CHAPTER 6

ECONOMIC ASSESSMENT

Economic assessment of the PV pumping system will be considered based on the unit water cost obtained from a life cycle cost (LCC) analysis. The least unit of water cost is the most suitable system.

Procedure for economic assessment of the water pumping system

There are three common techniques that are used for making an economic appraisal: payback period, rate of return and life cycle cost.

The most complete approach to economic appraisal is to use the life cycle costing because all future expenses are then taken into account. In this method all the future costs andf benefits are discounted to present day values.

Determine the size of system components

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Determine the present value of the recurrent annual cost

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Life Cycle Cost (LCC)

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Annual Equivalent of the Life Cycles Cost (ALCC)

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Unit Water Cost

Figure 49 Step by step Procedure for economic assessment of water pumping system.

This step by step procedure is based on a life cycle costing of the whole system. It takes into account each of the identifiable costs, but ignores the non-monetary benefits gained by the users of the water. This methodology can be used to identify the pumping system, which has the lowest life cycle cost and hence will provide the lowest unit water cost. Of course, the least cost solution may not be the final choice since factors other than cost should also be taken into account. Reliability is of essential importance in a water supply system, especially in a remotely installed system where repair services are not readily available, and a user may be prepared to pay an increased cost for greater reliability. However, a cost appraisal is a necessary step before making the final choice.

Present value: While future value determines the value of today's money sometime in the future, present value says how much a sum of money in the future is worth today.

Another way of starting the concept of present value is that the present value of a future amount of money is that amount of money that must be invested today at the prevailing rate of interest to result in the amount needed in the future.

Present value and future value are therefore two ends to the same process of having money at interest for a period of time. One way to figure out the present value of a future sum of money is to try starting with different amounts and seeing how much money will result in the future at the prevailing interest rate. When an amount is found that results in the amount desired in the future, you have the present value. There is a formula which, can be used to determine exactly the present value of a future amount of money placed in an account with compound interest:

In mathematical terms:

$$PV = FV / (1+I)^{N} \qquad \ldots(13)$$

Where:

PV = Present value
FV = future value
I = Interest rate
N = the number of the interest periods from the present to the future date

Net Present Value: The difference between the present value of all future returns P and the present capital *C* required to make an investment which achieves the future value is the net present worth or net present value (*NPV*).

$$NPV = P - C \qquad \ldots(14)$$

The net present value (NPV) method of evaluating the desirability of investments can be calculated as follows:

$$NPV = S_1/(1+i) + S_2/(1+i)^2 + \ldots\ldots + S_n/(1+i)^n - C \qquad \ldots(15)$$

Where:

S = the expected net cash receipt at the end of each year
i = the annual discount rate
n = the duration in years
C = the present capital (initial investment)

The net present value is similar in concept to net profit, but with all monies discounted to the present time so that a dollar received in the 20th year is not as valuable as a dollar returned in the first year.

Internal Rate of Return (IRR): is another time-discounted measure of investment worth. The IRR is defined as that rate of discount, which equates the present value of the stream of net receipts with the initial investment outlay:

$$C = S_1/(1+R) + S_2/(1+R)^2 + \ldots\ldots + S_n/(1+R)^n \qquad \ldots(16)$$

Where: *R* denotes the internal rate of return (IRR). An alternative and equivalent definition of the IRR is the rate of discount, which equates the NPV of the cash flow to zero.

$$S_1/(1+R) + S_2/(1+R)^2 + \ldots\ldots + S_n/(1+R)^n - C = 0 \qquad \ldots(17)$$

Life cycle cost (LCC)

When analyzing the project either in the financial or the economic sense, it is not enough just to look at the initial cost of the project. In the future there will be the cost of operating the project, repairing, replacement and maintaining the equipment and ultimately disposing of the remains when it wears out. Often these costs will be greater than the initial cost of purchase. If these recurring or future costs are ignored when analyzing a project, the analysis will not provide a true picture of the real cost of the project. The method for analysis, which includes all, the cost associated with the project over its life is called Life Cycle Costing or LCC.

Annual Equivalent of the Life Cycles Cost (ALCC)

An alternative method of making the economic evaluation is to calculate the total equivalent annual cost over the lifetime of the system. Here the capital cost is converted into an equivalent annual cost that represents, in effect, the constant amount that would have to be paid annually over the lifetime of the system to repay a loan at the prevailing interest rate equal to the capital cost at the start.

$$ALCC = \frac{LCC}{Pa} \qquad \ldots(18)$$

$$Pa = \frac{\{1 + [(1+i)/(1+d)]^{Y}\}}{(d-i)}, \; i \neq d \qquad \ldots(19)$$

$$Pa = Y / (1+i), \; i = d \qquad \ldots(20)$$

d = Discount rate
i = Inflation Rate
Y = year

Unit of water cost

The unit water cost is determined by Annual Equivalent of the Life Cycles Cost divided by the annual water requirement.

$$C_W = \frac{ALCC}{V_A} \qquad ...(21)$$

Where C_W is unit water cost (Baht/m^3), V_A is annual water required (m^3).

Economic assessment of PV - water pumping system

Table 6 The cost of solar water pumping system.

No	Item Cost	Price/Unit	Quantity	Price (Baht)	Lifetime (year)
1	PV module (Wp)	12,500	24	300,000	20
2	Inverter and pump/motor	85,000	1	85,000	10
3	Pipe (m)	110	20	2,200	10
4	Tank	134,000	1	134,000	20
5	Electrical wire (m)	25	40	1,000	5
	Total cost			522,200	
	Recurrent annual cost (RAC)			26,110	

Table 7 Life Cycle Cost (LCC) Calculation.

Year	Cost Description	Expense	PV
0	Initial capital	522,200	522,200
1	RAC	26,110	23,522.5
2	RAC	26,110	21,191.5
3	RAC	26,110	19,091.4
4	RAC	26,110	17,199.5
5	RAC+Rep (5)	27,110	16,088.5
6	RAC	26,110	13,959.5
7	RAC	26,110	12,576.1
8	RAC	26,110	11,329.8
9	RAC	26,110	10,207.0
10	RAC+Rep (2,3,5)	114,310	40,258.2
11	RAC	26,110	8,284.3
12	RAC	26,110	7,463.3
13	RAC	26,110	6,723.7
14	RAC	26,110	6,057.4
15	RAC+Rep(5)	27,110	5,666.1
16	RAC	26,110	4,916.3
17	RAC	26,110	4,429.1
18	RAC	26,110	3,990.2
19	RAC	26,110	3,594.8
20	RAC	26,110	3,238.5
	Total Life cycle Cost (LCC)		761,987.6
	Discount rate = 11%		

Table 8 Unit water cost calculation.

LCC (Baht)	ALCC (Baht/year)	VA (m^3/year)	Cw (Baht/m^3)
761,987.6	34,398.60	10,950	3.14

In this thesis was used an 11% of discount rate and a 5% inflation rate, the lifetime of system analysis was 20 years. The present value of Life cycle cost (LCC) is 761,987.6 Baht and converts to an annual equivalent of the life cycle cost (ALCC) as 34,398.6 Baht/year.

The unit water cost is therefore 3.14 Baht/m^3, which the annual water requirement is 10,950 m^3/year (30*365).

Economic assessment of diesel water pumping system.

- Specific of motor/pump

Model:	WB20TK1 TM/TRM
Engine:	G150K1 QTM
	4 Stroke side valve single cylinder
Bore x Stroke (mm):	64*45
Displacement:	144 cc
Compression ratio:	6.5:1
Max. Horsepower:	3.7/3,600 Hp/rpm
Max. Torque:	0.76 kg-m/3,000 rpm
Max. Water volume:	600 Liters/min
Ignition system:	Transistor Magneto
Starting system:	Recoil starter
Fuel Tank capacity:	2.5 Liters
Fuel consumers:	310 cc./ps.h
Lubrication oil capacity:	0.7 Liters
Dimension L*W*H:	355*315*380 mm
Weight:	15.6 kg

Table 9 The cost of diesel water pumping system.

No	Item Cost	Price/Unit	Quantity	Price (Baht)	Lifetime (Year)
1	motor/pump	8,000	1	20,000	5
2	Pipe (m)	110	20	2,200	10
3	Electrical wire (m)	20	40	800	5
4	Tank	134,000	1	134,000	20
	Total			157,000	
5	Labor	5%		7,850	
	Total Cost			164,850	
	Inflation annual cost (RAC)			8,243	

Motor/Pump model WB20TK1 TM/TRM can be used to pump 30 m^3 of water continuously for one hour per day. The quantity of diesel used is 1.5 liters at a cost of 21 Baht/day (14 Baht/liters) and 7,665 Baht/year.

Table10 Life Cycle Cost (LCC) Calculation.

Year	Cost Description	Expense	Diesel
0	Initial capital	164,850	164,850.0
1	RAC+(Fuel Consumer/year)	15,908	14,331.1
2	RAC+(Fuel Consumer/year)	15,908	12,910.9
3	RAC+(Fuel Consumer/year)	15,908	11,631.4
4	RAC+(Fuel Consumer/year)	15,908	10,478.8
5	RAC+(Fuel Consumer/year)+Rep(1,3)	36,708	21,784.4
6	RAC+(Fuel Consumer/year)	15,908	8,504.8
7	RAC+(Fuel Consumer/year)	15,908	7,662.0
8	RAC+(Fuel Consumer/year)	15,908	6,902.7
9	RAC+(Fuel Consumer/year)	15,908	6,218.6
10	RAC+(Fuel Consumer/year)+Rep(1, 2, 3)	38,908	13,702.6
11	RAC+(Fuel Consumer/year)	15,908	5,047.2
12	RAC+(Fuel Consumer/year)	15,908	4,547.0
13	RAC+(Fuel Consumer/year)	15,908	4,096.4
14	RAC+(Fuel Consumer/year)	15,908	3,690.5
15	RAC+(Fuel Consumer/year)+Rep(1,3)	36,708	7,672.1
16	RAC+(Fuel Consumer/year)	15,908	2,995.3
17	RAC+(Fuel Consumer/year)	15,908	2,698.4
18	RAC+(Fuel Consumer/year)	15,908	2,431.0
19	RAC+(Fuel Consumer/year)	15,908	2,190.1
20	RAC+(Fuel Consumer/year)	15,908	1,973.1
	Total Life cycle Cost (LCC)		316,318.4
	Discount rate = 11%		

Table11 Unit water cost calculation.

LCC (Baht)	ALCC (Baht/year)	VA (m^3/year)	Cw (Baht/m^3)
316,318.4	14,279.68	10,950	1.30

In this thesis was used an 11% discount rate and a 5% inflation rate. The present value of the Life cycle cost (LCC) is 316,318.4 Baht and converts to an annual equivalent of the life cycles cost (ALCC) to 14,279.68 Baht/year.

The unit water cost is therefore 1.30 Baht/m^3, which the annual water requirement is 10,950 m^3/year (30*365).

When we compare the unit cost of the water provided by the PV water pumping system and the diesel water pumping system, the results showed that the unit cost of pumping water by the PV system is higher than that by the diesel system. However, if we were to adjust for the externality costs (i.e. environmental and social costs) of using the diesel system then still may be advantageous to use the PV system because of the many benefits of using renewable energy. Since environmental and social costs need to be evaluated on a case by case basis, an economic analysis needs to be done for each site considered and a blanket assurance that the PV pump will provide the lowest economic cost cannot be made from the available data.