

# Net Present Value Method: A Method Recommended by ISO 15686-5 for Economic Evaluation of Building Life Cycle Costs

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## Abstract

The publication of ISO 15686-5 is significant for studies related to the life-cycle costs of buildings. Among the many economic evaluation methods, the NPV method is recommended for use by this standard. This study explains the concept and method of PV, and then provides an explanation of the concept and method of NPV, and points out the limitations in the practical application of the method.

## Keywords

NPV, ISO 15686-5, Building, Life Cycle Cost, Economic Evaluation

## 1. Introduction

ISO 15686 developed by the International Organization for Standardization (ISO) is a multi-part series of international standards giving guidance on various aspects of planning the service life of buildings and constructed assets [1]. Part 5 of the series, published in 2008, is devoted to the Life Cycle Cost (LCC) in construction. It was published to establish a clear terminology and a universal methodology for LCC, enabling the practical application of LCC to be widely used in the construction industry [2]. The content of ISO 15686-5 has important implications for studying LCC in construction. The applicability of LCC in economic evaluation has been recognized in this literature [3].

Many methods for the economic evaluation related to LCC have emerged over the years [4]. Each method has its own different advantages and disadvantages. Common economic evaluation methods with LCC include Simple Payback Period (SPP), Discounted Payback Period (DPP), Equivalent Annual Cost (EAC),

Internal Rate of Return (IRR), Net Savings (NS) and Net Present Value (NPV) methods [5]. However, too many economic evaluation methods have the potential to lead to confusion in their application [6]. The NPV method is recommended to be applied in ISO 15686-5 as an important LCC economic evaluation method. It is also considered to be the most widely applied method [7]. It's conducive to understanding and using the MPV method for the researcher during calculating the LCC by systematical combination.

## 2. The Concept and Method of PV

First, in order to better understand the NPV method, it is necessary to explain the concept and method of Present Value (PV). If comparing the NPV with PV, it can be seen that the to know the latter is the basis to understand the former. This point is very obvious in the concept of each other.

PV is what cash flow generated at a time or series of other times is worth in a given moment. In other words, it is the value of future funds discounted to the present on the basis of some specified interest rate. If the cash flow occurs in the future, the researcher takes into account the time value of money in the calculation process, discounting it and also taking into account factors such as investment risk. If the cash flow occurs in the past, the researcher should reflect the interest earned on the cash flow during that period in the PV calculation. PV calculations allow for a degree of cross-sectional comparison of cash flows occurring at different points in time, the feature that has led to its widespread use not only in economics but also in the general business world.

To better explain the concept of PV, an example is given here. For example, an investor in a commercial building project expects to receive a rent of 5 million at the end of five years, and assuming a discount rate of 5%, the present value of the rental income is 4,414,000. This means that 5 million at the end of the 5-year period is equivalent to 4,401,400 today. This example shows that the time value of money is reflected in it. The PV is calculated by the following equation:

$$PV = \sum_{t=0}^n \frac{A_t}{(1+i)^t} \quad (1)$$

In this equation:

$A_t$ —Cash flow at the end of year  $t$ ;

$i$ —Discount rate.

The equation can also be expressed in the following way:

$$PV = \frac{A_1}{1+i} + \frac{A_2}{(1+i)^2} + \dots + \frac{A_n}{(1+i)^n} \quad (2)$$

To better explain the equation above, an example is given for illustration. For example, the cash flow data of a commercial building project within 5 years after completion is shown in **Table 1**.

If  $i = 5\%$ , the present value of this series of cash flows is 11,805,200.

**Table 1.** 5-year cash flow of a commercial building project (Unit: Ten thousand yuan).

| Year      | 1   | 2   | 3   | 4   | 5   |
|-----------|-----|-----|-----|-----|-----|
| Cash Flow | 100 | 250 | 300 | 350 | 400 |

$$PV = \frac{100}{1+0.5} + \frac{250}{(1+0.5)^2} + \frac{300}{(1+0.5)^3} + \frac{350}{(1+0.5)^4} + \frac{400}{(1+0.5)^5} = 1180.52 .$$

### 3. The Concept and Method of NPV

NPV is the difference between the PV of the future cash flows generated by the investment in a project and the initial investment in the project, calculated on the basis of a certain standard discount rate during the calculation period. The NPV method is mainly used to evaluate the profit capability or profit taking level of an investment project, and is a widely used project valuation tool.

It judges and evaluates the feasibility of an investment proposal by calculating the magnitude of the NPV of the investment project. In the case of a single investment project NPV calculation, if the NPV result is positive, the investment project is feasible from the financial point of view. If the NPV result is negative, the investment project is not feasible from the financial point of view. If there is more than one option in an investment project, the NPV of different options for the same investment project with the same initial investment should be calculated, and then the NPV results of different options should be compared. Generally speaking, the investor should choose the option with the largest NPV result, which has a better investment value from the financial point of view. The formula for calculating the NPV is as follows:

$$NPV = \sum_{t=1}^n \frac{A_t}{(1+i)^t} - A_0 \quad (3)$$

In this equation:

$A_t$ —Cash flow at the end of the  $n$ th year;

$A_0$ —Initial investment amount;

$i$ —Discount rate;

$n$ —Investment calculation period.

If the initial investment amount is considered as the cash flow at the end of year 0 in the calculation process, in which case  $t = 0$ , the above NPV formula can be translated as follows:

$$NPV = \sum_{t=0}^n \frac{A_t}{(1+i)^t} \quad (4)$$

In this equation:

$A_t$ —Cash flow at the end of the  $n$ th year;

$i$ —Discount rate;

$n$ —Investment calculation period.

For example, the expected investment in a commercial building project and

the cash flows generated during the sale process are shown in **Table 2**, and the NPV calculation process is shown below for a discount rate of 5%. The contents in **Table 3** then clearly illustrate the process of calculating the NPV in the above example.

$$\text{NPV} = -2000 + \frac{500}{1+0.5} + \frac{1000}{(1+0.5)^2} + \frac{700}{(1+0.5)^3} + \frac{250}{(1+0.5)^4} = 152.4$$

Within the framework of the NPV approach, if it involves the comparison and selection of multiple investment options, the investor should compare the NPV figures of different investment options for the same investment amount in the same period and select the option with the largest NPV among them. For example, a commercial building project has two different investment options, Option A and Option B. The expected investment and the cash flow generated during the sale process are shown in **Table 4**, respectively.

With a discount rate of 5%, the process of calculating each the NPV of the two investment options is shown in **Table 5**. The NPV of Option A (1,524,000) is smaller than the NPV of Option B (2,703,000) after calculation according to the aforementioned formula, so the investor should choose Option B.

The NPV method takes all the cash flows of the project of interest into account during the calculation process, and attaches great importance to the time value of money. At the same time, the NPV method also takes into account the risks arising from the investment through the adjustment of the discount rate in

**Table 2.** Cash flow of a commercial building project during the calculation period (Unit: Ten thousand yuan).

| Year      | 0     | 1   | 2    | 3   | 4   |
|-----------|-------|-----|------|-----|-----|
| Cash Flow | -2000 | 500 | 1000 | 700 | 200 |

**Table 3.** The process of solving NPV for a commercial building project during the calculation period.

| Year | Discount rate | PV (ten thousand yuan) |
|------|---------------|------------------------|
| 0    | 1             | -2000                  |
| 1    | 0.952         | 476                    |
| 2    | 0.907         | 907                    |
| 3    | 0.864         | 604.8                  |
| 4    | 0.823         | 164.6                  |

**Table 4.** Cash flows during the calculation period for Option A and Option B of a commercial building project (Unit: Ten thousand yuan).

| Year               | 0     | 1    | 2    | 3   | 4   |
|--------------------|-------|------|------|-----|-----|
| Option A cash flow | -2000 | 500  | 1000 | 700 | 200 |
| Option B cash flow | -2000 | 1100 | 600  | 500 | 300 |

**Table 5.** NPV solution process for an office building project during the calculation period.

| Year | Discount rate | Option A PV<br>(ten thousand yuan) | Option B PV<br>(ten thousand yuan) |
|------|---------------|------------------------------------|------------------------------------|
| 0    | 1             | -2000                              | -2000                              |
| 1    | 0.952         | 476                                | 1047.2                             |
| 2    | 0.907         | 907                                | 544.2                              |
| 3    | 0.864         | 604.8                              | 432                                |
| 4    | 0.823         | 164.6                              | 246.9                              |

the calculation process. For example, if an investor believes that an investment project is risky after a comprehensive judgment, a higher discount rate can be used in the NPV calculation process; if an investor believes that an investment project is less risky after a comprehensive judgment, a lower discount rate can be used in the NPV calculation process.

#### 4. Limitations of the NPV Method

Although the NPV method has many advantages in the process of practical application, there are still certain shortcomings: 1) It is difficult to obtain a completely objective value for future cash flows in the NPV calculation process, which means that the estimated future cash flows may not be consistent with the actual results; 2) The NPV method can only calculate costs that can be quantified more precisely, but not those intangible costs that cannot be specifically quantified; 3) The determination of discount rate in the NPV method is more difficult to master. Although the NPV method reflects the time value of money, in practice, the discount rate can be determined only after considering various factors (such as nominal interest rate, real interest rate, inflation, etc.). In addition, the determined discount rate can only reflect that the rate of return of an investment plan should not be lower than this value, but it cannot explain or account for the future rate of return of the investment plan itself, which also means that the determination of the discount rate will have a certain negative impact on the investment decision if there is a deviation; 4) When comparing multiple investment options, the NPV method can usually only be used for comparison between different investment options with the same investment amount in the same period. It cannot correctly explain and account for the different solutions with different investment amounts.

#### 5. Conclusion

ISO 15686-5, published by the ISO, sets standards for construction LCC and recommends the use of the NPV method for calculation and analysis. Understanding the concept of PV is the basis for applying the NPV method. The NPV method can be used to evaluate the profit capability or profit taking level of an

investment project, and thus to judge and assess the feasibility of the investment proposal. To use this method should be aware of its scope of application and its inherent limitations.

### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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