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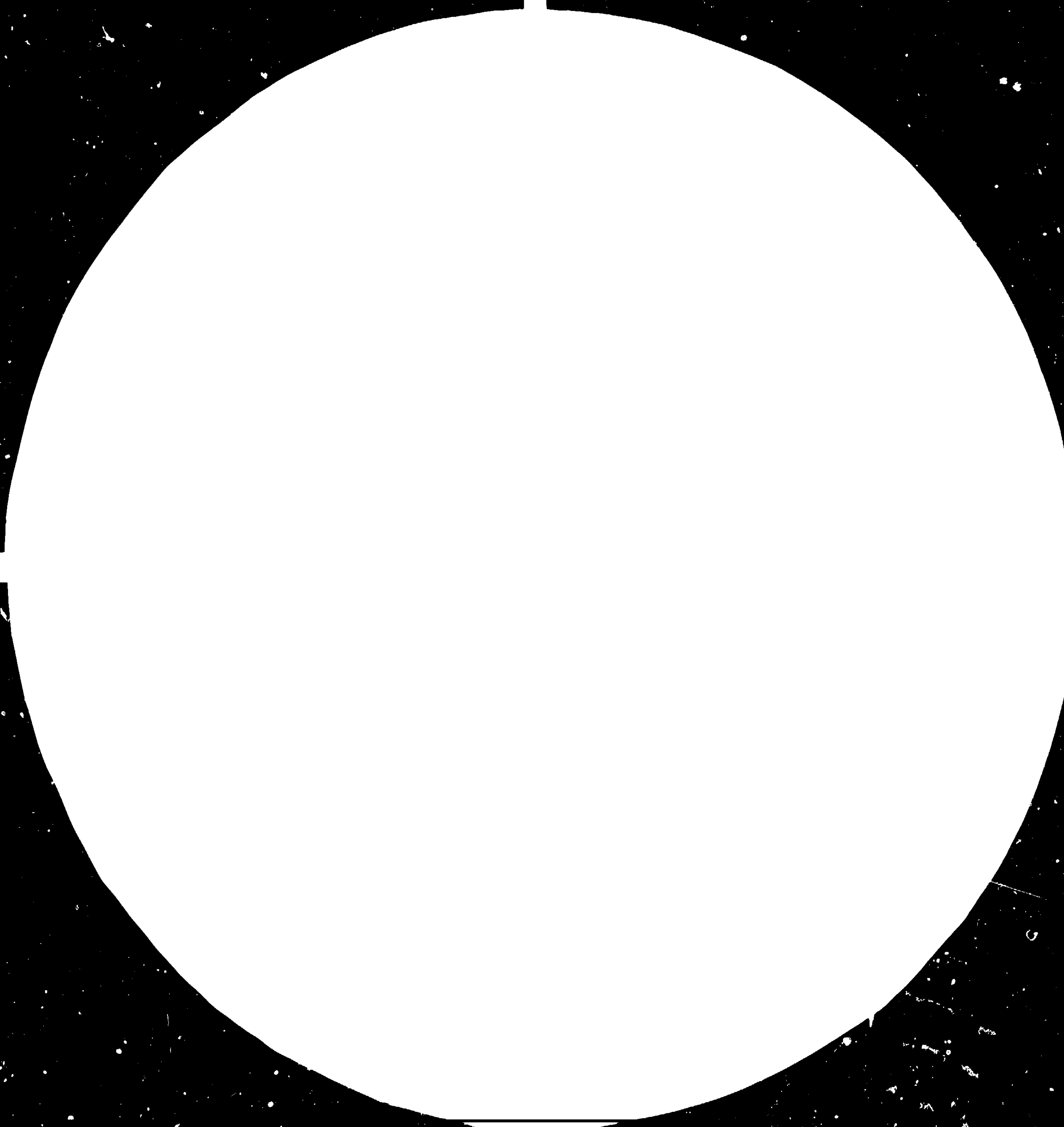

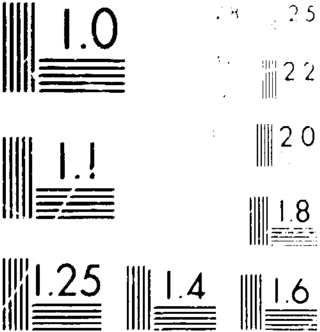
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ECONOMIC APPRAISAL OF SMALL-SCALE HYDRO POWER PROJECTS*

by

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Financing institutions, both national and international, normally require confirmation that a project proposed for funding is economically feasible. To meet with this requirement, it is necessary to carry out an economic appraisal which is to show that the return from the investment in the project complies with certain predetermined conditions of profitability.

In carrying out an economic appraisal, two pre-conditions have to be assumed:

1. That there is a power market available to absorb the output from the scheme. This power market must lie within a radius which can be reached by transmission and distribution circuits emanating from the scheme. If such circuits exist, any incremental costs of interconnecting them with the scheme or reinforcing them must be included in the investment requirements for the scheme. If the circuits do not exist, their cost forms part of the cost of the scheme. It is also important to ensure that the output with which the scheme is credited is no greater than the demand made on the scheme by the existing or projected power market (plus appropriate losses). Output restrictions imposed by the power market must be taken into account in computing the output with which the scheme can be credited.

2. That there is an alternative source of supply which could satisfy the power market determined as under 1 above. The assumption is then made that, if the scheme is not built, the alternative source of supply would be developed instead. The costs of developing this alternative source are then the investment requirements with which those of the scheme in question have to be compared. The economic feasibility

of the scheme is normally determined in comparison with this alternative solution; profitability is expressed in terms of the extra revenue the scheme is able to earn over the revenue that might be achieved with the alternative solution. The usual method of economic appraisal is thus never one of justifying the scheme as an isolated development, although this would be possible by showing that the profitability of the scheme is attractive in relation to the opportunity costs of capital in the particular economy. The reason is that, in order to justify the investment at all, a tied power market must exist which, by definition, must be supplied from one source or other.

Several methods of economic appraisal are used which are all technically the same, i.e. all involve comparison of two alternative solutions, and they differ only in detail. The most usual methods involve:

(a) <u>Benefit/cost analysis</u>. In this method, the benefits from a scheme are normally expressed in terms of the extra revenue which the scheme can earn to the costs which the scheme entails, both with reference to the alternative solution. The term "extra revenue" implies that the costs of the energy the scheme produces will be lower than the costs of energy from the alternative so that, at a fixed sale price, the scheme will earn an extra revenue.

It is often undesirable to rely on revenue assessments because the relationship between tariffs, which determine the revenue, and productions costs is a very tenuous one. It is more usual to compute the production costs (which must include capital charges, operating and maintenance expenses . and fuel costs) for both solutions as well as investment requirements for the two solutions and then express the benefit/cost ratio in terms of difference in production cost and the difference in capital investment requirements. Calculations are normally done at current price levels but sensitivity studies are sometimes introduced to illustrate the effect of price variations on the result; this is particularly important if the benefit/cost ratio lies close to or below the opportunity cost of capital. Judgement of acceptable profitability relies essentially on the relationship of the benefit/cost ratio to the opportunity cost of capital.

(b) Comparison of present worth of cash flow. In this method, the present worth of the total cash flow for the scheme is computed at a fixed discount rate. The cash flow includes both the capital investment, phased ower the period of incidence, and the annual expenses over the lifetime of the plant. Where elements of different asset lives are involves, for example the civil works, electro-mechanical equipment and transmission system associated with a hydro scheme, the reinvestment required for replacing the shorter lived assets are entered into the cash flow as an additional capital expenditure at the time they occur. This means, for example, in a hydro scheme where the civil works may have an asset life of 60 years, the electro-mechanical plant an asset life of 30 years and the transmission system an asset life of 20 years, there will be an investment phase after 20 and 40 years for transmission and after 30 years for electro-mechanical plant. The reinvestment is phased according to the probable incidence of expenditure over 2 or 3 years. If any restitution of land or in demolition expenses are likely to be incurred at the end of the life of the longest lived asset, these expenses are likewise entered into the cash flow.

The discount rates used for the present-worthing process are usually pitched slightly above the opportunity cost of capital to allow for finance expenses and "incentive rates" that may have to be met. All costs in the cash flow schedule are normally computed at current price levels and are discounted to the start of the construction phase.

The same procedure is adopted for alternative solutions and the present worths are then compared to determine the least-cost solution. The advantage of this solution, over the alternative, is often expressed in terms of "extra return" or profitability.

(c) Internal Rate of Return. A varient of the computation of the present worth explained under (b) is to compute present worth of the 2 alternative solutions at various discount rates and then to determine graphically at what discount rate the 2 present worths are equal. This discount rate is then the internal rate of return on the project which has the higher initial investment cost. The internal rate of return provides a very convenient decision point for assessing the economic worth of a project. If it lies below the opportunity cost of capital, the project will probably have little merit. If, on the other hand, it lies above and well above the opportunity cost of capital, the project will have considerable merit. The difference between the internal rate of return and the opportunity cost of capital is sometimes quoted as "extra return" or "additional profitability". In marginal cases where the internal rate of return is close to the opportunity cost, sensitivity studies should be carried out to determine under what conditions the rate of return might be improved.

(d) Comparison of production costs. The production costs of a hydro scheme and the alternative thermal solution can be computed and compared and the merit of one solution or other can be derived from the difference of these costs.

This merit is generally expressed as a benefit or even a benefit/cost ratio. The production costs are made up of capital charges (interest and depreciation for the whole scheme), operating and maintenance costs, fuel costs, consumable stores and administration expenses. All these elements must be taken into account in the computation.

The output for which these production costs are computed must be realistically related to the power market demand; it would be wrong to ascribe to a scheme a synthetic plant factor for an energy quantity which the scheme will not have to supply in a given year. Naturally, the output figures may well vary from year to year. What is then sometimes done is to establish both production costs and output values over the lifetime of the plant and compute the ratio of the present worth of both these data streams. The result will present the "normalized" production costs appropriate to that particular solution.

It is not generally necessary to use more than one method for the economic appraisal of a small-scale project. If the parameters are correctly chosen, all the three methods outlined above should give the same kind of answer although the results will be numerically different. It should not be overlooked that the primary purpose of the economic appraisal is to underwrite a decision to implement a given scheme. Use of alternative methods can sometimes be confusing and may give rise to difficulties in interpretation.

It is important that all parameters used in an economic appraisal are as realistic as is possible at the time the computations are carried out. If one of the solutions is more liable to price variations than the other, sensitivity studies should be undertaken to test the effect of such price variations. It is also important that internally compatible data are used when comparing two alternative solutions. Shadow pricing should be introduced only if it has a major effect on one of the alternatives; it is sometimes used in cases where one of the solutions has to rely on imported fuels. Taxation is generally not taken into account.

Any output restrictions acting on one of the solutions must be considered in the computation of variable annual costs, in particular of fuel costs. It is often assumed that, in the case of a hydro scheme, annual outgoings are practically fixed and independent of the plant factor of the particular scheme. Output restrictions for a scheme of a given size are therefore left out of account. For an alternative fuel-based solution, output restrictions will directly affect the fuel consumption in a particular year and will therefore influence the cash flow situation.

Where a hydro scheme suffers periodic output restrictions on account of hydrological conditions and where it can therefore not meet the market requirements for some period of time in the year, compensating thermal plant may have to be provided to overcome the output deficiency. The cost of this plant, both capital and running, forms an integral part of the scheme and must be taken into account in the cash flow.

The economic appraisal will give reliable results only if all the elements affecting costs and benefits of the alternative solutions are fully taken into account.

A typical example which was used to evaluate the merit of a ..... small-scale hydro project is attached.

Nam Mae Suk Project
(Thailand)

Note on methodology adopted for economic appraisal

For determining the economic feasibility of the proposed small hydropower projects, we have carried out an economic comparison with an alternative diesel power plant. For purposes of the exercise we have assumed the following:

1. The net benefit of the hydropower project is the difference between the net present values of the two schemes.

2. The discount factor is 12%.

3. The internal rate of return is determined by a graphical discounting method. The internal rate of return is the point where the net present value of two schemes under different discount rates meet.

4. The interest charges during construction, the financing charges and price escalation are not taken into consideration.

5. The cost of the diesel power plant is taken to be $700 per kW.

NAM MAE SUK PROJECT

Estimate of Costs	Hydropower Scheme 640 kW (in '000 US$)
Preparatory Works	173
Civil Works	1,138
Hydraulic Equipment	150
Electro mechanical Equipment	430
Transmission	104
	1,995

Investment Cash Flow ('000 US$)

Year	Civil Works	Plant	Transmission	O + M	Total Cash flow
1	131				131
2	524	203	36		763
3	590	319	58		967
4	66	58	10	30	164
29		203	36	30	269
30		319	58	30	407
31		58	10	30	98
32				30	30
54				30	30

Notes:

1. All expenditures are incurred at the end of the year.

2. Excludes interest and other financing charges during construction.

3. Asset life of civil works is 50 years.
   Asset life of plant is 25 years.
   Asset life of transmission system is 25 years.

4. Power plant is to be commissioned by the end of third year.

Alternative Diesel Power Scheme 640 kW

Investment Cash Flow (in '000 US$)

Year	Generation	Distribution	O + M	Fuel	Total Cash Flow
1	90				90
2	179	52			231
3	22	52			74
4	157		14	90	171
5			14	179	193
6			20	269	289
7			20	358	378
29	90	52	14	90	246
30	179	52	14	179	424
31	22		20	269	311
32	157		20	358	535
54			20	358	378

Note:

1. Installed capacity of 640 kW with an investment cost of US$700 per kW.

2. Transmission costs for 22 kV line approximately 10 km long.

3. Excludes interest and financing charges during construction.

4. O + M costs until the year six is 2.5% of the first installation, 1% of the total investment and 2% of the transmission system. After the sixth year, the costs consist of 2.5% of the total installation, 1% of the investment for generation and 2% for distribution.

5. kWh generated at an average annual load factor of about 45% is to be utilized 25% in the fourth year, 50% in the fifth year, 25% in the sixth year and 100% in the seventh year.

6. The fuel price is assumed to be US$ 0.11 per kWh.

Computation of Benefit

Year	Hydro	Diesel	PV factor	PV hydro	PV thermal
1	131	90	.8929	116.97	80.36
2	763	231	.7972	608.26	184.15
3	967	74	.7118	688.31	52.67
4	164	261	.6355	104.22	165.87
5	30	193	.5674	17.02	109.51
6	30	289	.5066	15.20	146.41
7	30	378	.4524	13.57	171.01
↓	30	378	3.3543	97.455	1267.93
29	269	246	0.0374	10.06	9.20
30	407	424	0.0334	13.59	14.16
31	98	311	0.0298	2.92	9.27
32	30	535	0.0266	0.80	14.23
↓	30	378	0.1620	4.86	61.24
54	30	378	0.0022	0.01	0.83
				1693.22	2286.84

Benefit for Hydro = US$ 588.62

Benefit Cost Ratio = $1 + \frac{\text{PV (Thermal)} - \text{PV (Hydro)}}{\text{PV (Hydro)}}$

1.35

NET PRESENT VALUE AT DIFFERENT DISCOUNT RATES

	HYDRO	THERMAL
8%	2002.73	3465.18
12%	1698.22	2286.84
16%	1501.89	1615.27
18%	1422.06	1390.50
20%	1353.21	1212.90
24%	1240.14	950.90