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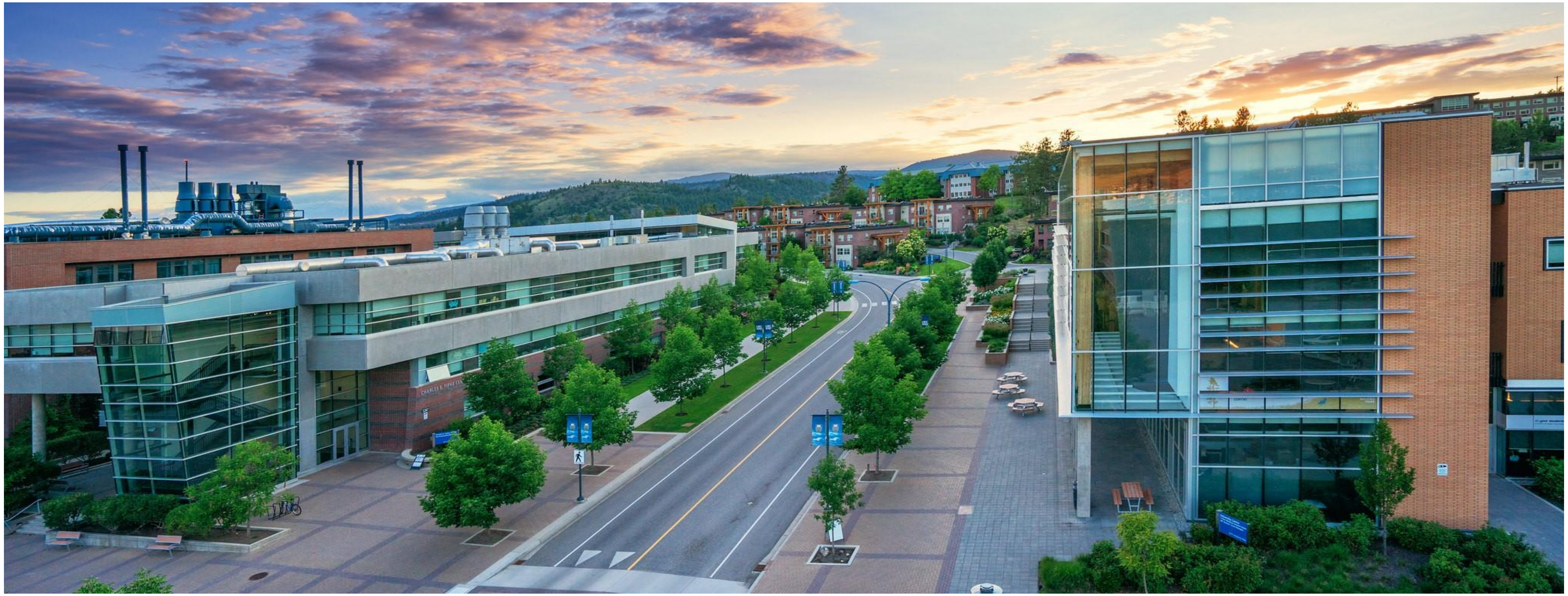


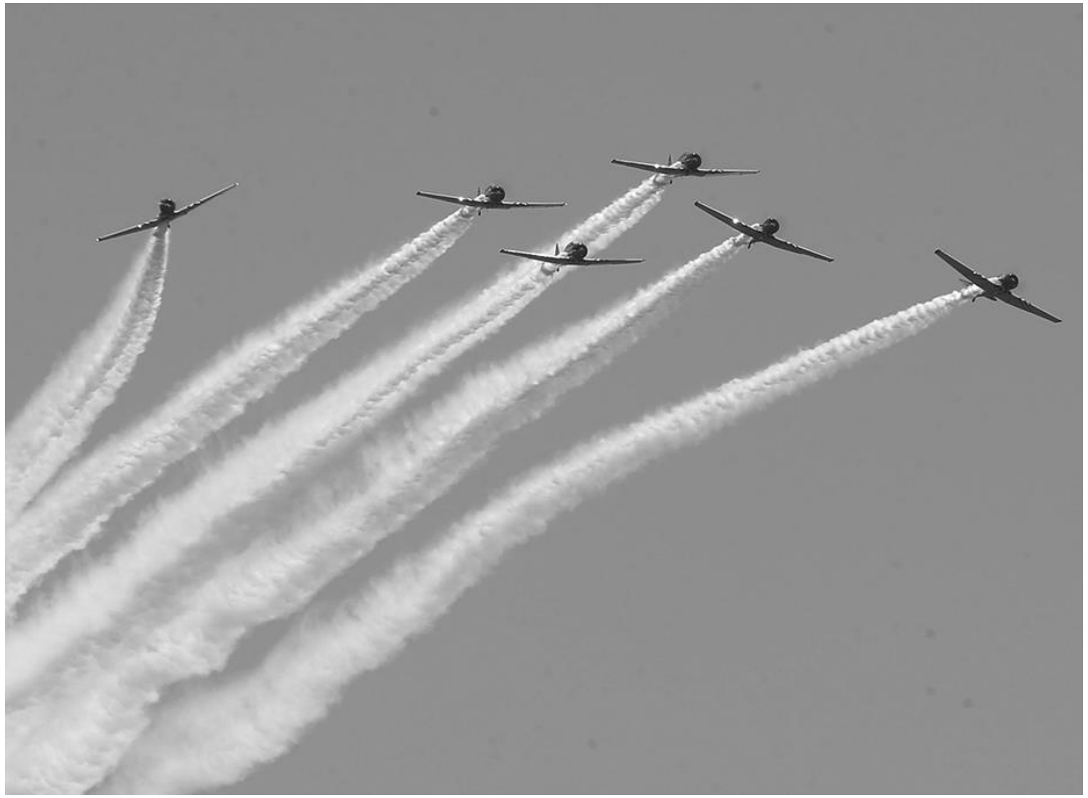
ENGR 544, Life Cycle Assessment and Management

School of Engineering, Faculty of Applied Science

The University of British Columbia (Okanagan)

Chapter 8, Rate of Return (ROR) Analysis: Multiple Alternatives

1. ROR analysis requires incremental analysis
2. Calculation of incremental cash flow (CF)
3. Interpretation of ROR (Δi^*) on incremental CF
4. Select alternative by Δi^* based on PW relation
5. Select best from several alternatives using incremental ROR method



ROR Analysis Requires Incremental Analysis

Why ROR Incremental Analysis is Necessary (1)

Assume there are two projects; must select one

- Selecting an alternative with the larger ROR may not yield the best return on available capital, if not all funds are used for the project.
- Must consider weighted average of total capital available.
- Funds not committed in a project are assumed to earn at the MARR (minimum attractive rate of return).

Example:

\$90,000 is available for investment and MARR = 16% per year. Alternative A can earn 35% per year on an investment of \$50,000. B can earn 29% per year on an investment of \$85,000. Determine the overall weighted ROR averages.

$$\textbf{Overall } ROR_A = [50{,}000(0.35) + 40{,}000(0.16)] \,/\, 90{,}000 = 26.6\%$$

$$\textbf{Overall } ROR_B = [85{,}000(0.29) + 5{,}000(0.16)] \,/\, 90{,}000 = 28.3\%$$

Which investment is better economically -- A or B?

Why ROR Incremental Analysis is Necessary (2)

If selection basis is larger ROR:

Select alternative A **(wrong answer)**

If selection basis is larger overall ROR:

Select alternative B **(correct approach)**

Conclusion:

- To use an incremental ROR analysis for a correct selection of ME alternatives.
- To conduct an incremental ROR analysis, it is necessary to calculate the incremental cash flow series over the lives of the alternatives.

Calculation of Incremental CF: Equal Lives

Incremental cash flow = cash flow_B - cash flow_A
where larger initial investment is for Alternative B

Example:

Either of two cost alternatives with equal expected lives can be selected for a grinding process. Tabulate the incremental cash flows.

	Quiet (Q)	Whisper (W)	W – Q
Investment, $	−40,000	−60,000	−20,000
Annual Operating Cost (AOC), $/year	−25,000	−19,000	+6,000
Salvage value, $	+8,000	+10,000	+2,000

Incremental CF is shown as (W - Q) column

The (incremental) ROR on the extra $20,000 investment in W will determine which alternative to select

Incremental ROR Evaluation Procedure

Procedure for two alternatives A and B; B has larger first cost

1. Order alternatives by increasing initial investment cost

2. Develop <u>incremental CF series</u>

3. Draw incremental cash flow diagram, if needed

4. Set up PW = 0 relation and find Δi^*_{B-A} (Can use AW or FW)

5. Select economically better alternative

   If Δi^*_{B-A} > MARR, select B; otherwise, select A

Example: Incremental ROR Evaluation (1)

Either of the cost alternatives shown below can be used in a chemical refining process. If the MARR is 15% per year, determine which should be selected on the basis of ROR analysis

	A	B
First cost, $	40,000	60,000
Annual cost, $/year	25,000	19,000
Salvage value, $	8,000	10,000
Life, years	5	5

Example: Incremental ROR Evaluation (2)

Solution, using procedure

	A	B	B – A
First cost, $	– 40,000	– 60,000	– 20,000
Annual cost, $/year	– 25,000	– 19,000	+ 6000
Salvage value, $	+ 8,000	+ 10,000	+ 2000
Life, years	5	5	

PW = 0 = Δfirst cost + ΔAOC (P/A, Δi*, n) + F(P/F, i*, n)

Write ROR equation of incremental CF series based on PW = 0

$$\mathbf{0 = -20{,}000 + 6000(\mathit{P/A}, \Delta \mathit{i}^*, 5) + 2000(\mathit{P/F}, \Delta \mathit{i}^*, 5)}$$

Solve for Δi* and compare to MARR

Spreadsheet function: = RATE(5, 6000, -20000, 2000) displays 17.2%

$$\Delta i^*_{B-A} = 17.2\% > \text{MARR} = 15\%$$

ROR on $20,000 extra investment is acceptable: Select B

Class Participation 25: Incremental ROR Comparison (Two Alternatives)

Polytec Chemical, Inc. must decide between two additives to improve the dry-weather stability of its low-cost acrylic paint. Additive A will have an equipment and installation cost of $125,000 and an annual cost of $55,000. Additive B will have an installation cost of $175,000 and an annual cost of $35,000. If the company uses a 5-year recovery period for paint products and a MARR of 20% per year, which process is favored on the basis of an incremental rate of return analysis? Also, write the function to display Δi^*.

Incremental ROR Analysis of Multiple (> 2) Alternatives

Incremental ROR Analysis of Multiple (> 2) Alternatives

General criteria: Select one alternative requiring the largest investment that has an extra investment over another justified alternative

Procedure for multiple ME alternatives

1. Order alternatives from smallest to largest initial investment

3. Determine incremental CF between defender and challenger **(next lowest-cost alternative)**. Set up incremental ROR relation using PW, AW, or FW relation

4. Calculate **Δi^*** on incremental CF (using factors or IRR function)

5. If **$\Delta i^* \geq$ MARR**, eliminate defender; challenger becomes new defender against next alternative. If $\Delta i^* <$ MARR, remove challenger; defender remains

6. Repeat steps (3) through (5) until only one alternative remains. Select it.

Example: ROR for Multiple Alternatives

Five alternatives are under consideration for improving visitor safety and access to additional areas of a national park. If all alternatives are considered to last 30 years, determine which one should be selected on the basis of an incremental ROR analysis and MARR = 10%

	A	B	C	D	E
First cost, $ millions	20	40	35	45	70
Annual M&O cost, $ millions	3.0	0.5	1.0	0.3	0.5

Solution: Rank by increasing initial cost: **A, C, B, D, E**; lives are equal at 30; use PW basis and determine Δi^* values using

PW = 0 = Δfirst cost + ΔM&O(P/A, Δi^*, 30) or the RATE function

C vs. A:

PW = 0 = -15+ 2(P/A, Δi^*, 30) or

RATE function: RATE(30, 2, -15) displays Δi^* = 13.0% > MARR, So (eliminate A)

	A	B	C	D	E
First cost, $ millions	20	40	35	45	70
Annual M&O cost, $ millions	3.0	0.5	1.0	0.3	0.5

PW = 0 = Δfirst cost + ΔM&O(P/A, Δi^*, 30) or the RATE function

MARR = 10%

B vs. C:

PW = 0 = -5+ 0.5(P/A, Δi^*, 30) or

RATE function: RATE(30, 0.5, -5) displays Δi^* = 9.3% < MARR, So (eliminate B)

D vs. C:

PW = 0 = -10+ 0.7(P/A, Δi^*, 30) or

RATE function: RATE(30, 0.7, -10) displays Δi^* = 5.7% < MARR, So (eliminate D)

E vs. C:

PW = 0 = -35+ 0.5(P/A, Δi^*, 30) or

RATE function: RATE(30, 0.5, -35) displays Δi^* = -4.8% < MARR, So (eliminate E)

Select C

Class Participation 26: Multiple Alternative (more than Two) Evaluation

Old Southwest Canning Co. has determined that any one of four machines can be used in its chili-canning operation. The cost of the machines are estimated below, and all machines have a 5-year life. If the minimum attractive rate of return is 25% per year, determine which machine should be selected on the basis of a rate of return analysis.

Machine	First Cost, $	AOC, $
1	28,000	20,000
2	51,000	12,000
3	32,000	19,000
4	33,000	18,000

Class Participation 26: Multiple Alternative (more than Two) Evaluation

Chapter Summary

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1. Mutually exclusive alternatives: Determine incremental cash flows.

$$\textbf{Incremental cash flow} = \boldsymbol{CF_B - CF_A}$$

where alternative with ***larger*** initial investment is **B**

Use the relation PW = 0 to find Δ*i**, the incremental ROR Eliminate B if Δ*i** < MARR; *otherwise*, eliminate A

2. For multiple (> 2) alternatives, compare two at a time and eliminate alternatives until **only one acceptable alternative remains.**

3. **Independent projects**: Compare *i** for each project against DN and select all that have *i** ≥ MARR.

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