TECHNICAL AND ECONOMICAL ANALYSIS OF COMBINED CYCLES OF GAS TURBINE – STEAM TURBINE ON PIPELINE COMPRESSOR STATIONS

Part II – Economic analysis

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Abstract

In this part there have been shown issues of combined cycle which are on Gas Compressor Stations, reclaiming steam blocks. In analysis of this issue there have been taken few variants of steam cycle configuration and few variants of part load of gas turbine. To steam cycles there have been taken all basis parameters, and then there have been made thermodynamic calculations, which result was value of possibility to make electric energy through steam turbine. In summarizing there have been made an opinion about profitability investment and compared economic results for separate variants.

Key words: *Pipeline Compressor Stations, Combined Cycle, Thermodynamic and Economic calculations*

1. Introduction

The goal of every business activity is to make financial profits. Profitability is the main criterion of investment assessment. Investor must be sure that the enterprise is for him profitable and make profit on appropriately size. In that case there must to be made essential economic and technical analysis, market resources and studies of viability on different stages, from beginning assessment of investment possibility to ending version of project.

Economic analysis which is shown here has a goal to show investment profitability of adding steam block to gas turbine on Gas Compressor Stations. This analysis is also to shown to compare (from economic point of view) technical analysis which was shown in Part I in this investment.

2. Method

Economic analysis was made with using NPV method [1, 2, 3]. It is dynamic method which is based on analysis of discounting cash flow in giving discount rate. Because this is approximate analysis there were not additional analysis of statistic methods, sensitivity resources etc. For assessment of investment profitability there were determined main economic rates.

a) NPV - net present value which can interpret as increase of investor wealth which result from realisation of investment with consider changing of money value in time.

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+R)^t}$$

were:

CF_t - cash flow in time *t*,
t - next years of exploitation (investment),
R - discount rate

b) IRR – internal rate of return; it is discount rate, which should be used in balance investment cost with future incomes connected with those costs. To calculate IRR value means to find discount rate which meet the following condition:

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+R)^t} = 0 \quad \Rightarrow R = IRR$$

Giving in this method value of discount rate it is the value of IRR index.

c) R – net present value ratio, which measure relation between essential capital outlay of project and getting current value of project. This index is to compare different variants of testing investment.

$$NPVR = \frac{NPV}{I_0}$$

were:

I_0 - all beginning outlays

3. Generally assumption

Economic analysis was made with the following assumptions:

a) investment will be realised in 2 years, but investment outlays in the first year will be 30 % of all outlays,
b) investment will be financed from own capital,
c) discount rate: R=12 %,
d) amortization of tangible assets: 7 %,
e) time of investment amortization is accepted on 15 years,
f) time of steam turbine work: 7000 hours per year,
g) own needs of electric energy of steam arrangement are accepted on 1,5 % of produced energy,
h) predictable selling price of electric energy: 40 USD/MWh,
i) income tax: 19 %.

4. Financial outlays

All costs which are shown here are assessed [1]. Individual contracts between order person and supplier will decide the real costs.

*Table1. Combined cycle in configuration **A** (see Part I)*

Investment outlays		
Administration costs (supervision in there)	[USD]	150 000
Project and author’s supervision	[USD]	600 000
Arrangement of building place	[USD]	100 000

Building-installation works	[USD]	2 000 000
Supply of machines and devices	[USD]	9 400 000
Installation on Power Plant place	[USD]	600 000
Outside installations	[USD]	1 000 000
Reserve	[USD]	500 000
All together	[USD]	14 350 000
Exploitation costs		
Remunerations and remuneration services	[USD/year]	80 000
Materials, fuels and energy	[USD/year]	65 000
Renovation and maintenances	[USD/year]	287 000
All-plant costs	[USD/ year]	40 000
Taxies and charges	[USD/ year]	20 000
Others	[USD/ year]	9 000
All together	[USD/ year]	501 000

Table 2. Combined cycle in configuration ***B*** *(see Part I)*

Investment outlays		
Administration costs (supervision in there)	[USD]	150 000
Project and author’s supervision	[USD]	600 000
Arrangement of building place	[USD]	100 000
Building-installation works	[USD]	2 000 000
Supply of machines and devices	[USD]	9 588 000
Installation on Power Plant place	[USD]	600 000
Outside installations	[USD]	1 000 000
Reserve	[USD]	500 000
All together	[USD]	14 538 000
Exploitation costs		
Remunerations and remuneration services	[USD/year]	80 000
Materials, fuels and energy	[USD/year]	65 000
Renovation and maintenances	[USD/year]	291 000
All-plant costs	[USD/ year]	40 000
Taxies and charges	[USD/ year]	20 000
Others	[USD/ year]	9 000
All together	[USD/ year]	505 000

Table 3. Combined cycle in configuration ***C*** *(see Part I)*

Investment outlays		
Administration costs (supervision in there)	[USD]	150 000
Project and author’s supervision	[USD]	600 000
Arrangement of building place	[USD]	100 000
Building-installation works	[USD]	2 100 000
Supply of machines and devices	[USD]	11 280 000
Installation on Power Plant place	[USD]	615 000
Outside installations	[USD]	1 025 000
Reserve	[USD]	500 000
All together	[USD]	16 370 000
Exploitation costs		
Remunerations and remuneration services	[USD/year]	80 000

Materials, fuels and energy	[USD/year]	65 000
Renovation and maintenances	[USD/year]	328 000
All-plant costs	[USD/ year]	40 000
Taxies and charges	[USD/ year]	20 000
Others	[USD/ year]	9 000
All together	[USD/ year]	542 000

5. Counting of rates of economic effective

The detailed calculations are shown for variant A1. For others variants are shown only results. In case of changing loads of gas turbine made calculations for middle loads of 90 % and 80 % gas turbine's power.

5.1. Variant A1

Table 4. Energy production

Power of steam turbine	[MW]	12,485
Production of electric energy	[MWh/year]	87395
Selling	[MWh]	86084

Table 5. Calculations of cash flow (USD)

Proposition	Building		Exploitation			
	year 1	year 2	year 1	year 2	...	year 15
Selling income	0	0	3 443 363	3 443 363		3 443 363
Amortisation of tangible assests	0	0	1 004 500	1 004 500		287 000
Operational costs	0	0	1 505 500	1 505 500		788 000
Profit and loss account						
Pre-tax profit	0	0	1 937 863	1 937 863		2 655 363
Income tax	0	0	368 194	368 194		504 519
Profit after tax	0	0	1 569 669	1 569 669		2 150 844
Demand for working capital	0	0	414 997	414 997		414 997
Cash flow						
Ending netto value	0	0	0	0		414 997
Year's balance	-4 305 000	-10 045 000	2 159 172	2 574 169		2 852 841
Growing balance*	-4 305 000	-14 350 000	-12 190 828	-9 616 659		24 126 210

* Positive value of growing balance appears in 6 year of exploitation, will be calculated: 680 017 USD and will be increased gradually till ending value.

Table 6. Economy efficiency rate

NPV	[USD]	1 870 293
IRR	[%]	14,65
NPVR	[-]	0,130

IRR value bigger than discount rate and positive value of NPV mean that the investment is profitable. Achievement value of rates can say that profitability of investment is on quite good level, in giving assumptions [1, 2, 3].

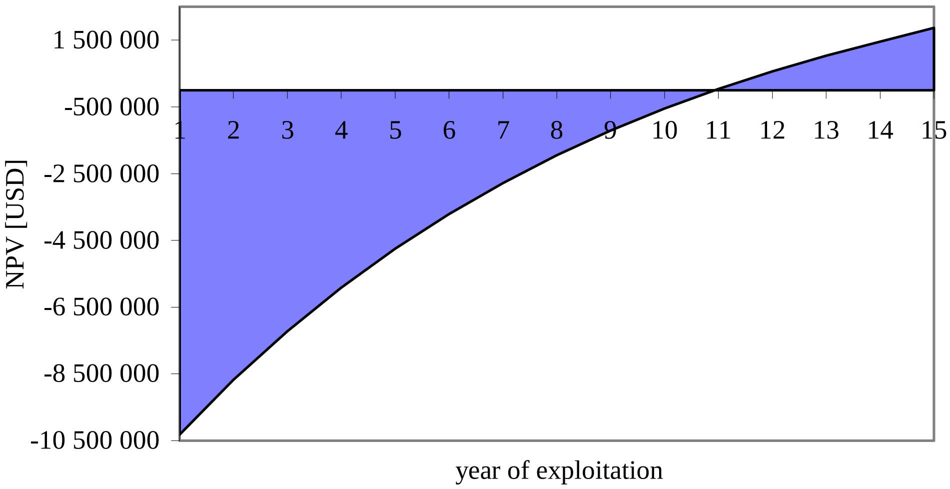

Fig. 1. Value of NPV rate for variant A1 as a function route of exploitation time

5.2. Result balance for all variants

Table 7. Balance of economic efficiency rate

variant	Middle loan TG	Power TP	NPV	IRR	NPVR
	[%]	[MW]	[USD]	[%]	[-]
A1	100	12,484	1870293	15	0,130
A2 90	90	10,987	72775	12	0,005
A2 80	80	9,808	-1341961	10	-0,094
B1	100	12,570	1812254	15	0,125
B2 90	90	11,068	9936	12	0,001
B2 90	80	9,883	-1411999	10	-0,097
C1	100	14,703	2821199	15	0,172
C2 90	90	12,321	-37071	12	-0,002
C2 80	80	11,098	-1504604	10	-0,092

How we can see not all variants are profitable. Negatively value of NPV means no meet of basic criterion of profitable of investment, Fig. 1.. The same is to IRR rate which value under 12 % (amount of discount rate) disqualify giving variant in economic assessment.

6. Conclusion

This shown analysis show that giving investment is profitable but it needs to implement some requirements. Above all gas turbine must constant work with full power or in the little range with changing power, which are decided about power produced by steam turbine. With economic seeing needed amount of energy should be produced from steam block, the middle load of gas turbine could not be lower than 90 %. Doing more precise analysis and specify datas which have been implied in this work, there can be calculated with big precision value of upper shown middle still of gas turbine loads. It should also be said that in giving case there will be always same value of description still and profitability of investment will be depended on it in the main measure.

For saying “profitably still” there will be also influence of type taking gas turbine in Gas Compressor Stations.

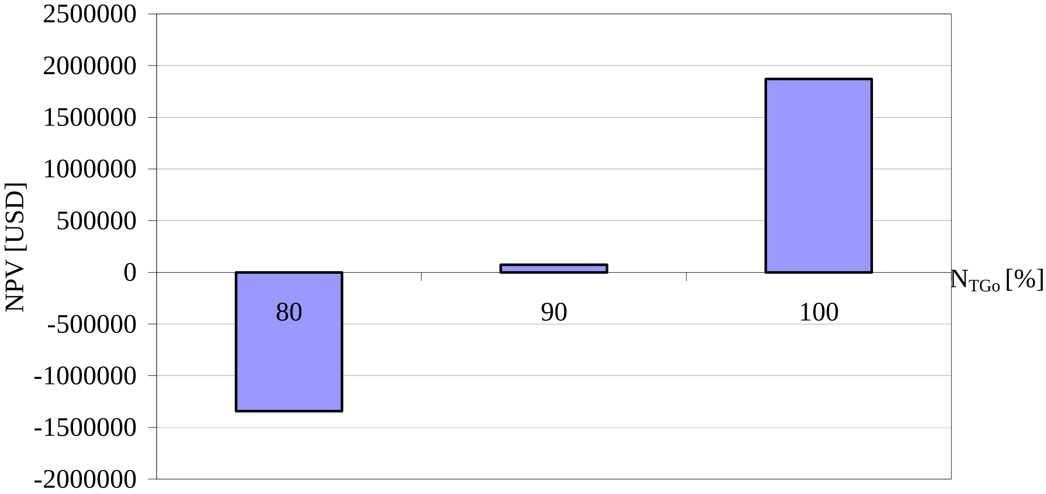

Fig. 2. Value of NPV rate for variant A2 in function of middle load of gas turbine

Very important thing is also energy selling. Significant thing has here the individual contracts between order person and supplier which have prices and amount of taking energy. In economic analysis there is taken the work time of steam block in size of 7000 hours/year.

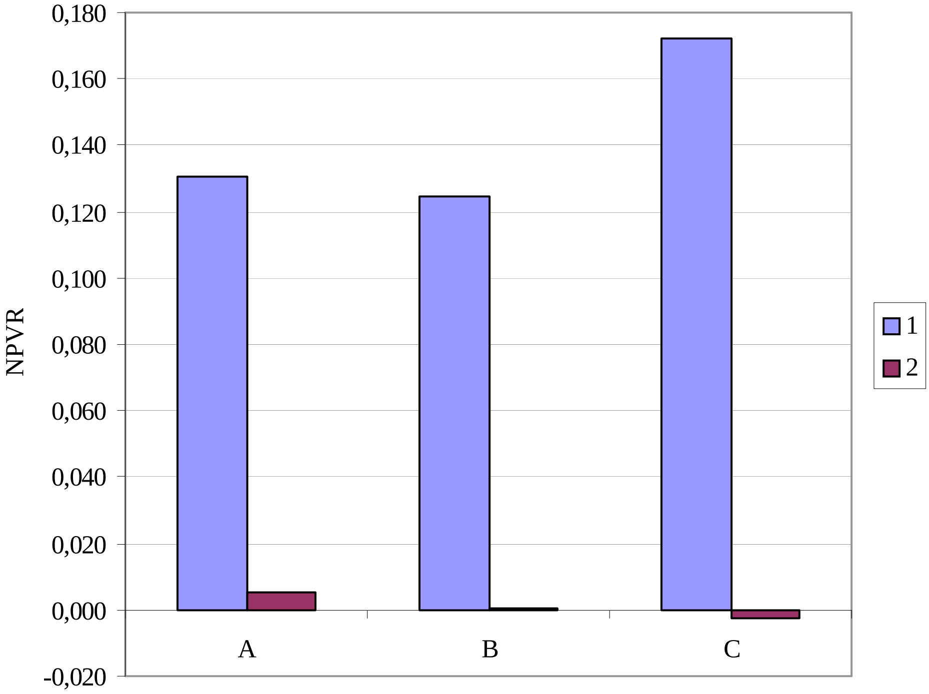

Fig. 3. Comparison of NPVR rate for variants A, B, C project with using of gas turbine working with full power (1) and with gas turbine working with changing loads – results for middle load 90% (2)

The most profitable variant from economic point of view is of course arrangement project to work with gas turbine which work with under full power, Fig. 2 and 3. In that case the most optimistic is project realization with using two-pressure system (variant C). It is very responded on changing load of Gas Compressor Stations. In fragmentary loads its efficiency is decreased and that is why this solution is not economic. In that case the most profitable solution is to use configuration of steam block and single-pressure system (variant A).

Using steam block in variant B gave a little increase of efficiency to variant A, but it is a little less profitable solution with economic point of view on account of buying cost of this arrangement. Those differences are not so big and can be results of not precise estimation of investment issues. It can be said that profits which are from efficiency increase are the same with expected additional costs. Variant A and B can be said that they are compared with themselves from the point of ending economic profit or less. But variant B is the most modern solution.

On Pipeline Compressor Stations usually there are more than one turbo-compressor block which allow on configuration 2+2+1 (two gas turbines, two heat recover boilers, one steam turbine) or 3+3+1. Power output of that variants will be the same like properly double taken 1+1+1 and thrice taken 1+1+1 and investment issues are little less because of steam turbine, generator, converter etc. which are a little less expensive than two or tree turbines with lower power.

References

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