SOME THOUGHTS ON THE CHOICE OF THE KEBAN HYDRO-ELECTRIC PROJECT

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Introduction :

The Keban Hydro-Electric Project was one of the largest investment projects selected for execution during the First Five-Year Plan period, 1963-67. The evaluation of the Keban HE Project and its Thermo-electric Alternative was made by the Electric Research Unit (E.I.E.), of the Turkish Ministry of Energy and Natural Resources. Since the projects by nature were very technical and required detailed engineering data the planners at the E.I.E. were given the assignment of appraising both projects independently, by using their own evaluation technique. The State Planning Organisation (SPO) whose function is, among other things, to evaluate investment projects submitted by the Government Agencies and private sector, has never attempted to re-appraise the above mentioned projects on the basis of their investment criteria and evaluation method.(1)

Since its selection in 1964 the Keban Project has received nationwide attention because it is the largest hydro-dam project to be carried out in Turkey and in the Middle East. The initial investment of the project was estimated to be $ 315,933 thousand(2) which was basically to be financed by a special consortium created to this effect. The choice of the Keban HE Project at that time, drew great intellectual interest and stirred up academic enthusiasm.

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(1) There is some evidence which suggests that the Keban Hydro-electric project was reviewed more than once at the State Planning Organisation in the years 1963 and 1966 where joint meetings were held with the participation of some planners and technical experts. But despite these meetings the evaluation of the Keban Project was not carried out by the SPO.
A note received from Mr. Argun Ceyhan, an electrical engineer at the Turkish Electric Corporation (TEK), January 20, 1975, Ankara.

(2) This was the initial cost on the basis of 4 generators to be installed in the Keban HE Plant.

Various studies have been made in connection with the Keban Hydro-electric dam by experts and engineers most of whom were critical of the selection of the Keban HE Project,

The criterion applied by the Electrical Research Unit was the "total annual cost" rule which combines both the "equivalent annual cost of fixed investment" and the 'operation and maintenance costs". As will be seen, the treatment of both projects by the Research Unit was rather inarticulate and not sufficiently reliable. Evidence indicates that the SPO's project appraisal technique differs largely from the one adopted by the E.I.E. The criteria used by the former are social present value and internal rate of return rules.

It is true that some considerable time has elapsed since the Keban Project was chosen and executed; but the purpose of this paper is merely to challenge the selection of the Keban HE in place of the fuel-oil burning Thermal Alternative. My analysis would indicate that the acceptance of the Keban HE Project was not justified when the comparison is made on the basis of direct benefits and on internal rate of return rule. The present paper will also focus on the indirect benefits which emanate from the Keban HE Project and the effect of these benefits on the E.I.E.'s final choice between the two projects. It will be shown that even the inclusion of indirect benefits on the benefit side would not enhance the admissibility of the Keban HE Propect.

It should be noted that the evaluation of the Keban HE Project and its Thermal Alternative in this paper will be analysed on the basis of 4 generators and data available at the time they were first appraised in 1966. Thus data and relevant tables which will be used in the evaluation are taken from the original projects themselves. In view of the present World fuel crisis which has more or less crippled the economies of developed and developing nations alike, it would perhaps be more appropriate to pursue the analysis by considering the new fuel prices and indicate the effect of these on the choice of both projects. With some regret this new issue will not be taken into account as the purpose of this article is not to question the choice of the Keban HE project under the present conditions but rather under the earlier conditions.

In the last few years, fresh interest in the Keban HE Project has assumed enormous proportions as its completion has been delayed due to unexpected difficulties in its construction and

financing. Ultimately its capital outlay has by far exceeded the initial estimates.[1] Further, resettling villagers to outside the dam area has involved a considerable amount of associated cost which need to be referred to the Keban HE Project. However, a lack of reliable and accurate data puts the analysis of these factors beyond the scope of this paper.

It is hoped that this paper will elicit further thinking on the selection of the Keban HE dam and project appraisal technique pursued in Turkey for public investments. Further, attention is drawn to the fact that certain dangers are inherent in the use of E.I.S.'s project evaluation technique considering the objective is efficient allocation of limited capital funds.

The first section provides a succinct but informative description of the two projects; while the second section presents the evaluation of both projects by the E.I.E. by explaining their evaluation technique in some detail. In the third section, I have provided a thorough analysis of both projects on the basis of internal rate of return rule. A critical commentary on the selection of the Keban HE is reserved for the conclusion.

I — Description of the Projects :

The 1961 Report "Northwest Anatolia Power Priority Study" investigated 4 hydroelectric projects selected by the E.I.E., Electrical Research and Planning Unit of the Ministry of Engery and Natural Resources as the most promising for early development. From among these projects, Keban and Çicezor were recommended.

Keban, on the River Fırat (Euphrates), had been fully investigated from the geological standpoint and it was found that it had sufficient hydro-electric potential. Keban is 45 Km. northwest of Elazığ. The Murat and Karasu, main tributaries merging together

(1) In the Feasibility Report, its inital cost of construction was given as 3.1 billion TL. but this figure in 1971 reached 4.2 billion TL and the ultimate cost was estimated to approximate to 5 billion TL. However, in 1975 the final cost of the Keban HE project with 8 generators (8x155 MW) is expected to reach 8 billion TL. See, İktisadi Rapor 1971, Turkish Chambers of Commerce and Industry, Ankara p. 215; and also a Commentary Note on the present paper by Mr. Ahmet Cebeci, Head of the Technical Project Appraisal Group, State Investment Bank. (SIB), January 22, 1975.

about 10 Km. upstream of the Keban Dam site make up the River Fırat.

The function of the Keban Hydro- dam is to store and regulate water as the key facility on river Firat and to generate electricity. The Keban Project when developed to its fullest capacity with 4 generators will produce 5 billion and 430 million kilowatt hours of power.[1] However, this is correct only on the assumptions that the 4 generators will work continuously for 8760 hours per annum and that the water supply of the river Firat will not show any oscillation throughout the year. However, full capacity production may not be easy to realise as each generator has to be stopped for a reasonable time for maintenance and repairs. If, it is assumed that the 4 generators will only work for 8,000 hours per annum then the total energy produced would amount to 4.96 billion kw/hours.[2]

The total generated power with the initial facilities of 3 generating units of 155 MW each, will be 4 billion and 0.70 million Kwh-per annum, where 205 million Kwh will be transmission line losses, leaving a net available power of 3 billion and 865 million Kwh in 1970. The report also states that when the fourth 155 MW unit is added in 1970, annual power generation will reach 5 billion and 430 million Kwh, but after allowing for transmission losses it will leave a net available power of 5 billion and 160 million Kwh.[3]

It is pointed out in the General Report that there is no hydro -site in Turkey that combines the hydro-electric potential, the advanced stage of geological study and the proximity to the load centres that would provide a plausible alternative to the Keban Pro-

(1) See, Keban Dam and Hydro-electric power Plant (brochure), State Water Supply (DSI), 1963, p. 2. The Keban HE project, with all 8 generators in full operation, is expected to produce 9.9 billion kwh of energy. This is of course based on the assumption that the working hours per annum will be 8,000 so as to allow for repair and maintenance of the hydro-turbines. An interview with Mr. Vedat Alabeyi, electrical engineer at the State investment Bank; 22nd January, 1975.

(2) This can be computed as follows : 4x155 MW = 620,000 kwh, and from this, the energy produced per annum will be : 620,000 x 8,000 hrs. = 4.96 billion kwh. Further. it we take a more realistic assumption and allow for repairs and loss due to factor loads, the working hours per year will be 7,400 and the energy produced will amount to 4.78 billion kwh.
interview with Mr. Vedat Alaybeyi, electrical engineer at the State Investment ment Bank; 22nd January, 1975.

(3) See, Keban Dam and Hydro-electric Power Plant, State Water Supply (DSI), 1963. p. 3.

ject.[1] It is also stated in the Report that no combination of hydro -electric projects was considered as an economic alternative to Keban.

Consequently, the only alternative proposed to the Keban hydro-electric was the "Thermal electric Project" with a resource as large as Keban Project. The Thermal alternative was supposed to require a number of smaller plants at various load centres. Of course, annual power generation of the Thermal alternative was assumed to be similar to Keban with a net available power of 5 billion and 160 million Kwh. (For this energy the Thermal plant was to use 4 generating units).

The General Report pointed out that 110 MW of electric power would be developed in the Keban-Elazığ area by 1973. As a part of the Alternative Thermal Circuit and in order to meet the local load, a thermal station (oil-burning) containing 2 units each with 60 MW was to be installed at Elazığ at the same time as Keban's initial construction.[2] The greater part of the thermal electric capacity was also to be obtained by oil-burning units, but these latter stations were to be located somewhere on the sea coast and cities like Mersin, İzmir and İzmit were investigated. İzmit was finally decided upon.[3]

No costs would be required for the transmission of thermai power to and from İzmit since it would be located on the İstanbul -Çiceroz-Ankara line which would be built simultaneously with the Çiceroz project. Whereas the Keban HE Project would require a single circuit Istanbul-Ankara, a double circuit Ankara-Keban with substations, switching and capacitive facilities and a single lower-voltage circuit Keban-Elazığ[4] Thus in comparison with the Thermal Alternative these transmission costs were charged against the Keban HE Project.

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(1) Karakaya, Keferege and Karababa dams were also considered but all these alternatives did not represent as high a potential as Keban. See, E.I.E., Engineering and Economic Feasibility of Keban Dam. Ebasco Services Inc. New York, October, 1963, pp. 79 - 80.

(2) Ibid, p. 81

(3) Ibid, p. 81

(4) All other lower-voltage transmission that may be required to deliver power to load centres was assumed to be common to either alternative. Ibid, p. 82.

II — Economic Evaluation of the Keban Hydro-Electric Project and the Thermal Alternative :

This section will include the comparative evaluation of the two alternatives as worked out by the Electrical Research Unit (E.I.E.) The economic evaluation of the two electrical projects was conducted on the basis of 4 as well as on 8 generating units (each unit with 155 MW.) I shall, however, concentrate on the economic evaluation carried out on the basis of 4 generators in each alternative because capital investment figures given in the Report are broken down between foreign and domestic capital only as regards 4 generating units.

Before presenting the E.I.E.'s project evaluation technique, it may be useful to cite below the main principles they have adopted. As endorsed in the **General Report,**[1] these are :

(i) In economic comparison of alternatives the target to be met by one plan would also be met by the alternative plan.

(ii) It is assumed that hydro-electric projects will have a 50 year-lifespan and thermal projects a 35 year life-span'

(iii) Transmission lines and sub-stations are also to have a 50 year life-span.

(iv) The procedure adopted is "capital-recovery factor" incorporating sinking fund depreciation method.

(v) Interest rate charged on foreign capital and domestic capital will be 3 1/2 % and 6 % respectively.[2]

(vi) Finally, economic comparison of alternative projects will be undertaken on the basis of "without" and "with" taxes and duties.

A — Keban Hydro-Electric Project :

1. Investment Cost :

On the basis of 4 electric generating units, the Keban Project would require a capital outlay of $ 315,933 thousand dollars. Out of

(1) E.I.E. General Report-Power Resources Priority Study, Vol. I. Dec. 1967. Stone and Webster, Appendix 2, pp. 2-3.

(2) A private document obtained from Kemal Arkun, a planner at the E.I.E. Feb. 1969. Ankara, p. 1.

this total, domestic investment represent 214,948 thousand dollars and the foreign exchange component 109,985 thousand dollars. (See, Table 1). Again, as can be seen from the Table, the Generating Station will require a domestic capital of $ 185,070 thousand and the transmission system a domestic capital of $ 29,878 thousand. Total foreign exchange; on the other hand, is distributed between the generating station and transmission system as $ 49,915 thousand and $ 51,070 thousand respectively. It is clear that the domestic component of capital outlay constitutes 68 percent of the total, while the foreign exchange component is 32 percent.

Table 1 — Capital Investment of Keban Hydro-Electric Project and Thermal Alternative $ 000

	KebanHE Project 4 Units of 155 MW	Alternatife Thermal 4 Units of 150 MW
I — **Generating Station**		
1. Foreign Exchange	49,915	53,500
2. Domestic Currency	185,070	23,000
II — **Transmission System**		
1. Foreign Exchange	51,070	—
2. Domestic Currency	29,878	—
III — Total	315,933	76,500

Source: A private typed document obtained from the Electrical Research Centre (EIE), July, 1969. Ankara, p. 1.

2. Annual Cost :

The criterion applied by the E.I.E. planners was the "total annual cost" rule which consists of (1) equivalent annual cost of fixed investment (fixed charges) and (2) annual operating and maintenance cost. The "equivalent annual cost of fixed investment" which comprise the sinking fund depreciation method can be written as follows :

$$R = P \left[\frac{i(1+i)^n}{(1+i)^n-1} \right] = p \text{ (c.r.f)}$$

where p denotes initial investment, i rate of interest and n life period of the project.[1]

a) Fixed Charges :

By applying the capital recovery factor to the Keban's fixed investment, "equivalent annual cost" of the fixed investment can be calculated. Annual fixed charges can be computed separately for domestic capital and for foreign exchange component of investments since the interest rate charged for the former is 6 percent and for the latter 3 1/2 percent.

(i) The annual fixed charges on the foreign exchange component of capital outlay can be worked out by multiplying the foreign capital by the capital recovery factor which corresponds to the 3 1/2 % interest rate and to the 50 year life-span. The capital recovery factor is is 0.04263[2]. Thus :

FC_f = \$ 49.915 (c.r.f. - 3 1/2 % - 50 years)
= \$ 49.915 (0.04263)
= \$ 2.128.000

(ii) Similarly, annual fixed charges on domestic capital can be computed by multiplying the domestic capital with the c.r.f for the 6 % interest rate and for the 50 year life period.

FC_d = \$ 185.070 (c.r.f - 6 % - 50)
= \$ 185.070 (0.06344)
= \$ 11.741.000

(iii) Annual fixed charges on transmission system were also calculated on the same basis by distinguishing domestic capital from the foreign exchange component.

FC_f = \$ 51.070 (0.04263)
= \$ 2.177.000 and
FC_d = \$ 29.878 (0.06344)
= \$ 1.895.000

(1) By this method, investment can be converted into a series of equivalent annual payments. By this formula the payment of amortization and interest rate can be considered as a single annual item.

(2) For capital Recovery Factors See, W. G. Ireson and E. L. Grant, Principles of Engineering Economy. 4th Ed. The Ronald Press Com. N. York. 1964, p 545.

b. Operation and Maintencance Cost :

Operating and maintenance cost of the Keban Project amounts to $ 574 thousand per annum. This item includes expenditures on labour and material and repairs both on generating station and transmission system. Taxes are not included in operation and maintenance costs since the comparison between the two alternatives was carried out on the basis of "without taxes".

If annual fixed costs (a) (i + ii + iii) and annual operating and maintenance costs (b) are taken together, this will give us the total annual cost of the Keban Project. As can be seen from Table 2, total annual costs of Keban amount to $ 18.515 thousand. The comparison of the two alternatives is presented below.

Table 2 — Annual Costs of Keban HE Project and Thermal Alternative (Without Taxes) $ 000

	Keban HE Project 4 Units of 155 MW	Alternative Thermal 4 Units of 150 MW
Annual Cost		
A. Fixed Charges	17.941	4.261
Generating Station		
a) Foreign Exchange	2.128	2.675
b) Domestic Currency	11.741	1.586
Transmission System		
a) Foreign Exchange	2.177	—
b) Domestic Currency	1.895	—
B. Operation and Maintenance	574	22.307
Generating Station		
a) Labour and Material	250	635
b) Fuel	—	21.672
Transmission System		
a) Labour and Material	324	—
TOTAL ANNUAL COST	18.515	26.568

Source : E.I.E. Private typed Document. July 1969. Ankara, p. 1.

B — Thermal Alternative :

Total capital outlay of the Thermal Alternative amounts to $ 76.500 thousand, comprising $ 53.500 thousand in foreign exchange and $ 23.000 thousand in domestic currency (See, Table 1).

Annual fixed charges of the Thermal Project can also be computed on the same basis. Fixed charges on foreign exchange component of the total capital outlay are found after multiplying the said component by the capital recovery factor (c.r.f.) which corresponds to the 3.5% interest and to the 35 year life period. The capital recovery factor for the foreign exchange component is 0.05000 and for the domestic component of capital is 0.06897.[1]

$FC_f = \$\ 53.500 \times (0.05000)$

$FC_f = \$\ 2.675,000$

$FC_d = 23.000.\ (0.06897)$

$FC_d = 1.586,000$

The transmission system in this alternative does not involve any cost since the Thermal power does not require transmission lines. The fuel-oil burning thermal stations would be built in the load centre of the İzmit and Istanbul regions, and the existing system can meet the transmission requirements of the Thermal Alternative.[2]

The operation and maintenance costs appear to be extremely high. This is due to the fact that the Thermal Alternative would be burning fuel oil most of which would be imported.[3] In the event of oil prices rising, this is clearly a factor which would run against the admissibility of the project. Annual expenditure on fuel oil by the thermal alternative was estimated to be $ 21,672 thousand. Labour and material expenditure required for the generating stations is small compared with that required for fuel though still more than double the corresponding figure for the Keban Project. Fixed charges and the operation and maintenance costs taken together would give a total annual cost of $ 26,568 thousand.

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(1) For capital recovery factor figures. See, Ireson and Grant. Op. cit., p. 550 Table E. 13.

(2) K. Arkun, a planner at the E.I.E. Feb. 1969.

(3) Up to 1969 the oil production in Turkey has anly met half of the total demestic consumption requirement, and from 1970 onwards its share of the total has fallen even below half. An interview with Mr. Ahmet Cebeci, Head of the Technical Project Appraisal Group, State Investment Bank, 23rd January, 1975.

C — Benefit-Cost Ratio :

The benefit-cost ratio in the feasibility report is taken to be the ratio between the annual cost of the Thermal Alternative over the annual cost of the Keban hydro-dam and this turns out to be 1.37 (See, Table 2). The logic behind this evaluation is that the two alternatives with their 4 generating units would produce the same amount of electrical power; therefore the alternative with the least annual cost was considered more economical. Thus the Keban Project was selected because it is 1.37 times cheaper to operate annually than the Thermal Alternative.

III — Internal Rate of Return of the Keban HE and the Thermal Alternative :

As was pointed out in the foregoing sections, total benefits of the two alternatives are not given, nor are they brought into the economic evaluation of these projects. Benefits being identical, the E.I.E. planners have confined their evaluation method to the comparison of total annual costs of the two alternatives. Simply, the least costly project was selected for implementation.

Annual gross revenue and net profit data, are only given as estimates in one of the preliminary brochures published by D.S.I. in 1964. It is stated in this document that, if 1962 selling price, that is 8.94 kuruş - per/Kwh,[1] is taken as the electric-power selling rate at consumer centres, the annual gross revenue will amount to 461.820.000 T.L. Annual net profit, which is obtained by deducting operating and maintenance cost, and depreciation from the gross revenue, will amount to 272.357.000 T.L.

But, there is here a very important point which needs to be made clear before we start computing the internal rate of return of the Keban Project, That is, the accounting Net Profit given above (272.357.000 T.L.) is a wrong concept to employ in internal rate of return calculations. In deriving accounting net profit, depreciation is included in the annual cost of the Project. It is however, wrong to include depreciation in costs, since this particular cost is alre-

(1) This preliminary price is perhaps changed now, but for simplifying my analysis I shall assume that, the above price is valid. For the gross Annual Revenue and net profit figures, See, D.S.I., Keban Hydro-Dam and Electric Project, 1964, p. 3.

ady fully allowed for by counting the initial investment as a negative cash flow at the time it takes place.[1]

Therefore, for internal rate of return, we cannot take the accounting profit of the Keban as representing cash flows since it indicates profits after depreciation. Thus, what we need for internal rate of return, is the annual cash flow which is simply gross revenue minus annual operating cost and maintenance. From the Table presented earlier, we know that, operating and maintenance cost of the Keban HE, is $ 574.000 dollars. If this sum, is converted into Turkish Lira (at 1 $ = 9 T.L.), we obtain 5.166.000 T.L. as operating and maintenance costs.

On the assumptions that the gross annual revenue is 461.820.000 T.L. and operation and maintenance cost is 5.166.000 T.L. annual cash flows (receipts) becomes;

ACF = 461.820.000 — 5.166.000 T.L.
ACF = 456.654.000 T.L.

This is the annual cash flow of the project which we need to use in the internal rate of return calculations.

Because the Thermal project and Keban HE have identical electrical capacities, it is fairly logical to assume that the annual gross revenue of the Thermal will be similar to that of the Keban Hydro -electric Project. But it must be pointed out that annual net cash flows of the Thermal will depend on the annual cost which includes operation and maintenance cost.

The following assumptions need to be made in the computations of internal rate of return :

1. First, the above-mentioned figure (456.654.000 T.L.), will be taken as representing the relevant annual cash flows;

2. Second, annual cash flows will be assumed to remain constant throughout the life of the project.[2]

(1) For the treatment of depreciation in Internal Rate of Return See P.D. Henderson, Notes on Public Investment Criteria in the U.K., Bulletin of the Oxford University Institute of Economics and Statistics. Vol. 27, Feb. 1965, p 59; also, See, A.J. Merrett and A. Sykes, The Finance and Analysis of Capital Projects, Longmans, 1965. p. 43. He states: "Cash receipts or positive cash flows comprise the incremental cash in flows such as profit rent and depreciation". p, 43.

(2) This is a widely-used assumption in PV and internal rate of return calculations.

3. Third, for internal rate of return computations, market prices will be used and not social prices as contrary to the case in social present value (SPV) rule. Similarly, the capital investment of the respective alternatives ought to be taken, on the basis of incorrected market prices. Thus foreign-exchange correction which should be introduced on the foreign-exchange component of total investment will not be necessary here.[1]

As can be remembered, the rate of return of any project is the discount rate at which the present value of **net** cash flow is zero. This rate will be calculated by a trial-and-error method.

1. Keban Hydro-Electric Project : Internal Rate of Return

It must be noted that, to find the internal rate of return of a project, it is first necessary to estimate the trial Discounted Cash Flow (DCF) rate.[2] Frequently a simple inspection of the cash flow series will tell us whether to start by guessing a fairly low rate or a fairly high one. In general, it is necessary to take the average of the annual **net** cash flows and use this avarage to work out the trial DCF rate as if the project were an annuity.

But in our Case Study, the average will not be needed, since the annual net cash flows are constant. Then, the simple rule is to divide the capital cost of the project by the annual net cash flow and find from the present worth factor Tables,[3] the nearest DCF rate to be used for interpolation method. Thus, in our Case Study :

$$\frac{\text{Capital Cost I}}{\text{Annual Cash Flow B}} = \frac{\$\ 315.933.000 \times 9^{4}}{456.654.000}$$

$$\frac{I}{B} = \frac{2.843.397.000}{456.654.000} = 6.2$$

The nearest DCF rate for a 50 year annuity of 6.2, is 16 per-

(1) Corrections on foreign exchange and wage rates would be necessary however, if we were pursuing the social present value criterion.

(2) It should be noted that DCF rate is nothing but internal rate of return.

(3) For series present worth factor (pwf) tables, see Merrett and Sykes, The Finance and Analysis of Capital projects. Longmans, 1963 Appendix B.

(4) The capital of the Keban Project which is given in U.S. $, is converted into T.L. at official exchange rate of 1 $ = 9. T.L.

cent; the peresent worth factor of which is 6.2462.[1] Hence, 16 percent should be used as the first trial discount rate and this is done in Table 3 and 4 where the net present value (NPV), is found to be +6.123.960 T.L. (See Table 3).

This suggests that the DCF rate should be somewhat higher than 16 percent. Therefore, the other trial discount rate, to be on the safe side, will be taken as 18 percent.

Now, the internal rate of return computation can be carried out in the following manner :

A — The Net Present Value of the Keban HE at 16% discount rate :

1. Present value of annual net cash flows :

   = 456.654.000 x (pwf — 16% — 50)

   = 456.654.000 (6.2462)

   PV_{b1} = 2.849.520,960 T.L.

2. Capital investment of the Keban Project which is given as $ 315.933.000, must be converted into T.L. because the annual benefits are given in T.L.

   I = 315.933.000 x 9

   I = 2.843.397.000 T.L.

3. The net present value (NPV) of the Keban Project at 16% discount rate, will be the PV of annual cash flows minus the capital investment I, thus :

   NPV = 2.849.520.960 — 2.843,397.000

   NPV = 6.123.960

   i = 16

(1) See Appendix Table, B, in Merrett and Sykes, p. 160.

Table 3 — PV of Annual Cash Flows of the Keban HE : At i = 16% and i = 18%

T.L.

Years	Annual net cash flows T.L. (a)	Present worth factor (pwf) at i = 16%	PV of cash flows i = 16%	Present worth factor (pwf) i = 18%	PV of cash flows i = 18%
1	456.654.000	(pwf-16%-50)		(pwf-18%-50)	
2	456.654.000				
.					
.					
.				5.5541)	
.					
.					
.					
.					
50	456.654.000	x (6.2462) =	2.849.520.960		2.534.429.700
TOTAL			2.849.520.960		2.534.429.700

Note: a) The annual cash flow figures of each year need to be multiplied by the respective **single** present worth factors (pwf) for interest rates of 16% and 18%. But, since annual cash flows are regular series, the PV of annual cash flows over 50 years will simply be annual cash flows multiplied by the series pws. This, is 6.2462 for 16% interest and 5.5541 for 18% interest. For the pwfs, see the Tables, in Appendix Table B, in Merrett and Sykes, **op. cit.**, p. 160.

B — Net Present Value (NPV) of the Keban Project at i = 18% :

1. Present value (PV) of annual cash flows over 50 years and at 18% discount rate :
   = 456.654.000 (pwf - 18% - 50)
   = 456.654.000 (5.5541)
   PV_{b2} = 2.534.429.700 T.L.
2. The initial capital investment of the Keban HE Project :
   I = 2.843.397.000 T.L.
3. The net present value (NPV) of the project at i = 18%
   NPV = 2.534.429.700 - 2.843.397.000
   $NPV_{i=18}$ = —308.967.300

The above PV computations explain that the DCF return lies between 16% and 18%. As is seen, I have calculated above the PV of the net cash flows at both rates and subtracted the initial capital cost of 2.843.397.000 T.L., to find the NPV's of the project at these two rates. The results of these PV calculations, are tabulated in Table 4.

Table 4 — PV of Cash Flows of the Keban HE : At i = 16% and i = 18%

Years	Project Annual Cash Flows T.L.	16% Series Present worth factor (pwf)	Discounted Cash Flows at i = 16%	18% Series Present worth factor (pwf)	Discounted Cash flows at i = 18%
	1	2	3 = 1 x 2	(4)	5 = 1 x 4
0	—2.843.397.000		—2.843.397.000		—2.843.397.000
1	456.654.000				
2	456.654.000				
.					
.					
.					
50	456.654.000	(6.2462)[a]	2.849.520.960	(5.5541)[b]	2.534.429.700
Net Present Value			+6.123.960		— 308.967.300

Note: (a) Series present worth factor (pwf), which correspond to 16% interest and to 50 years life period.

(b) Series pwf for 18% interest and for 50 year life period. Appendix Table B, in Merrett and Sykes, **op. cit.**, p. 160.

C — Interpolation[1] Method to Work out DCF Rate :

At the correct DCF rate, the calculated **net** present value is zero, but we have one positive net present value of T.L., + 6.123.960 and one negative net present value of T.L., — 308.967.300. The correct internal rate of return (or DCF) is somewhat between 16% and 18% and this can be found by simple interpolation.

(1) In calculation DCF return we use simple proportional interpolation. Strictly speaking this is not correct, but proportional interpolation gives such an approximately near result that it is generally not worth the effort to be more

Net PV at 16%	:	+ 6.123.960
Subtract NPV at 18%	:	—308.967.300
Difference in net present value	:	315.091.260

Thus, the correct internal rate of return must lie 6.123.960/315.091.260 of the way between 16% and 18%, so the internal rate of return becomes :

$r_1 = 16\% + 6.123.960/315.091.260 \times (18\% - 16\%)$
$r_1 = 16\% + 0.019 \times (2)$
$r_1 = 16\% + 0.038$
$r_1 = 16.03\%$

2. The Thermal Alternative : Internal Rate of Return .

Following the above method, one can easily compute the internal rate of return of the Thermal Alternative.

As we have mentioned earlier, annual gross revenue of the Thermal, will be similar to that of Keban HE since both projects will be producing the same amount of electric power and also sell at the same rate per Kwh. Thus, gross annual revenue will be 461.820.000 T.L., as it was for the Keban Hydro-electric.[1]

But the annual cash flow of the Thermal will, naturally be different than Keban HE because annual cost comprising operation and maintenance cost in Thermal is different. In order to find the annual net cash flows (not accounting profits), we must subtract annual operating and maintenance cost (0 + M) from the gross annual revenue of 461.820.000 T.L. Annual operating and maintenance cost of Thermal is given as $ 22.307.000, as can be seen

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accurate it must be noted that, for interest rates separated by 1% (e.g. 3% and 4%) the possible error from linear interpolation is relatively small. But this error can become larger when PVs are computed for rates separated by 5% (e.g. 15%-20%). But errors introduced by a linear interpolation are too small to have appreciable influence on the decision-making on investment projects.

For more details on Interpolation Method, see W.G. Ireson and E.L. Grant, "The Principles of Engineering Economy", op. cit. pp. 119-127; and A.J. Merrett and A.Sykes, 'Capital Budgeting and Company Finance', Longmans, 1966, pp. 10-16.

(1) Information on the Thermal project is quite limited, but the above assumption seems to be a logical one to allow us to compute its annual cash flows and consequently its rate of return.

from Table 2.[1] Then, annual cash flows of the Thermal Alternative becomes :

ACF = Gross annual revenue — Annual cost (operating and maintenance costs)

= 461.820.000 (T.L.) — $ 22.307.000 x 9[2]

= 461.820.000 (T.L.) — 200.763.000 TL.

AFC = 261.057.000 (T.L.)

This net annual cash flow figure, is what we need for computing the PV of cash flows over a 35 year period.[3] To aid our internal rate of return calculations, it is necessary to find the trial DCF rate by dividing the initial capital cost by the evarage annual cash flow of the Thermal.

$$\text{Trial DCF rate} = \frac{I}{ACF} = \frac{\$\ 76.000.000 \times 9^{4}}{261.057.000}$$

$$= \frac{688.500.000}{261.057.000}$$

Trial DCF rate = 2.63

This means that the trial rate of discount can be taken to be 38%, where the present wort factor (pwf) for 35 years is 2.6315.[5]

A — Net Present value of Thermal Alternative at 38% discount rate :

1. PV of annual cash flows over 35 years at i = 38%

= 261.057.000 x (pwf — 38% — 35)

= 261.057.000 (2.6315)

= 686.579.910 T.L.

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(1) Total annual cost of the Thermal is $ 26.568.000, but this includes fixed charge, (depreciation), E.E.I., A Private Typed Document, July, 1968. p. 1.

(2) Annual operating and maintenance cost is given in U.S. dollars and should be converted into T.L. at the official exchange rate of 1 $ = 9. T.L.

(3) As may be remembered, this is the life-span of the Thermal project See, Section II.

(4) Capital investment of the Thermal is converted into T.L. at official exchange rate of 1 $ = 9. T.L.

(5) For present worth factor, See, Appendix Table B, in Merrett and Sykes. "Capital Budgeting and Company Finance", Longmans, 1965, p. 164.

2. PV of capital investment of the Thermal
   I = $ 76.500.000 x 9
   I = 688.500.000 T.L.

3. The NPV, which is the difference between PV of annual cash flows and capital cost :
   NPV = 686.579.910 — 688.500.000
   i = 38%
   NPV = —1.920.090 T.L.
   i = 38%

B — In order to obtain a positive value for the NPV of the project, we must now apply a trial rate which is a little lower than 38%. Let us take 36%.

NPV of the Thermal Project at i = 36% :

1. PV of annual net cash flows over 35 years :
   = 261.057.000 x (pwf — 36% — 35)
   = 261.057.000 (2.7777) [1]
   = 723.127.890 T.L.

2. Investment cost of the Thermal :
   I = 688.500.000 T.L.

3. The NPV of the Thermal Alternative at 36% rate of discount, will be the present value (PV) of net cash flows minus the initial capital cost. Thus,
   NPV = 723.127.890 — 688.500.00
   i = 36%
   NPV = +34.627.890 T.L.
   i = 36%

C — Interpolation Method : To find DCF Rate

Now, we have one positive **net** present value of + 34.627.890 T.L. and one negative **net** present value of — 1.920.090 T.L. The internal rate rate of return of the Thermal is then somewhat between 36% and 38% and this can be computed by interpolation.

NPV at i = 36% :	+34.627.890
NPV at i = 38% :	— 1.920.090
TOTAL	36.547.090

(1) Present worth factor (pwf) for 36% interest and for 35 years. See, Appendix Table B in Merrett and Sykes, op. cit. p. 164.

Therefore, internal rate of return of the Thermal Alternative becomes :

$$r_2 = 36\% + \frac{34.627.890}{36.547.980} \times (38\% - 36\%)$$

$$r_2 = 36\% + 0.94 \times (2)$$
$$r_2 = 36\% + 1.88\%$$
$$r_2 = 37.88\%$$

IV — Conclusion :

The following points should be stressed as far as the evaluation technique of the Electrical Research Unit is concerned. First of all, investment decision based on the "equivalent annual cost" criterion is a misleading one when the alternatives have different life -spans.[1] The fact that the Keban HE Project involves a 50 year period and the Thermal Project a 35 year period, means that "annual costs" corresponding to their actual life period cannot form a sensible basis for comparison. Therefore, the life periods of both projects must first be equated so as to obtain equivalent years of service. Some assumptions must be made as to the use to which the capital available at the end of the shortest project will be put. For instance, it may be assumed that the Thermal Project would be renewed in exactly the same form for another 15 years so as to make its life equal to 50 years.

Second, the annual costs ratio which is used by the E.I.E. planners can be deceptive because it does not tell us much about the scale of the benefits and costs and the magnitude of the initial investment outlays incurred by the projects. To decide in favour of a project using this sort of criterion is tacitly to assume that the internal rates of return and life spans of projects are not significant for the cost-benefit analysis. It can be observed that while on the rule of annual costs ratio the Keban HE Project becomes more acceptable, the use of the internal rate of return criterion has indicated to us that the choice should have been in favour of the Thermal Alternative as the "yield" of its investment represents 37%.

Third, although the Keban HE Project was compared with the Thermal Alternative, other alternative projects with different scales of

(1) It should, however, be noted that the same argument holds true against the internal rate of return rule when the two projects have different lifespans.

production and location were not seriously considered during the appraisal of the Keban HE Project. The Keban Project should have been compared with a number of technical alternatives; for instance, two small scale hydro-dams vs the Keban HE or a coal-burning Thermal station vs the Keban HE etc. Therefore, it can be argued that scarce resources particularly capital and foreign exchange cannot be efficiently allocated in the absence of such a wide range of alternative projects.

Fourth, in the application of the "equivalent annual cost" rule calculations are made on the basis of market prices rather than social prices. For instance, fixed capital outlay comprising a foreign exchange component and a domestic capital component was given on market prices. Whereas, for a sound economic evaluation which takes into account the imperfections in the market mechanism, all market prices of factor inputs should be substituted by social prices. Therefore, corrections would be needed on (a) the foreign-exchange component of capital outlay, (b) the foreign-exchange component of variable costs (operation and maintenance costs), (c) market wage payments to unskilled workers and (d) the interest rate taken on market prices.

The Electrical Research Unit did not introduce any correction on foreign exchange nor on the wages paid to workers. Since the two alternative projects are of a capital-intensive character they do not involve large labour cost and therefore correction on wage rates would probably not have a decisive effect on the choice of projects. But the same thing cannot be said for the correction required on the foreign exchange component of capital outlay. This correction has to be introduced since foreign exchange constitutes a very high proportion in the capital outlay and the official rate may overstate the value of the national currency.

No doubt the application of the present value rule, which takes into account the relative futurity of gains and costs by using a discount rate and also makes use of social prices of inputs rather than market prices, would provide better and more accurate results in project appraisal. However, in underdeveloped countries in particular, there is no general agreement as to the rate of discount. This usually is due to imperfections in the capital market or to there being no capital market at all. The internal rate of return may then be of some use, as it obviously gives at least a rough indication of the value of an investment operation. There is also the reason that the notion of yield (and internal rate of return is

nothing but "yield") is familiar to many businessmen and administrators.[1] Another advantage of using the internal rate of return rule is that it is stated in a much more familiar form since people are used to thinking in terms of rates of return on capital.[2]

On the basis of direct benefits emanating from both projects, we have observed in the third section that the Keban HE represents an internal rate of return of 16% and the Thermal Alternative 37%. Thus according to this criterion the Thermal Project turns out to be more attractive[3]. The remarkable difference in the internal rate of return of the Keban dam project and of the Thermal Alternative is due to the fact that the latter has identical benefit streams to the Keban HE whereas its initial investment cost is much lower than that of the Keban HE Project. However, for accurate comparison the renewal of the Thermal Alternative for another 15 years (to bring it to a 50 year life span) should be taken into account. Admittedly this is not an easy task while we are considering the internal rate of return rule[4]. However, if the life period of the Thermal plant is extended for another fifteen years this would put its internal rate of return at even higher than 37%.

It can be argued that a social overhead project such as the Keban one, with a high capital intensity should not be judged only

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(1) In each case the use of the internal rate of return will normally give a single figure which can be directly compared with alternative estimates of the cost of capital or with the rates that may be stipulated as the minimum required in the case of risky projects.

(2) The IRR rule is criticised however, because it ranks projects according to an average rate of return which does not tell us anything about the scale of the initial capital and the magnitude of benefits. If, the social discount rate is different than the market interest rate the use of IRR criterion may lead to wrong selection of projects. It may also point to an unsuitable set of projects when mutually exclusive projects are considered. On this issue, See, P.D. Henderson, op. cit. pp. 60-65; and R. Turvey, "Present value versus internal Rate of Return", Economic Journal, vol. 73, March, 1963.

(3) When the present value criterion is applied it can be found that on the basis of 6% and 8% discount rates the choice will be in favour of the Keban HE Project. But when the computations are carried out at a 10% discount rate the choice changes in favour of the Thermal Alternative. See, C. Karataş, Ph. D Thesis (unpublished) : "A Study of Turkish Planning with Particular Reference to Project Evaluation Technique, Glasgow University, 1970, p. 328.

(4) The difficulty of comparing two mutually exclusive projects with different lives is one of the major objections raised against the internal rate of return rule. It is therefore, advisable to opt for the present value criterion, it being a more straightforward and meaningful rule to apply in project appraisal.

according to its direct benefit flows. It is true that its indirect benefits should be estimated and used as a component of the annual benefit flows for an accurate evaluation. Yet, it is interesting to note that the spillover effects[1] of the Keban HE Project on flood control, irrigation, navigation, fishing and technological external economies generated on the nearby mining industry (Maden and Ergani) do not turn out to be of significant magnitude.

In the evalutaion of the Keban Project most of the indirect benefits of the project were mentioned in a **private report** related to the economic feasibility of the Keban dam and Hydro-electric Project[2].

The selection of the Keban HE Project becomes even more reprehensible if one considers the indirect benefits of the Project. First, it was indicated by one of the E.I.E. planners that there can be no direct irrigation benefit from the Keban Hydro-Dam because the plains which could benefit from irrigation are situated 250-300 Km. downstream from Keban. In other words the region which could be irrigated is the lower Fırat basin which includes Malatya, Mardin, Viranşehir and Urfa. As the River Fırat flows 200 metres below the irrigable land it would be necessary to build another hydro-dam in the lower Fırat to provide irrigation facilities.

Second, it is pointed out in the Report that although with the establishment of long reservoirs in the valleys the movement of ships could become possible, there would be no market for goods and farm products along these waters. It is also stated that almost no benefit from reduction of floods in the lower Fırat basin can be credited to the Keban Hydro-dam since there are no cities or villages located along the lower section of the Fırat anyway. Thus flood control effect did not enter the benefit side of the project evaluation.

Third, the same Report reveals the fact that the cost of equipment required for watersports or other recreational activities would be beyond the reach of the majority of the local inhabitants; so any

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(1) R. McKean defines spillovers as "impacts of actions by some decision-making unit upon the activities of others, impacts which are not directly felt by the first group". See, Efficiency in Government Through Systems Analysis. John Wiley and Sons Inc., New York, 1958. p. 134.

(2) See, Electric Power Resources Survey and Development, Engineering and Economic Feasibility of Keban Dam and Hydro-electric Project of the Fırat River Development,, Ebasco Services Inc. New York, October 1963, pp. 98-100.

benefits accruing from recreational activities would seem to be so minimal as to be almost discounted. However, the Keban Reservoir could have a large potential economic value as a fishing ground for the local population. But, there has been no estimate of the amount of fish the Reservoir might provide in the future.

Fourth, it is indicated in the Report that technological external effects of the Keban HE plant could be significant, especially on the copper mining industry in Ergani near Keban. It is true that copper mining could enjoy considerable expansion in output thanks to the availability of electrical supply at lower costs.[1] Clearly an external economy will exist when the provision of electric power to copper-mine producers at a lower cost induces an expansion in the output of copper ore. The value of physical incremental increase in the output of the latter needs to be ascribed to the Keban HE Project. It should also be noted that the Keban HE Project might lead to "secondary benefits"[2] which need to be added to the benefits side of the Project. It is plausible, for instance, to suppose that the Keban HE plant would lead to an increase in the production of copper sufficiently great as to cause the price of copper to consumers to fall. In this situation the copper producers willingness to pay for electric power fails to reflect the consumption gains of consumers due to lower prices. Therefore, the willingness to pay of project users (here copper producers) must be supplemented by the "consumers' surplus" enjoyed by the consumers other than project users.[3]

As is stated in the Report, from copper-mining cobalt and zinc are produced and from copper-refining sulphuric acid is obtained as a by-product which in turn would be used in producing superphosphate fertilizers. These activities which will be affected by the expansion in the copper production could be expected to increase their profits. The net incomes in the above activities are

(1) It is also true that the same indirect benefit could equally well be provided by the Thermal Alternative.

(2) J. Margolis states that "secondary benefits are the values added by incurring secondary costs in activites stemming from or induced by the project". On this issue See, J. Margolis- Secondary Benefits, External Economies and the Justification of Public Investment, RES. Vol. 39, 1957 p. 285. Also See, S.A. Marglin, Public Investment Criteria, George Allen and Unwin Ltd. London 1967, p. 80.

(3) On this issue, S.A. Marglin - ibid, p. 81 and E.J. Mishan - Cost - Benefit Analysis. Unwin University Books, London 1971, pp. 31-48.

considered as "stemming from" benefits as they are generated by the supply of energy by the Keban HE. It should be indicated that the incremental incomes in these activities should not be restricted to profits but include "wages and salaries, rents, interest and profits before income tax".[1]

It is apparent from the above discussion that the indirect benefits of the Keban HE dam Project are only mentioned in its feasibility report and no serious attempt was made to value and measure them. The benefit-cost analysis of the Keban HE was therefore confined to primary effects. Anyway, the foregoing information reveals that the indirect benefits of the Keban Project as they stand are not really very significant and therefore it has seemed to us plausible to compare both projects on the basis of only direct benefits. In this case, the Thermal Alternative would seem to be more acceptable than the Keban HE dam as this has been clearly indicated both by the internal rate of return and discounted present value rules. One might conclude therefore, that the Keban Project has not received adequate treatment by the relevant agencies and it was selected more for its impressiveness rather than for its economic viability.

Admittedly one is curious to know whether the above findings would be invalidated at present, in view of the considerable rise in oil prices which would naturally make the Thermal Alternative much more expensive to operate annually. Therefore it would be interesting to re-evaluate both projects under these new circumstances to show whether the preference granted to the Keban Project a long time ago was justified after all.

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(1) This broad definition corresponds to gross value added stemming from these activities. See, J. Margolis, op. cit., p. 286.

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ÖZET

KEBAN HİDRO-ELEKTRİK PROJESİNİN SEÇİMİ ÜZERİNDE BAZI DÜŞÜNCELER

Bu makalede amacımız Keban HE Projesinin 1966 yılında yapılan ilk analizler sonucu, eş üretimde bulunan Termal alternatife tercih edilmesinin isabetli bir karar olup olmadığını araştırmak ve Elektrik İşleri Etüd İdaresince (E.İ.E.İ.) izlenen proje değerlendirme yönteminı bilimsel bir açıdan incelemektir. İkinci kısımda ise her iki proje iç kârlılık (internal rate of return) kriterine göre değerlendirilmiş ve buna göre Termal alternatifin Keban Projesine nazaran daha kârlı bir proje olduğu saptanmıştır.

Bu yazıda, Keban HE ve Termal Alternatif projeleri, 4 jeneratörlük üniteler üzerinden ve 1966 yılına ait proje verileri gözönünde tutularak mukayese edilmişlerdir. Ancak, bugün Dünya petrol kriziyle birlikte görülmemiş artışlar kaydeden petrol fiatlarının, Termal Santral projesinin aleyhinde işleyen önemli bir etken olacağını gözönünde tutmak gerekir. Bu açıdan konuya eğilmek şüphesiz daha yararlı olurdu; fakat bu çalışmada her iki projenin analizi ilk ele alındıkları tarihlerdeki verilere dayandırılmıştır.

Keban projesi beklenmedik bazı jeolojik engeller ve finansman güçlükleri nedeniyle, ancak Ekim 1974 tarihinde işletmeye açılabilmiştir. 1971 yılında toplam yatırım tutarı 4.2 milyar TL. tahmin edilen Keban Projesinin takriben 5 milyar TL'nı bulacağı ileri sürülmüştür. Ancak, 1975 yılında yapılan son tahminlere göre 8 jeneratör'lük (8x155 MW) Keban hidro Santralının yatırım tutarı 8 milyar TL. civarında olacaktır. Keban hidro santralı, 4 jeneratörün (4x155 MW) tam kapasite çalışması halinde, 5.43 milyar kilowatt/saat'lik enerji üretebilecektir. Ancak, her jeneratörün yılda bir süre bakım için atıl kalması söz konusu olduğuna göre tam kapasite üretimin elde edilmesine olanak yoktur. Böylece Keban'daki 4 jeneratörün yılda 8.760 saat yerine 8,000 saat çalışması halinde üretilen net toplam enerji miktarı 4,96 milyar kilowatt/saat olacaktır.

Elektrik İşleri Etüd İdaresinin, Keban HE Projesi ve fuel-oil i yakıt olarak kullanması tasarlanan Termal Alternatifin ekonomik değerlendirmesinde izlediği kriter "toplam yıllık maliyet"tir. **Bu kri-**

ter, bilindiği gibi, "yıllık eşdeğer yatırım" ile "yıllık işletme ve bakım masraflarını" kapsar.

Fizibilite Raporunda, 4 jeneratör'lü Keban HE projesinin (her biri 155 MW olan 4 unite) yıllık toplam maliyeti $18.515.000 buna karşılık Termal Alternatifin (yine 4 ünitesi) yıllık toplam maliyeti $26.568.000 olarak hesap edilmiştir. Her iki projenin enerji üretimi eşit olduğundan, ölçüt olarak Keban projesinin yıllık maliyeti ile Termal projenin yıllık maliyeti arasındaki oran esas alınmıştır. Bu orana göre, Termal Alternatif Keban HE projesine nazaran 1,37 defa daha pahalı bulunmuştur.

Bununla beraber E.İ.E.İ.'nin izlediği proje değerlendirme yönteminde, şu sakıncalar göze çarpmaktadır :

(i) Her iki projenin hayat süreleri farklı olduğundan sadece 'eşdeğer yıllık maliyet"e bakarak proje değerlendirmesi yapmak hatalıdır. Bu nedenle, 50 yıllık hayat süresi olan Keban hidro santralının, 35 yıllık ömrü olan Termal Santral projesi ile eşit hayat sürelerine dönüştürülerek, fayda-maliyet oranlarının hesap edilmesi gerekirdi.

(ii) E.İ.E.İ.'nin uyguladığı yıllık maliyetler oranı, projeden doğan fayda akımlarının ölçüsüne ve projenin orijinal yatırım miktarına gerekli önemi vermeyen bir ölçüttür. Bu nedenle her iki projenin daha üstün denektaşları olan "indirgenmiş nakit akımı" (internal rate of return) veya "sosyal bugünkü değer" kriterlerine göre değerlendirilmiş olmaları daha isabetli olurdu.

Nitekim, yazıda uyguladığımız birinci kritere göre Termal Alternatif %37 ve Keban HE projesi %16 olan sermaye iç kârlılık oranları göstermişlerdir. Şu halde, iç kârlılık denektaşına göre Keban projesinin seçimi hatalı olmuştur.

(iii) Çok amaçlı bir proje olan Keban HE projesinin yarattığı endirekt faydaların ve ikincil masrafların da, fayda-maliyet analizlerinin kapsamına alınması gerekirdi. Oysa, Keban projesinin dolaylı faydaları meyanında yer alan selden koruma, sulama etkisi, göl nakliyatı, balıkçılık ve özellikle Maden ve Ergani'deki (demir ve bakır cevherleri) maden sanayii üzerindeki teknolojik dış ekonomiler etkileri kantatif olarak hesap edilmemiştir. Kaldı ki, ilgili Rapor'larda verilen bilgilere göre, Keban projesinin bu faydaları gerçekte önemli değildir.

(iv) Keban projesi, Termal Santral ile mukayese edilmekle beraber, değişik kapasite, üretim metodu ve farklı kuruluş yeri öneren

çok sayıda alternatif projeyle mukayese edilmeden kabul edilmiştir. Kuşkusuz, az gelişmiş ülkelerde kıt olan sermaye ve döviz gibi kaynakların rasyonel bir tarzda dağılımı, ancak geniş sayıda alternatif projelerin gözönünde tutulması ile mümkündür.

(v) E.İ.E.İ.'nin izlediği "eşdeğer yıllık maliyet" kriterinin uygulanmasında, piyasa fiyatları kullanılmıştır. Oysa, tam rekabet koşullarının var olmadığı bir ortamda, sermaye, döviz kuru ve işçi ücretlerinin "sosyal" fiatlara dönüştürülmesi gerekirdi.

Yukarıda belirtildiği gibi, dolaylı faydaların önemli bir yer tutmaması nedeniyle, Keban HE projesinin ve Termal alternatifin yalnız direkt faydaları açısından karşılaştırılmaları uygun görülmüştür. Bu durumda ise gerek "iç kârlılık" ve gerek "sosyal bugünkü değere" indirgeme kriterlerine göre, Termal Alternatif daha kârlı ve cazip bir proje niteliğini kazanmaktadır.