (43.90)	2,161
B. *Variable cost*						
Power/fuel	1,93,500	8,062	47,993	1,548	65,544	1,170
Oil	—	—	—	—	29,438	525
Repairs	33,075	1,378	17,425	562	36,375	469
Labour	53,400	2,225	9,050	292	28,550	510
Total (B)	2.79,975 (37.38)	11,665	74.468 (43.34)	2,402	1.59,907 (56.10)	2.854
Total operating cost (A + B)	7,49,052 (100·00)	31,210	1,71,858 (100·00)	5,543	2,84,989 (100·00)	4,915

Note :—Figures in parentheses indicate the percentagns to the total operating cost.

Table III reveals that the proportion of fixed cost to the total cost was about 63 per cent in ETW, 57 per cent in EDBW and 44 per cent in DDBW, while the variable cost was comparatively higher in DDBW than in EDBW and ETW. It may be due to the higher cost of operating the oil engine than the electric motor. Since the operating cost depends on several factors like number of hours operated per year, size and type of prime mover, quantity of water lifted, etc., therefore for better comparison of different types of pumps, the cost per hour, cost per horse power hour and cost per hectare centimetre were calculated and are presented in Table IV.

TABLE IV—PERFORMANCE AND OPERATING COST PER UNIT

Particulars	ETW	EDBW	DDBW
Number of pumpsets	24	31	56
Total horse power	883	332	485
Horse power per pumpset	36·79	10·70	8·66
Operated hours per year	50,587	36,862	51,966
Operated hours/pump/year	2,107	1,189	928
Water lifted per year in hectare centimetre	27,890	8,458	12,342
Water lifted per pump per year in hectare centimetre	1,162	272	220
Cost per hour (Rs.)			
Fixed	9·42	2·64	2·46
Variable	5·53	2·02	3·08
Total	14·95	4·66	5·54
Cost per horse power hour (Rs.)			
Fixed	0·27	0·25	0·29
Variable	0·16	0·19	0·36
Total	0·43	0·44	0·65
Cost per hectare centimetre (Rs.)			
Fixed	16·82	11·51	10·13
Variable	10·33	8·80	12·96
Total	27·15	20·31	23·09
Average discharge of water			
Cusec	0·60	0·23	0·24

Operating Cost Per Unit

It can be observed from Table IV that the operating cost per hour for ETW, EDBW and DDBW was Rs. 14.95, Rs. 4.66 and Rs. 5.54 respectively, which shows that there is considerable variation in the operating cost among different types of pumps. In ETW the fixed cost was four times more than DBW, while the variable cost was three times more in ETW. It was mainly due to the investment of more capital in the creation of water and the big size of pump and prime mover required for lifting the water from ETW. But no significant difference was observed in the fixed cost between EDBW and DDBW, because both are of same group, namely, dug-cum-bore-well and also there was not much variation in the size of prime movers. The variable cost was higher in DDBW than in EDBW, which indicates that EDBW is the cheapest among all the three types of pumpsets. For removing variation in the variable cost due to size of prime mover, the cost per horse power hour was calculated and it was found highest in DDBW and lowest in ETW, which shows that running of DDBW is more than two times costlier than ETW and EDBW. Further, the table reveals that the total cost per hectare centimetre was Rs. 27.15, Rs. 20.31 and Rs. 23.09 for ETW, EDBW and DDBW respectively, which shows that irrigation cost will be more if the crop is irrigated through ETW rather than through DBW. Among DBW, the cost of irrigation per hectare will be higher in DDBW than in EDBW. Thus, the above analysis shows that the water lifted from DBW for irrigation is cheaper than ETW and among DBW, EDBW is cheaper than DDBW. It may be due to lower discharge of water per unit investment from ETW than from DBW. The capital investment in ETW is seven to nine times more than DBW, while the discharge is only about two and half times more.

Cost at Different Levels of Performance (hours)

The unit operating cost at different levels of operation of pumpset in hours is given in Table V.

TABLE V—OPERATING COST AT DIFFERENT LEVELS OF PERFORMANCE OF PUMPSETS IN HOURS

(*Rupees*)

Level of operation (hours/year)	ETW		EDBW		DDBW	
	Cost per		Cost per		Cost per	
	Hour	Hectare cm.	Hour	Hectare cm.	Hour	Hectare cm.
Below 500	77·00	95·02	18·32	49·61	8·92	35·08
501 — 1,000	27·30	62·72	6·30	26·81	6·73	27·15
1,001 — 1,500	26·94	36·64	4·76	21·45	4·53	19·42
1,501 — 2,000	16·22	34·33	3·59	15·63	4·25	18·57
2,001 — 2,500	13·19	30·66	2·55	10·80	3·24	14·79
2,501 — 3,000	13·23	20·20	2·44	11·04	—	—
3,001 — 3,500	12·61	19·33	2·18	15·11	—	—
Above 3,500	9·12	17·43	—	—	—	—
Average	14·95	27·15	4·66	20·31	5·54	23·09

Table V clearly indicates that the total cost per hour and per hectare centimetre decreased with the increase in the operating hours per year. The unit operating cost of ETW operated below 2,000 hours per year was more than the average cost. Similarly, the unit cost of EDBW operated below 1,500 hours per year was more than the average cost, while it was 1,000 hours in the case of DDBW.

Cost at Different Levels of Performance (hectare cm.)

The unit operating cost according to the volume of water lifted by pumpset in hectare centimetre per year can be seen in Tabe VI.

TABLE VI—OPERATING COST AT DIFFERENT LEVELS OF PERFORMANCE OF PUMPSETS IN HECTARE CENTIMETRE

(*Rupees*)

Performance level in hectare cm./ year	ETW Cost per		Performance level in hect. cm. year	EDBW Cost per		DDBW Cost per	
	Hour	Hectare cm.		Hour	Hectare cm.	Hour	Hectare cm.
Below 250 ..	31·72	91·66	Below 100	9·83	70·58	7·29	49·03
251 — 500 ..	26·95	67·90	101 — 200	5·25	29·51	6·25	30·11
501 — 750 ..	—	—	201 — 300	7·11	24·58	5·07	21·59
751 — 1,000 ..	17·17	34·38	301 — 400	4·34	19·92	4·72	15·01
1,001 — 1,250 ..	13·44	30·34	401 — 500	2·19	16·11	4·67	14·24
1,251 — 1,500 ..	11·71	19·48	501 — 600	2·89	10·51	4·66	11·87
1,501 — 1,750 ..	11·85	25·10	Above 600	2·89	7·26	—	—
1,751 — 2,000 ..	11·94	20·51	—	—	—	—	—
Above 2,000 ..	11·99	13·77	—	—	—	—	—
Average ..	14·95	27·15	Average	4·66	20·31	5·54	23·09

It is revealed that the cost per hectare centimetre decreased with the increase in the performance in the case of EDBW and DDBW, while no clear trend was observed in ETW.

Relationship between Cost and Performance

The relationship between total operating cost and performance of pumpset in terms of hours of operation as well as the quantity of water lifted was studied through regression analysis. Since the operating cost (Y) depends on number of hours (Xh) operated as well as quantity of water lifted in hectare centimetre (Xhc) by the pumpset, therefore the effects of Xh and Xhc on Y were studied separately with the help of linear regression and the form of equation is given below. :

$$Y = a + b\ Xh$$

$$Y = a + b\ Xhc$$

where

Y denotes total operating cost in rupees/year,

Xh performance of pumpsets in hours/year,

Xhc performance in terms of quantity of water lifted/year,

a constant and

b regression coefficient.

The result of regression analysis is given in Table VII.

TABLE VII—RELATIONSHIP BETWEEN TOTAL OPERATING COST AND PERFORMANCE

Type of pumps	Linear equation	R^2
ETW	Y = 21000+5·6332Xh**	0·76
	Y = 21000+7·1818Xhc**	0·66
EDBW	Y = 4400+1·0188Xh**	0·57
	Y = 4400+3·7418Xhc**	0·52
DDBW	Y = 2850+2·2370Xh	0·24
	Y = 9850+9·4905Xhc*	0·29

* Significant at 5 per cent level.
** Significant at 1 per cent level.

It can be observed from Table VII that the performance of pumpsets in terms of hours operated as well as water lifted in hectare centimetre showed significant (at 1 per cent level) impact on operating cost of different types of pumpsets, except DDBW. Further, the total operating cost increased by Rs. 5.63 in ETW, Re. 1.01 in EDBW and Rs. 2.24 in DDBW with the increase in operation by one hour. Similarly, this cost was Rs. 7.18 in ETW, Rs. 3.74 in EDBW and Rs. 9.49 in DDBW for lifting one hectare centimetre of water. This clearly indicates the superiority of EDBW over ETW and DDBW.

CONCLUSIONS

The foregoing analysis of capital investment for different types of pumps reveals that investment in ETW is almost seven times more than that in EDBW and nine times more than that in DDBW. The operating cost for lifting one hectare centimetre of water is lowest in EDBW, followed by DDBW and ETW, which shows that the water lifted from DBW for irrigation is cheaper than ETW and among DBW, EDBW is cheaper than DDBW. Therefore, it is suggested that before investing heavy amount on ETW in the area, the other feasible alternatives such as EDBW and DDBW need to be carefully examined and investment in an unplanned manner should be checked.

BIO-GAS FOR FUEL AND FERTILIZERS IN RURAL INDIA—A SOCIAL BENEFIT-COST ANALYSIS

S. Bhavani*

With the ever increasing population the three major and inter-connected problems facing India are food, fuel and fertilizers. Out of over 5 lakh villages, only 1,05,440 villages were electrified and 16,20,522 pumpsets and tube-wells set up by the end of the Fourth Plan. The targets for the Fifth Plan are even higher and in the context of high oil prices, bio-gas plants are expected to play an important role in meeting the fertilizer and fuel requirements of rural India. As a rough estimate, if the entire quantum of cow-dung available for India's 237 million cattle were processed through bio-gas plants, it would provide 28 million tons of fertilizer nutrients (N P K) for Indian agriculture. In addition, these will also produce 22,425 million cu.m. of gas (29.152 million tons of soft coke) to meet the energy needs of the village for irrigation, lighting, agro-based industries and cooking.

I

The objectives of this paper are (*i*) to present a social cost-benefit analysis of a bio-gas plant; (*ii*) to study the economics of a household bio-gas plant vis-a-vis a community plant; and (*iii*) the role of bio-gas plants in meeting the rural energy needs.

It is well-known that, from time immemorial, cow dung has been used in India either for preparing farmyard manure or as a traditional fuel for cooking purposes in village homes. In this connection, it has been estimated that nearly one-third of the cattle dung available in the country is burnt away as fuel owing to the scarcity of alternative sources of energy. This wasteful practice of burning cow dung for fuel in the countryside not only deprives the soil of an important source of organic matter for improving fertility, but also acts as a great hindrance in fully exploiting the energy potential present in the dung.

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