Chapter 6

Economic Analysis of CCE Projects

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Chapter 6

Economic Analysis of EEC Projects

EEC regulations or sub-decrees are indispensable. EEC should bring some benefits to owners of factories and commercial buildings. Otherwise, EEC should never be promoted. Thus, the owners want to know the expected benefits of investing in energy-efficient equipment and facilities to reduce energy consumption. This chapter shows how to conduct an economic analysis on energy-saving projects to reduce energy consumption.

6.1. Economic Analysis Method

There are several ways to conduct an economic analysis of energy-saving projects.

1) Financial Statements

To do an economic analysis of energy-saving projects, we should first produce the income statement or profit and loss statement and the cash balance statement. The purpose of these financial statements is to achieve a precise economic analysis of energy-saving projects. These financial statements could be simple, not complicated, such as the financial statement of existing companies or organisations.

a) Income statement

The income statement clarifies the process of calculating income tax payments. The income statement comprises the following items:

i) Revenue: benefits from energy savings come from the replacement of low energy-efficient equipment to high energy-efficient equipment
ii) Operation and maintenance costs: costs to operate and maintain energy-efficient equipment to be installed
iii) Depreciation: refer to b)
iv) Interest payment (long): refer to c)
v) Interest payment (short): refer to c)
vi) Interest received: refer to c)
vii) Profit before tax: i – ii – iii – iv – v + vi
viii) Income tax: vii x income tax rate after adjustment of carrying over the income losses
ix) Profit after tax: vii - viii

b) Calculation of depreciation

The purpose of depreciation is to smooth a large amount of capital costs to annual costs in a certain period. However, it should not be an actual cost or expenditure and a presumed one. There are two calculation methods:

Straight-line method:

$$DP_t = \frac{CC_0(1-sv)}{N}$$

where,

DP_t: Depreciation at year t

CC_0: Initial capital cost at year 0

sv: Salvage value ratio

N: Depreciation period

t: 1,….,n

Accelerated method or Fixed-ratio method:

$DP_t = OSDP_{t-1}\ DPR$

$OSDP_t = OSDP_{t-1} - DP_t$

$OSDP_0 = CC_0 * (1-sv)$

where,

DPR: Depreciation ratio

$OSDP_{t-1}$: Outstanding of capital cost on book at year $t-1$

T: 1,…,n

c) Calculation of interests

The interest payment is the annual cost of external financing, such as borrowed money, from commercial and public banks. On the other hand, if this project has some remaining cash, it puts this cash in its savings account in commercial banks and gains interest. The calculation method of interest payment and interest received are shown below:

Payment (long):

$OSBM_t = OSBM_{t-1} - RP_{t-1}$

$INT_t = OSBM_t * ir$

where,

$OSBM_t$: Outstanding of long-term borrowed money at year t

INT_t: Interest payment (long-term) at year t

ir: Interest rate of long-term borrowed money

Payment (short):

If the project incurs a money shortage, this project must borrow short-term (less than 1 year) money from commercial banks. So that this project needs to pay a short-term interest, as calculated below:

If $SBM_{t-1} > 0$, $SINT_t = SBM_{t-1} \times sr$

where,

SBM_{t-1}: Short-term borrowed money at year $t-1$

$SINT_t$: Interest payment (short-term) at year t

sr: Interest rate of short-term borrowed money

Interest received:

If $ACF_{t-1} > 0$, $RINT_t = ACF_{t-1} \times ei$

where,
ACF_{t-1}: Accumulated cash flow at year *t-1*
$RINT_t$: Interest received at year *t*
ei: Rate of interest received

d) Cash balance statement

On the other hand, the cash balance statement comprises the following:

- Cash inflow
  i) Share capital
  ii) Borrowed money (long-term)
  iii) Borrowed money (short-term): refer to accumulated cash flow below
  iv) Profit after tax: from the income statement
  v) Depreciation: from the income statement
- Cash outflow
  vi) Capital costs
  vii) Repayment of long-term borrowed money refer to e)
  viii) Repayment of short-term borrowed money
    $RSBMt = SBMt-1$
    where,
    RSBMt: Repayment of short-term borrowed money at year *t*
    SBMt-1: Short-term borrowed money at year *t-1*
- Cash flow defined as Cash inflow – Cash outflow
- Accumulated cash flow
  If $ACFt < 0$, $SBMt = - ACFt$
  where,
  ACFt: Accumulated cash flow at year *t*
  SBMt: Short-term borrowed money at year *t*

e) Calculation of repayment of borrowed money

There are two methods to repay the principal of long-term borrowed money:

Straight-line method:

Repay the same amount of principal within the repayment period
$RP_t = BM_0/N$
where,
RP_t: Repayment at year *t*
BM_0: Initial borrowed money at year *0*
N: Repayment period

Straight payment (repayment + interest) method:

Repay the same amount plus interest within the repayment period

$$RI = \frac{BM_0 \cdot ir \cdot (1+ir)^N}{(1+ir)^N - 1}$$

where,
RI: Annual payment of repayment plus interest

BM_0: Initial borrowed money at year *0*

ir: Interest rate

N: Repayment period

$INT_t = OSBM_{t-1}*ir$

$RP_t = RI–INT_t$

$OSBM_t = OSBM_{t-1}-RP_t$

where,

INT_t: Interest payment at year *t*

$OSBM_{t-1}$: Outstanding of borrowed money at year *t-1*

RP_t: Repayment at year *t*

f) Production of the financial statements using the sample data

Using the sample data below, the financial statements are shown as Table 6.1 for the income statement and Table 6.2 for the cash balance table.

Description of Sample Data:

Factory A uses a manufacturing machine; its electricity expense has been increasing due to the machine's older age. Therefore, the owner of Factory A is considering replacing the old machine with a new one. Thus, the owner wants to know the economic feasibility of this EEC project through its financial statements. The assumptions of this EEC project are mentioned below:

Initial capital cost of energy-efficient-type equipment: US$70 million

Equity ratio: 30% of initial capital cost

Energy-saving amount: 100 GWh/year

Electricity price: 9.5 cents/kWh

Operating costs: US$10,000/year

Depreciation: 10 years straight-line method and 0 salvage value

Borrowed money: 10 years straight-line repayment method and 5% interest rate

Income tax rate: 50%

Income loss can be carried over within 5 years

Table 6.1 Income Statement for Economic Analysis (US$1,000)

Year	0	1	2	3	4	5	6	7	8	9	10
Benefits from energy saving		9,500	9,500	9,500	9,500	9,500	9,500	9,500	9,500	9,500	9,500
Operation cost		700	700	700	700	700	700	700	700	700	700
Depreciation		7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
Interest payment (long term)		2,450	2,205	1,960	1,715	1,470	1,225	980	735	490	245
Interest payment (short term)			0	0	0	0	0	0	0	0	0
Interest received			44	96	157	227	307	387	468	554	645
Profit before tax		-650	-362	-64	242	557	882	1,207	1,533	1,864	2,200
Income tax							302	604	767	932	1,100
Profit after tax		-650	-362	-64	242	557	579	604	767	932	1,100

Source: Author.

The income statement indicates that this project lost income in the first 3 years. After that, this project can make a profit and pay income tax from the sixth year due to tax exemption regulations. The income loss can be carried over within 5 years.

Table 6.2. Cash Balance Statement (US$1,000)

Year	0	1	2	3	4	5	6	7	8	9	10
Cash inflow	70,000	6,350	6,639	6,936	7,242	7,557	7,579	7,604	7,767	7,932	8,100
Shared capital	21,000										
Borrowed money (long term)	49,000										
Borrowed money (short term)											
Profit after tax		-650	-362	-64	242	557	579	604	767	932	1,100
Depreciation		7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
Cash outflow	70,000	4,900	4,900	4,900	4,900	4,900	4,900	4,900	4,900	4,900	4,900
Capital cost	70,000										
Repayment of borrowed money (long)		4,900	4,900	4,900	4,900	4,900	4,900	4,900	4,900	4,900	4,900
Repayment of borrowed money (short)											
Cash balance	0	1,450	1,739	2,036	2,342	2,657	2,679	2,704	2,867	3,032	3,200
Accumulation of cash balance	0	1,450	3,189	5,224	7,566	10,223	12,902	15,606	18,472	21,504	24,705

Source: Author.

The cash balance table indicates that this project never had a money shortage and its accumulated cash gained within 10 years is more than the share capital.

2) Cash Flow

Based on the financial statements, we produce a cash flow table. There are two types of cash flow tables: return on investment (ROI), based on the whole investment, and return on equity (ROE), based on equity. ROI analyses how much return is expected for the entire capital cost so that this cash flow just uses capital cost and benefits from energy savings. Table 6.3 shows the cash flow of the sample data.

Table 6.3: Cash Flow on ROI (US$1,000)

Year	0	1	2	3	4	5	6	7	8	9	10
Capital cost	70,000										
Benefits from energy saving		9,500	9,500	9,500	9,500	9,500	9,500	9,500	9,500	9,500	9,500
Operation cost		700	700	700	700	700	700	700	700	700	700
Cash flow on ROI	-70,000	8,800	8,800	8,800	8,800	8,800	8,800	8,800	8,800	8,800	8,800
Accumulated cash flow	-70,000	-61,200	-52,400	-43,600	-34,800	-26,000	-17,200	-8,400	400	9,200	18,000

ROI = return on investment.

Source: Author.

On the other hand, ROE analyses how much return is expected on equity or share capital using the following: profit after tax, depreciation, repayment (long-term), and equity or share capital.

Table 6.4 shows the cash flow of the sample data.

Table 6.4: Cash Flow on ROE (US$1,000)

Year	0	1	2	3	4	5	6	7	8	9	10
Profit after tax		-650	-362	-64	242	557	579	604	767	932	1,100
Depreciation		7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
Equity	21,000										
Repayment (long)		4,900	4,900	4,900	4,900	4,900	4,900	4,900	4,900	4,900	4,900
Cash flow on ROE	-21,000	1,450	1,739	2,036	2,342	2,657	2,679	2,704	2,867	3,032	3,200
Accumulated cash flow	-21,000	-19,550	-17,812	-15,776	-13,434	-10,777	-8,098	-5,394	-2,528	504	3,705

ROE = return on equity.
Source: Author.

Both tables indicate that the accumulated cash flow becomes positive in the eighth year of ROI and the ninth year of ROE. The initial cost seems to be too large compared to the return.

3) Internal Rate of Return (IRR)

The IRR is a typical index to assess the economics of energy projects, calculated through the following formula, with the iteration method.

$$CC_0 = \sum_t \frac{CF_t}{(1+r)^t}$$

where,

CC₀: Initial capital cost at year *0*

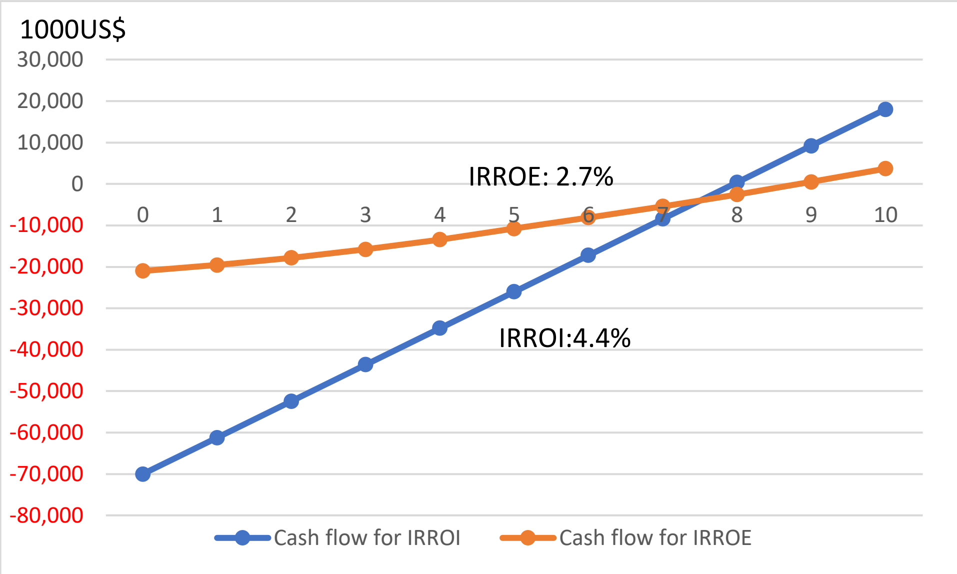
CFt: Annual benefit at year *i*

r: IRR

t: year from *1* to *n*

There are also two kinds of IRR: IRR on investment (IRROI) and IRR on equity (IRROE). Based on the cash flows in Tables 6.3 and 6.4, we can get 4.4% as IRROI and 2.7% as IRROE using the IRR numerical formula, one of the financial formulas installed in MS-Excel (refer to Table 6.5). Both the IRROI and IRROE of this sample project look unattractive. However, the savings on electricity consumption indeed reduce fossil fuel consumption, such as coal and gas for thermal power generation. As a result, CO2 emissions can be reduced. Suppose the owner could get financial incentives from the government for this investment: applicable soft loans, exemption from income tax, subsidies for capital costs, etc. This project should be implemented with appropriate government support.

Figure 6.1: Cash Flow for ROI and ROE



IRROE = internal rate of return on equity, IRROI = internal rate of return on investment.
Source: Author.

4) Payback Period

The IRROI payback period is on the eighth year after the start of operations; that of IRROE is on the ninth year (refer to the accumulated cash flow in Tables 6.3 and 6.4 and Figure 6.1). Generally, the payback period should be less than 5 years so that these results are also not attractive for private company owners. But for the same reason mentioned above, this project should be implemented.

6.2. Exercises of Economic Assessment of Energy-Saving Projects

1) Exercise 1

Building A currently uses 20,000 incandescent bulbs for lighting, and its owner wants to replace the incandescent bulbs with LED. Based on the conditions below, analyse the economic feasibility of this energy-saving project:

Assumed conditions:
Power rating of incandescent bulb: 60 W each
Power rating of LED: 10 W per each but same lumen of 60 W incandescent bulb
Duration period of LED: 5 years
Operating hours of building A: 10 hours/day
Price of LED: US$50 each
Electricity price: 11 cents/kWh
Share capital: 100%

Assessment Results:

The difference between the power rating of an incandescent bulb and a LED is assumed to be 50 W. This difference is significant even though the initial cost to install 20,000 LED at US$50 per unit is US$1 million. Thus, this project has profited from the first year and has never had a money shortage (refer to Tables 6.5 and 6.6).

Table 6.5: Income Statement of Exercise 1 (US$1,000)

Year	0	1	2	3	4	5	6	7	8	9	10
Benefits from energy saving		287	287	287	287	287	287	287	287	287	287
Operation cost		0	0	0	0	0	0	0	0	0	0
Depreciation		200	200	200	200	200	200	200	200	200	200
Interest payment (long term)		0	0	0	0	0	0	0	0	0	0
Interest payment (short term)			0	0	0	0	0	0	0	0	0
Interest received			7	15	22	30	38	45	53	62	70
Profit before tax		87	94	101	109	117	124	132	140	148	157
Income tax		43	47	51	55	58	62	66	70	74	78
Profit after tax		43	47	51	55	58	62	66	70	74	78

Source: Author.

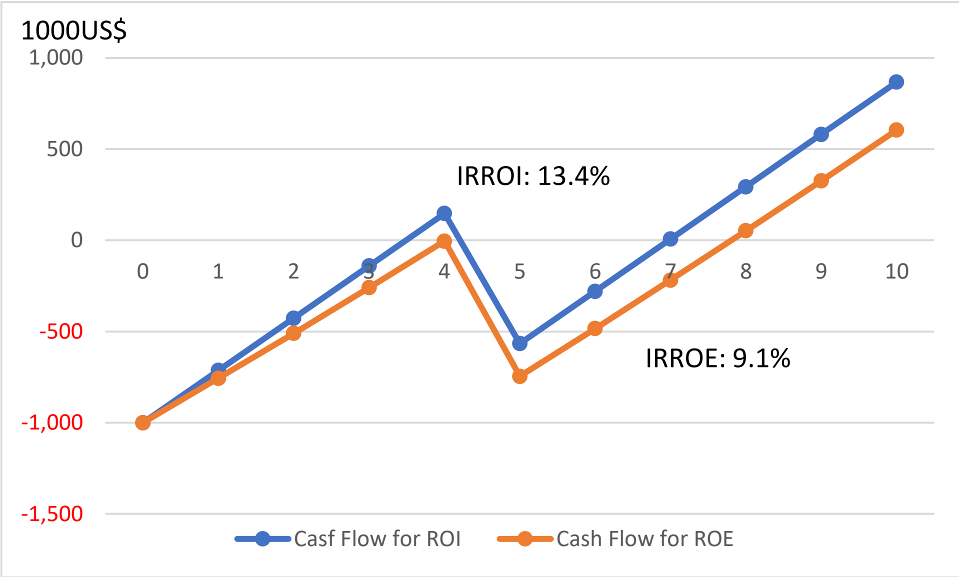
Table 6.6: Cash Balance Statement of Exercise 1 (US$1,000)

Year	0	1	2	3	4	5	6	7	8	9	10
Cash Inflow	1,000	243	247	251	255	1,258	262	266	270	274	278
Shared capital	1,000					1,000					
Borrowed money (long term)	0					0					
Borrowed money (short term)											
Profit after tax		43	47	51	55	58	62	66	70	74	78
Depreciation		200	200	200	200	200	200	200	200	200	200
Cash outflow	1,000	0	0	0	0	1,000	0	0	0	0	0
Capital cost	1,000					1,000					
Repayment of borrowed money (long)		0	0	0	0	0	0	0	0	0	0
Repayment of borrowed money (short)											
Cash balance	0	243	247	251	255	258	262	266	270	274	278
Accumulation of cash balance	0	243	490	741	996	1,254	1,516	1,782	2,052	2,327	2,605

Source: Author.

The IRRs of this project are also reasonable, 13.4% ROI and 9.1% ROE. Therefore, this financial feasibility study surely greenlights the implementation of this EEC project.

Figure 6.2: Cash Flow for ROI and ROE of Exercise 1



IRROE = internal rate of return on equity, IRROI = internal rate of return on investment.
Source: Author.

2) Exercise 2

Hotel A uses an old chiller system to supply cool air to guest rooms and other areas. It plans to replace the old one with a new one. Therefore, based on the conditions below, we analyse the economic feasibility of this energy-saving project:

Assumed conditions:

Capital cost of a new chiller system: US$1.25 million
Saved electricity amount: 2,171,224 kWh/year
Duration period of the chiller system: 10 years
Electricity price: 16 cents/kWh
Produce cash flow on ROI and seek IRROI and payback period

Assessment Results:

The expected electricity saving (2.2 GWh/year) is significant compared to the initial cost (US$1.24 million) to install a new chiller system. Both financial statements indicate that Hotel A has profited from the first year of operation and has had no money shortage in 10 years due to the significant electricity savings and relatively higher electricity price at 16 cents/kWh. In addition, a remarkable reduction of CO2 emissions is expected every year if a coal power plant generates electricity.

Table 6.7: Income Statement of Exercise 2 (US$1,000)

Year	0	1	2	3	4	5	6	7	8	9	10
Benefits from energy saving		347	347	347	347	347	347	347	347	347	347
Operation cost		0	0	0	0	0	0	0	0	0	0
Depreciation		125	125	125	125	125	125	125	125	125	125
Interest payment (long term)		44	39	35	31	26	22	18	13	9	4
Interest payment (short term)			0	0	0	0	0	0	0	0	0
Interest received			4	8	12	16	20	25	29	34	39
Profit before tax		179	187	195	204	212	221	230	239	248	257
Income tax		89	93	98	102	106	110	115	119	124	128
Profit after tax		89	93	98	102	106	110	115	119	124	128

Source: Author.

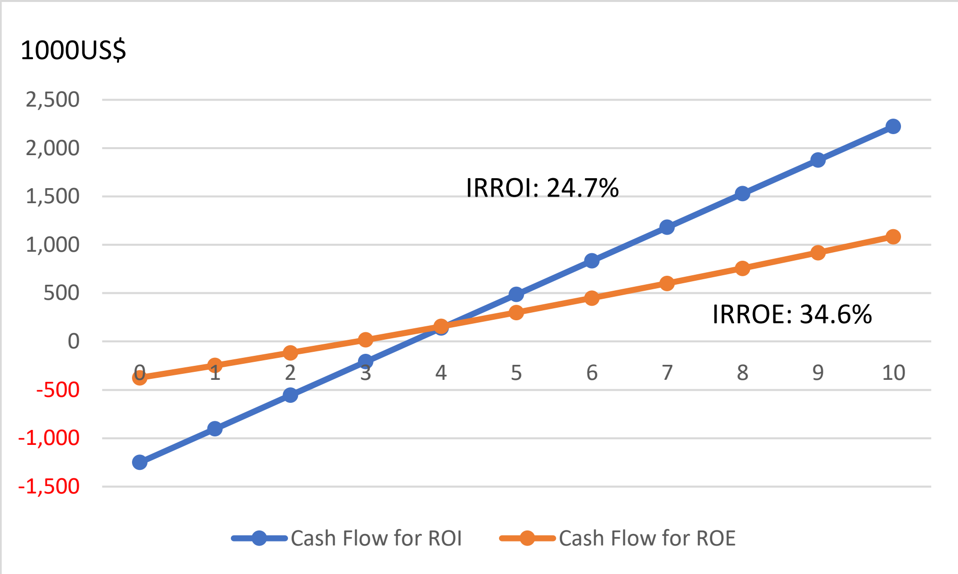
Table 6.8: Cash Balance Statement of Exercise 2 (US$1,000)

Year	0	1	2	3	4	5	6	7	8	9	10
Cash Inflow	1,250	214	218	223	227	231	235	240	244	249	253
Shared capital	375										
Borrowed money (long term)	875										
Borrowed money (short term)											
Profit after tax		89	93	98	102	106	110	115	119	124	128
Depreciation		125	125	125	125	125	125	125	125	125	125
Cash outflow	1,250	88	88	88	88	88	88	88	88	88	88
Capital cost	1,250										
Repayment of borrowed money (long)		88	88	88	88	88	88	88	88	88	88
Repayment of borrowed money (short)											
Cash balance	0	127	131	135	139	144	148	152	157	161	166
Accumulation of cash balance	0	127	258	393	532	676	824	976	1,133	1,294	1,460

Source: Author.

Both IRRs are significant, 24.7% ROI and 34.6% ROE. Thus, the financial indicators of this EEC project give the green light to proceed.

Figure 6.3 Cash Flow for ROI and ROE of Exercise 2



IRROE = internal rate of return on equity, IRROI = internal rate of return on investment.
Source: Author.

3) Exercise 3

The owners of Building A plan to install a solar photovoltaic (PV) system to utilise auto-generated electricity for its internal use and reduce electricity procurement from a power utility company. Based on the conditions below, we analyse the economic feasibility of this energy-saving project:

Assumed conditions:

Capacity of solar/PV system to be installed: 1 MW
Unit price of solar/PV system: US$3,000/kW
Duration period of solar/PV system: 10 years
Electricity price: 12 cents/kWh
Share capital: 30%

Assessment results:

The installation of a 1 MW solar PV system seems to be profitable for Building A. The initial cost is US$3 million, but the annual saving from electricity payments to a power utility is around US$0.5 million. So, 6 years is enough to recover the initial cost according to a simple calculation. In addition, both financial statements reflect good conditions of a profit–loss (positive profit from the first year of operation) and cash balance (no money shortage in 10 years).

Table 6.9: Income Statement of Exercise 3 (US$1,000)

Year	0	1	2	3	4	5	6	7	8	9	10
Benefits from energy saving		473	473	473	473	473	473	473	473	473	473
Operation cost		30	30	30	30	30	30	30	30	30	30
Depreciation		300	300	300	300	300	300	300	300	300	300
Interest payment (long term)		105	95	84	74	63	53	42	32	21	11
Interest payment (short term)			0	0	0	0	0	0	0	0	0
Interest received			3	7	10	14	18	23	27	32	37
Profit before tax		38	52	66	80	94	109	124	139	154	170
Income tax		19	26	33	40	47	54	62	69	77	85
Profit after tax		19	26	33	40	47	54	62	69	77	85

Source: Author.

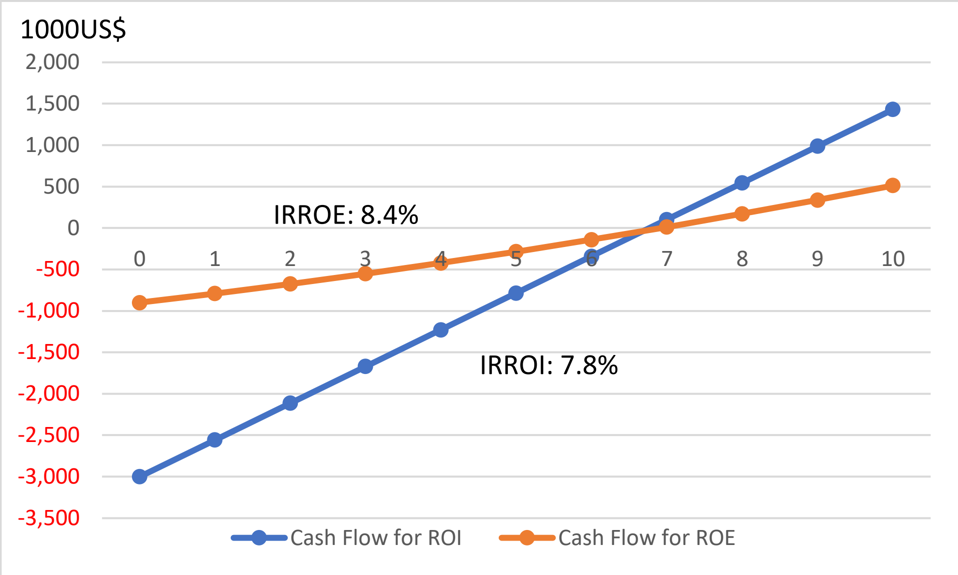
Table 6.10: Cash Balance Statement (US$1,000)

Year	0	1	2	3	4	5	6	7	8	9	10
Cash Inflow	3.000	319	326	333	340	347	354	362	369	377	385
Shared capital	900										
Borrowed money (long term)	2.100										
Borrowed money (short term)											
Profit after tax		19	26	33	40	47	54	62	69	77	85
Depreciation		300	300	300	300	300	300	300	300	300	300
Cash outflow	3.000	210	210	210	210	210	210	210	210	210	210
Capital cost	3.000										
Repayment of borrowed money (long)		210	210	210	210	210	210	210	210	210	210
Repayment of borrowed money (short)											
Cash balance	0	109	116	123	130	137	144	152	159	167	175
Accumulation of cash balance	0	109	225	348	478	615	759	911	1.071	1.238	1.413

Source: Author.

The actual payback period is on the seventh year, which is more than 5 years, the expected longest payback period. In addition, the IRRs look better, 7.8% ROI and 8.4% ROE. As a result, this solar PV installation project is recommended to proceed due to a better financial situation, a reasonable rate of return, and an increase of low carbon energy and CO2 emission reduction. But this project also needs to pay attention to the electricity price of 12 cents/kWh. If it is lower than this price, the financial situation and the rate of return will be worse.

Figure 6.4: Cash Flow for ROI and ROE of Exercise 3



IRROE = internal rate of return on equity, IRROI = internal rate of return on investment.
Source: Author.

6.3. Energy Service Companies (ESCOs)

Energy service companies (ESCOs) consult with factories and commercial buildings to save the latter's energy costs by proposing to replace lower energy-efficient equipment and facilities with higher ones. A factory can save US$5,000 of electricity cost per month. Thus, a certain share (usually 30%–50%) of the energy costs saved goes to the ESCO as revenue or consultation fee. Energy managers who belong to ESCOs should understand the economic analysis of EEC projects mentioned in Sections 6.1 and 6.2. Suppose factories and commercial buildings want to reduce energy costs, such as electricity payment to a utility company. In that case, they can ask an ESCO to prepare energy-saving measures after a survey on their energy consumption, expected energy-saving amount in physical and monetary units, and initial costs. The ESCO produces the financial statements – income statement and cash balance statement, cash flow tables, IRR, and payback period – to assess the economic feasibility of the EEC project.

Consequently, the ESCO should be familiar with the technical and economic aspects of EEC. The ESCO should also know EEC regulations in countries, especially the EEC financial incentives provided by the government, the minimum energy performance standards, standard and labelling system, and others. Thus, the ESCO contributes to energy saving and CO2 emission reduction on a business basis. Some ESCOs can arrange to finance the initial cost (capital costs) from commercial and public development banks.