CPET 581 Smart Grid and Energy Management
Nov. 20, 2013
Lecture

References

[1] Mechanical and Electrical Systems in Building, 5th Edition, by Richard R. Janis and William K.Y. Tao, Publisher Pearson
[2] Project Management, Ninth edition, Harold Kerzner, publisher Wiley

Economic Project Selection Criteria: Capital Budgeting

- Project managers need to be in charge of benefit-to-cost analysis of project selection.
- Capital budgeting
    - The process of identifying the financial benefits is called capital budgeting, which may be defined as the decision-making process by which organizations evaluate projects that include the purchase of major fixed assets such as buildings, machinery, and equipment.
- Sophisticated capital budgeting techniques take into consideration depreciation schedules, tax information, and cash flow

Economic Evaluation

- To evaluate and compare options for making good business decision
- Methods considered
    - Payback period analysis
    - Life-Cycle cost analysis/Net Present Value (NPV)
    - Discounted cash flow (DCF)
    - Internal rate of Return (IRR)

Life-Cycle Cost [pp. 576-579, Reference – 2]

- Life-cycle costs are the total cost to the organization for the ownership and acquisition of the product over its full life.
- This include the cost of R&D, production, operation, support, and where applicable, disposal. A typical breakdown description might include
    - R&D costs
    - Production cost
    - Construction cost
    - Operation and maintenance cost
    - Product retirement and phase-out cost (also called disposal cost)

Payback Period Analysis

- The payback period is the exact length of time needed for a firm to recover its initial investment as calculated from cash in-flows.
- The least precise method of estimation
- Ignore the value of longer-term savings
- Payback period = Extra Cost / Saving
    - Extra cost – the difference in initial cost between two options
    - Saving – the annual difference in operating cost, generally including utilities and maintenance

Life-Cycle Cost Analysis

- A tool for comparing options based on basis of economics
- Use the discounted cash flow method
- Includes calculation of Escalation, Amortization and Net Present Value
- Method
  - List the cash flows associated with an option over a given period defined as the life cycle
  - Initial cost can be accounted for a single outlay at year zero
  - Cost can be treated as payments to amortize a loan or as yearly depreciation of the asset for accounting and tax purposes

The Time Value of Money [Reference 2, pp. 583]

- Future value of money
- Present value of money
- Future Value ($FV) = PV(1 + k)^t$, where PV is present value, K is the interest rate or discount rate, t is the number of year
- $PV = FV/(1 + k)^t$

NET Present Value (NPV) [Reference 2, pp. 584-585]
The net present value (NPV) method is a sophisticated capital budgeting technique that equates the discounted cash flows against the initial investment. Mathematically,

$$NPV = \sum_{t=1}^{m} \left[\frac{FV_t}{(1+k)^t}\right] - II$$

Where FV = future value, k = interest rate or discount rate, t = year, II initial investment

Example 1. What is the payback period for a renewable energy system that costs $20,000 to install, last 5 years, saves $6,000 per year in utilities (current rates), and requires on average $500 per year for maintenance and repair? [from Reference – 1]
Solution:
Payback period = $20,000/($6,000 - $500) = 3.6 years

Example 2. [page 583 of reference 2]
Project A requires an initial investment of $10,000, and has the following expected Cash Inflows. And this project will last for 5 years

Initial Investment: $10,000
Year 1 (Inflow cash): $1,000
Year 2 (Inflow cash): $2,000
Year 3 (Inflow cash): $2,000
Year 4 (Inflow cash): $5,000
Year 5 (Inflow cash): $2,000
This project will have a Payback period of 4 years.

Example 3. With the data from Example 2, also include a 10% discount rate, calculate the NPV for the Project A (in Example 2) for a period of 5 years.

Year	**Cash Flow**	**Present Value**
1	$1,000	909 = $1000/(1+0.1)^1$
2	$2,000	1,652 = $2000/(1+0.1)^2$
3	$2,000	1,503
4	$5,000	3,415
5	$2,000	1,242= $2000/(1+0.1)^5$
Present value of cash inflows		Sum(909, 1653, .. 12242) = $8,722
Less investment		$10,000
Net Present Value		<$1,278>

This table shows that the cash inflows discounted to the present will not recover the initial investment since it has a NPV of <$1278>. This is considered a BAD Investment.
The decision-making criteria using NPV are as follows:

- If the NPV is greater or equal to zero dollars, accept the project.
- If the NPV is less than zero dollars, reject the project

Example 4. What is the payback period for a renewable energy system that costs $30,000 to install, last 20 years, saves $6,000 per year in utilities (current rates), and requires on average $5,000 per year for maintenance and repairs? [from Reference – 1]

Solution:
Payback period = $30,000/($6,000 - $500) = 5.5 years

Purchase decision based on Payback Period Analysis of Example 1 & 2:

- Low investment, shorter payback period – Example 1
- Higher investment, longer payback period – Example 2
- But over the economic life of the option, the higher investment could produce superior results

Example 5. Use the same problem statement as shown in Example 4. Assume that energy costs will escalate at 5 percent per year and that maintenance/repair cost will escalate at 3 percent per year. Assume also that the owner expects 1 15 percent rate of return for investment. [from Reference – 1 & 2]
Life-Cycle Cost Analysis: $20,000 installation, 5 year life, 3.6 years payback.

- Life cycle of investment (years) – 5 years
- Installation cost - $20,000
- First year energy saving (utility rates first year) - $6,000
- Annual maintenance/repair cost (first year value) - $500
- Energy escalation rate – 5%
- Repair and maintenance escalation rate – 3%
- Discount rate – 15%

- Net present value can be found from the table below: $163 today. Or we could spend $20,000 plus $163 to generate the 5-year savings and meet the expectation of profit.

Future Value (FV) = $PV(1 + k)^t$, where PV is present value, K is the interest rate or discount rate, t is the number of year

$PV = FV/(1 + k)^t$

Net Present Value (NPV) = $\sum_{t=1}^{m}\left[\frac{FV_t}{(1+k)^t}\right] - II$

Where FV = future value, k = interest rate or discount rate, t = year, II initial investment

Cash Flows in Year of Occurrence					
Year	**Install cost**	**Energy Saving (with 5% escalation) = $6000(1+0.05)^t$**	**Repair & Maintenance (with 3 % escalation = $500(1+0.03)^t$**	**Total Annual Cash Flow (In-Flow)= Energy Saving – Repair& Maintenance FV**	**Present Value Total Annual $PV = FV/(1 + k)^t$ K = 0.15**
0	(20,000)	0	0	(20000)	(20000)
1	0	6000	(500)	5500	$4783 = 5500/(1+0.15)^1$
2	0	6300=600x1.05	(515)=500x 1.03	5785	$4374 = 5785/(1+0.15)^2$
3	0	6615	(530)	6085	4001
4	0	6946	(546)	6399	3659
5	0	7293	(563)	6730	$3346=6790/(1+0.15)^5$
NPV of Life Cycle Cash Flows ($) $\sum_{t=1}^{m}\left[\frac{FV_t}{(1+k)^t}\right] - II$					20000 – Sum(4783, 4374, .. 3346) = **163**

Example 6. Use Example 4's data but change it to life-cycle cost method. Assume that energy costs will escalate at percent per year and that maintenance/repair cost will escalate at 3 percent per year. Assume also that the owner expects 1 15 percent rate of return for investment. [from Reference – 1 & 2]

Life-Cycle Cost Analysis: $30,000 installation, 10 year life, 5.5 years payback.

- Life cycle of investment (years) – 10 years
- Installation cost - $30,000
- First year energy saving (utility rates first year) - $6,000
- Annual maintenance/repair cost (first year value) - $500
- Energy escalation rate – 5%
- Repair and maintenance escalation rate – 3%
- Discount rate – 15%

- Net present value can be found from the table below: $3059 today. Or we could spend $30,000 plus $3059 to generate the 10-year savings and meet the expectation of profit.

Future Value (FV) = $PV(1 + k)^t$, where PV is present value, K is the interest rate or discount rate, t is the number of year

$PV = FV/(1 + k)^t$

Net Present Value (NPV) = $\sum_{t=1}^{m}\left[\frac{FV_t}{(1+k)^t}\right] - II$, Where FV = future value, k = interest rate or discount rate, t = year, II initial investment

Cash Flows in Year of Occurrence					
Year	**Install cost**	**Energy Saving (with 5% escalation) = $6000(1+0.05)^t$**	**Repair & Maintenance (with 3 % escalation = $500(1+0.03)^t$**	**Total Annual Cash Flow (In-Flow)= Energy Saving – Repair& Maintenance FV**	**Present Value Total Annual $PV = FV/(1 + k)^t$ K = 0.15**
0	(30,000)	0	0	(30000)	(30000)
1	0	6000	(500)	5500	4783 = $5500/(1+0.15)^1$
2	0	6300 = 6000x1.05	(515)=500x1.03	5785	4374 = $5785/(1+0.15)^2$
3	0	6615	(530)	6085	4001
4	0	6946	(546)	6399	3659
5	0	7293	(563)	6730	3346=$6790/(1+0.15)^5$
6	0	7658	(580)	7078	3060
7	0	8041	(597)	7444	2798
8	0	8443	(615)	7828	2559
9	0	8865	(633)	8231	2340
10	0	9308	(652)	8656	2140
NPV of Life Cycle Cash Flows ($) $\sum_{t=1}^{m}\left[\frac{FV_t}{(1+k)^t}\right] - II$					20000 – Sum(4783, 4374, .. 3346, ..2140) = **3059**