POLITYKA ENERGETYCZNA – ENERGY POLICY JOURNAL

2023 ✦ Volume 26 ✦ Issue 3 ✦ 121–140

DOI: 10.33223/epj/163506

Le Tat Tu[1], Vu Minh Phap[2], Nguyen Thi Thu Huong[3]

A study on loan repayment options for power plant construction: a case study of the Son La hydropower plant, Vietnam

Abstract: Using loans is an effective solution for the investment and construction of energy works in general and power plants in particular, especially for developing countries. In economic and financial studies of the project investment preparation stage, the options of using capital and paying interest will be taken into account to minimize risks and increase the project's ability to pay due debts. However, it is difficult to know which loan repayment option is the most beneficial for the project and when the risk is for the project in the context of debt repayment. The current economic and financial analysis of the project mainly focuses on determining the feasibility of the project through basic parameters, such as net present value (NPV), benefit – cost – ratio (B/C), internal rate of return (IRR), profitability index (PI) and payback period (PP). These parameters do not indicate the most difficult time to pay off the project's loans. This paper analyzes two options for repayment of long-term loans in Vietnam using the case study of Son La hydropower plant to clarify the above difficult times and recommend a suitable repayment plan for the power project. The analytical me-

✉ Corresponding Author: Vu Minh Phap; e-mail: vuminhphap@ies.vast.vn

[1] Institute of Energy Science, Vietnam Academy of Science and Technology, Viet Nam; ORCID iD: 0000-0002-8735-4025; e-mail: lttu@ies.vast.vn

[2] Institute of Energy Science, Vietnam Academy of Science and Technology, Viet Nam; ORCID iD: 0000-0001-5230-6835; e-mail: vuminhphap@ies.vast.vn

[3] Institute of Energy Science, Vietnam Academy of Science and Technology, Viet Nam; ORCID iD: 0000-0002-4427-9707; e-mail: ngthuhuong@ies.vast.vn

thod is used to actualize the cash flow of capital and interest during the construction and operation of the works. In Option 1, the debt is paid annually for interest and capital with a constant amount of money during the repayment period. In Option 2, the original dept without interest is paid with a constant amount of money during the repayment period, the interest (due to the remaining original capital) must be paid in the year when the interest is incurred. The study results show that the amount of the annual payment in option 1 is smaller than in Option 2 in the first four years (of ten years of debt repayment). Thus, capital and interest payment in Option 2 may be more detrimental than Option 1 in the first three years of debt repayment, and the amount of money from debt repayment is greater than the profit obtained from power generation. Thus, depending on the profit in the first years when the power plant comes into operation, the investor needs to decide on a reasonable way to repay the loan so that the project can self-finance.

Keywords: economic effects, electric power system, hydropower plant, investment, NPV, IRR

Introduction

Investment project evaluation is a complex multi-objective analysis process, which requires taking into account many possibilities as its results form the basis for making investment decisions. Recent studies have focused on a detailed analysis of the assumptions underpinning the calculation of expected cash flows and an in-depth assessment of risks. The proposed evaluation should be a three-stage process of the selection and application of the method; changes in the investments of the project; analysis, interpretation results, and conclusion (Mackevičius et al. 2011). The main evaluation indicators of investment projects are net present value (NPV), profitability index (PI), and payback period (PP) (Chubarkina 2020; Azzheurova and Bessonova 2015; Bartošová et al. 2015). The technical, financial, and economic feasibility assessments of investment proposals include steps for the determination of project objectives, technical feasibility, financial analysis, and economic analysis (Đukić and Zidar 2021; Khan 2004; European Investment Bank 2013). Determining the potential attractiveness of the project through social efficiencies, such as the positive impact on the living standards of the population, and the economic results reflected in the ratio of the cost and benefit of the project in the national and regional range (Dikareva and Voytolovskiy 2016; Hanssen et al. 2020). Investment analysis evaluates the advantages and disadvantages of investments in business assets that represent the difference in cash flows through four factors for the evaluation of the amount of initial capital; the expected annual net cash flow from investment opportunities; the residual value of the investment opportunity; the economic lifetime of the investment (Baresa et al. 2016; Bartošová et al. 2015). The method of complex assessment of investment projects through traditional indicators of investment productivity (NPV > 0, IRR > E, PI > 1, PP < T, where E – the discount rate, T – the project term is implemented). Fulfilling these conditions to varying degrees for some projects from a portfolio creates the problem of selecting a set of NPV, IRR, PI, and PP values that meet all the essential requirements of the investor. To determine the aggregate impact of the investment from performance indicators (NPV, IRR, PI, PP), a quantitative indicator of trade performance (Eice) is used (Kuvshinov and Komarova 2017; Culyer and Chalkidou 2018). The profitability index (PI) refers to the ratio of discounted benefits to discounted costs. The benefit-cost ratio is one of the effective ways to quantify and measure the effectiveness of the proposed investment. The profitability index represents the net present value for an initial cost in one currency (Gurau 2012; Eliasson et al. 2015; Prakash and Mitchell 2015). Kaliński et al. (2018) proposed a method to determine risk in the construction investment of biogas plants with the help of the Monte Carlo simulation method. The simulation is performed with two indicators, NPV and VaR, to determine the level of risk (Kaliński et al. 2018).

The study compares possible conditions for factors that directly impact investment efficiencies, such as investment capital (own and borrowing), funding, energy prices, and support policies, which also help investors to obtain information and important news for making investment decisions. A study on the investment efficiency of household biogas projects has compared the investment efficiency according to two unsourced options with and without support funds (Tabanli and Ertay 2013; Bedi et al. 2017). An analysis of net present value has been performed to clarify the efficiency of a wind power project (Agar et al. 2022). A financial analysis of reservoirs and hydropower projects with financing options from the government has also been executed (Nechifor et al. 2022). The relative ratio of debt and equity also affects investment performance (Markkanen et al. 2020; Sunardi et al. 2020). The use of incentive measures is also a solution to promote project investment. These incentives include concessional loans or credits, which usually have lower interest rates, longer grace periods, and longer loan terms. There may also be grants that provide financing without reimbursement (Hertina and Saudi 2019; The University of Manchester and University of Cambridge Institute for Sustainability Leadership 2019; The European Union 2019). The IEA's study of funding for small-scale hydropower projects also found that funding conditions depend on each project, funding institutions, and conditions in the banking market. In general, the loan rate accounts for 50 to 80% of the total investment cost of the project. Borrowed capital is usually characterized by three components, namley interest rate, loan term, and grace period. In addition, government incentives also promote small hydropower such as public loans with more favorable conditions in the private market, power purchase contracts, guarantees of repayment of loans, and tax relief (Council on Economic Policies 2015). Net present value (NPV), internal rate of return (IRR), and discounted payback period have a dominant role in the evaluation of electrical engineering investments (Michalak 2013).

Thus, the study of the calculation of the efficiency of investment in the construction of electrical works is associated with the determination of the economic and financial parameters of the project and the analysis of the fluctuations of cash flow from construction to the end of the economic life of the power plant. The basic parameters to be calculated are NPV, B/C, IRR, profitability (PI), and payback period (PP). Different capital and interest repayment plans have different effects on cash flows and the ability to repay the debt of the project. The value of capital repayment and interest over the years needs to be distributed harmoniously so that the electricity generated by the project can ensure debt repayment.

Borrowing capital to invest in building power plants is an effective support solution for investors. Normally, the total value of borrowed capital will be determined after calculating the total investment in construction works and the amount of capital invested that enterprises can arrange by themselves. The investment projects have to comply with current legal regulations in order to ensure investment efficiency for both businesses and the economy. In Vietnam, investment projects comply with regulations with a maximum loan rate of only 70% of the total investment capital. The loan term is determined according to the capital recovery capacity of the project and the repayment capacity of the investor following the production and business characteristics of the project but not exceeding twelve years. During the grace period, the investor does not yet pay the principal but must pay interest according to the signed credit contract. The interest rate on investment loans is not lower than the average interest rate of capital sources plus operating fees of the Vietnam Development Bank (IEA Technical Report 2000; Decree No. 75/2011/ND-CP 2011). Thus, current legal regulations only stipulate the maximum loan rate, repayment period, and interest rate, and they will be decided through agreements between investors and credit institutions in specific projects.

In Vietnam, there are currently two capital and interest repayment options used in power plant investment as specified below (Decree No. 54/2013/ND-CP 2013; Gutierrez and Dalsted 2012; Hofstrand 2013):

- Annual repayment (both interest and borrowed capital) an amount of K_{ng}^{bq} unchanged during T_0.
- Pay the principal without interest divided equally by T_0 years. The interest (due to the remaining principal capital) incurred in any year must be paid in full.

This paper studies the capital repayment plan and loan interest for the case study of the Son La hydropower plant with the assumption that the loan rate, grace period, interest, and repayment period have been determined. Furthermore, the study analyzes the current capital and interest payment options to assess the advantages and disadvantages of each option for investment in power plants, and investors can minimize risks and improve investment efficiency.

1. Methodology

The method of calculating two plans for the repayment of capital debts and interest on investment projects for the construction of electrical works is shown in Figure 1. Input data include the value of capital borrowed at the beginning of construction, loan interest, construction time, grace period, and the rate of annual loan allocation during construction.

In Figure 1, the blocks have the following functions:

- Input data: enter input data, including total loan amount, capital allocation ratio for construction years, interest rate, construction period, grace period.
- Calculating capital growth during construction period: calculating the process of capital increase due to interest rates in construction years, applying Formulas 2 and 3.

- Calculate cash flow to pay capital and interest in the first way: applying Formula 5.
- Calculate cash flow to pay capital and interest in Method 2: applying Formula 6.
- Comparative analysis of two options: Compare the results of calculating the cash flow to repay the debt for the years of the two options.

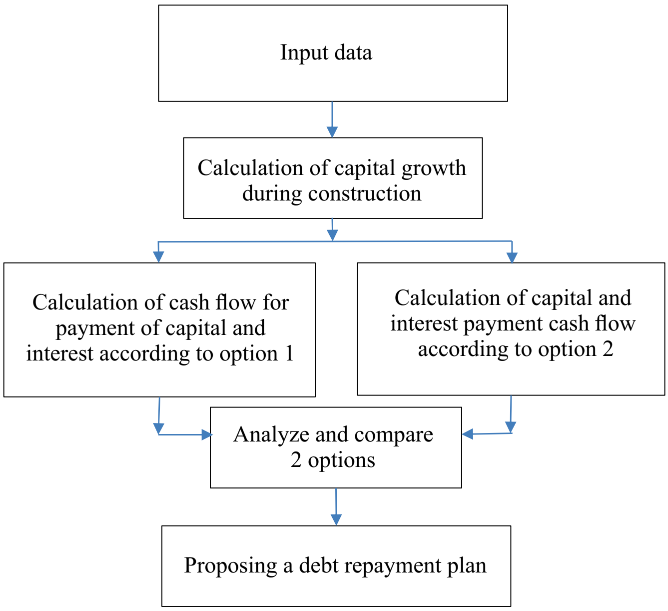

Fig. 1. Method for calculating two capital and interest repayment options

Rys. 1. Sposób obliczania dwóch wariantów spłaty kapitału i odsetek

In the step of the calculation of capital growth during construction, the interest of the construction years is calculated plus the capital of that year, which is added to the previous year. By the end of the construction period, the amount of capital and interest to be paid will be the total annual capital and accrued interest.

The calculation of cash flow for capital and interest according to Option 1 and Option 2 is then studied. In Option 1, a constant amount of capital and interest during the repayment period is described. In Option 2, paying the principal without interest is divided equally by T_0 years. The interest (due to the remaining principal capital) incurred in any year must be paid in full.

The next step compares the annual repayment value and analyzes the advantages and disadvantages of the two options.

Finally, the selected option is proposed based on the annual repayment value and the characteristics and capacity of the project.

Investment capital for the construction of energy projects in general and power plants in particular has two components which are loans from domestic and foreign commercial banks (index symbol is ng) and the own capital of enterprises (index symbol is no) as can be seen as follows:

$$K = K^{ng} + K^{no} \tag{1}$$

This study focused on loans from domestic and foreign commercial banks. The equity portion of the business is not commercial loans, so it is not mentioned in this study.

The current investment loan regime of commercial banks usually stipulates the following common loan repayment conditions when lending capital. In different years during construction, the project will have different loan requirements. The construction phase of the project, starting from the year of receiving the loan to the year of completion of the project (thereby ensuring that the project operates in accordance with the design capacity), is denoted as T_c. During this time, the annual loan portion is usually granted by the lender at the beginning of the year. Therefore, the capital received in any year is subject to additional interest on the borrowed capital at the prescribed interest rate. This interest on the loan will be included in the cost of the project but is not yet repaid and is called "construction loan interest".

In the loan regime, depending on the level of relationship and specific conditions, the lender may allow an additional number of years after the loan has not been repaid, which is called the grace period – T_{ah}. After the grace period has expired, the lender will specify the number of years to pay off the debt, including interest incurred during the repayment period. The repayment period is denoted as T_0. The grace period is usually calculated from the year the construction begins (the first year $T_c = 1$). The grace period of T_{ah} is usually equal to or greater than the construction time T_c ($T_{ah} >= T_c$). During the period after the completion of the project, the total capital borrowed for construction must include the amount of interest payable not only during the remaining grace period but also during the repayment period of T_0.

Some loan repayment regimes as mentioned above, establish the formulas for calculating the total loan capital, both interest and how to repay the loan to the lender. If the symbol α is the percentage of interest-paying annually for the loan and K_o^{ng} is the total loan borrowed for the project, and K_t^{ng} is the annual loans in the t years of the construction period of T_c, the movement of borrowed capital and interest during the construction period is as follows:

- The loan of any year has to add the interest incurred in that year.
- The total interest loan of the previous year belongs to the construction period of T_c when in the following years, each year has new interest incurred annually.

Therefore, when calculating the annual loans K_t^{ng} taking into account the interest incurred annually on the year of inauguration of the project (end of T_c), the total amount of investment loans including the annual interest payable K_o^{ng} is as follows:

$$K_o^{ng} = \sum_{t=1}^{T_c} K_t^{ng} \left(1+\alpha\right)^{T_c - t} \tag{2}$$

when:

K_t^{ng} – the part of foreign investment capital borrowed in the calculation year t.

Thus, the total construction investment capital, including the interest on the construction loans of a project, depends not only on the total investment estimated in research projects but also on the interest payment regime when borrowing capital. K_0^{ng} is an exponential function of α.

There is additional time to pay the debt for works after construction is completed (after the inauguration of the project). In the case of $T_{ah} > T_c$, the project has finished construction but the loan for the construction of the project K_0^{ng} still generates interest during the remaining T_{ah} period. Thus, it is not enough to calculate the total investment loan debt including K_0^{ng} interest according to the above formula (2). In this case, the total investment capital for the project (including construction interest) must be included in the annual interest incurred during the remaining grace period ($T_{ah} - T_c$). Since K_t^{ng} will be zero during the grace period if the total loan payable at the end of the grace period is K_v^{ng}, the amount of capital and interest before repayment will be determined in two parts: the debt part K_0^{ng} during the construction period and the interest incurred by K_0^{ng} during the construction period and the interest incurred by K_0^{ng} during the construction period remaining grace.

$$K_v^{ng} = \sum_{v=T_c}^{T_{ah}} \left[\sum_{t=1}^{T_c} K_t^{ng} (1+\alpha)^{T_c - t} \right] (1+\alpha)^{T_{ah} - v} \tag{3}$$

As mentioned above, the payment of borrowed capital and interest occurs during T_0 (loan repayment period). If the repayment rate and loan capital must be secured so that by the end of this period, the repayment of the debt (including the interest incurred during the repayment period of T_0) will end.

a) *Annual repayment (both interest and loan) with a constant amount of* K_{bq}^{ng} *during* T_0 *(option 1)*

To repay the total debt (both capital and interest) K_v^{ng} has reached the last year of the grace period of T_{ah}, so an annual average amount of K_{bq}^{ng} must be paid during the repayment period T_0 such that through each year of debt repayment. On the one hand, the principal payable is still discounted and the interest incurred on the remaining principal since that year is still at the borrowing rate. Thus, the average annual repayment amount K_{bq}^{ng} depends not only on the borrowed capital but also on the time of T_0 and the annual repayment rate α. The process that establishes the formula for determining the annual K_{bq}^{ng} payable is presented as follows:

Determining the amount of annual debt payable K_{bq}^{ng} during the T_0 period with the amount of debt borrowed for the entire project is K_v^{ng} (the amount of capital borrowed both interests after the construction period of T_c and the grace period T_{ah}) according to the annual loan repayment coefficient α.

If the annual amount payable at the end of the year is an average amount of K_{bq}^{ng}, then:

At the end of the year: T_0 will be out of debt: $K_v^{ng}(1+\alpha)^{To} - K_{bq}^{ng} \sum_{t=1}^{To-1} (1+\alpha)^t - K_{bq}^{ng}$;

The year-end repayment expression T_0 must be zero. Therefore, when balancing the repayment expression in year T_0, the average annual repayment amount (both capital and interest) during the period T_0 will be as follows:

$$K_{bq}^{ng} = K_v^{ng} \frac{(1+\alpha)^{T_0}}{\sum_{t=1}^{T_0-1} (1+\alpha)^t + 1} \tag{4}$$

To make it easier to calculate the multiplication and the sample for (1 + α):

$$K_{bq}^{ng} = K_v^{ng} \frac{(1+\alpha)^{T_0+1}}{\sum_{t=1}^{T_0}(1+\alpha)^t} \tag{5}$$

Expression 4 in Table 1 is used to determine the average annual repayment amount (both capital and interest) according to the repayment period T_0 and the interest payment rate α.

b) *The principal without interest is divided equally by T_0 years, the interest (due to the remaining principal capital) arising in which year must be paid* (*Option 2*)

The repayment of the total loan K_v^{ng} of the project is divided into two components. Firstly, the principal of K_v^{ng} without interest, divided equally by T_0 years, each year must be paid on average Kv/T_0. Secondly, the interest is generated by the remaining (unpaid) investment capital of that year. The interest (due to the remaining principal capital) incurred in any year must be paid in full. The details of this payment are calculated as follows:

Each year will ensure the repayment of a constant amount of principal investment capital plus the amount of interest incurred by the remaining loan capital of that year.

For a total loan debt of K_v^{ng} payable during T_0, each year (year-end) payable is K_v^{ng}/T_0 plus the remaining (unpaid) debt of that year:

Dept with year 1 is: $\dfrac{K_v^{ng}}{T_0} + \alpha K_v^{ng}$

Dept with year 2 is: $\dfrac{K_v^{ng}}{T_0} + \alpha\left(K_v^{ng} - \dfrac{K_v^{ng}}{T_0}\right)$

Dept with year t is: $\dfrac{K_v^{ng}}{T_0} + \alpha\left(K_v^{ng} - \dfrac{(t-1)K_v^{ng}}{T_0}\right)$

In general, we have an annual debt payable in year *t* which K_t^{tr} would be:

$$K_t^{tr} = \frac{K_v^{ng}}{T_0}\left[1+\alpha\left(T_0 - t + 1\right)\right] \tag{6}$$

In which the interest incurred annually (due to unpaid principal) in year $t \in T_0$ is:

$$K_t^{tr} = \frac{K_v^{ng}}{T_0}\left[\alpha\left(T_0 - t + 1\right)\right] \tag{7}$$

Thus, Option 1 is to ensure a constant annual repayment amount during the payable period of T_0 so that at the end of the year T_0 still pays off both the principal and the interest incurred by the remaining principal during T_0. The principal payment component of investment capital gradually increases and the component of interest payment of borrowed capital decreases from the first year to year T_0.

Option 2 also guarantees the repayment of all debts (both principal and interest incurred) during T_0. However, the share every year paid for the principal of the invested capital is constant, and the interest incurred annually (during the repayment period) is paid in full for that year. Thus, this part of "interest incurred" will gradually decrease over time $t \in T_0$.

These calculation methods applied in investment and construction research of power plants are very suitable. Both calculation methods have the same number of repayment years, interest rate, total capital, and interest at the time of repayment. Applying them for a comparative calculation will show the advantages and disadvantages of each option for a particular power-plant project. Power-plant projects often have large investment capital and long construction period, especially thermal power projects and hydropower projects. The construction period of hydropower projects is more than ten years. Thus, the investment capital in the construction years and the grace period (if any) will push up the total capital and interest. In the years of debt repayment, if a suitable payment plan is identified, the risk of payment imbalance is reduced because the amount of debt to be paid in the first years may exceed the ability of the project to pay for the profit due to electricity generation is not enough to pay the debt.

2. Study results

Vietnam's power system with a variety of power sources has been developing quite rapidly in recent years. By the end of 2020, Vietnam's electricity system had a total installed capacity of 69,340 MW. In which the coal-fired power capacity is about 21,380 MW, hydropower is about 20,990 MW, solar power (including rooftop solar power) is about 16,510 MW, gas turbines is about 7,420 MW, wind power is about 538 MW, and other sources including thermal oil, biomass and imported power with a total capacity account for about 2,500 MW.

The study results are presented for the Son La hydropower plant. This hydropower plant is located on the Da River in It Ong town, Muong La district, Son La province, Vietnam. The plant has an installed capacity of 2,400 MW, with six units (Electricity of Vietnam 2008).

Son La hydropower has a construction preparation period of two years, the construction period of T_c is 10 years, the grace period of T_{ah} is 15 years and the loan repayment period of T_0 is 10 years.

Son La hydropower project has a total loan capital of 3,951.46 million USD by the end of the construction period, the capital components are as follows:

- The investment capital for two years of preparation (3.66% of total investment capital for each year) is 312.3 million USD;

- The total remaining capital to build the hydropower plant in ten years, to borrow is 3,915.69 million USD with an annual loan interest rate of 8.5%/year. Table 1 (Electricity of Vietnam 2008) shows the annual loan amount for the construction of the project and its development (including the interest payable annually) during the construction period $T_c = 10$ years and the grace period $T_{ah} = 15$ years.

TABLE 1. Capital allocation and progress of the loan process and annual interest [million USD]

TABELA 1. Alokacja kapitału i przebieg procesu kredytowego oraz oprocentowanie roczne [mln USD]

Year	Annual capital allocation		Loans Cumulative, VDON	Annual loan interest, LNAM	Capital + interest to year t, VLT	Capital + Interest to year t of T_{ah}, VLAH
	rate (TYLE) [%]	eeal value, TNAM				
Preparation	3.66	156.18	0.00	0.00	0.00	0.00
Preparation	3.66	156.18	0.00	0.00	0.00	0.00
1	3.78	160.98	160.98	13.68	174.66	174.66
2	4.11	175.32	336.30	29.75	379.73	379.73
3	5.74	244.79	581.09	53.08	677.61	677.61
4	5.51	234.82	815.91	77.56	989.98	989.98
5	9.30	396.46	1,212.37	117.85	1,504.29	1,504.29
6	11.12	473.95	1,686.32	168.15	2,146.39	2,146.39
7	13.51	576.18	2,262.50	231.42	2,953.99	2,953.99
8	17.21	733.69	2,996.19	313.45	4,001.13	4,001.13
9	13.32	567.78	3,563.97	388.36	4,957.27	4,957.27
10	9.09	387.49	3,951.46	454.30	5,799.06	5,799.06
Total year T_c	100.00	3,951.46		1,847.60	5,799.06	
Total Capital + Interest incurred after completion of the project (during the grace period $T_{ah} - T_c$):						
11		0		492.92		6,291.98
12		0		534.82		6,826.80
13		0		580.28		7,407.08
14		0		629.60		8,036.68
15		0		682.40		8,719.80
Capital + Interest to Tah		0		2,920.02		8,719.80

The calculation in Table 1 follows calculation Formulas 2 and 3 as below:

- Ratio (TYLE) is the percentage of capital invested in years 1 to 10.
- The "real value" (TNAM) column is the column that records the actual annual loan values for the project (issued by the lender at the beginning of that year).
- The "cumulative loan" (VDON) column is the column that shows the actual value of the construction loan from the time of construction ($T_c = 1$) until the corresponding year t.

- The “annual loan interest” (LNAM) column records the interest incurred by the annual loan (in $t \in T_c$ years) caused by the total calculated annual loan interest up to the end of the previous year.
- The column “Capital +interest to year t” (VLT) is the result of calculations according to Formula 4 for the construction time of T_c.
- Because the grace period of T_{ah} is fifteen years, the construction period of T_c is ten years, so after the construction of the project, interest must be charged for the next five years to the repayment period. Therefore, the last column is the calculation of capital + annual interest t until the end of the grace period (T_{ah} = 15 years) (VLAH). From the eleventh year, $K_t^{ng} = 0$; only the value K_0^{ng} generates interest in five years, so the column “annual loan interest” and the column “capital + interest to year t” are different.

Table 1 shows that the total real value of loans for the construction of works is only 3,951.46 million USD, but the interest due to annual loans increased to 1,847.6 million USD during the construction period T_c of ten years, so the total construction loan including interest during the construction period up to the end of the T_c period reached 5,799.06 million USD, which is an increase of almost 1.5 times.

Due to the grace period of five years, there are five more years of unpaid debt (the lower part of Table 3) after ten years of construction (completion of the project). During this time, the interest amount increased to 2,920.02 million USD, so the total value of the loan (including interest) to the point of repayment was 8,719.80 million USD, and this was up to 2.2 times to the value of the actual loan.

According to the calculation results in Table 1, the total investment capital for this power project as of the fifteenth year, the last year of the grace period (T_{ah} = 15 years), is 8,719.8 million USD. The repayment of this debt is required to be completed within T_0 = 10 years (immediately after the expiration of the grace period).

Debt repayment for this hydropower plant is calculated according to two options. In the first option, the amount of debt to be paid off in ten years, each year must be paid at a constant average. When calculating according to formula five with a loan amount of 8719.8 million USD, T_0 of ten years, α of 0.085, so the value K_{bq}^{ng} is the numbers in the total column (third column from the left of Table 2).

Analysis of the remaining capital in year t (Column 2) (K_{vi}), the amount payable annually including interest (Column 4), principal (Column 5) (K_{bq}^{ng}), and the total amount of annual interest liabilities during the period T_0, currently referred to year T_0 = 1 (VHTH), is presented in Table 2.

In Option 2, the debt is paid off in ten years, each year pay an average amount of unchanged principal investment capital and the entire amount of interest incurred (due to the remaining unpaid principal) of any year paid off in that year. The annual repayment value $t = 1 - T_0$ is K_i^{tr}. The amount of debt remaining in Year t (Column 2) (Vn) and the total amount of debt paid annually when present in Year t = 1 (Column 6) (VHTH) is presented in Table 3.

TABLE 2. Settlement of debt repayment in Option 1 [million USD]

TABELA 2. Rozliczenie spłaty zadłużenia w Wariancie 1 [mln USD]

Year	Outstanding debt at year *t*, (Vn)	The total amount payable is at year *t* (K_{bq}^{ng}), where			Total repayment present, VHTH
		Sum (Vt)	Interest (Vtl)	Root (Vtg)	
(1)	(2)	(3)	(4)	(5)	(6)
1	8,719.80	1,328.96	741.18	587.78	1,328.96
2	8,132.02	1,328.96	691.22	637.74	1,224.85
3	7,494.28	1,328.96	637.01	691.95	1,128.90
4	6,802.32	1,328.96	578.20	750.77	1,040.46
5	6,051.56	1,328.96	514.38	814.58	958.95
6	5,236.97	1,328.96	445.14	883.82	883.82
7	4,353.15	1,328.96	370.02	958.95	814.58
8	3,394.21	1,328.96	288.51	1,040.46	750.77
9	2,353.75	1,328.96	200.07	1,128.90	691.95
10	1,224.85	1,328.96	104.11	1,224.85	637.74
Sum		13,289.65	4,569.85	8,719.80	9,460.98

TABLE 3. Calculation of debt repayment in Option 2 [million USD]

TABELA 3. Kalkulacja spłaty zadłużenia w Wariancie 2 [mln USD]

Year	Outstanding debt at year *t*, (Vn)	The total amount payable is at year *t* (K_i^{tr}), where			Total repayment Present, VHTH
		Sum (Vt)	Interest (Vtl)	Root (Vtg)	
(1)	(2)	(3)	(4)	(5)	(6)
1	8,719.80	1,613.16	741.18	871.98	1,613.16
2	7,847.82	1,539.04	667.06	871.98	1,418.47
3	6,975.84	1,464.93	592.95	871.98	1,244.39
4	6,103.86	1,390.81	518.83	871.98	1,088.87
5	5,231.88	1,316.69	444.71	871.98	950.09
6	4,359.90	1,242.57	370.59	871.98	826.37
7	3,487.92	1,168.45	296.47	871.98	716.20
8	2,615.94	1,094.33	222.35	871.98	618.22
9	1,743.96	1,020.22	148.24	871.98	531.20
10	871.98	946.10	74.12	871.98	454.01
Sum		12,796.31	4,076.51	8,719.80	9,460.98

3. Discussion

In terms of commercial loans for the construction of energy projects, the construction time of works (T_c) and the grace period (T_{ah}) have a great determination on the efficiency of the project. Because in addition to the real value of the loan, the interest generated during this period affects the cost of the project.

Production efficiency reaches the rated capacity and energy in the first years of operation of the project, which greatly determines whether or not there is a grace period (after construction), even the ability to repay the loan. Because, if the design project is too large, but when the project is completed, the demand is smaller (not using up the electricity output), then immediately after the operation, the project does not have enough income to pay capital due to the "profitable interest" caused by the construction investment loan.

In construction loans, depending on the income obtained immediately after the project goes into production (after construction is completed), it is decided whether or not to have the next grace period. This is also an issue that needs research attention when choosing a loan strategy. The regime of paying loans immediately after production or applying for additional grace periods is determined by the efficiency of using the income brought by the project after the project goes into production.

The average annual total payment in the first payment option is constant, while Option 2 of the total annual payment decreases during the T_0 period. The amount payable annually in Option 1 is smaller than Option 2 for the first four years (of the ten years payable). The first annual payment of payment Option 2 (1,613.16 million USD) is 1.2 times greater than Option 1 (1,328.96 million USD). Thus, depending on the profit of the first years of operation of the hydropower project (after paying income tax), it is decided how to pay reasonably so that when using profit after income tax to repay debts every year, it is not borrowed from abroad to compensate for the shortfall caused by the repayment.

The total amount of debt (calculated in absolute terms of each year) payable over ten years (including interest) in Option 1 and Option 2 has values of $13,289.96 million and $12,796.31 million, respectively. Thus, it is clear that the repayment in Option 2 has an absolute value of the repayment amount less than that in Option 1.

When bringing back the amount payable annually (for ten years) to the original year, the first year of T_0 (see the last column of Tables 4 and 5), then the amount payable in both calculations is the same value. The total amount of repayment (including loans) of this power project is equal to 9,460.98 million USD.

Figure 2 and Figure 3 show the progress of the total remaining loan, the total amount of capital payable, the movement of principal repayment, and the movement of loan interest repayment in year t.

The plotted data is taken from Table 2 and has been divided by 1,000.

The plotted data is taken from Table 3 and has been divided by 1,000.

Monetary values (debt, principal, interest, and annual repayment) are represented on both axes. The left axis is the value of debt (Vn) (loan and interest) and the annual amount payable

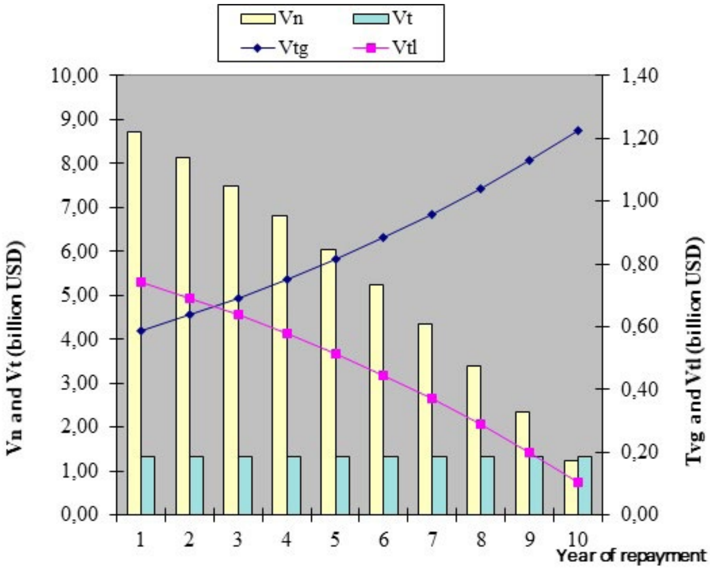

Fig. 2. Debt repayment in Option 1

Rys. 2. Spłata zadłużenia w Wariancie 1

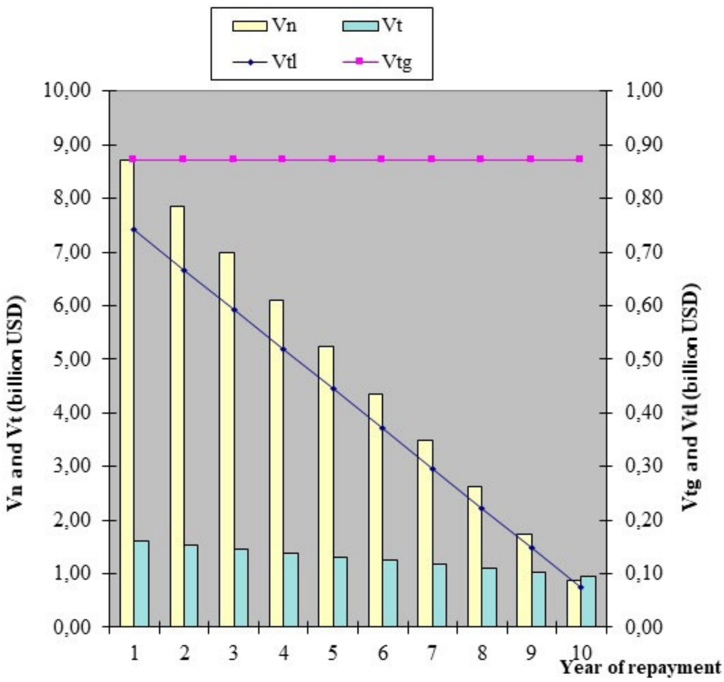

Fig. 3. Debt repayment in Option 2

Rys. 3. Spłata zadłużenia w Wariancie 2

for that year (Vt), while the external axis represents two values payable for the principal (Vtg) and the annual interest (Vtl).

It can be seen that the principal repayment and the interest are different for the two payment methods. The size of the right vertical axis of Figure 2 (Option 1) exceeds \$1.2 billion (actually \$1.33 billion), while the right vertical axis of Figure 3 (Option 2) does not exceed \$0.9 billion (actually \$0.872 billion). But the curve represents the level of full interest payment arising from the outstanding loan of Option 2 during the initial $t \in T_0$ starting too high (a large amount of money) and too steep with the increase of $t \in T_0$. This means causing a large amount of money to be paid in the early years of repayment. Thus, there is a different evolution in how to repay the principal and interest. However, from the point of view of the economic-technical calculation of the market mechanism, they all give the same result in economic-financial calculations, although each option of repayment has its advantages. The application of these calculations is discussed when applied to hydropower projects.

According to the first option in Figure 2, it is shown that paying the interest on the loan (the "interest" curve) is gradually decreasing, and paying the principal (the "principal" curve), by contrast, gradually increases. However, the total amount paid with regard to both interest and annual borrowed capital during T_0 is a constant (the "pay" columns). By this calculation, we can easily use Formula 4 to immediately determine the amount of annual debt to be paid following the intended repayment period of T_0. When increasing or decreasing the specified time to repay the debt T_0, it is easy to quickly determine the amount of annual debt repayment (which, by contrast, will decrease or increase) accordingly. Therefore, it will also be easy to quickly compare with the annual income brought by the operation of the project (for the years immediately after construction is completed) to find a solution to repay the debt. The repayment will be reasonable if the amount of annual liabilities is less than (or equal to) the amount of income brought by the project. At that time, the repayment of the debt within the T_0 term, according to this method, will not cause trouble when repaying the debt, there is no need to continue borrowing more or taking the income from other projects to repay the debt.

In Option 1, every year the project will have a higher ability to ensure the source of money to repay the debt stably. This payment method is suitable when using it to select projects with different technologies in the research problem of selecting optimal options for energy system development. However, to ensure the comparative base when researching and optimizing the development of cooperatives, the projects included in the comparison must ensure independence in the ability to self-borrow and self-pay loans, without affecting the overall revenue and expenditure of cooperatives. Thus, if the works included in the comparison are subject to those conditions and methods, during the repayment period, the works must pay a constant amount annually and can immediately equal the income earned in the first years of operation. Thus, the repayment of debts in Option 1 will be suitable for projects and energy systems that are at the stage of strategic development research.

In Option 2, the principal repayment is a constant (the "principal" line). In addition, an additional portion of the loan principal of that year's remaining loan principal must be paid annually (the "interest" curve). The result was that the total annual payment in the first year was too large, and the next year's payment decreased gradually compared to the previous year. The repayment of debts in the early years of the operation of the project with a large amount of money will cause some difficulties for the project because the annual income earned in the early years of many projects is not enough to repay the debt in this way. Therefore, it is necessary to continue borrowing more foreign money to pay, thus affecting the borrowing of capital to build other works in the cooperative. In this case, even if the remaining grace period ($T_{ah} - T_c$) is still active for some years, the longer this period, the greater the interest rate increase during the grace period. Therefore, raising the grace period does not usually cause a significant effect on loan repayment. However, this method of payment in Option 2 is most likely a specific requirement of the capital lender. Thus, this calculation is more suitable for specific projects at the stage where the economic-technical thesis has been completed and is explored for loans. Then, this option can check the efficiency (feasibility) of the project with the loan regime of the lender to make construction decisions. Therefore, Calculation 2 is more suitable in the calculation to check the effectiveness of the specific project being surveyed at the level of capital preparation with regard to considering the ability of the project to satisfy the loan requirements and interest payment of the investor. At that time, depending on the results of calculating the total annual debt payable under the loan regime, the grace period, and the repayment period, the borrower makes suggestions and requests to calibrate the loan regime with the lender so that the amount to be paid is reasonable and the project proves to be effective.

Conclusions

Research results show that investing in the construction of power plants is necessary to consider and evaluate loan repayment options in order to minimize risks and ensure that the project can pay off debts with profits from power generation. The first three years of the debt repayment process are the most difficult years of the project with regard to paying debts.

In terms of commercial loans for the construction of energy projects, the construction time T_c of the project and the T_{ah} grace period have a great influence on the efficiency of the project. This is because in addition to the real value of the loan, the interest generated during this period will affect the cost of the project. During this time, the cumulative increase in interest on capital can be up to 2.2 times to the size of the actual loan.

Two loan repayment options are suitable for different conditions of the investment research process. In Option 1, an annual repayment plan (both interest and loan) in a constant amount during T_0 is suitable for projects and energy systems that are at the stage of development strategy research.

In Option 2, the plan to pay the principal without interest is divided equally across T_0 years. The interest (due to the remaining principal capital) incurred in which year must be paid off, so Option 2 is more suitable in the calculation of checking the effectiveness of the specific project being surveyed at the level of capital preparation, to consider the ability of the project to satisfy the loan requirements and interest payment of the investor's loan.

Each stage of investment in the project needs to consider a suitable repayment plan that satisfies the conditions of the lender and the repayment capacity of the project.

Nomenclature and abbreviation

Amount of debt for the entire project	K_v^{ng}	USD
Annual repayment value $t = 1–T_0$	K_i^{tr}	USD
Annual loans	K_t^{ng}	USD
Annual amount payable of that year	Vt	USD
Annual interest	Vtl	USD
Annual loan interest	LNAM	USD
Average annual repayment amount	K_{bq}^{ng}	USD
Benefit – cost – ratio	B/C	
Capital + interest to year t	VLT	USD
Construction time	T_c	year
Cumulative loan	VDON	USD
Grace period	T_{ah}	year
Internal rate of return	IRR	%
International Energy Agency	IEA	
Net present value	NPV	USD
Outstanding debt at year t	Vn	USD
Profitability index	PI	
Payback period	PP	year
Principal	Vtg	USD
Ratio	TYLE	%
Real value	TNAM	USD
Repayment period	T_0	year
Repayment rate	α	%
Total repayment present	VHTH	USD
Total loan	K_o^{ng}	USD
Total debt	K_v^{ng}	USD

References

Agar et al. 2022 – Agar, A.A., Athanassiadis, D. and Pavelka, B.J. 2022. The CO_2 cutting cost of biogas from humanure and livestock manure. *Sustainable Energy Technologies and Assessments* 53(A), DOI: 10.1016/j.seta.2022.102381.

Azzheurova, K.E. and Bessonova, E.A. 2015. Development of Methods for Analysis and Assessment of the Efficiency of Regional Investment Projects Seeking State Support. *Mediterranean Journal of Social Sciences, MCSER Publishing* 6(5 S2), pp. 362–371, DOI: 10.5901/mjss.2015.v6n5s2p362.

Baresa et al. 2016 – Baresa, S., Bogdan, S. and Ivanovic, Z. 2016. Capital investments and financial profitability. *UTMS Journal of Economics* 7(1), pp. 49–59.

Bartošová et al. 2015 – Bartošová, V., Majerčák, P. and Hrašková, D. 2015. Taking Risk into Account in the Evaluation of Economic Efficiency of Investment Projects: Traditional Methods. *Procedia Economics and Finance* 24, pp. 68–75, DOI: 10.1016/S2212-5671(15)00614-0.

Bedi et al. 2017 – Bedi, A.S., Sparrow, R. and Tasciotti, L. 2017. The impact of a household biogas programme on energy use and expenditure in East Java. *Energy Economics* 68, pp. 66–76, DOI: 10.1016/j.eneco.2017.09.006.

Chubarkina, I.Y. 2020. Improving the Efficiency of the Investment Strategy of the Development Company. *Advances in Economics, Business and Management Research* 128, p. 567, Moscow, Russia: Moscow State University of Civil Engineering.

Council on Economic Policies (CEP), The Impact of Interest Rates on Electricity Production Costs, June 2015. [Online] https://www.cepweb.org/wp-content/uploads/CEP_DN_Interest_Rates_Energy_Prices.pdf [Accessed: 2023-02-10].

Culyer, J.A. and Chalkidou, K. 2018. Economic Evaluation for Health Investments en route to Universal Health Coverage: Cost-benefit analysis or cost-effectiveness analysis? *Value in Health* 22(1), pp. 99–103, DOI: 10.1016/j.jval.2018.06.005.

Decree No. 54/2013/ND-CP dated 22/5/2013 on Supplement to Decree No. 75/2011/ND-CP dated 30/8/2011 on investment credit and export credit of the state.

Decree No. 75/2011/ND-CP dated 30/8/2011 on investment credit and export credit of the State.

Dikareva, V. and Voytolovskiy, N. 2016. The efficiency and financial feasibility of the underground infrastructure construction assessment methods. *Procedia Engineering* 165, pp. 1197–1202, DOI: 10.1016/j.proeng.2016.11.839.

Đukić, M. and Zidar, M. 2021. Sustainability of investment projects with energy efficiency and non-energy efficiency costs: case examples of public buildings. *Sustainability* 13(11), DOI: 10.3390/su13115837.

Electricity of Vietnam, Son La Hydropower Feasibility Study, 2008. [Online] https://cosodulieu.evn.com.vn/pages/cms/viewdetail-cong-trinh-thuy-dien-son-la-phan-nghien-cuu-kha-thi-(tap-1-den-tap-6)-va-thiet-ke-ky-thuat-giai-doan-2-(tap-1-thuyet-minh-tong-hop-va-tap-6-nghien-cuu-on-dinh-do-ben-cong-trinh-quyen-1-tinh-toan-on-dinh-do-ben-cong-trinh)-id-25738.html [Accessed: 2023-02-10].

Eliasson et al. 2015 – Eliasson, J., Börjesson, M., Odeck, J. and Welde, M. 2015. Does Benefit–Cost Efficiency Influence Transport Investment Decisions? *Journal of Transport Economics and Policy* (*JTEP*) 49(3), pp. 377–396.

European Investment Bank, "The Economic Appraisal of Investment Projects at the EIB", Projects Directorate, March 2013. [Online] https://www.eib.org/attachments/thematic/economic_appraisal_of_investment_projects_en.pdf [Accessed: 2023-02-10].

Gurau, M.A. 2012. The use of profitability index in economic evaluation of industrial investment projects. *Proceedings in Manufacturing Systems* 7(1), pp. 55–58.

Gutierrez, P.H. and Dalsted, N.L. 2012. Long-Term Loan Repayment Methods. *Colorado State University, Fact Sheet No. 3.757, Farm and Ranch Series|Economics*. [Online] https://extension.colostate.edu/docs/pubs/farmmgt/03757.pdf [Accessed: 2023-03-06].

Hanssen et al. 2020 – Hanssen, T.-E.S., Helo, P., Solvoll, G., Westin, J. and Westin, L. 2020. Dissimilarities between the national cost/benefit models of road projects: Comparing appraisals in Nordic countries. *Transportation Research Interdisciplinary Perspectives* 8, DOI: 10.1016/j.trip.2020.100235.

Hertina, D. and Saudi, M.H.M. 2019. Stock Return: Impact of Return on Asset, Return on Equity, Debt to Equity Ratio and Earning Per Share. *International Journal of Innovation, Creativity and Change* 6(12), pp. 93–104.

Hofstrand, D. 2013. Types of Term Loan Payment Schedules. *Iowa State University, Ag Decision Maker File C5-93*. [Online] https://www.extension.iastate.edu/agdm/wholefarm/pdf/c5-93.pdf [Accessed: 2023-01-15].

IEA Technical Report 2000, "Financing of Small-Scale Hydropower Projects". [Online] https://www.ieahydro.org/media/cf7bd79f/Financing%20of%20Small-hydro%20Projects.pdf [Accessed: 2023-02-10], pp. 4–15.

Kaliński et al. 2018 – Kaliński J., Paska, J., Pawlak, K., Terlikowski, P. and Urbanek, D. 2018. Investment risk in the energy sector on the example of a biogas power plant. *Polityka Energetyczna – Energy Policy Journal* 21(4), pp. 125–140, DOI: 10.24425/124504.

Khan, A.R. 2004. Economic Feasibility of Investment in Agro-Based Industries – Using AIES. *International Journal Of Agriculture & Biology* 6(4), pp. 676–682.

Kuvshinov, M.S. and Komarova, N.S. 2017. Improvement of methods of evaluation of investment projects in the context of import substitution. *SHS Web of Conferences* 35, DOI: 10.1051/shsconf/20173501095.

Mackevičius, J. and Tomaševič, V. 2011. Model for evaluating the economic efficiency of investment projects: architecture and main aspects of application. *Ekonomika* 90(4), pp. 133–149, DOI: 10.15388/Ekon.2011.0.920.

Markkanen et al. 2020 – Markkanen, S., Braeckman, J.P. and Souvannaseng, P. 2020. Mapping the evolving complexity of large hydropower project finance in low and lower-middle income countries. *Green Finance* 2(2), pp. 151–172, DOI: 10.3934/GF.2020009.

Michalak, J. 2013. Selected methods aiding investment decisions in power engineering (*Wybrane metody wspomagaj¹ce podejmowanie decyzji inwestycyjnych w energetyce*). *Polityka Energetyczna – Energy Policy Journal* 16(4), pp. 77–86 (*in Polish*).

Nechifor et al. 2022 – Nechifor, V., Basheer, M., Calzadilla, A., Obuobie, E. and Harou, J.J. 2022. Financing national scale energy projects in developing countries – An economy-wide evaluation of Ghana's Bui Dam. *Energy Economics* 111, DOI: 10.1016/j.eneco.2022.106065.

Prakash, S. and Mitchell, D. 2015. Probabilistic Benefit Cost Ratio – A Case Study. *Australasian Transport Research Forum* (*ATRF*), *37th*, Sydney, New South Wales, Australia.

Sunardi et al. 2020 – Sunardi, N., Husain, T, and Kadim, A. 2020. Determinants of Debt Policy and Company's Performance. *International Journal of Economics and Business Administration* VIII(4), pp. 204–213, DOI: 10.35808/ijeba/580.

Tabanli, R.M. and Ertay, T. 2013. Value stream mapping and benefit–cost analysis application for value visibility of a pilot project on RFID investment integrated to a manual production control system – a case study. *The International Journal of Advanced Manufacturing Technology* 66, pp. 987–1002, DOI: 10.1007/s00170-012-4383-x.

The European Union, "Funding Energy Efficiency through Financial Instruments", March 2019. [Online] https://www.interregeurope.eu/sites/default/files/2021-12/Policy%20brief%20on%20funding%20energy%20efficiency_0.pdf [Accessed: 2023-02-10].

The University of Manchester and University of Cambridge Institute for Sustainability Leadership (2019), "Financing Sustainable Hydropower Projects in Emerging Markets: An Introduction to Concepts and Terminology". [Online] https://www.cisl.cam.ac.uk/system/files/documents/Financing-sustainable-hydropower-projects-concepts-terminology.pdf [Accessed: 2023-02-10], p. 22.

Le Tu, Vu Minh Phap, Nguyen Huong

Badanie możliwości spłaty kredytu na budowę elektrowni: studium przypadku elektrowni wodnej Son La w Wietnamie

Streszczenie

Korzystanie z kredytów jest skutecznym rozwiązaniem dla inwestycji i budowy zakładów energetycznych w ogóle, a w szczególności elektrowni, zwłaszcza w krajach rozwijających się. W analizach ekonomiczno-finansowych etapu przygotowania inwestycji projektu uwzględnione zostaną możliwości wykorzystania kapitału i spłaty odsetek w celu zminimalizowania ryzyka i zwiększenia zdolności projektu do spłaty wymaganych długów. Trudno jednak stwierdzić, która opcja spłaty kredytu jest najkorzystniejsza dla projektu i kiedy występuje ryzyko dla projektu w kontekście spłaty zadłużenia. Bieżąca analiza ekonomiczno-finansowa projektu koncentruje się głównie na określeniu wykonalności projektu poprzez podstawowe parametry, takie jak wartość bieżąca netto (NPV), stosunek korzyści do kosztów (B/C), wewnętrzna stopa zwrotu (IRR), wskaźnik rentowności (PI) i okres zwrotu (PP). Parametry te nie wskazują na najtrudniejszy czas na spłatę kredytów projektu. W niniejszym artykule przeanalizowano dwie opcje spłaty kredytów długoterminowych w Wietnamie na przykładzie elektrowni wodnej Son La, uwzględniając obecne trudne warunki i zalecając odpowiedni plan spłaty dla projektu energetycznego. Metoda analityczna służy do aktualizacji przepływów pieniężnych kapitału i odsetek w trakcie budowy i eksploatacji obiektu. W Wariancie 1 dług jest spłacany corocznie na odsetki i kapitał stałą kwotą w okresie spłaty. W Wariancie 2 pierwotny dług bez odsetek spłacany jest stałą kwotą w okresie spłaty, odsetki (należne od pozostałego kapitału pierwotnego) muszą być zapłacone w roku, w którym naliczone zostały odsetki. Wyniki badań wskazują, że wysokość rocznej spłaty w Wariancie 1 jest mniejsza niż w Wariancie 2 w pierwszych czterech latach (z dziesięciu lat spłaty zadłużenia). Zatem spłata kapitału i odsetek w Wariancie 2 może być bardziej szkodliwa niż w Wariancie 1 w pierwszych trzech latach spłaty zadłużenia, a kwota pieniędzy ze spłaty zadłużenia jest większa niż zysk uzyskany z produkcji energii. Zatem w zależności od zysku w pierwszych latach od uruchomienia elektrowni, inwestor musi zdecydować, jak rozsądnie spłacić kredyt, aby projekt mógł się sam sfinansować.

Słowa kluczowe: efekty ekonomiczne, system elektroenergetyczny, elektrownia wodna, inwestycja, NPV, IRR