

ECONOMICAL SELECTION OF TUBEWELL COMPONENTS

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Different alternatives for each component of a tubewell are available in the country at present. This has created a problem for the farmers to select the economical alternative for various components of the tubewell. A study conducted to find out the economical alternate for each component of the tubewell considering the life span and replacement cost of respective component. The most economical set of components for the tubewell consists of PVC strainer, PVC suction and blind pipe, local manufactured pump, MS discharge and delivery pipe and electric motor as prime mover. The cost per hectare centimeter of the tubewell using four types of prime mover (Peter engine, Black engine, Electric motor and Tractor) was also compared. The cost per ha-cm for the electric tubewell is less than other types for the both cases (with or without electrical connection and electrical accessories) of electric tubewell.

INTRODUCTION

Irrigation water is an essential input for increasing cultivated land and is the most crucial factor of Pakistan's agricultural production which contributes 45 percent of the gross national product (Awan, 1979). To increase agricultural production, land is not a limiting factor as there is more cultivable land than can ever be properly irrigated. The main cause of low agricultural production is the shortage of irrigation water (Awan, 1979). One cumec of a perennial canal discharge is supplied for 4887 hectares in most of the irrigated areas of Pakistan which is insufficient to meet the desired cropping intensity of 200 percent (Bukhari *et al.* 1980).

Ground water is the major supplementary source of irrigation. Fortunately, the substrata of the Indus plain consists of a good aquifer, mostly unconfined near the river beds and in other cases confined underlain or overlain

by impermeable layers. The entire aquifer is saturated with water and assures a vast reservoir of ground water which can supply additional water through pumping. Inadequacy and unreliability of canal supplies and the population pressure for more food production, gave an impetus to private tubewell development in Pakistan.

Various studies in the past have been conducted such as Afzal, 1980, Bukhari, *et al.* 1980, etc. for the estimation of cost of pumping water and the economical selection of various components. Different components of the tubewell have different working life. But in most of the previous work (Afzal, 1980) only one installment of each component has been considered. It was therefore, planned to find out the economical alternative for each component of the tubewell with replacement and to determine the cost per hour and per hectare centimeter for the tubewell using four types of prime mover i.e. high speed diesel engine locally called "Black Engine",

electric motor (with and without external electrical connection and electrical accessories) and tractor.

MATERIALS AND METHODS

Data Acquisition: The data was collected from drillers, manufacturers of tubewells, farmers and Government organizations for the pertinent informations in tubewell installation and operational costs. For the collection of data, "Interview method" was followed. The cost of each component of tubewell as well as a complete unit was collected from the standard organizations and some private (local) manufacturers. Charges for well digging, boring, bricks, labour, fuel and energy (electrical energy) was also collected from the respective agencies. The informations were collected during the period September to November, 1991.

Economic Considerations: The economical approach was used to estimate the cost of tubewell using different alternatives for each component. The present worth value (PWV) for any component was calculated as follows.

$$PWV = T \frac{(1+r)^n}{(1+I)^n} \quad (1)$$

where:

- PWV = Present worth value (Rs.)
- I = Interest rate %
- n = Life of component or period of analysis in years
- T = Replacement cost (Rs.)
- r = Cost escalation %

PWV takes into account the cost of replacement that will occur at the

beginning of the project. The present worth of the salvage value remaining at the end of the analysis period has also been determined and subtracted from the initial capital and present worth costs. The components with lowest present worth values have been selected for the complete unit of a tubewell. The total initial cost of tubewell has been determined adding the initial costs of the components.

Costs Comparison: The comparison amongst different types of prime movers has been made to evaluate the cheapest one for the same annual hours of operation, i.e., 1839 hours (5 hours daily). The present custom hiring rate of tractor, Rs. 50 per hour has been considered for this comparison. The equivalent annual cost (EAC) has been determined of the annual operational costs for 40 years period of operation to suggest the prime mover of the lowest operational cost.

$$EAC = C \left[\frac{(1+rt)^n (1+I)^n}{(1+r)^n - (1+I)^n} \times \frac{[1 - (1+I)^{-n}]}{(1+I)^n - 1} \right] \quad (2)$$

where:

- EAC = Equivalent annual cost (Rs.)
- C = Purchase cost (Rs.)

The capital recovery factor (CRF) has been determined as:

$$CRF = \frac{I \times (1+r)^n}{(1+r)^n - 1} \quad (3)$$

The annual amortization value (AAV) of present worth value (PWV) has been determined from the following relationship.

$$AAV = PWV \cdot CRF \quad (4)$$

The values of the above two items (EAC and AA V) have been added to evaluate the cheapest alternative in terms of both capital and operational costs.

Cost of Operation

A) Fixed costs: Fixed costs include those for depreciation, interest, taxes, shelter and insurance.

a) Depreciation Cost: This cost reflects the reduction in value of the machine (tubewell) due to wear. For the purpose of estimating cost of operation of agricultural machines, the straight line depreciation method is widely followed where in equal reduction of value is used for each year the machine is owned (Pandey and Ojha, 1986). Following this method, the average annual depreciation (AAD) has been determined by the following formula.

$$AAD = \frac{P-S}{Y} \quad (5)$$

where:

- AAD = Average annual depreciation
- P = Purchase price of tubewell (Rs.)
- S = Salvage value (Rs.)
- Y = Average life of tubewell unit in years

The hourly depreciation cost has been determined by dividing the AAD with annual use in hours.

b) Interest: This is a direct cost on borrowed capital, even if cash is paid for purchased machinery, the money is tied up which could be used elsewhere in the business. This component of the fixed cost is proportional to the average investment

and is determined by using the following formula (Pandey and Ojha, 1986).

$$Q = \frac{I(P+S)}{200H} \quad (6)$$

where:

H = Annual use of the tubewell in hours.

c) Insurance, Taxes and Shelter: Insurance policies may be included for the case of tubewell as a safety factor from theft etc. Taxes are paid on some machinery in the same manner as for other property. The total of all these (Insurance, taxes, etc.) may be taken as 3.5% of the average investment annually. Assuming taxes, Insurance etc. as 3.5% of initial cost the equation 6 becomes

$$Q = \frac{0.55(I + 3.5)P}{100H} \quad (7)$$

H) Variable Costs

a) Repair and Maintenance:

Although there is wide variations in the repair and maintenance costs with the annual use of different types of components of tubewell, but for comparison purposes of four types of tubewells (Black engine, Electric motor, Peter engine and Tractor), the average value of this component may be taken.

b) Fuel and Lubricants: Fuel consumption depends on the size of the power unit, load factor and operating conditions. The annual cost of fuel has been determined by the following relationships. For Black and Peter engine:

$$\text{Annual Cost (C)} = F_e \cdot 11 \cdot R_f \quad (8)$$

The fuel consumption (F_e) has

been used 0.23 lit/BHP-hr (Michael, 1990). The present fuel price (Rc) @ Rs. 5.07 per liter was taken for this study. The lubricants costs was considered as 15% of annual fuel charges and repair costs as 6% of initial cost of Black and Peter engine respectively. The pump repair costs have been considered 4% and power transmission accessories 6% of their initial costs respectively (Jensen, 1980). The total fuel and lubricant costs can be written in the form:

$$\text{Fuel \& Lubricants cost} = 1.15 P_c R_c \quad (9)$$

c) Electrical energy cost: When the prime mover for a tubewell is electric motor, the electric energy cost per hour can be calculated by the relation (Micheal, 1990).

$$E_e = \frac{\text{BHP}}{E} \times 0.746 \times R_e \quad (10)$$

where:

- BHP = Break horse power of the motor, hp.
- E = Efficiency of electric motor.
- E_e = Energy cost per hour
- R_e = Energy price (Rs/kWh)

The present energy price was taken as 0.85 Rs/kWh. The repair costs have been taken as 2% of the initial cost and lubricants costs 2% of the annual energy costs for the electric motor. (Janeson, 1980). Efficiency of electric motors usually vary from 80 to 90% (Michael, 1990). The average value of 85% motor efficiency was used in the present study.

d) Operator/Labour Cost: In performing operations with a tubewell, one operator is required. The charges for

labour have been selected as Rs. 3 per hours. On the basis of the above assumptions and by taking all components of fixed and variable costs, as described above, the hourly cost of operation (H.C.O.) of a tubewell can be expressed as follows (Pandey and Ojha, 1986).

$$\text{H.c.a.} = \left[\frac{0.9 + 0.55}{Y.F} \frac{(1 + 3.5)^F}{100H} \right]^{P+F+N} \times R \quad (11)$$

where:

- F = 1.15 x F_{ex} R_c
= 1.02 x (BHP / E) x 0.746 x R_e
- F_m = Maintenance cost factor per hour per unit purchase price.
- F_e = Fuel consumption, l/hr
- N_o = Number of operators required
- R₁ = Hiring rate of operator, (Rs/Hour)

The cost per hac-cm can be determined by the following relation.

$$C/\text{ha-cm} = \frac{C/\text{hr} \times 100}{3.6 \times Q} \quad (12)$$

where:

- C/h = Cost per hour of tubewell
- C/ha-cm = Cost per ha-cm of tubewell water
- Q = Discharge of tubewell in lps

RESULTS AND DISCUSSION

Economical Analysis: The analysis has been made assuming 40 years period of

operation by determining the present worth values of replacements for the each alternative of the component against its expected life using interest rate as 12% and cost escalation taken as 10%. The present worth of the salvage value remaining at the end of the analysis period has been estimated and subtracted from the initial capital and present worth costs. This set of calculations resulted in a single present worth value for the present case.

adopt this method. The present worth for the drilling and gravel material is equal to their initial investments for the analysis of 40 years period. This is because the replacement of these two is due with the replacement of strainer and PVC strainer has its first replacement after 40 years. The alternatives for the components of the tubewell have been selected on the basis of above decision and their initial costs have been added. the selection of various components on economical analysis is

Table 1. Economical analysis of tubewell components

Type of component	Life years	Initial cost (Rs)	Present Worth (PW) Replacement (Rs.)				Salvage value (Rs)	Actual PW (Rs)
			1	2	3	4		
Strainers								
Coir string	9	2800	2380	2024	1721	1437	735	9627
Cement	8	2000	1732	1499	1218	973	-	7502
PVC	40	5540	-	-	-	-	-	5540
Brass	20	27200	18170	-	-	-	2957	476170
Fiber glass	50	30400	-	-	-	-	-	27443
Pipes								
Suction PVC	40	3140	-	-	-	-	-	3140
Suction MS	25	2200	1441	-	-	440	440	2850
Delivery PVC	40	4820	-	-	-	-	-	4820
Delivery MS	25	3200	2007	-	-	640	640	4000
Standard	8	2727	2367	2044	1770	1532	-	10434
	25	9090	5793	-	-	-	1768	13115
MOTOR								
Motor & Acc, Externat connection	25	27600	17590	-	-	-	5370	39820
	50	30000	-	-	-	-	7782	72218
Blackengin	14	36000	27974	21736	-	-	2510	83209
Peter engin	14	20000	15541	12000	-	-	1380	46161
Pump house	50	25697	-	-	-	-	2500	23197
Civilworks	50	20000	-	-	-	-	1946	18054
Gravel								
	20	4182	3189	2000	2305	1003	1003	7099
	40	4182	2971	-	-	-	-	4182
	50	4182	-	-	-	-	406	3076

The drilling by manual method has been selected because most of the farmers

shown in Table 1,

Thus the most economical and

movers in terms of operational costs (Table 2). The equivalent annual cost (EAC) for the electric tubewell is least in both cases i.e. Rs. 92,130 and 1,18,220 for tariff and flat rate respectively and tractor being highest (Rs. 3,20,280).

As the results represented in Table 2, show that the (EAC) is the highest for the tractor followed by Black, Peter engine and electric motor respectively. The total of two components (equivalent annual cost (EAC) and annual amortization value (AA V) is lowest for the electric tubewell in all the four cases and highest for the tractor (Rs. 3,29,684), although the initial cost of the tractor has not been included. The value is least (Rs. 1,03,633) of the electric tubewell for the case, without cost of electrical connection and electrical accessories and energy charges on the tariff basis. The value for Black engine and Peter engine is Rs. 1,83,775 and Rs. 1,75,492 respectively. So, the electric tubewell is economical in terms of total costs i.e. capital plus operational cost than other prime movers. The annual energy cost for the electric tubewell based on tariff is less than flat rate for 5 hours of daily operation. The flat rate is more economical than tariff above 7.62 hours of daily operation. The initial investment for the electric tubewell (without electrical connection and electrical accessories) is least and also highest for the same (with electrical connection and electrical accessories).

The table 3 shows costs comparison for different types of tubewell of 28035 lps (one cusec) capacity. Fixed cost per hour for the electric tubewell is highest i.e. Rs. 12.26 per hour (with cost of electrical connection and electrical accessories) and is about 200% to that of Peter engine.

The operational cost of Black and Peter engine is 190% of the operational

cost of electric tubewell. The cost per ha-cm for the tractor tubewell is highest (Rs. 59.68 per ha-cm) followed by Black engine, Peter engine and electric tubewell respectively. The cost for electric tubewell (without electrical connection and electrical accessories) is lowest (Rs. 21.38 per ha-cm). The fixed cost per hour for the case (with electrical connection and electrical accessories) is highest (Rs. 12.26 per hour) and operational cost is less (Rs. 16.06 per hour) than other prime mover, so that total cost per hour becomes less in this case.

REFERENCES

- Afzal, M. (1980). Private tubewells and current rate of investment, Master Planning and Review Division, WAPDA, Pakistan. 60-65.
- Awan, N.M. (1979). Development of private tubewells in Pakistan using locally manufactured equipments. Center of Excellence in Water Resources Engineering, Lahore, CEWRE, Publication No. 14: 14-15.
- Bukhari, A.S., Koondhar, LDoM. and Devrajani, B.T. (1980) Tubewell Irrigation System Installation, Operation and Cost of Water. Agricultural Mechanization in Asia, Africa and Latin America, 11(1): 37-42.
- Janeson, M'E. (1980). Farm resources and system selection. Design and operation of farm irrigation system. pp. 55-68.
- Michael, A.M. (1990). Irrigation theory and practice. Vikas publishing house (Pvt) Ltd., New Dehli 110014: 279.
- Pandey, M.M. and Ojha, ToP. (1986). Graphical determination of cost of operation on Agricultural machine. Agricultural Mechanization in Asia, Africa and Latin America 17(1): 63-67.