Life-cycle Cost Analysis

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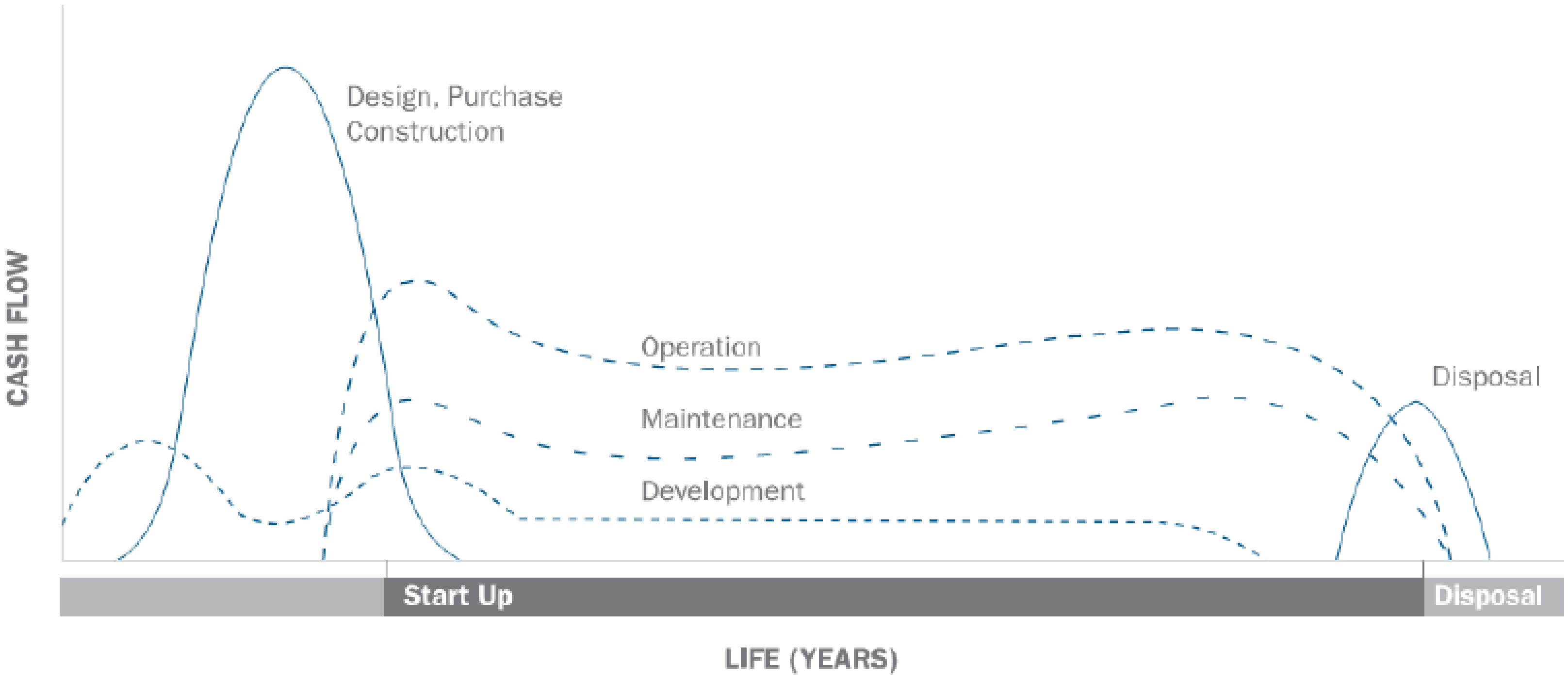
Life-cycle Cost Analysis:

- Introduce the life-cycle cost (LCC) analysis procedure
- Present how to calculate the present and future value of capital
- Describe how LCC can be used to guide purchasing decisions



Luttenberger, A. and Luttenberger, L. R. 2015. Environmental aspects of public procurement in transport sector. 17th International Conference on Transport Science., Portoroz, Slovenia.

Life-cycle Cost Analysis:

Economic performance metrics:

- Payback period
- Benefit-to-cost ratio
- Internal rate of return
- Net benefits
- Risk analysis
- Etc…

ASTM* E1185: Guide for Selecting Economic Methods for Evaluating Investments in Buildings and Building Systems

Life-cycle cost analysis:
Economic evaluation method for comparing project alternatives based on the present and future costs that occur during a specified time period.

- Will buying a water heater insulation kit be worth the purchase price?
- Carpet, tile, or wood laminate? Which flooring option is the most cost effective over the lifetime of a building?
- How much money could be saved by upgrading a building's air conditioner efficiency

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Life-cycle Cost Procedure:

ASTM E917: Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems

Procedure:

1. Identify objectives, alternatives, and constraints
2. Establish basic assumptions for analysis
3. Compile cost data
4. Compute LCC for each alternative
5. Compare alternatives to find the minimum LCC
6. Make final decision based on LCC while also considering risk, uncertainty, funding constraints

Life-cycle Cost: Heating System Example

Procedure:

Define the:

- Objective: Chose the most cost effective heating system for a 2,500 square foot, newly constructed home.
- Alternatives: gas heater, oil heater, electric heat pump, electric baseboard heating
- Constraints: Homeowner has specified they are not interested in oil heating.

gas heater

oil heater

electric heat pump

Electric baseboard heating

Images Source: https://www.homedepot.com

Life-cycle Cost: Heating System Example

Procedure:

2. Establish basic assumptions for analysis:
   - Present value or annual value basis: present
   - Study period: assumed service life of the heating system is 10 years
   - Discount rate*: 8% (nominal) with 2% general inflation
     - Nominal rate: 8%
     - Real rate, assuming 2% inflation: $\mathrm{r} = \left(\frac{1.08}{1.02} - 1\right) x\ 100 = 5.9\%$

ASTM* E917, equation 1

*Discount rate: represents the project investor's minimum acceptable rate of return

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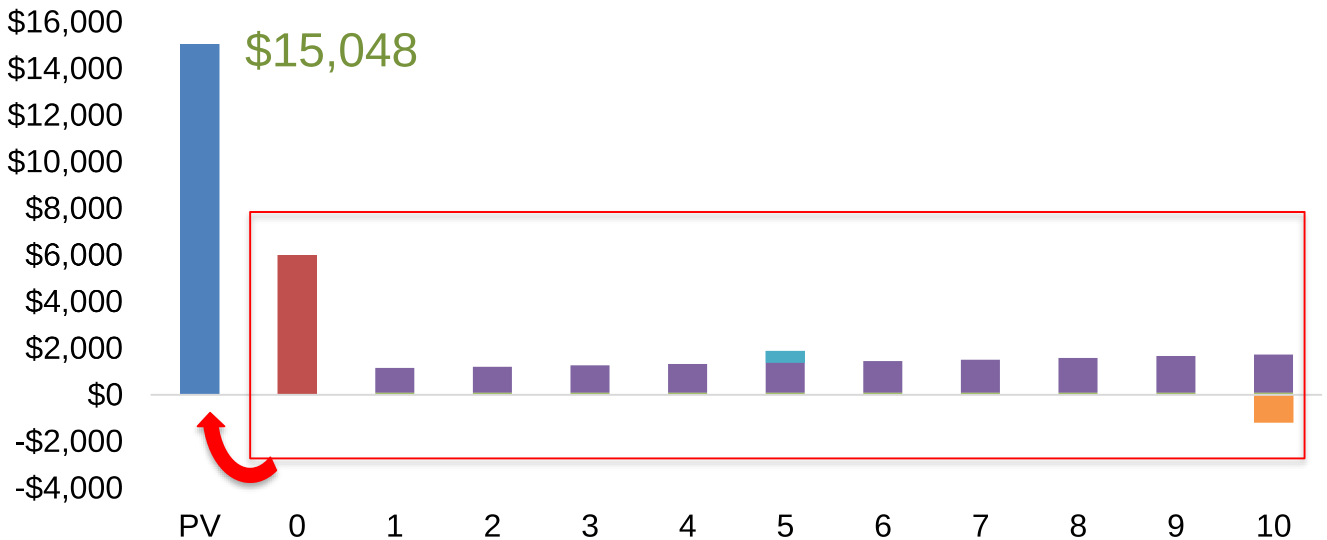
Life-cycle Cost: Heating System Example

Procedure:

3. Compile cost data:
   - The heating unit's purchase price is $6,000 dollars
   - The unit comes with a maintenance service plan for $100 a year
   - The yearly energy cost associated with running the unit is $1000 and will increase by 5% each year
   - Part replacement in year 5: $500
   - Scrap value of the heating unit in year 10: $1,200



Life-cycle Cost: Additional Considerations

Could include:

1. Initial investment costs
   1. Planning, design, engineering
   2. Site acquisition and preparation
   3. Construction costs
   4. Financing costs
2. Resale value of property or piece of equipment
3. Salaries, overhead, supplies
4. Don’t forget about planning for unscheduled maintenance

Must consider the timing of these costs!

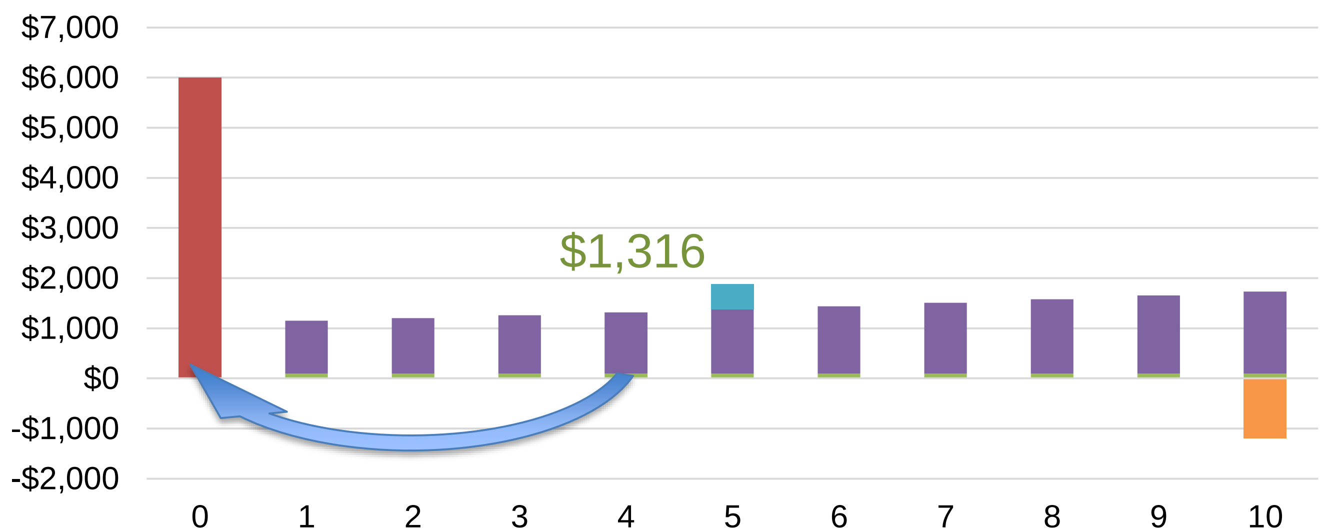
- Lump sum
- Spread out over many years

Example:

Project span: 10 years
Real discount rate: 8%

Year:

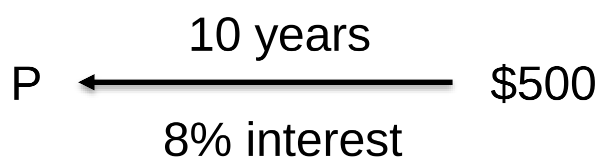
0, project investment:	$6,000	$6000
1, energy and maintenance:	$100 + $1000*(1+0.05)^1	$1150
2, energy and maintenance:	$100 + $1000*(1+0.05)^2	$1203
3, energy and maintenance:	$100 + $1000*(1+0.05)^3	$1258
4, energy and maintenance:	$100 + $1000*(1+0.05)^4	$1316
5, replacement, energy and maintenance:	$500 + $100 + $1000*(1+0.05)^5	$1876
6, energy and maintenance:	$100 + $1000*(1+0.05)^6	$1440
7, energy and maintenance:	$100 + $1000*(1+0.05)^7	$1507
8, energy and maintenance:	$100 + $1000*(1+0.05)^8	$1577
9, energy and maintenance:	$100 + $1000*(1+0.05)^9	$1651
10, resale, energy and maintenance:	$100 + $1000*(1+0.05)^10 - $1200	$529



Life-cycle Cost: Net Present Value Calculation

Procedure:

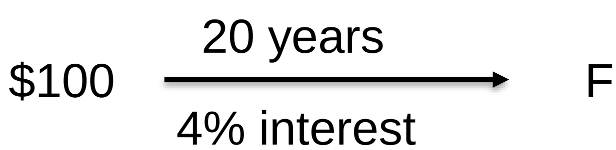
4. Compute life-cycle cost of project:



$$P = F\ x \left(\frac{1}{(1+i)^N}\right)$$

$$P = 500\ x\ \left(\frac{1}{(1+0.08)^{10}}\right)$$

$$P = \$232$$



$$F = P\ x\ [(1+i)^N]$$

$$F = 100\ x\ [(1+0.04)^{20}]$$

$$F = \$219$$

Life-cycle Cost: Net Present Value Calculation

Procedure:

4. Compute life-cycle cost of project

P ⟵ $300 + $300… + $300

A = $300
i = 6%
N = 3 years

$$P = A\ x \left(\frac{(1+i)^N - 1}{i\,(1+i)^N}\right)$$

$$P = \$801$$

$10,000 ⟶ $? + $?... +$?

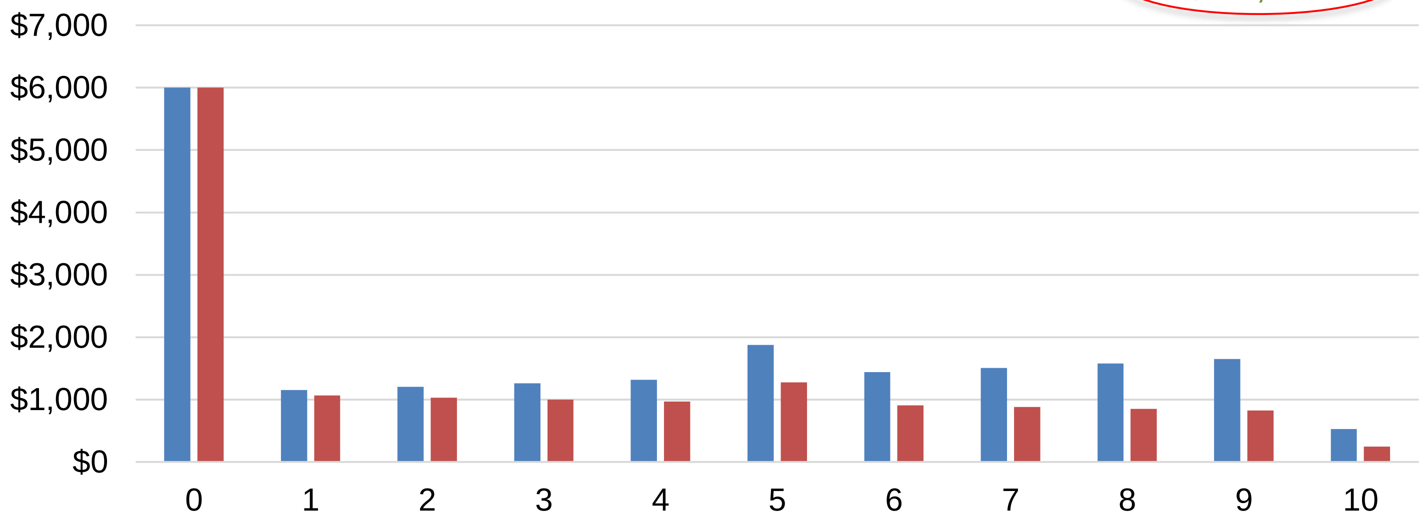
$10,000
5 years
4% interest

$$A = P\ x \left(\frac{i\,(1+i)^N}{(1+i)^N - 1}\right)$$

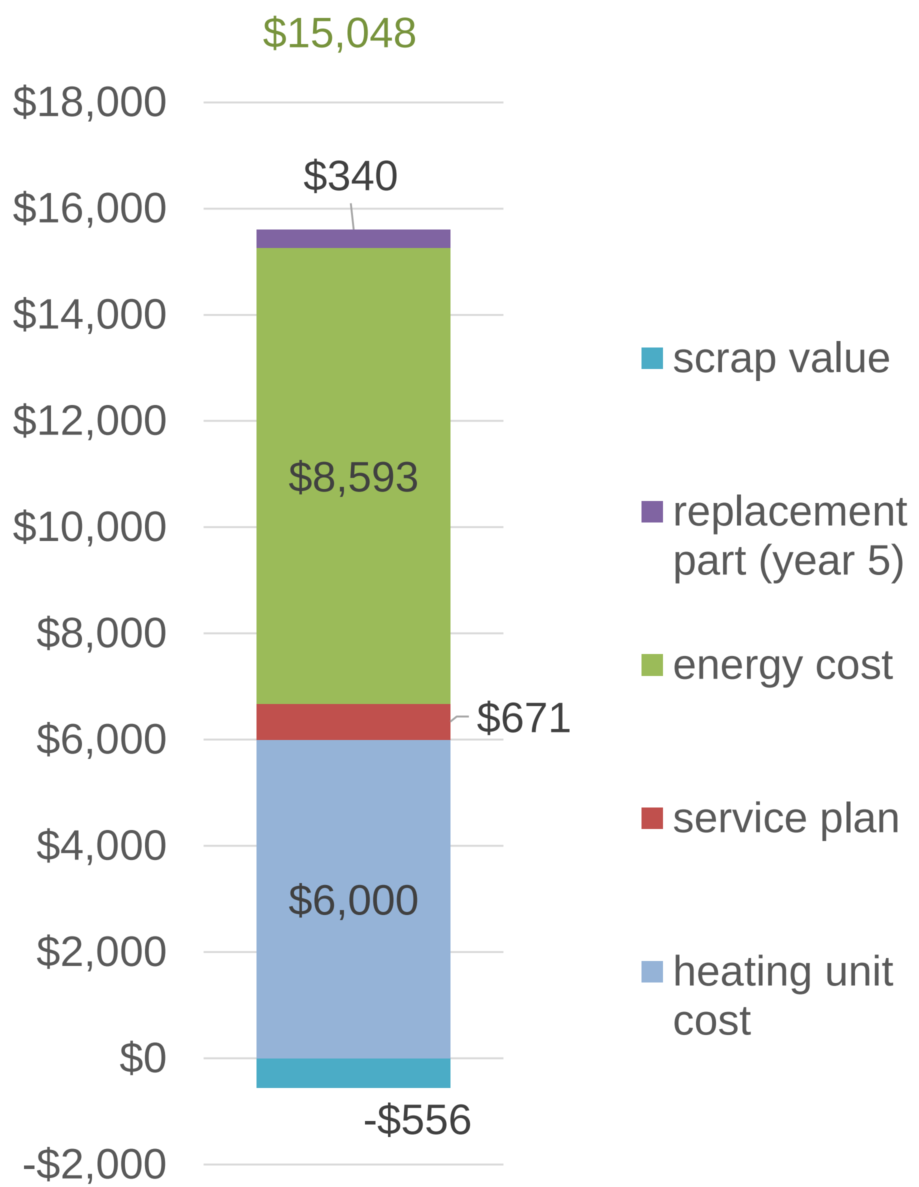
$$A = \$2{,}244$$

Example:

Year:			Present value*:
0, project investment:	$6000		$6000
1, energy and maintenance:	$1150		$1065
2, energy and maintenance:	$1203	8% discount rate →	$1031
3, energy and maintenance:	$1258		$998
4, energy and maintenance:	$1316		$967
5, replacement, energy and maint:	$1876		$1277
6, energy and maintenance:	$1440		$908
7, energy and maintenance:	$1507		$879
8, energy and maintenance:	$1577		$852
9, energy and maintenance:	$1651		$826
10, resale, energy and maintenance:	$529		$245
			$15,048



Example:


$15,048
$18,000
$16,000
$14,000
$12,000
$10,000
$8,000
$6,000
$4,000
$2,000
$0
-$2,000
$340
$8,593
$671
$6,000
-$556
scrap value
replacement part (year 5)
energy cost
service plan
heating unit cost

Example:

gas heater

$17,300

oil heater

electric heat pump

$15,048

Electric baseboard heating

$14,020

BUT…

LCC as a Decision Criteria:

After comparing LCC of project alternatives:

- What does it cost to “do nothing”
- Consider the risk associated with the alternatives
- Consider cash flow constraints
- Consider unquantifiable attributes (aesthetics)
  - ASTM* E1765: Multi Attribute Decision Analysis
- Consider sensitivity analysis
  - What will happen if your assumptions are different

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Visit Our Project Website

https://faculty.cnr.ncsu.edu/yuanyao/green-buildings-and-sustainable-materials/

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