# TECHNICAL NOTES

# CONSERVATION ECONOMICS

June 26, 1986

NOTE NO. 3

Subject: Economics - Report - Estimating Breakeven Cost When Converting From Pump to Gravity Pressurized Irrigation Systems

This Conservation Economics Technical Note transmits Report No. 3.

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# TECHNICAL NOTE

Subject: ECONOMICS

Series No.: 3

Reference: ESTIMATING BREAKEVEN COST WHEN CONVERTING FROM PUMP TO GRAVITY PRESSURIZED IRRIGATION SYSTEMS

Date: AUGUST 28, 1984

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

# ESTIMATING BREAKEVEN COST WHEN CONVERTING FROM PUMP TO GRAVITY PRESSURIZED IRRIGATION SYSTEMS
AUGUST 1984

Faced with rising energy costs and continuing maintenance and repair for pumps and motors, irrigators are searching out means to reduce cost. One alternative may be to replace the pump and motor with a pipeline having an inlet elevation which will deliver water with sufficient gravity pressure to operate the sprinkler system. The purpose of this technical note is to describe a procedure for estimating the breakeven capital investment which can be made to replace pumped pressure with gravity pressure in a sprinkler irrigation system.

Economic feasibility of replacing pumped pressure with gravity pressure can be indicated by comparing all future pumped costs plus the value of salvageable items to the cost of works required to provide gravity pressure.

Questions which must be answered to estimate maximum feasible (breakeven) capital investment and indicate economic feasibility are:

1. What planning horizon or evaluation period will be used in the analysis?

2. What interest rate will be used in the analysis?

3. What is the current value of the average annual energy consumed to provide pumped pressure including hookup or demand charges?

4. What annually compounded rate of escalation in the price of the energy source is expected?

5. What is the current average cost of repair and maintenance for the pump and motor?

6. What annually compounded rate of escalation in the price of pump and motor repair and maintenance items is expected?

7. What is the current salvage value of the pump and motor which would be eliminated?

8. What is the current installation cost of the gravity pressure pipeline?

9. What is the current average cost of repair and maintenance for the gravity pressure pipeline?

10. What annually compounded rate of escalation in the cost of gravity pressure pipeline repair and maintenance items is expected?

Items 1 through 7 above are inputs used to calculate the present value of costs which will be replaced. Inputs 1, 2, 8, 9, and 10 are used to calculate the

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present value of costs which will be added. Economic feasibility of a gravity pressure pipeline installation is indicated when costs replaced are greater than costs added or, more simply, if there is a cheaper way of providing pressure.

EXAMPLE

The procedure and development of present value factors is explained using the following example problem:

A cooperator has installed a pump, motor, mainline, and sideroll to irrigate 40 acres. His records indicate that he is currently (1984) spending \$1,500 (3) per year for energy, and has averaged \$500 (5) per year for pump and motor maintenance and repair. The current salvage value for the pump and motor is \$4,000 (7).

The cooperator expects energy costs to increase 10 percent (4) and repair and maintenance items 5 percent (6) per year during his 15-year planning horizon (1). The cooperator would like to compare his options using the current interest rate of 14 percent (2) he pays for borrowed funds.

The description above answers questions 1 through 7 which are used to calculate the present value of costs which would be replaced by a gravity pressure pipeline. Costs which are replaced include energy purchases, pump and motor repair and maintenance, and the pump and motor salvage value.

ENERGY

Replaced energy purchases during the 15-year evaluation period must be adjusted for the expected 10 percent per year price increase and discounted to present value using the interest earning power of money of 14 percent. Consider that energy purchased with \$1 today has a present value of \$1, but the same amount of energy 1 year hence will cost \$1.10 (10 percent increase) and that the same dollar could have earned 14 percent interest. Therefore, the expected energy cost of \$1.10, 1 year hence, discounted to present value is \$1.10 times .87 (present value of 1, 1 year hence, 14 percent interest) or \$.96. The same adjustment must be made for two years hence when energy is expected to cost \$1.21 (another 10 percent increase) and all subsequent years covering the 15-year period, now through 14 years hence. Factors for determing the future cost of energy can be obtained from the table of interest and annuity factors for 10 percent interest. Factors for determining the present value of future energy cost can be obtained from the table of interest and annuity factors for 14 percent. Calculation of the present value per \$1 of current energy costs expected during the evaluation period can be made by constructing the following table or by solving the equation:

$$\text{Present value per \$1 of current costs} = 1 + \sum_{t=1}^{n-1} \left( \frac{(1+i)^t}{(1+d)^t} \right)$$

Where: t = number of years hence, n = evaluation period, i = expected annual price increase, and d = discount rate or interest rate used in evaluation.

TABLE 1. Calculating Present Value of Future Energy Purchases

| Years Hence | Current Cost | Present value of 1, 10% | = | Future Cost | X | Present value of 1, 14% | = | Present Value |
|---|---|---|---|---|---|---|---|---|
| Now | 1 | 1.00000 | | 1.00 | | 1.00000 | | 1.00 |
| 1 | 1 | .90909 | | 1.10 | | .87719 | | .96 |
| 2 | 1 | .82645 | | 1.21 | | .76947 | | .93 |
| 3 | 1 | .75131 | | 1.33 | | .67497 | | .90 |
| 4 | 1 | .68301 | | 1.46 | | .59208 | | .86 |
| 5 | 1 | .62092 | | 1.61 | | .51937 | | .84 |
| 6 | 1 | .56447 | | 1.77 | | .45559 | | .81 |
| 7 | 1 | .51316 | | 1.95 | | .39964 | | .78 |
| 8 | 1 | .46651 | | 2.14 | | .35056 | | .75 |
| 9 | 1 | .42410 | | 2.36 | | .30751 | | .73 |
| 10 | 1 | .38554 | | 2.59 | | .26974 | | .70 |
| 11 | 1 | .35049 | | 2.85 | | .23662 | | .67 |
| 12 | 1 | .31863 | | 3.14 | | .20756 | | .65 |
| 13 | 1 | .28966 | | 3.45 | | .18207 | | .63 |
| 14 | 1 | .26333 | | 3.80 | | .15971 | | .61 |
| | | | | | | TOTAL | = | 11.82 |

In Table 1, future cost is the expected price of the amount of energy that $1 will buy today. As an example, diesel fuel that cost $1 per gallon today is expected to cost $1.46 four years from now, $2.59 in 10 years, etc., when price increases 10 percent per year. Figures in the present value column are the present amounts of money required to grow to the expected price levels when interest earning capacity is 14 percent. As an example, $.96 today earning 14 percent interest will grow to $1.10 next year ($.96 x 1.14 = $1.10).

The total of the present value column, 11.82, is, therefore, the present amount of money when earning 14 percent interest per year, required to purchase the amount of energy $1 will buy today over the 15-year planning horizon after considering price escalation of 10 percent per year. In the example problem, the cooperator would need $11.82 for every dollar presently spent for energy to meet future energy costs or $17,730 ($11.82 x $1,500(3)). With installation of a gravity pressure pipeline, energy purchases will not be needed, thereby creating a $17,730 saving at present value. In a breakeven context, considering only energy purchases, the cooperator could afford to spend up to $17,730 for installation of a gravity pressure pipeline because of the savings expected from reduced energy costs.

## MAINTENANCE AND REPAIR

The second category of savings is maintenance and repair costs for the pump and motor. Calculation of the present value per $1 of current maintenance and repair cost is made using either the equation or tabular procedure described above for energy costs. In the case of maintenance and repair costs, expected price increase is 5 percent per year. Appropriate factors are therefore obtained from the 5 percent "interest and annuity tables."

TABLE 2. Calculating Present Value of Future Maintenance and Repair Purchases

| Years Hence | Current Cost | Present Value of 1, 5% | = | Future Cost | X | Present Value of 1, 14% | = | Present Value |
|---|---|---|---|---|---|---|---|---|
| Now | 1 | 1.00000 | | 1.00 | | 1.00000 | | 1.00 |
| 1 | 1 | .95238 | | 1.05 | | .87719 | | .92 |
| 2 | 1 | .90703 | | 1.10 | | .76947 | | .85 |
| 3 | 1 | .86384 | | 1.16 | | .67497 | | .78 |
| 4 | 1 | .82270 | | 1.22 | | .59208 | | .72 |
| 5 | 1 | .78353 | | 1.28 | | .51937 | | .66 |
| 6 | 1 | .74622 | | 1.34 | | .45559 | | .61 |
| 7 | 1 | .71068 | | 1.41 | | .39964 | | .56 |
| 8 | 1 | .67684 | | 1.48 | | .35056 | | .52 |
| 9 | 1 | .64461 | | 1.55 | | .30751 | | .48 |
| 10 | 1 | .61391 | | 1.63 | | .26974 | | .44 |
| 11 | 1 | .58468 | | 1.71 | | .23662 | | .40 |
| 12 | 1 | .55684 | | 1.80 | | .20756 | | .37 |
| 13 | 1 | .53032 | | 1.89 | | .18207 | | .34 |
| 14 | 1 | .50507 | | 1.98 | | .15971 | | .32 |
| | | | | | | TOTAL = 7.00 | | 8.97 |

Interpretation of the figures in Table 2 is the same given above for Table 1. In the example problem, the cooperator could afford to spend up to $4,485 (8.97 X $500) for installation of works that eliminate pump and motor maintenance and repair and still breakeven.

SALVAGE

The third category of savings is the economic salvage value of the pump and motor. The pump and motor not needed could be sold at salvage value and that amount invested in installation of the gravity pressure pipeline. A more casual view could be that since $4,000 is already committed to irrigation facilities, it makes no difference if it is a pump and motor or pipeline.

A special note on pump and motor costs is appropriate. The current procedure considers only the salvage value of the existing pump and motor. If the current pump and motor would need to be replaced one or more times during the evaluation period, future replacement costs would be avoided. The appropriate procedure for calculating the present value of future replacement needs is to estimate expected future replacement cost and discount that cost to present. As an example, in the problem described, the estimated cost for a new pump and motor today is $9,050 and expected to increase 5 percent per year. If it were estimated that the pump and motor would need to be replaced 4 years hence and that the replacement would last through the 15 year planning horizon, present value of replacement must be considered. In the case described, the pump and motor are expected to cost $11,000 four years hence ($9,050 ÷ .82270 present value of 1, 5%, 4 years hence). When replacement of existing equipment is expected, the present value of expected future cost should be computed and added to the salvage value.

BREAKEVEN COST

From the above analyses of costs, the present value of future expenditures to operate the irrigation system using a pump and motor was determined to be $26,215 ($17,730 + $4,485 + $4,000). Installation of a gravity pressure pipeline will eliminate the evaluated costs associated with the pump and motor. Therefore, the most that can be spent for the pipeline is $26,215 which is considered the breakeven cost for the pipeline. If the present value of total expected costs for the pipeline is less than $26,215, net economic benefits would occur by installing the pipeline. However, if pipeline costs are greater than $26,215, the cooperator should continue using the pump and motor.

The breakeven estimate of $26,215 is very sensitive to the discount or interest rate used to calculate present value, the length of the planning horizon, and the rate at which energy and maintenance and repair costs are expected to increase in the future. The effect on the breakeven cost for the pipeline when each of these values is varied separately is described below in general terms and related to the example problem.

As the discount rate used in evaluation increases, the present value of expected future costs decreases and conversely, as the discount rate decreases, present value increases. In the example problem, if the discount rate is increased from 14 to 16 percent, breakeven total cost would decrease from $26,215 to $23,963 ($15,918 + $4,045 + $4,000). If the discount rate is decreased from 14 to 12 percent, breakeven cost would increase from $26,215 to $28,851 ($19,885 + $4,966 + $4,000).

As the length of the planning horizon or evaluation period increases, the present value of cost savings increases and conversely, as the period decreases, present value decreases. In the example problem, if the planning horizon were extended from 15 to 20 years, breakeven cost would increase from $26,215 to $30,929 ($21,822 + $5,107 + $4,000). If the planning and evaluation period were shortened from 15 to 10 years, breakeven cost would decrease from $26,215 to $20,390 ($12,840 + $3,550 + $4,000).

The higher the expected rate of cost increase, the higher the present value of future costs avoided and the lower the rate of cost increase, the lower present value of future costs avoided. If the rate of increase for energy and maintenance and repair costs is increased 2 percentage points from 10 and 5 percent to 12 and 7 percent, respectively, breakeven cost would increase from $26,215 to $28,931 ($19,936 + $4,995 + $4,000). If the rate of expected cost escalation is decreased 2 percentage points to 8 and 3 percent, respectively, breakeven cost decreases from $26,215 to $23,885 ($15,834 + $4,051 + $4,000).

Expected rates of cost increase are the most difficult to define. Therefore, calculation of present value using a zero rate of cost increase can be used to establish a range for breakeven cost. Using a 14 percent discount rate and 15-year evaluation period but no expected increase in energy and maintenance and repair cost, breakeven cost is $18,004 ($10,503 + $3,501 + $4,000). The range for breakeven cost from $18,004 to $26,215 can be used as a guide in planning and decision making.

A simultaneous change in two or more variables will have a multiplicative effect on breakeven cost. Therefore, adjustment to calculated breakeven cost cannot be made by adding differences calculated in the examples above.

Analysis of potential cost savings completed to this point are useful in planning and decision making to the extent that judgment can be made on whether the pipeline works can be installed, maintained, and repaired for less than the breakeven amount. Judgment (are we in the ballpark?) will permit planners to determine if time and expense required for engineering studies and cost estimates are merited. Complete feasibility determination requires analysis of expected costs associated with the gravity pressure pipeline. The two most important costs are an estimate of the current installation cost for a pipeline which would replace pressure requirements and an estimate of the current cost for the average pipeline maintenance and repair. In addition, an estimate of the rate of increase for pipeline maintenance and repair costs is required.

PIPELINE INSTALLATION

Installation cost must be an estimate using current prices to be comparable with present values calculated above. The estimate should include all installation work necessary to provide an operational facility which will replace the items considered in breakeven calculations and have a physical life equal to, or longer than, the evaluation period. For the example problem described, assume that a gravity pressure pipeline and appurtenances can be installed for $13,000 at today's prices and that physical life is expected to be at least 15 years.

PIPELINE MAINTENANCE AND REPAIR

Estimates of maintenance and repair should be made by considering the average kind and amount of work which will be required for 1 year during the 15-year evaluation period. The average annual kind and amount of work should be valued at today's prices to develop the estimate of maintenance and repair cost. In addition, an estimate of the rate of increase for annual maintenance and repair costs must be made.

For an example problem, assume that the estimate of average annual pipeline maintenance and repair costs at today's prices is $200 and is expected to increase 5 percent per year. Calculation of the present value of maintenance and repair cost considering expected cost increase is done using the same procedures described for the pump and motor option. The present value of pump and motor maintenance and repair cost was determined to be $8.97 per $1 of present average cost. Using 5 percent per year increase in cost, 14 percent discount rate, and 15-year evaluation period, the present value of all expected pipeline maintenance and repair costs is $1,794 ($200 x $8.97). If no increases are expected for pipeline maintenance and repair costs, the present value estimate is $1,400 ($200 x 7.00).

The estimate of present value of all costs for the pipeline would therefore range from $14,400 ($13,000 + $1,400) with no increases for maintenance and repair costs, to $14,794 ($13,000 + $1,794) when a 5 percent increase is expected.

## FEASIBILITY DETERMINATION

Comparison of the present value of savings and costs for the pipeline permits evaluation of the economic feasibility of installation. In the example problem, present value of savings are estimated to be between $18,004 and $26,215, while present value costs are estimated to be between $14,400 to $14,794. Economic feasibility of the pipeline installation is indicated because the present value of net benefits is positive, ranging from $3,210 ($18,004-$14,794) to $11,815 ($26,215-$14,400).

In a case where the range of savings overlaps the range of costs, economic feasibility is unclear. The cooperator must weigh the potential gain against the potential loss and carefully consider price expectations as well as financial ability to assume risk.