رویکردی جامع برای ارزیابی اقتصادی در پروژه همراه با آموزش مدلسازی در اکسل (Excel)

بخش چهارم:

ارزیابی اقتصادی: تصمیم گیری بین گزینه های مختلف سرمایه گذاری

ارائه دهندگان:

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What we will learn?

- Types of alternatives
- How to use quantitative methods
- Methods of comparison between alternatives
- Sunk costs
- Minimum attractive rate of return (MARR)
- Present worth (PW) or net present value (NPV)
- Perpetual life
- Annual equivalent
- Rate of return (ROR)
- Internal rate of return (IRR)
- Incremental rate of return
- External rate of return (ERR)
- Payback period without interest
- Payback period with interest
- Project balance
- Study period
- Unequal lives

Unequal life - Study period

- The **time** which **alternatives** are **compared**.
- Determining the **study period** is difficult as **determining the MARR**. It is selected in one of the following ways:

1. **Company policy**
   - For example, a company may have a **policy** that all **investments** are compared over a **five-year period**.

2. **May be matched to the life of one of the investments**
   - **Common practice** is to **match** the study period to the **alternative with either** the **longest** or **shortest life**

3. **May be set to the least common denominator of the alternative lives**
   - For example, when comparing alternatives that have lives of 3 years, 4 years, and 6 years, the **least common dominator is 12 years**.

4. **May be set based on the length of a need.**
   - For example, if the company **needs to purchase** some **earthmoving equipment** to fulfill its obligation on a highway project with an **expected duration of four years**, the study period could be **set to the life of the project**.

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Unequal life - Study period

BUT, which method should be adopted?

- There are **no clear-cut answers** to this question.
- **Depending** on your **assumptions**, **different methods** may lead to **different results**.
  - For example, using a **study period equal to the least common denominator** is a **good solution** if one is trying to **replace its computers**, such as **every two years or every three years**.
    - However, it would **not be a suitable method** to determine **which computer** a company should **purchase** for a **three-year project**.
      - For **this type of problem**, one should **match the study period** to the **life of the project**.

How to adjust the lives? – Study period methods

1. **Study period = alternative's life**
   a) **Calculate** **only AE** for **each alternative** **regardless** of **alternative's life**
   b) **Compare** the **AE of alternatives** and **choose the best one**

How to adjust the lives? – Study period methods

2. **Study period < alternative's life**
   a) **Shorten** the **life of an alternative** with longer life than study period
   b) **Use** **"implied salvage value"** method for **an alternative** with **longer life** than **study period**.
   c) **Calculate** only **AE for all alternatives**
   d) **Make** **alternatives equal** and **find** **salvage value**
   e) **Calculate** **PW** or **AE** or **FW** for alternatives to **compare** and **choose** the **best one**.

The weakness of this method is that it assumes a salvage value, which may or may not reflect the value of the asset at the end of the study period.

How to adjust the lives? – Study period methods

3. **Study period > alternative's life**
   a) **Lengthen** the **life of an alternative** with **shorter life** than **study period**
   b) **Continue** the **cash flow** based **on previous cash flow** or **new assumptions**
   c) **Calculate PW** or **AE** or **FW** for **alternatives** to **compare** and **choose** the **best one**

The weakness of this method is that it assumes a maintenance or upgrade cost, which may or may not reflect the actual costs

How to adjust the lives? – Study period methods

NOTE:

If AE is calculated, the results of Cases 1 and 2 are 100% equal, however the result of Case 3 may be different.

How to adjust the lives? – Repeated life method

4. Repeated life method

a) **Make** the **alternatives comparable** by **multiplying** them in **opposite coefficients**

- ✓ For example, Alt 1 has 5 years of life and Alt 2 has 3 years of life. Alt 1 is multiplied by 3 and Alt 2 is multiplied by 5.

b) **Repeat** the **cash flows** based on **previous cash flows** or **new assumptions**

c) **Calculate** **PW** or **AE** or **FW** for **alternatives** to **compare** and **choose** the **best one**.

NOTE:

It is cumbersome to calculate PWs for alternatives with long life durations.

We can instead calculate AE of alternatives considering their original cash flows, and then expand the similar AEs for remained years added to cash flows.

At the end we can calculate PWs

How to adjust the lives? – Repeated life method

The weakness of this method is that it assumes we can repeatedly purchase the same item, with the same cash flows in the future.

This is often not the case. Investments and products change over time.

How to adjust the lives? – Study period methods

NOTE:

If AE is calculated, the results of Cases 1, 2, and 4 are 100% equal, however the result of Case 3 may be different.

Alternatives with unequal lives – Example 10

Example 10: Compare two excavators whose cash flows are given below. The rate of interest is 10%. Which excavator is more desirable?

Use the Study Period Method for **similar years study period equal to alternatives' lives.**

	EXCAVATOR 1	EXCAVATOR 2
First Cost	$100,000	$90,000
Annual Income	$30,000/yr	$40,000/yr
Salvage Value	$0	$0
Service Life	5 yrs	3 yrs

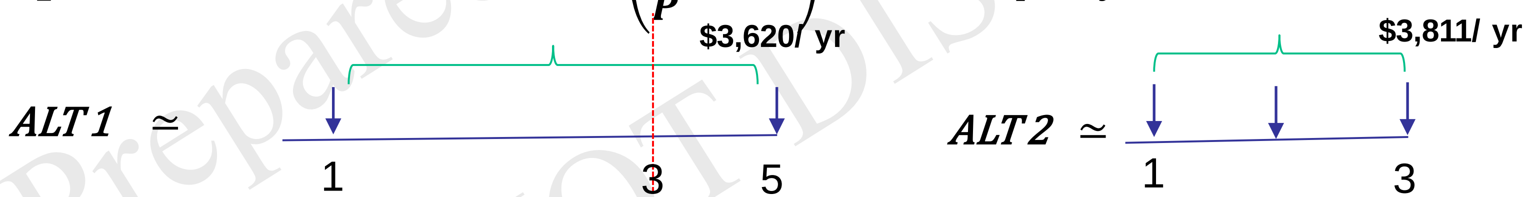
Alternatives with unequal lives – Example 10

$i = 10\% = MARR$

a(i): Shortest lived act : just use this method for AE

$$AE_1(10\%) = \$30,000 - \$100,000\left(\frac{A}{P}, 10, 5\right) = \$3,620 \, per\ year$$

$$AE_2(10\%) = \$40,000 - \$90,000\left(\frac{A}{P}, 10, 3\right) = \$3,811 \, per\ year$$



In 3 years which is shortest like of Alteratives

ALT 2 selected $\Leftarrow AE_2 > AE_1$

Alternatives with unequal lives – Example 11

Example 11: Compare two excavators whose cash flows are given below. The rate of interest is 10%. Which excavator is more desirable?

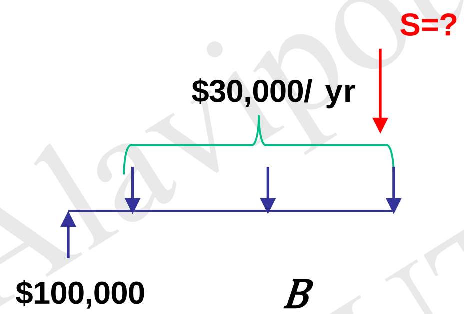
Use the **Study Period Method for 3 years study period**.

	EXCAVATOR 1	EXCAVATOR 2
First Cost	$100,000	$90,000
Annual Income	$30,000/yr	$40,000/yr
Salvage Value	$0	$0
Service Life	5 yrs	3 yrs

Alternatives with unequal lives – Example 11

a(ii): implied salvage value

$ALT\ 1 \quad =$



A

$$A = B \Rightarrow \$30,000 - \$100,000\left(\frac{A}{P}, 10, 5\right) = \$30,000 - \$100,000\left(\frac{A}{P}, 10, 3\right) + S\left(\frac{A}{F}, 10, 3\right)$$

$$S = \$45,780$$

$$AE_1(10\%) = \$30,000 - \$100,000\left(\frac{A}{P}, 10, 3\right) + \$45,780\left(\frac{A}{F}, 10, 3\right) = \$3,620\, per\ year$$

$$AE_2(10\%) = \$40,000 - \$90,000\left(\frac{A}{P}, 10, 3\right) = \$3,811\, per\ year$$

Select Alt 2

Same result as method 1

Alternatives with unequal lives – Example 12

Example 12: Compare two excavators whose cash flows are given below. The rate of interest is 10%. Which excavator is more desirable?

Use the Study Period Method for 5 years study period assuming that the second excavator will continue to bring in $40,000 per year for another two years provided that a major overhaul is made at the end of the third year estimated at $66,000.

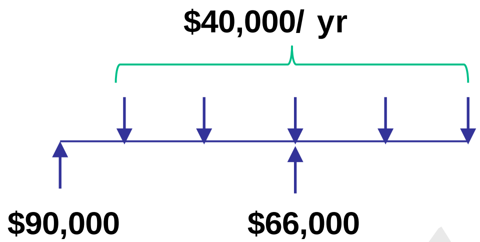
	EXCAVATOR 1	EXCAVATOR 2
First Cost	$100,000	$90,000
Annual Income	$30,000/yr	$40,000/yr
Salvage Value	$0	$0
Service Life	5 yrs	3 yrs

Alternatives with unequal lives – Example 12

a(iii): study year are more than alternative's life

$ALT\ 1 \longrightarrow$ *The same*

$ALT\ 2$



$$AE_1(10\%) = \$3,620 \text{ per year}$$
$$AE_2(10\%) = \$3,177 \text{ per year}$$

Method 3 is different in both result and decision $\Rightarrow$ *Select ALT 1*

Alternatives with unequal lives – Example 13

Example 13: Compare two excavators whose cash flows are given below. The rate of interest is 10%. Which excavator is more desirable? **Use the repeated life method**

-

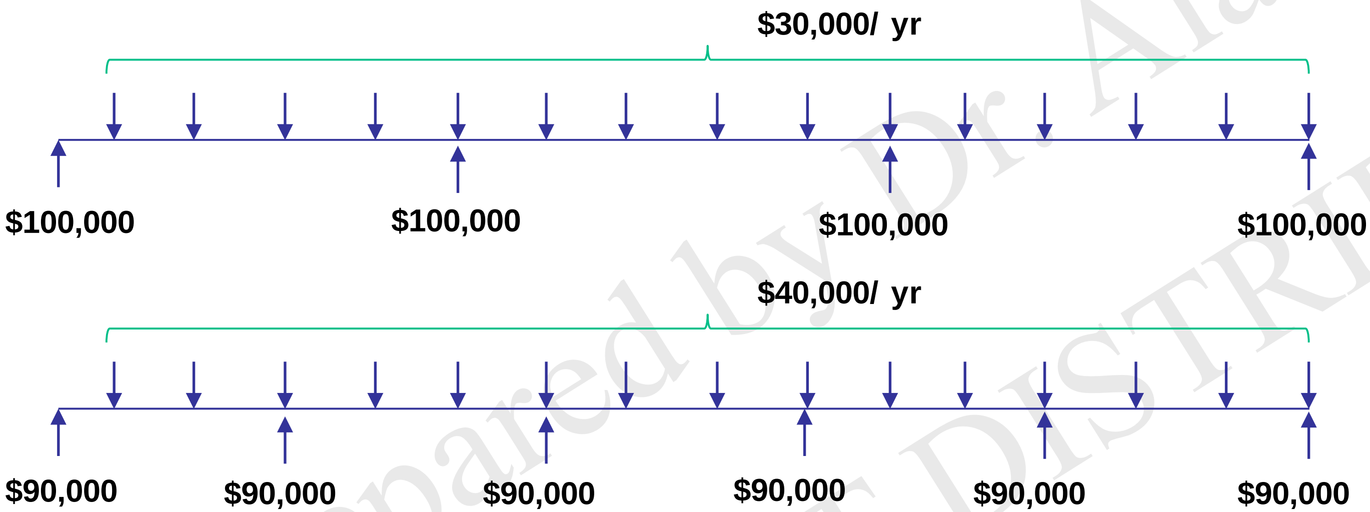
	EXCAVATOR 1	EXCAVATOR 2
First Cost	$100,000	$90,000
Annual Income	$30,000/yr	$40,000/yr
Salvage Value	$0	$0
Service Life	5 yrs	3 yrs

Alternatives with unequal lives – Example 13

b: Repeated life

ALT 1 ⟶ *Multiply by 3* ⟶ *Continue for two more 5 year*

ALT 2 ⟶ *Multiply by 5* ⟶ *Continue for four more 3 year*



$$AE_1(10\%) = \$3,620 per\ year$$
$$AE_2(10\%) = \$3,811 per\ year$$
$\Rightarrow$ *Select Alt 2*

Method 1,2 and Repeated life are 100% identical when AE is used!

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بخش پنجم:

ارزیابی اقتصادی: تصمیم گیری بین نگهداری یا جایگزینی

ارائه دهندگان:

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What we will learn?

- Introduction to replacement study
- Reasons for replacement study
- Physical deterioration and obsolescence cost items
- Classification of assets
- Replacement analysis – Example
  - Depreciation and replacement costs
  - Investment costs
  - Maintenance and repair costs
  - Downtime costs
  - Cost of productivity loss
  - Obsolescence costs
- Outsider's view point method
- Comparative value method
- Receipts and disbursements method
- Economic life method

Introduction to replacement study

- One of the **most common** and **important** issues in **construction** and **industrial practice** is that of **replacement** or **retention** of an **asset**, **process**, or **system**
  - This **differs** from **previous situations** where **all the alternatives** were **new**.

- The **fundamental question answered** by a **replacement study** (also called a **replacement-retention study**) about a **currently system** is:
  - ***Should it be replaced now or later ?***
    - ✓ In **reality**, a **replacement study answers** the question of **when** to **replace**.

Introduction to replacement study

- A **replacement study** is usually **designed to**:
  - **Make the economic decision to retain or replace *now*.**
    1. **If** the decision is to **replace**
       - ✓ The study is **complete**
    2. **If** the decision is to **retain**
       - ✓ The **cost estimates** and **decision** can be **revisited each year** to **ensure** that the **decision** to **retain** is **still economically correct**.

Introduction to replacement study

- **If** a **study period** is **specified**, the **replacement study procedure** is **different** from that used **when no study period is set**.

- **This study** is used **many times** in **construction** and also **industrial** projects.

Introduction to replacement study

- Comparing **existing asset** with **replacement asset**:

Cost category	Existing Asset	Replacement Asset
Capital cost	Low	High
Operating cost	High	Low
Life	Short	Long
*Difficulty in estimating parameters	Easy	Difficult

Reasons for replacement

1. **Physical deterioration (فرسودگی فیزیکی)**
   - Gets **old** and becomes **less productive**
     - **Productivity rate** of a loader **reduced** and the **fuel consumption increased**
2. **Obsolescence (منسوخی و کهنگی)**
   - The **new one** with **better technology** is **produced**

Physical deterioration and obsolescence cost items

- **<u>Replacement analysis should consider:</u>**

1. Depreciation and replacement costs
   - Due to inflation, the cost increases
2. Investment costs
   - If the money used somewhere else
3. Maintenance and repair costs
4. Downtime costs
5. Cost of productivity loss
6. Obsolescence costs
7. Cost of owning
8. Cost of operating

Replacement analysis – Example 1

Replacement analysis example:

- **Initial cost:** $200,000
- **No. of hrs. used per year:** 2,000
- **Hourly cost of owning and operating:** $60 per hour
- **Hourly cost of owning:** $45.00 per hour
- **Obsolescence factor:** %5 per year
- **Rate of increase in average cost of construction equipment:** $10,000 per year

Year	Salvage Value	Maintenance and Repair Cost	Average Downtime	Productivity Factor	Obsolescence Factor
1	$150,000	$8,800	3%	100%	0%
2	$120,000	$16,200	6%	99%	5%
3	$100,000	$22,500	8%	98%	10%
4	$85,000	$27,400	10%	96%	15%
5	$70,000	$33,600	12%	96%	20%
6	$60,000	$38,700	14%	94%	25%
7	$52,000	$47,400	17%	92%	30%
8	$45,000	$54,800	20%	90%	35%

Replacement analysis – Depreciation and replacement costs – Example 1

- **Depreciation** is the **loss in value of the equipment** due to **wear and tear**
- The **price of equipment increases** over the years due to many factors (sanctions, inflation, etc.)
- *Time value of money not considered yet.*

Depreciation and Replacement Costs

End of Year	Replacement Cost	Salvage Value	Loss on Replacement	Cumulative Hours of Use	Cumulative Cost per Hour
0	$200,000	$200,000	$0	0	$0
1	$210,000	$150,000	$60,000	2,000	$30.00
2	$220,000	$120,000	$100,000	4,000	$25.00
3	$230,000	$100,000	$130,000	6,000	$21.67
4	$240,000	$85,000	$155,000	8,000	$19.38
5	$250,000	$70,000	$180,000	10,000	$18.00
6	$260,000	$60,000	$200,000	12,000	$16.67
7	$270,000	$52,000	$218,000	14,000	$15.57
8	$280,000	$45,000	$235,000	16,000	$14.69

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Replacement analysis – Investment costs – Example 1

- The **value of the money** **tied up** in the **equipment**
- The **rate of interest** needs to be **known**
- Does **not need** to be considered if **economic analysis** performed

Investment Costs

Year	Salvage Value at End of Year	Investment at Start of Year	Investment Cost	Cumulative Investment Cost	Cumulative Use, hr	Cumulative Cost per Hour
1	$150,000	$200,000 *0.05	$10,000	$10,000	2,000	$5.00
2	$120,000	$150,000	$7,500	$17,500	4,000	$4.38
3	$100,000	$120,000	$6,000	$23,500	6,000	$3.92
4	$85,000	$100,000	$5,000	$28,500	8,000	$3.56
5	$70,000	$85,000	$4,250	$32,750	10,000	$3.28
6	$60,000	$70,000	$3,500	$36,250	12,000	$3.02
7	$52,000	$60,000	$3,000	$39,250	14,000	$2.80
8	$45,000	$52,000	$1,040	$40,290	16,000	$2.52

Replacement analysis – Maintenance and repair costs – Example 1

- **Maintenance and repair <u>increases</u>** with age and use
- **Best source** of M&R costs is **<u>Equipment Ledger</u>**

Maintenance and Repair Costs

Year	Annual M&R Cost	Cumulative M&R Cost	Cumulative Use, hr	Cumulative Cost per Hour
1	$8,800	$8,800	2,000	$4.40
2	$16,200	$25,000	4,000	$6.25
3	$22,500	$47,500	6,000	$7.92
4	$27,400	$74,900	8,000	$9.36
5	$33,600	$108,500	10,000	$10.85
6	$38,700	$147,200	12,000	$12.27
7	$47,400	$194,600	14,000	$13.90
8	$54,800	$249,400	16,000	$15.59

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Replacement analysis – Downtime costs – Example 1

- **Downtime <u>increases</u>** with age and use
- **<u>Best source</u>** of downtime costs is **historical records (Time Cards)**
- **<u>Downtime cost</u>** obtained by **multiplying <u>downtime percent</u>** by **<u>owning cost</u>**
  - **Does not cover <u>operating cost</u>** because **<u>if</u>** the **equipment is down**, there is **<u>no</u> <u>operating cost</u>**

Downtime Costs

Year	Average Downtime, % *$45	Downtime Cost per Hour*2,000hrs	Downtime Cost per Year	Cumulative Downtime Cost	Cumulative hours of Use	Cumulative Cost per Hour
1	3%	$1.35	$2,700	$2,700	2,000	$1.35
2	6%	$2.70	$5,400	$8,100	4,000	$2.03
3	8%	$3.60	$7,200	$15,300	6,000	$2.55
4	10%	$4.50	$9,000	$24,300	8,000	$3.04
5	12%	$5.40	$10,800	$35,100	10,000	$3.51
6	14%	$6.30	$12,600	$47,700	12,000	$3.98
7	17%	$7.65	$15,300	$63,000	14,000	$4.50
8	20%	$9.00	$18,000	$81,000	16,000	$5.06

Replacement analysis – Cost of productivity loss – Example 1

- **Machine's productivity <u>deteriorates</u>** with age and use
- **Best source of productivity** data **<u>is historical records (Time Cards)</u>**
- Yearly cost of owning and operating = $60 per hour * 2,000 hrs./year

Cost of Productivity Loss

Year	Yearly Cost of Owning and Operating	Productivity Factor	Yearly Cost of Lost Productivity	Cumulative Cost of Lost Productivity	Cumulative hours of Use	Cumulative Cost per Hour
1	$120,000	100%	$0	$0	2,000	$0.00
2	$120,000	99%	$1,200	$1,200	4,000	$0.30
3	$120,000	98%	$2,400	$3,600	6,000	$0.60
4	$120,000	96%	$4,800	$8,400	8,000	$1.05
5	$120,000	96%	$4,800	$13,200	10,000	$1.32
6	$120,000	94%	$7,200	$20,400	12,000	$1.70
7	$120,000	92%	$9,600	$30,000	14,000	$2.14
8	$120,000	90%	$12,000	$42,000	16,000	$2.63

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Replacement analysis – Obsolescence costs – Example 1

- **New machines** on the market have **higher productivity** than **older machines**
- **Best source of obsolescence** information is <u>**trade magazines**</u>
- Usually this does **not have high impact** since contractors are **not willing** to **renew** their machines every year.
  - The rate would be **more higher** in other industries.

Obsolescence Costs

Year	Obsolescence Factor	Hourly Cost of Owning and Operating	Obsolescence Cost per Hour	Obsolescence Cost per Year	Cumulative Obsolescence Cost	Cumulative Hours of Use	Cumulative Cost per Hour
1	0%	$60.00	$0.00	$0	$0	2,000	$0.00
2	5%	$60.00	$3.00 *2000	$6,000	$6,000	4,000	$1.50
3	10%	$60.00	$6.00	$12,000	$18,000	6,000	$3.00
4	15%	$60.00	$9.00	$18,000	$36,000	8,000	$4.50
5	20%	$60.00	$12.00	$24,000	$60,000	10,000	$6.00
6	25%	$60.00	$15.00	$30,000	$90,000	12,000	$7.50
7	30%	$60.00	$18.00	$36,000	$126,000	14,000	$9.00
8	35%	$60.00	$21.00	$42,000	$168,000	16,000	$10.50

Replacement analysis – Summary of cumulative costs per hour – Example 1

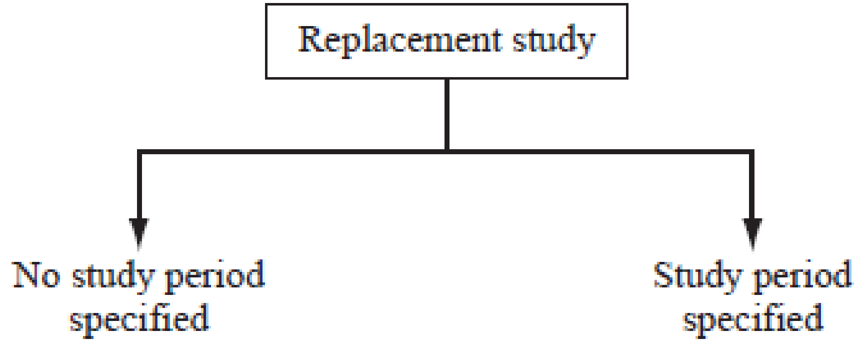
Summary of Cumulative Costs per Hour

Item	Year							
	1	2	3	4	5	6	7	8
Depreciation and Replacement	$30.00	$25.00	$21.67	$19.38	$18.00	$16.67	$15.57	$14.69
Investment	$5.00	$4.38	$3.92	$3.56	$3.28	$3.02	$2.80	$2.52
Maintenance and Repair	$4.40	$6.25	$7.92	$9.36	$10.85	$12.27	$13.90	$15.59
Downtime	$1.35	$2.03	$2.55	$3.04	$3.51	$3.98	$4.50	$5.06
Productivity Loss	$0.00	$0.30	$0.60	$1.05	$1.32	$1.70	$2.14	$2.63
Obsolescence	$0.00	$1.50	$3.00	$4.50	$6.00	$7.50	$9.00	$10.50
Total	$40.75	$39.46	$39.66	$40.89	$42.96	$45.14	$47.91	$50.99
		Min						

Replacement analysis methods

1. Outsider's viewpoint method
2. Comparative value method
3. Receipts and disbursements method
4. Economic life method

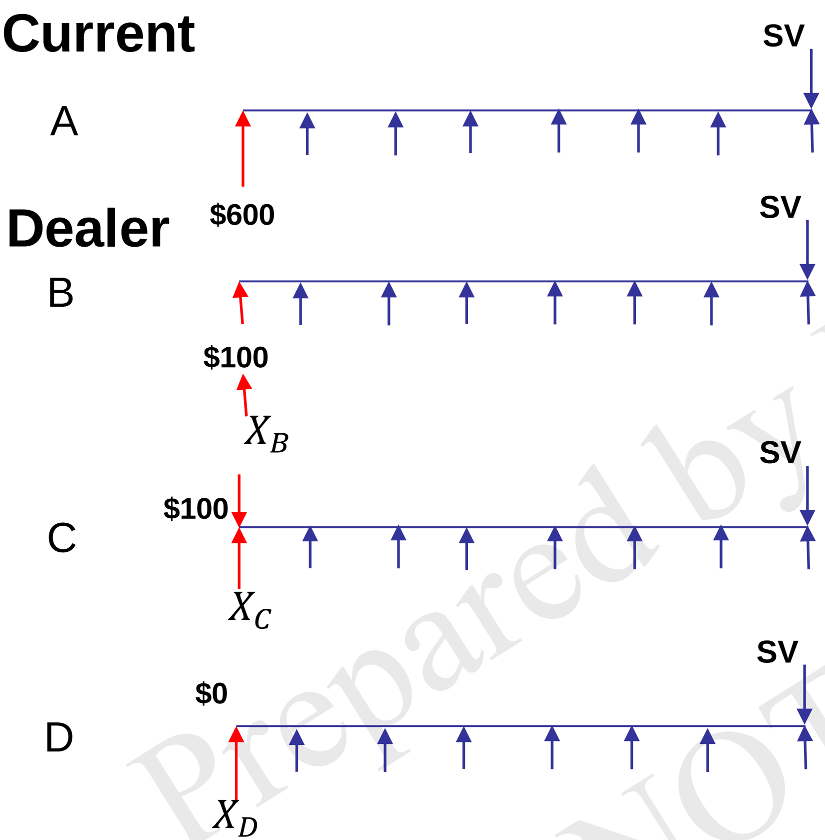
- **First three methods** are used **if study period** is **specified**
- **Economic life method** is used **if no study period** is **specified**



Outsider's view point method

- **Outsider's viewpoint** or **consultant's viewpoint** or **non-owner's viewpoint method**
  - **This viewpoint** performs the analysis **without bias**;
    - ✓ It means the **analyst** owns **neither** the **defender** nor the **challenger**.

Outsider's view point method



ارزش فعلی =$600

B → دارایی فعلی ما را 500 دلار میخرد

X_B → قیمت دارایی Bبرای فروش

C → دارایی فعلی مارا 700دلار می خرد.

X_C → قیمت داریی cبرای فروش

D → دارایی فعلی مارا 600 دلار می خرد.

X_D → قیمت داریی Dبرای فروش

Outside's view point method – Example 2

Example 2:

The **existing machine** had an initial cost of $2,200 four years ago. Its useful life is 10 years and its salvage value at the end of its useful life is estimated as $200. Operating costs are $700 per year. This machine's present market value is $600.

A **replacement machine** has an initial cost of $2,400, a useful life of 6 years, a salvage value of $300, and operating costs of $400 per year.

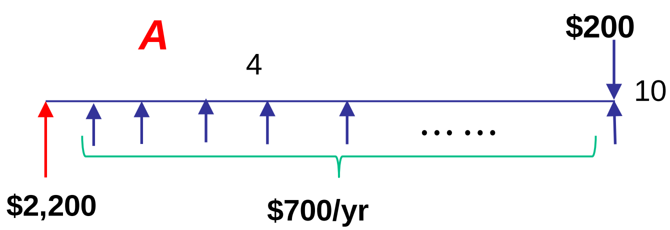
If MARR is taken as 15%, should the existing machine be replaced by the replacement alternative?

Use AE values and the "Outsider's Viewpoint" method.

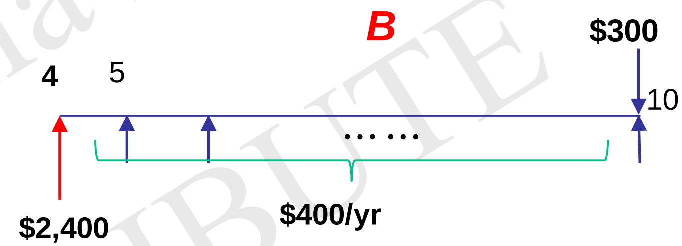
Outside's view point method – Example 2

MARR=15%

Existing machine



Replacement machine

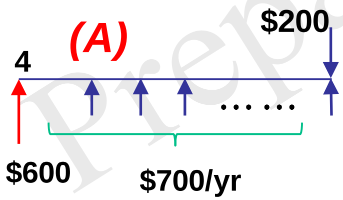


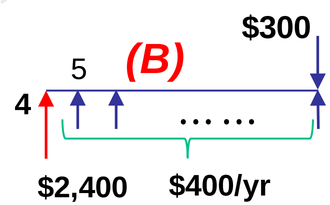
Present value: $600

a) Outsider view point

A

❖ For existing machine the first four years are sunk cost that should be disregarded





Outside's view point method – Example 2

$$AE_A(10\%) = -\$700 - \$600\left(\frac{A}{P}, 15, 6\right) + \$200\left(\frac{A}{F}, 15, 6\right) = -\$677 \; per\ year$$

$$AE_B(10\%) = -\$4000 - \$240\left(\frac{A}{P}, 15, 6\right) + \$300\left(\frac{A}{F}, 15, 6\right) = -\$1,000 \; per\ year$$

$$\Rightarrow AE_A > AE_B \qquad \Rightarrow$$ Do not replace

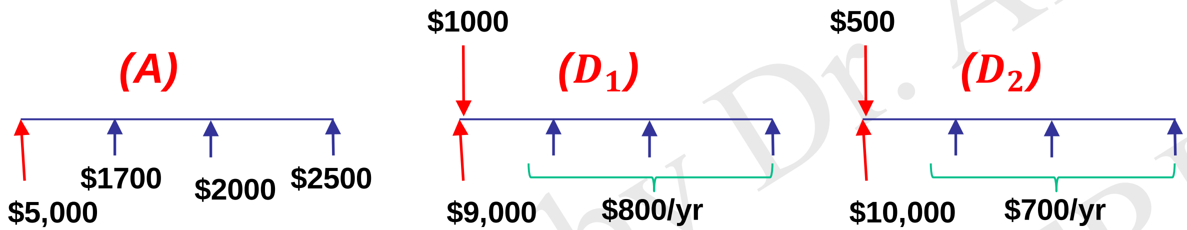
بهترین کار استفاده از AE در تمامی مسائل است

Outside's view point method – Example 3

Example 3: An existing machine has a current market value of $5,000 and a new machine is being offered for $9,000 by Dealer 1 who also guarantees that operating costs will be no more than $800 per year for the new machine. Dealer 1 offers to buy the old machine for $6,000. Dealer 2, on the other hand, wants to buy the existing machine for $5,500 and sell the new machine for 10,000; he claims that operating costs will not exceed $750 per year. All machines have a service life of three years with no salvage value expected at the end of that time. The operating costs for the existing machine are $1,700, $2,000, and $2,500 in the first, second and third years respectively. Should one replace the existing machine and if so, which dealer should one select? MARR is 12%.

Outside's view point method – Example 3

Solve by
-outside view



$$PW_{(A)}(12\%) = -\$9,392$$

$$PW_{(D_1)}(12\%) = -\$9,921$$

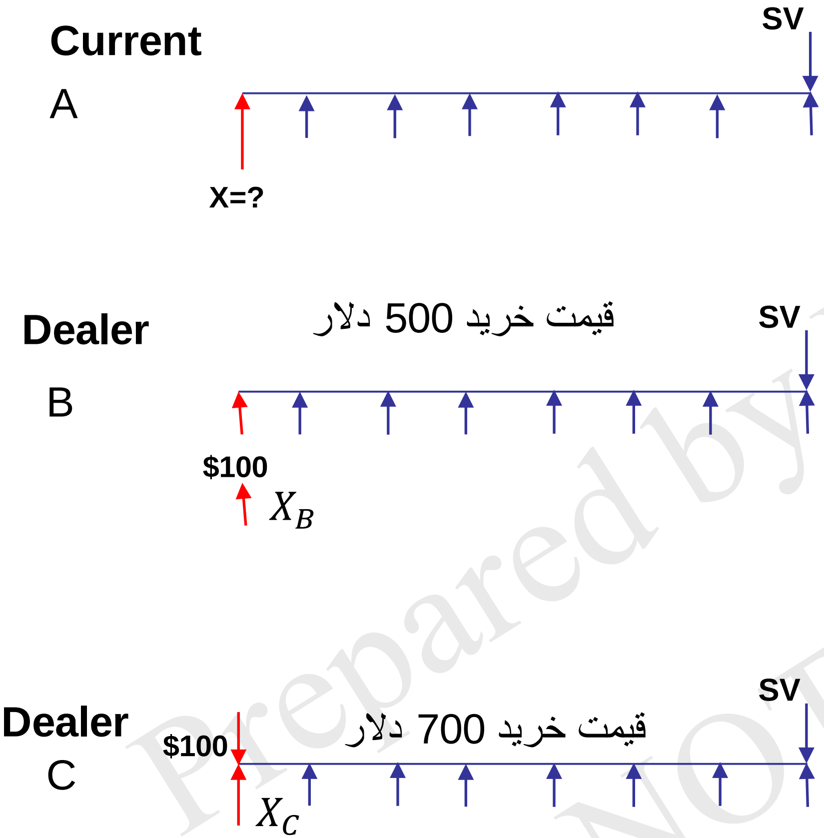
$$PW_{(D_2)}(12\%) = -\$11,301$$

❖ Do not replace

Comparative value method

- **Similar to outsider's viewpoint method** **but** with an **exception**:
  - We **assume the current market value** is **unknown**.

Comparative value method



برای رسم cash flow از
outside…. باید استفاده شود.

ارزش فعلی =$600

1. $A = B$ → X=?
- اگر X>600 عدم جایگزینی با B
- اگر X<600 جاگزینی با B

2. $A = C$ → X=?
- اگر X>600 عدم جاگزینی با C
- اگر X<600 جاگزینی با C

3. اگر → در هر دو مورد 1 و 2 از 600 کمتر شد،
بین B,C آن گزینه را که رقم کمتری به x داده انتخاب می نماییم.

Comparative value method – Example 4

Example 4:

The **existing machine** had an initial cost of $2,200 four years ago. Its useful life is 10 years and its salvage value at the end of its useful life is estimated as $200. Operating costs are $700 per year. This machine's present market value is $600.

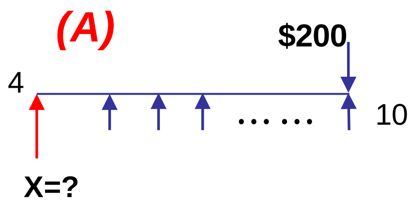
A **replacement machine** has an initial cost of $2,400, a useful life of 6 years, a salvage value of $300, and operating costs of $400 per year.

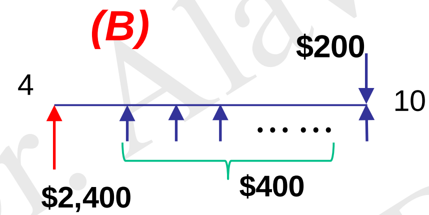
If MARR is taken as 15%, should the existing machine be replaced by the replacement alternative?

Use AE values and the "Comparative Use Value" method.

Comparative value method – Example 4

b) Comparative use value method





نکته مهم اینست که در Comparative use value باید از قیود outside view برای رسم cash flow استفاده کرد و تنها فرق آن، این است که ارزش فعلی مارکت و بازار در cash flow دارایی فعلی x به جای رقم آن لحاظ می گردد.

$$A = B \Rightarrow \quad -\boldsymbol{X}\left(\frac{\boldsymbol{A}}{\boldsymbol{P}},\mathbf{15},\mathbf{6}\right) - \$\mathbf{700} + \$\mathbf{200}\left(\frac{\boldsymbol{A}}{\boldsymbol{F}},\mathbf{15},\mathbf{6}\right)$$

$$= -\mathbf{2,400}\left(\frac{\boldsymbol{A}}{\boldsymbol{P}},\mathbf{15},\mathbf{6}\right) - \$\mathbf{400} + \$\mathbf{300}\left(\frac{\boldsymbol{A}}{\boldsymbol{F}},\mathbf{15},\mathbf{6}\right)$$

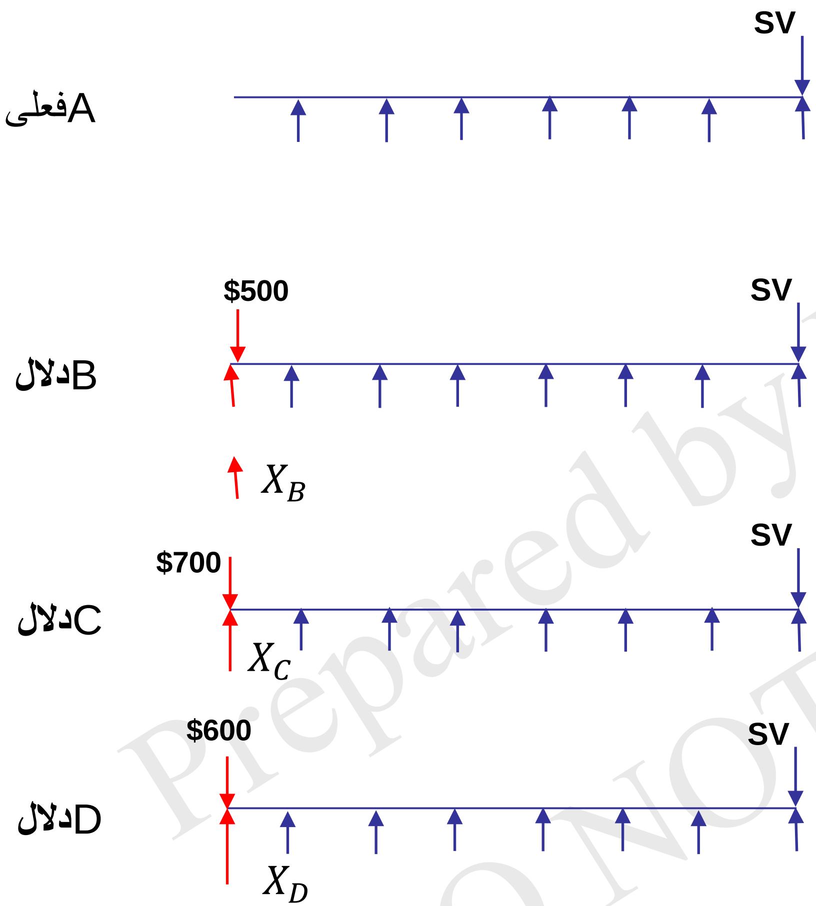
$$\Rightarrow \boxed{\boldsymbol{X} = \$\mathbf{1,221} > \$\mathbf{600} \ \Rightarrow \textbf{\textit{Do not replace}}}$$

Receipts and disbursements method

- **Exactly** based on the **receipts** and **disbursements**
  - Current market value is not considered as the cost for defender.

Receipts and disbursements method

ارزش فعلی=$600

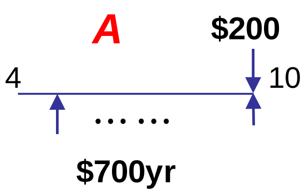


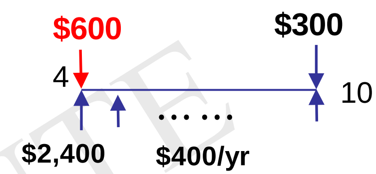
Receipts and disbursements method – Example 5

Example 5: The existing machine had an initial cost of $2,200 four years ago. Its useful life is 10 years and its salvage value at the end of its useful life is estimated as $200. Operating costs are $700 per year. This machine's present market value is $600. A replacement machine has an initial cost of $2,400, a useful life of 6 years, a salvage value of $300, and operating costs of $400 per year. If MARR is taken as 15%, should the existing machine be replaced by the replacement alternative? Use AE values and the "Receipts and Disbursements" method.

Receipts and disbursements method – Example 5

C)





$$AE_A(15\%) = -\$700 + \$200\left(\frac{A}{F}, 15, 6\right) = -\$677 per\ year$$

$$AE_B(15\%) = -\$400 - \$2400\left(\frac{A}{P}, 15, 6\right) + \$600\left(\frac{A}{F}, 15, 6\right) + \$300\left(\frac{A}{F}, 15, 6\right) = -\$800 per\ year$$

Receipts and disbursements method – Example 6

Example 6:

An **existing machine** has a current market value of $5,000 and a new machine is being offered for $9,000 by Dealer 1 who also guarantees that operating costs will be no more than $800 per year for the new machine.

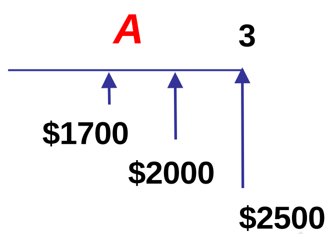
Dealer 1 offers to buy the old machine for $6,000.
Dealer 2, on the other hand, wants to buy the existing machine for $5,500 and sell the new machine for 10,000; he claims that operating costs will not exceed $750 per year.
All machines have a service life of three years with no salvage value expected at the end of that time. The operating costs for the existing machine are $1,700, $2,000, and $2,500 in the first, second and third years respectively.

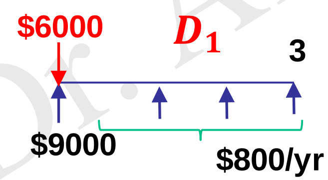
Should one replace the existing machine and if so, which dealer should one select? MARR is 12%.

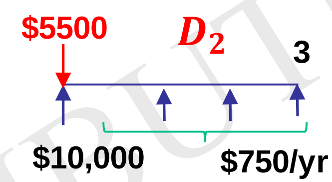
Receipts and disbursements method – Example 6

Current value : $5,000
Dealer 1:$6000
Dealer 2:$5,500

❖ *Best Choice : Receipts & Disbursement method*







$$PW_{(A)}(12\%) = -\$4,892$$

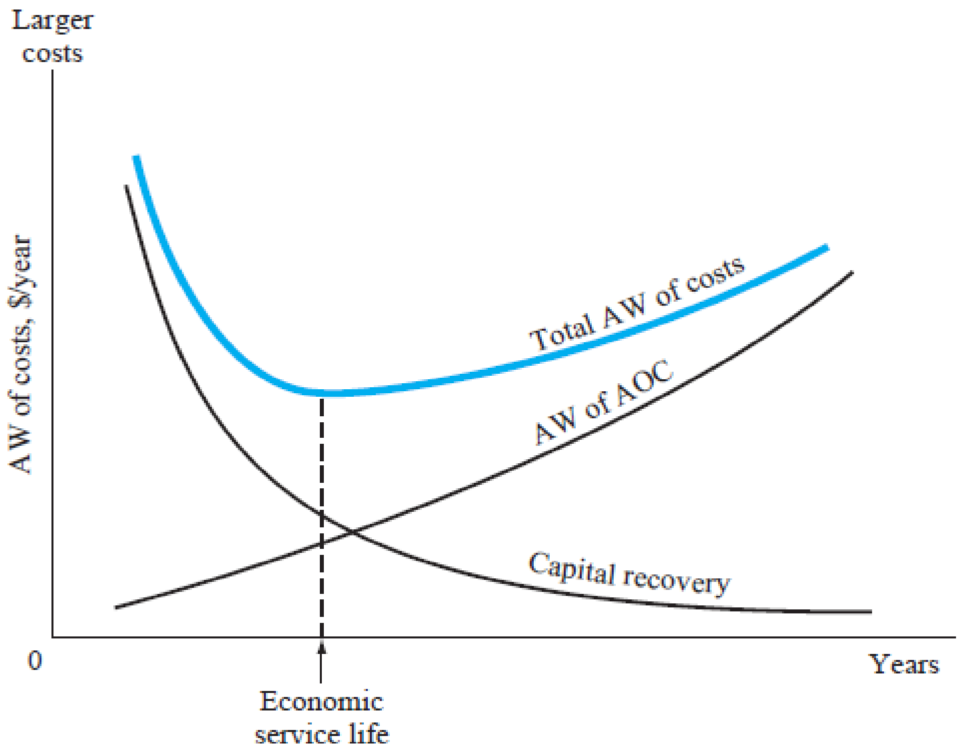
$$PW_{(D_1)}(12\%) = -\$4,921$$

$$PW_{(D_2)}(12\%) = -\$6,301$$

❖ No replacement

Economic life method

- For an **alternative** is the ***number of years at which the lowest AE of cost*** occurs.
- It is also referred to as the ***minimum cost life***.
  - Salvage value usually decreases: $1500, $1,000, $500, and 0.
  - Operating costs usually increases: $1,000, $1,700, $2,400, and $3,100.
  - Income usually decreases: $1,860, $1,303, $1,101, and $987.

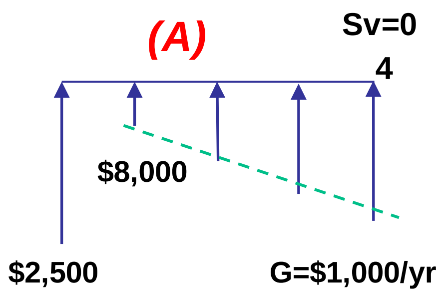


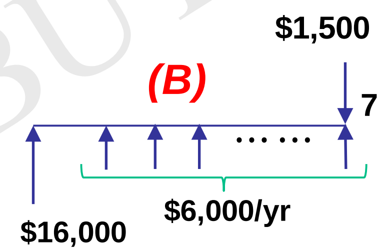
Economic life method – Example 7

Example 7: An existing machine is worth $2,500 today but will lose $1,000 in value by next year and $500 per year thereafter. Its $8,000 operating cost for this year is predicted to increase by $1,000 annually, owing to deterioration. It will be retired in 4 years, when its salvage value will be zero.

A new, improved machine that satisfactorily performs the same function as the existing machine can be purchased for $16,000 and is expected to have relatively constant annual operating costs of $6,000 to the end of its 7-year economic life, at which time the salvage value will be $1,500. No major improvements are expected in designs for machines of this type within 7 years. If the minimum attractive rate of return is 12%, should the existing machine be replaced? If so, when?

Economic life method – Example 7





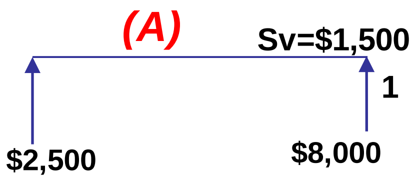
❖ ***Outside view method***

$$AE_A(12\%) = -\$2,500\left(\frac{A}{P},12,4\right) - \$8,000 - \$1,000\left(\frac{A}{G},12,4\right) = -\$10,182 per\ year$$

$$AE_B(12\%) = -\$16,000\left(\frac{A}{P},12,7\right) - \$6,000 + \$1,500\left(\frac{A}{F},12,7\right) = -\$9,357 per\ year$$

❖ ***Replace***

Economic life method – Example 7

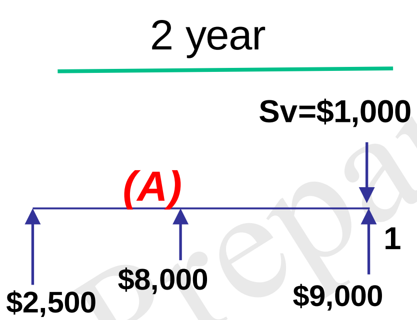


اگر در سال اول بعد از یکسال بفروشیم

$$AE_A(12\%) = -\$2,500\left(\frac{A}{P},12,1\right) - \$8,000 + \$1,500$$
$$= -\$9,300 per\ year$$
$$AE_B(12\%) = -\$9,357 per\ year$$

❖ ***Do not Replace***

$$AE_B - AE_A = -\$57$$



$$AE_A(12\%)$$
$$= -\$2,500\left(\frac{A}{P},12,2\right) - \left[\$8,000 + \$1,000\left(\frac{A}{G},12,2\right)\right]$$
$$+\$1,000\left(\frac{A}{F},12,2\right) = -\$9,680 per\ year$$
$$AE_B(12\%) = -\$9,357 per\ year$$
$$AE_B - AE_A = \boxed{\$323}$$

بیشتر ضرر
می دهیم اگر نگهداریم

چون اختلاف AE در حالت دوم بیشتر از حالت اول است،حالت اول
بهتر است

Replace A at the
End of 1 year

Economic life method – Example 8

Example 8: A small compressor can be bought for $10,000.

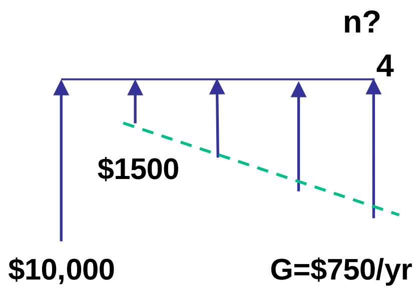
The salvage value is assumed to be negligible regardless of the replacement interval.

Annual operating and maintenance costs are expected to increase by $750 per year with the first year's cost anticipated to be $1,500.

Using a MARR of 8%, determine the year at which the replacement should take place with a like compressor.

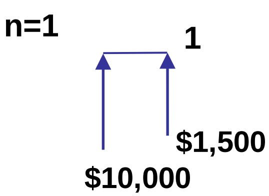
Economic life method – Example 8

-Economic life method : n?

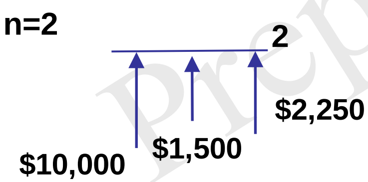


MARR=8%

دراین تحلیل فقط باید از Outside view استفاده کرد



$$AE(8\%) = -\$10,000\left(\frac{A}{P},8,1\right) - \$1,500 = -\$12,300 \text{ per year}$$

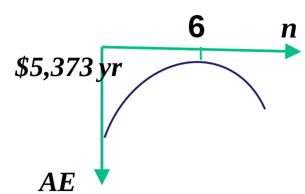


$$AE(8\%) = -\$10,000\left(\frac{A}{P},8,2\right) - \$1,500$$
$$-\$750\left(\frac{A}{G},8,2\right) = -\$7,468 \text{ per year}$$

AE_3 =-$6,093 AE_4 =-$5,563 AE_5 =-$5,392
AE_6 =-$5,373 AE_7 =-$5,438

1 min

n=6



موسسه مهندسی و مدیریت ساخت علوی پور

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ACEMI

رویکردی جامع برای ارزیابی اقتصادی در پروژه
همراه با آموزش مدلسازی در اکسل (Excel)

بخش ششم:

ارزیابی اقتصادی: تصمیم گیری بین خرید، اجاره یا لیزینگ

ارائه دهندگان:

سید محمدرضا علوی‌پور

(PhD, PMP, CMIT)

کامبیز کردانی

(M.Sc., PMP)

What we will learn?

- Types of equipment
- Introduction on how to select equipment
- Cost of owning
- Cost of operating
- Cost of owning and operating – example
- Advantages of purchasing over renting
- Disadvantages of purchasing over renting
- Purchase/rent decision example
- Purchase/rent/lease decision example

Types of equipment

1. Standard equipment
   - ❖ Ready to purchase
2. Special equipment
   - ❖ Produced based on order and customization

Types of equipment

- Factors in selecting construction equipment
  1. Delivery
  2. Versatility
  3. Availability of parts
  4. Disposal (after economical life)

Introduction on how to select equipment

- Equipment may be:
  - Purchased
  - Leased
  - Rented

The decision whether to buy, lease, or rent equipment depends on several factors.

The two most important issues are:

1. **Extent of time the equipment will be needed**
2. **Financial situation of the contractor**

If the contractor needs the equipment for a long time, buying is best.

Renting is the ideal solution for short-term needs.

Leasing, if available, is an extended rental contract.

Introduction on how to select equipment

- **Important costs for making decision:**
  1. Cost of owning (fixed cost)
  2. Cost of operating (variable cost)
  - **Calculated based on two methods:**
    1. Standard method **(more conservative)**
    2. Peurifoy - Schexnayder – Shapira-Schmitt (PSSS Method)
  - **Why costs of owning and operating needed?**
    1. **Economic analysis** to compare different equipment
    2. **Unit cost** for **bidding purposes**
    3. Decide as to whether **purchase**, **rent** or **lease**

Cost of owning

- Depreciation cost
- Spare part cost
- Maintenance and repair cost
- Investment cost
- Transportation – assembling – dismantling cost

Can be changed based on actual condition

Cost of owning – Depreciation cost

- It is the **loss** in **value of a piece of equipment over time**, generally **caused** by **wear** and **tear** from use, **deterioration**, **obsolescence**, or **needs** that are reduced.

- ***Reasons for calculating depreciation?***
  1. To **estimate** **market value** of equipment
  2. To **assess** **unit cost of production**
  3. **Tax purposes**
  4. To **make decision** between **rent**, **purchase** or **lease**

Cost of owning – Depreciation cost

- **Many methods** can be used, but we should look at the **financial law**.

- However, the **most common method** is **straight-line method (SL)**
  - In Construction usually:

Yearly SL depreciation = 1/N (P-S)

If no salvage value considered

Hourly depreciation = P/N'

- P = Purchase price of equipment
- N' = Depreciation periods expressed in hours
  - N' could be actual life, useful life, service life, depreciation life, taxable life, economic life

Cost of owning – Spare part cost

- **All parts** are subject to **failure** and must be **replaced** when broken
- **Always** expressed as a **percentage of the depreciation cost**

Hourly spare parts cost = 0.53 P/N’

Cost of owning – Maintenance and repair cost

- **Depends on:**
  1. Types of equipment
  2. Service to which equipment is assigned
  3. Care equipment receives

- **Always** expressed as a **percentage of the depreciation cost**

$$\textit{Hourly cost of maintenance and repair} = 0.13\ P/N'$$

Cost of owning – Investment cost

Interest cost and insurance cost = 0.12 P/N'

Storage cost and taxes = 0.08 P/N'

Investment cost = 0.2 × Average value of equipment

❖ We use **average value of equipment** to make **calculation easier and faster**

$$\bar{P} = \frac{P(N+1)}{2N} \text{ per year}$$

$$\bar{P} = \frac{P(N+1)}{2Nn} \text{ per hour}$$

$$\bar{P} = \frac{P(N+1)}{2N'} \text{ per hour}$$

AVERAGE VALUE WE USE IN INVESTMENT COST FORMULA

N= NUMBER OF YEARS WE USE THE MACHINE

n= NUMNBER OF HOURS WE USE THE MACHINE IN A YEAR

Cost of owning – Investment cost

$$Investment\ cost = 0.2 \times Average\ value\ of\ equipment$$

AVERAGE COST OF INVESTMENT
(NO SALVAGE VALUE)

$$\text{HOURLY INV COST} = 0.20\left[\frac{P(N+1)}{2N'}\right]$$

AVERAGE VALUE OF EQUIPMENT
(SALVAGE VALUE = S)

$$\overline{P} = \frac{P(N+1)+S(N-1)}{2N'}$$

AVERAGE COST OF INVESTMENT
(WITH SALVAGE VALUE = S)

$$\text{HOURLY INV COST} = 0.20\left[\frac{P(N+1)+S(N-1)}{2N'}\right]$$

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Cost of owning – Investment cost – Example 1

Example 1:

- Original cost of equipment: $25,000
- Estimated useful life: 5 yrs
- Estimated hours of work per year: 2,000
- Salvage value: zero
- Straight-line method of depreciation
- Calculate average value of equipment
- Calculate average hourly investment cost of equipment

START OF YEAR	ANNUAL DEPRECIATION	BOOK VALUE
1	$0	$25,000
2	$5,000	$20,000
3	$5,000	$15,000
4	$5,000	$10,000
5	$5,000	$5,000
	TOTAL	$75,000

- AVERAGE YEARLY VALUE OF EQUIPMENT: $75,000 / 5 yrs = $15,000/yr
- AVERAGE HOURLY VALUE OF EQUIPMENT: $15,000/yr / 2,000 hrs/yr = $7.50/hr
- AVERAGE HOURLY INVESTMENT COST: 20% x $7.50/hr = $1.50/hr

Cost of owning – Transportation – assembling - dismantling cost

- Equipment have to be transported from site to site
- Always expressed as a percentage of depreciation cost

Transportation-assembling-dismantling cost = 0.02 P/n

✓ n = Number of hours using machine per year

Cost of operating

1. Fuel cost
2. Lubrication oil cost
3. Labor cost

Cost of operating – Fuel cost

- Depends on **horsepower (HP) (اسب بخار)**

Hourly fuel cost = (fuel consumed per hour) × (unit price of fuel)

❖ *Hourly fuel consumption = (unit consumption in kg/HP.hr) × (HP) × (Operating factor)*

1. **When engine is working at full power and 60 minutes per hour:**
   - **Gasoline engine:**
     - (0.200 kg/HP.hr) × (HP) × 1
     - (0.06 gal/HP.hr) × (HP) × 1
   - **Diesel engine**
     - (0.150 kg/HP.hr) × (HP) × 1
     - (0.04 gal/HP.hr) × (HP) × 1

Cost of operating – Fuel cost

- Depends on **horsepower (HP)**

Hourly fuel cost = (fuel consumed per hour) × (unit price of fuel)

- ***Hourly fuel consumption = (unit consumption in kg/HP.hr) × (HP) × (Operating factor)***

2. **When engine is not working at full power and 60 minutes, we need to calculate operating factor:**
   - ***Operating factor = (engine factor) × (time factor)***
     - Engine factor = average power generated compared to full power
     - Time factor = average time equipment is used per 60 minute hr

Cost of operating – Fuel cost – Example 2

Example 2:

- Consider a front shovel with a diesel engine rated at 160 hp. When used to load trucks, the engine operates at maximum power while filling the dipper, requiring 5 seconds out of a cycle time of 20 seconds. During the other 15 seconds, the engine operates at half its rated power. Also, the shovel operates 50 minutes per hour on average. What is the consumption of fuel?

- **Solution**
  - Operating factor = (engine factor) × (time factor)
    - ✓ Engine factor = average power generated compared to full power
    - ✓ Time factor = average time equipment is used per 60 minute hr
  - Engine factor when filling the dipper = (5/20) × 1 = 0.250
  - Engine factor in the rest of the cycle = (15/20) × 0.5 = 0.375
  - Engine factor = 0.250 + 0.375 = 0.625
  - Time factor = 50/60 = 0.833
  - Operating factor = (engine factor) × (time factor) = 0.625 × 0.833 = 0.520
  - Hourly fuel consumption = (unit consumption in kg/HP.hr) × (HP) × (Operating factor)
    - Fuel consumed per hour = 0.150 kg/HP.hr × 160 HP × 0.520 = 12.48 kg/hr

Cost of operating – Lubricating oil cost

Hourly lubricating oil cost = (oil consumed per hour) × (unit price of fuel)

- **Depends on:**
  - Size of engine
  - Capacity of the crankcase (محل اتصال میل لنگ)
  - Condition of the piston rings
  - Number of hours between oil changes

- **Calculation is based on two conditions:**
  1. When data are enough
  2. When data are not enough

Cost of operating – Lubricating oil cost

1. When data are enough

Consumption of lubricating oil = (quantity put during change) + (make-up oil in between)

EMPIRICAL FORMULA:

$$q = \frac{HP \times f \times 0.006\,(\text{lbs/HP.hr})}{7.4\,(\text{lbs/gal})} + \frac{c}{t}$$

WHERE
q = QUANTITY CONSUMED (gal/hr)
HP = HORSE-POWER OF ENGINE
f = OPERATING FACTOR عین فرمول قبل
t = HRS BETWEEN OIL CHANGES
c = CRANKCASE CAPACITY (gal)

Cost of operating – Lubricating oil cost

2. When data are not enough:

a) When we do not have enough data and the engine is **working at full power and 60 minutes per hour**:

- ***Consumption of lubricating oil =***
  - ✓ (0.003 kg/HP.hr) × (HP) × 1
  - ✓ (0.0009 gal/HP.hr) × (HP) × 1

Cost of operating – Lubricating oil cost

2. When data are not enough:

b) When we do not have enough data and the engine is **not working at full power and 60 minutes**,

- ❖ We need to calculate operating factor.
- ❖ ***Consumption of lubricating oil =***
  - ✓ (0.003 kg/HP.hr) × (HP) × Operating factor
  - ✓ (0.0009 gal/HP.hr) × (HP) × operating factor
    - o ***Operating factor = (engine factor) × (time factor)***
      - Engine factor = average power generated compared to full power
      - Time factor = average time equipment is used per 60 minute hr

Cost of operating – Labor cost

- Consists of foreman, operator, mechanics, oilers
  - Mechanics, oilers and etc. are not separately considered as a labor cost in many countries.

Cost of owning and operating

- **Peurifoy - Schexnayder – Shapira-Schmitt (PSSS Method)**
  - **Ownership cost**
    - ✓ Depreciation cost
    - ✓ Cost of capital (Investment cost)
    - ✓ Tax savings
    - ✓ Major repairs
    - ✓ Taxes, insurance, and storage
  - **Operating cost**
    - ✓ Fuel
    - ✓ Lubricants
    - ✓ Maintenance and repair
    - ✓ Tires and high-wear items

Cost of owning and operating – Example 3

Example 3:

- Front shovel
- 100-hp diesel engine
- Bucket capacity: 1¾ cu yd
- Initial cost: $147,000
- Salvage value: $0
- Unit price of fuel: $3.40/gal
- Unit price of lubr: $7.00/gal
- Hours worked per year: 2,000
- Useful life: 8 yrs
- Crankcase capacity: 4.2 gal
- Oil changes: every 150 hours
- Operating factor: 0.60
- Company's tax rate: 40%
- Major repairs: none
- Min attractive rate of return: 5%

- OWNERSHIP COST
  - DEPRECIATION COST

$$C_d = \frac{P}{N_1} = \frac{\$147{,}000}{8\text{ yrs} \times 2{,}000\text{ hrs/yr}} = \$9.19/\text{hr}$$

  - SPARE PARTS COST

$$C_{sp} = 0.53 \times \frac{P}{N_1} = 0.53 \times \frac{\$147{,}000}{8\text{ yrs} \times 2{,}000\text{ hrs/yr}} = \$4.87/\text{hr}$$

Cost of owning and operating – Example 3

Example 3:

- Front shovel
- 100-hp diesel engine
- Bucket capacity: 1¾ cu yd
- Initial cost: $147,000
- Salvage value: $0
- Unit price of fuel: $3.40/gal
- Unit price of lubr: $7.00/gal
- Hours worked per year: 2,000
- Useful life: 8 yrs
- Crankcase capacity: 4.2 gal
- Oil changes: every 150 hours
- Operating factor: 0.60
- Company's tax rate: 40%
- Major repairs: none
- Min attractive rate of return: 5%

– MAINTENANCE AND REPAIR COST

$$C_{m\&r} = 0.13 \times \frac{P}{N_1}$$

$$= 0.13 \times \frac{\$147{,}000}{8\,\text{yrs} \times 2{,}000\,\text{hrs/yr}}$$

$$= \$1.19/\text{hr}$$

– INVESTMENT COST

$$C_{inv} = \frac{0.20(N+1)P}{2N_1}$$

$$= \frac{0.20 \times (8+1) \times \$147{,}000}{2 \times 8\,\text{yrs} \times 2{,}000\,\text{hrs/yr}}$$

$$= \$8.27/\text{hr}$$

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Cost of owning and operating – Example 3

Example 3:
- Front shovel
- 100-hp diesel engine
- Bucket capacity: 1¾ cu yd
- Initial cost: $147,000
- Salvage value: $0
- Unit price of fuel: $3.40/gal
- Unit price of lubr: $7.00/gal
- Hours worked per year: 2,000
- Useful life: 8 yrs
- Crankcase capacity: 4.2 gal
- Oil changes: every 150 hours
- Operating factor: 0.60
- Company's tax rate: 40%
- Major repairs: none
- Min attractive rate of return: 5%

– TRANSPORTATION-ASSEMBLING-DISMANTLING COST

$$C_{t-a-d} = 0.02 \times \frac{P}{n}$$
$$= 0.02 \times \frac{\$147,000}{2,000\,\text{hrs/yr}}$$
$$= \$1.47/\text{hr}$$

OWNERSHIP COST (FIXED COST)

$C_{ow} = C_d + C_{sp} + C_{m\&r} + C_{inv} + C_{t\text{-}a\text{-}d}$

$C_{ow} = 9.19 + 4.87 + 1.19 + 8.27 + 1.47$

$C_{ow} = \$24.99\ /\text{hr}$

- OPERATING COST

– FUEL COST

$$C_{fuel} = HP \times \text{consumption} \times \text{op fact} \times \text{unit cost}$$
$$= 100HP \times 0.04\text{gal}/HP.\text{hr} \times 0.60 \times \$3.40/\text{gal}$$
$$= \$8.16/\text{hr}$$

Cost of owning and operating – Example 3

Example 3:

- ❑ Front shovel
- ❑ 100-hp diesel engine
- ❑ Bucket capacity: 1¾ cu yd
- ❑ Initial cost: $147,000
- ❑ Salvage value: $0
- ❑ Unit price of fuel: $3.40/gal
- ❑ Unit price of lubr: $7.00/gal
- ❑ Hours worked per year: 2,000
- ❑ Useful life: 8 yrs
- ❑ Crankcase capacity: 4.2 gal
- ❑ Oil changes: every 150 hours
- ❑ Operating factor: 0.60
- ❑ Company's tax rate: 40%
- ❑ Major repairs: none
- ❑ Min attractive rate of return: 5%

– LUBRICATING OIL COST

$$C_{lu} = \left[\frac{HP \times op\,fact \times consumption}{density} + \frac{c}{t}\right] \times unit\ cost$$

$$= \left[\frac{100HP \times 0.60 \times 0.006\,lb/HP.hr}{7.4\,lb/gal} + \frac{4.2\,gal}{150\,hrs}\right] \times \$7.00/gal$$

$$= \$0.54/hr$$

OPERATING COST (VARIABLE COST)

$$C_{op} = C_{fuel} + C_{lu}$$
$$C_{op} = \$8.16/hr + \$0.54/hr$$
$$C_{op} = \$8.70\ /hr$$

COST OF OWNING AND OPERATING (FIXED + VARIABLE COST)

$$C = C_{ow} + C_{op}$$
$$C = \$24.99/hr + \$8.70/hr$$
$$C = \$33.69\ /hr$$

Advantages of purchasing over renting

- **More economical** if used **sufficiently**
- More likely to be **available when needed**
- More likely to be **kept in better mechanical condition**

Disadvantages of purchasing over renting

- It may be **more expensive** if **not used sufficiently**
- It may require **substantial initial investment**
- Ownership may **force contractor** to use **obsolete equipment**
- Ownership may **force contractor** to do **only the same type of work**
- Ownership may **force contractor** to **use** the **equipment beyond its economic life**

Purchase/Rent decision – Example 4

Example 4:

1. Purchase:
   - Initial cost = \$20,000
   - Depreciation period = 8 years
2. Rent:
   - Rental rate = \$18 per hour
   - Maintenance cost = 1/3 of owner's maintenance cost

FIXED HOURLY COST IF PURCHASED:

$$C_p = \left[\frac{A}{N\times n}\right] + \left[0.53\times\frac{A}{N\times n}\right] + \left[0.13\times\frac{A}{N\times n}\right] + \left[0.20\times\frac{A\times(N+1)}{2\times N\times n}\right] + \left[0.02\times\frac{A}{n}\right]$$

$$= \left[\frac{20{,}000}{8\times n}\right] + \left[0.53\times\frac{20{,}000}{8\times n}\right] + \left[0.13\times\frac{20{,}000}{8\times n}\right] + \left[0.20\times\frac{20{,}000\times(8+1)}{2\times 8\times n}\right] + \left[0.02\times\frac{20{,}000}{n}\right]$$

$$= \frac{6{,}800}{n}\ \$/\text{hr over 8 years}$$

Purchase/Rent decision – Example 4

Example 4:

1. Purchase:
   - Initial cost = $20,000
   - Depreciation period = 8 years
2. Rent:
   - Rental rate = $18 per hour
   - Maintenance cost = 1/3 of owner's maintenance cost

FIXED HOURLY COST IF RENTED:

$$C_r = C + \left[\frac{1}{3} \times 0.13 \times \frac{A}{N \times n}\right]$$

$$= 18.00 + \left[\frac{1}{3} \times 0.13 \times \frac{20{,}000}{8 \times n}\right]$$

$$= 18.00 + \frac{108.33}{n} \quad \$/\text{hr over 8 years}$$

Purchase/Rent decision – Example 4

Example 4:

1. Purchase:
   - ❖ Initial cost = $20,000
   - ❖ Depreciation period = 8 years
2. Rent:
   - ❖ Rental rate = $18 per hour
   - ❖ Maintenance cost = 1/3 of owner's maintenance cost

INTERSECTION OF THE "PURCHASE" OPTION WITH THE "RENTAL" OPTION:

$$C_p = C_r$$

$$\frac{6{,}800}{n} = 18.00 + \frac{108.33}{n}$$

$$\Rightarrow n = 371.76 \text{ hrs/yr}$$

Purchase/Rent decision – Example 4

Example 4:

1. Purchase:
   - ❖ Initial cost = $20,000
   - ❖ Depreciation period = 8 years
2. Rent:
   - ❖ Rental rate = $18 per hour
   - ❖ Maintenance cost = 1/3 of owner's maintenance cost

Purchase if you use the equipment **more than 371.76 hours** per year

Rent if you use the equipment **less than 371.76 hours** per year

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Purchase/Rent/Lease decision – Example 5

Example 5:

1. Purchase:
   - ❖ Initial cost = \$20,000, Depreciation period = 8 years
2. Rent:
   - ❖ Rental rate = \$18 per hour , Maintenance cost = 1/3 of owner’s maintenance cost
3. Lease: Rent with option to purchase:
   - ❖ 90% of rents paid in the first six months will be accepted towards the purchase price
   - ❖ All factors in the lease option, function of:
     1. *A’* (where A’ = Initial cost minus 90% of rents paid in the first six months)
     2. *N’* (where *N’* = 8 – 0.5 = 7.5 years)

FIXED HOURLY COST IN THE FIRST SIX MONTHS IN THE "LEASE" ALTERNATIVE:

$$C_{o1} = C + \left[\frac{1}{3} \times 0.13 \times \frac{A}{N \times n}\right]$$

$$= 18.00 + \left[\frac{1}{3} \times 0.13 \times \frac{20{,}000}{8 \times n}\right]$$

$$= 18.00 + \frac{108.33}{n} \quad \text{\$/hr over the first six months}$$

Purchase/Rent/Lease decision – Example 5

Example 5:

1. Purchase:
   - ❖ Initial cost = $20,000, Depreciation period = 8 years
2. Rent:
   - ❖ Rental rate = $18 per hour , Maintenance cost = 1/3 of owner's maintenance cost
3. Lease: Rent with option to purchase:
   - ❖ 90% of rents paid in the first six months will be accepted towards the purchase price
   - ❖ All factors in the lease option, function of:
     1. *A'* (where A' = Initial cost minus 90% of rents paid in the first six months)
     2. *N'* (where *N'* = 8 – 0.5 = 7.5 years)

FIXED HOURLY COST IN THE REMAINING 7.5 YEARS IN THE "RENT WITH OPTION TO PURCHASE" ALTERNATIVE (N' = 7.5 YRS):

$$C_{o2} = \left[\frac{A'}{N' \times n}\right] + \left[0.53 \times \frac{A'}{N' \times n}\right] + \left[0.13 \times \frac{A'}{N' \times n}\right] + \left[0.20 \times \frac{A' \times (N+1)}{2 \times N' \times n}\right] + \left[0.02 \times \frac{A'}{n}\right]$$

where:

$$A' = A - \left[0.90 \times C \times \frac{n}{2}\right] = 20{,}000 - \left[0.90 \times 18.00 \times \frac{n}{2}\right] = 20{,}000 - 8.10n$$

Purchase/Rent/Lease decision – Example 5

Example 5:

1. Purchase:
   - ❖ Initial cost = \$20,000, Depreciation period = 8 years
2. Rent:
   - ❖ Rental rate = \$18 per hour , Maintenance cost = 1/3 of owner’s maintenance cost
3. Lease: Rent with option to purchase:
   - ❖ 90% of rents paid in the first six months will be accepted towards the purchase price
   - ❖ All factors in the lease option, function of:
     1. *A’* (where A’ = Initial cost minus 90% of rents paid in the first six months)
     2. *N’* (where *N’* = 8 – 0.5 = 7.5 years)

$$C_{o2}=\left[\frac{A'}{N'\times n}\right]+\left[0.53\times\frac{A'}{N'\times n}\right]+\left[0.13\times\frac{A'}{N'\times n}\right]+\left[0.20\times\frac{A'\times(N'+1)}{2\times N'\times n}\right]+\left[0.02\times\frac{A'}{n}\right]$$

$$=\left[\frac{(20{,}000-8.10n)}{7.5n}\right]+\left[0.53\times\frac{(20{,}000-8.10n)}{7.5n}\right]+\left[0.13\times\frac{(20{,}000-8.10n)}{7.5n}\right]$$

$$+\left[0.20\times\frac{(20{,}000-8.10n)\times(7.5+1))}{2\times 7.5n}\right]+\left[0.02\times\frac{(20{,}000-8.10n)}{n}\right]$$

$$=\frac{7{,}092}{n}-2.87 \quad \text{\$/hr over the remaining 7.5 years}$$

Purchase/Rent/Lease decision – Example 5

Example 5:

1. Purchase:
   - ❖ Initial cost = \$20,000, Depreciation period = 8 years
2. Rent:
   - ❖ Rental rate = \$18 per hour , Maintenance cost = 1/3 of owner's maintenance cost
3. Lease: Rent with option to purchase:
   - ❖ 90% of rents paid in the first six months will be accepted towards the purchase price
   - ❖ All factors in the lease option, function of:
     1. *A'* (where A' = Initial cost minus 90% of rents paid in the first six months)
     2. *N'* (where *N'* = 8 – 0.5 = 7.5 years)

AVERAGE WEIGHTED FIXED HOURLY COST OVER THE ENTIRE 8 YEARS:

$$C_o = \frac{(0.5\times C_{o1}) + (7.5\times C_{o2})}{8}$$

$$= \frac{\left[0.5\times\left(18.00+\frac{108.33}{n}\right)\right]+\left[7.5\times\left(\frac{7{,}092}{n}-2.87\right)\right]}{8}$$

$$= \frac{6{,}655.52}{n} - 1.565 \quad \text{\$/hr over the entire 8 years}$$

Purchase/Rent/Lease decision – Example 5

INTERSECTION OF THE "LEASE" OPTION WITH THE "RENTAL" OPTION:

$$C_o = C_r \qquad \frac{6,655.22}{n} - 1.565 = 18.00 + \frac{108.33}{n} \Rightarrow n = 334.64 \text{ hrs / yr}$$

Lease if you use the equipment more than 334.64 hours per year

Rent if you use the equipment less than 334.64 hours per year

Purchase/Rent/Lease decision – Example 5

INTERSECTION OF THE "LEASE" OPTION WITH THE "PURCHASE" OPTION:

$$C_o = C_p$$

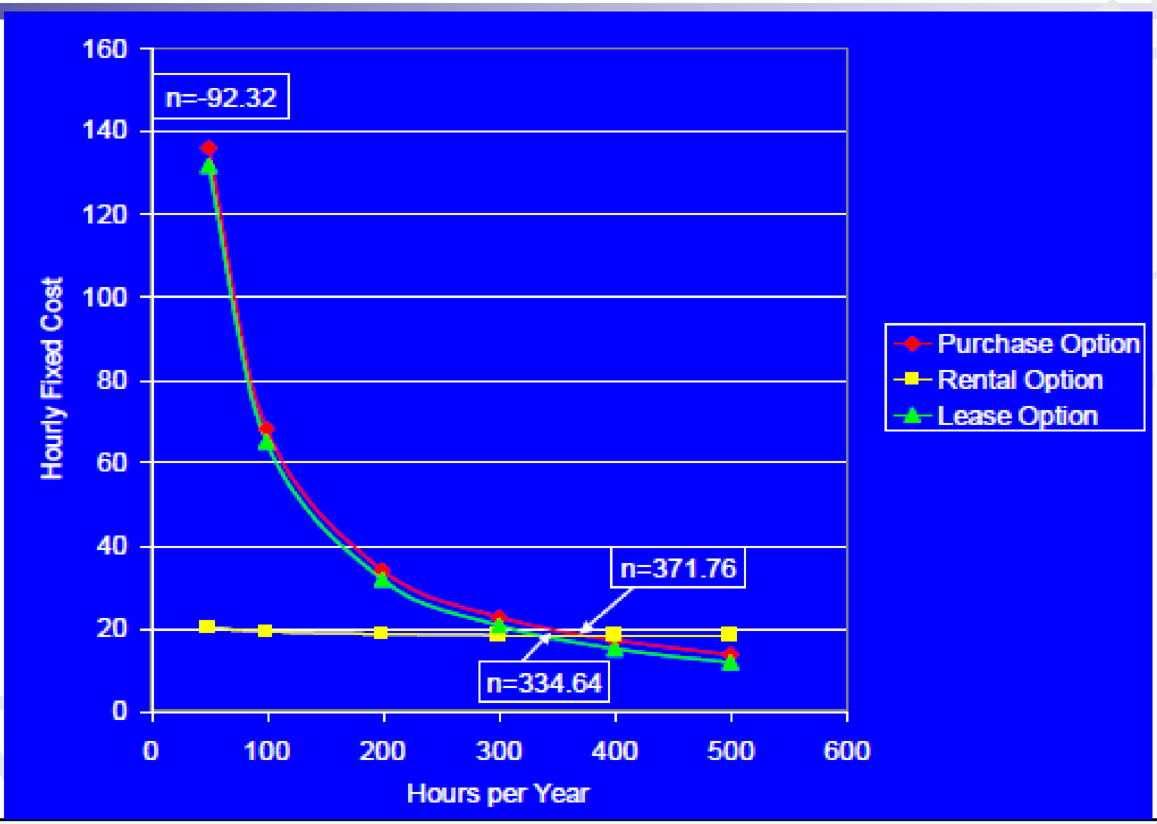
$$\frac{6{,}655.22}{n} - 1.565 = \frac{6{,}800}{n}$$

$$\Rightarrow n = -92.32 \text{ hrs / yr}$$

Lease at all times regardless of the value of *n*

Purchase never

Purchase/Rent/Lease decision – Example 5



If **one considers all three alternatives**:

- ❑ **Purchase** **never**
- ❑ **Rent** if you use the equipment **less than 334.64 hrs per yr**
- ❑ **Lease** if you use the equipment **more than 334.64 hrs per yr**

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