Life Cycle Calculation 1

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A. Life Cycle Cost (LCC) and Benefit (LCB) Introduction

This reference summarizes the main calculations in Life Cycle Input and Output calculators. The goals of these calculators were to: 1) match the life cycle calculations in the NIST 135 reference (USDOC, 2016), 2) extend the NIST 135 methods to include Allocated Overhead Costs, Outputs, Outcomes, Revenues, and Operating Budgets, 3) extend the NIST 135 context beyond energy conservation to include natural resources conservation and other fields, and 4) tie into "best practice" data management techniques (USGAO, 2009). The NIST 135 reference **(1*)** explains life cycle techniques in depth and should be read prior to this reference.

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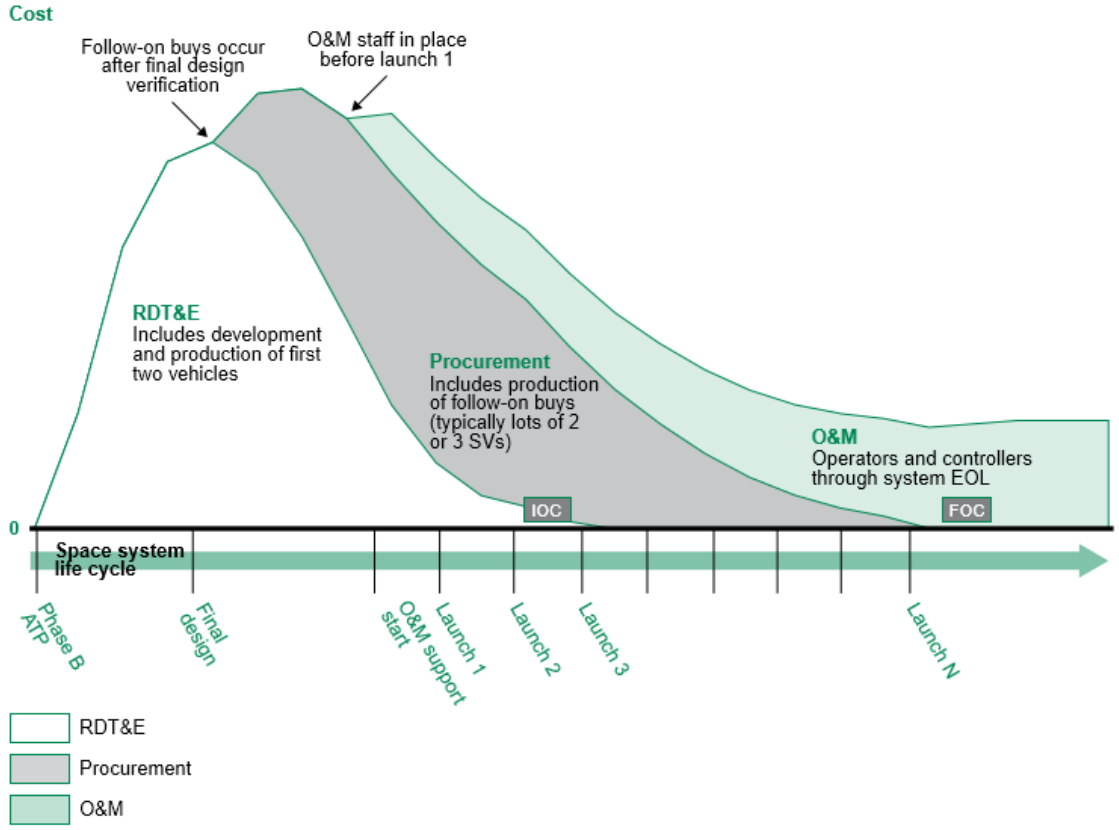
Version 2.0.8 upgraded the formulas used with this calculator because that release includes a new algorithm, algorithm1-subalgorithm16, which also carries out LCC/LCB calculations. The Social Performance Analysis 2 (SPA2) reference in the Performance Analysis tutorial includes

an example demonstrating how to use the algorithm. The major difference from the calculators introduced in this reference is that the SubCost and SubBenefit properties are added to TEXT datasets stored in Indicator.URLs. Both tools use the same formulas and produce identical results.

The following image (GAO, 2009) provides context for the importance of examining life cycle costs and benefits. The examples that follow demonstrate that life cycle costs and benefits are important regardless of the scale of the investment.

Figure 3: Life-Cycle Cost Estimate for a Space System



Source: DOD.

Note: O&M = operations and maintenance; RDT&E = research, development, test, and evaluation; SV = space vehicle; EOL = end of life; IOC = initial operational capacity; FOC = full operational capacity.

Figure 3 illustrates how space systems must invest heavily in research and development because once a system is launched into space, it cannot be retrieved for maintenance. Other systems such as aircraft, ships, and information technology systems typically incur hefty operations costs in relation to development and production costs. Such mission operations costs are very large because the systems can be retrieved and maintained and therefore require sophisticated logistics support and recurring broad-based training for large user populations. Thus, having full life-cycle costs is important for successfully planning program resource requirements and making wise decisions.

B. Data URLs

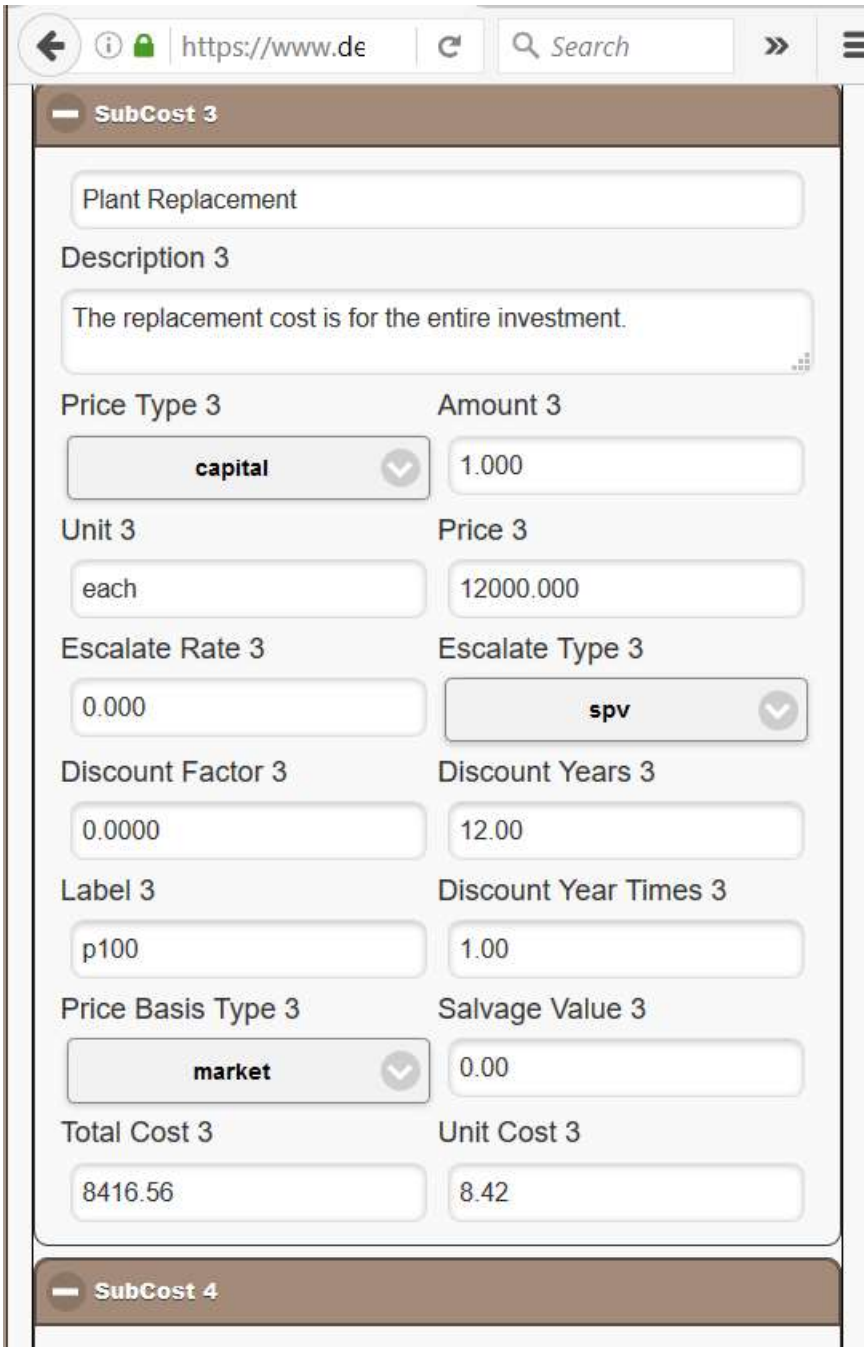
The Calculators demonstrated in this reference can be found at the following URL. These calculators belong to the Reconstruction Science club in the BuildTreks network group (if needed, switch default clubs).

https://www.devtreks.org/buildtreks/preview/commercial/linkedviewgroup/Life Cycle Cost and Benefit Calculators/49/none/

https://localhost:5001/buildtreks/preview/commercial/linkedviewgroup/Life Cycle Cost and Benefit Calculators/46/none

C. Life Cycle Calculators Properties

The following image shows that Step 2 of Life Cycle Assessment (LCA) calculators contain up to 10 individual SubPrices. Inputs contain SubCosts which are computed using Life Cycle Cost (LCC) calculators. Outputs contain SubBenefits which are computed using Life Cycle Benefit (LCB) calculators



These properties are defined as follows:

Price Type: Type of base Input or Output price to update when the calculators are saved. Options include

- **oc or Operating Costs**: In operating and capital budgets, the value of expendable Inputs.
- **aoh or Allocated Overhead Costs**: In operating budgets, anything that is not an operating cost. Networks can decide whether to include these costs in capital budgets.
- **cap or Capital Costs**: In capital budgets, the value of durable, or capital, Inputs.
- **rev or Revenues**: In operating and capital budgets, the value of Outputs.

Amount: The quantity of the LCA element to be used to determine costs or benefits. Unit costs and benefits often will use an amount of 1.

Unit: The unit of measurement of the LCA element.

Price: The unit price of the LCA element to be used to determine costs or benefits.

Escalate Rate: Rate of price increase or decrease over the life span of the Input. Will be divided by 100 in the calculations. The initial SubCost or SubBenefit will be multiplied by this rate and used with the linear or geometric Escalate Type property.

Escalate Type: Type of price escalation used to calculate life cycle costs and benefits. The options are used as followed:

- **none**: Use this option, along with the Discount Years and Salvage Value properties, to determine a present value SubCost or SubBenefit.
- **upvtable**: Use this option, along with the Discount Factor property, if NIST 135-style price indexes are being used to compute escalated costs and benefits.
- **spv or single present value**: Use this option, along with the Discount Years property, to calculate discounted costs and benefits.
- **upv of uniform present value**: Use this option, along with the Discount Years property, to calculate uniform discounted costs and benefits.
- **caprecovery or capital recovery**: Use this option, along with the Discount Years and Salvage Value properties, to calculate an amortized annual cost. In addition, the Discount Times property can be used to compute 'cost/benefit per hour' of use style calculations.

- **caprecoveryspv or capital recovery with single present value**: This option first uses the spv option, along with the project's Years From Base, to discount a future capital cost to present. It then uses the project's Service Life and Planning construction years to run the capital recovery calculation.
- **uniform, linear, or geometric**: Use this option, along with the project-related properties, to calculate a uniform price escalation. Use the 'linear' or 'geometric' options, along the Escalate Rate property, to calculate linear or geometric series price escalation.
- **exponential**: Use this option, along with the Discount Years and Escalation Rate properties, to calculate costs that increase at an exponential rate.
- **eaa or equivalent annual annuity**: Use this option, along with the Discount Years property, to calculate an equivalent annual annuity.

Discount Factor: A value taken from NIST 135-style price escalation indexes. The index should be for a period that sums together the service life of the project and the planning construction years. See table 5-4 in the NIST 135 reference.

Discount Years: The number of years to use in single present value and capital recovery discount formulas. Used when the Escalate Type property is 'spv' (Single Present Value) or "caprecovery" (Capital Recovery).

Label: Work Breakdown Structure label used to aggregate SubCosts and SubBenefits.

Discount Year Times: The number of times to use the Discount Years property to calculate recurrent costs. Only used when the Escalate Type property is 'spv', or Single Present Value, and the Discount Years property is greater than zero. Total number of times will not exceed the service life of the investment.

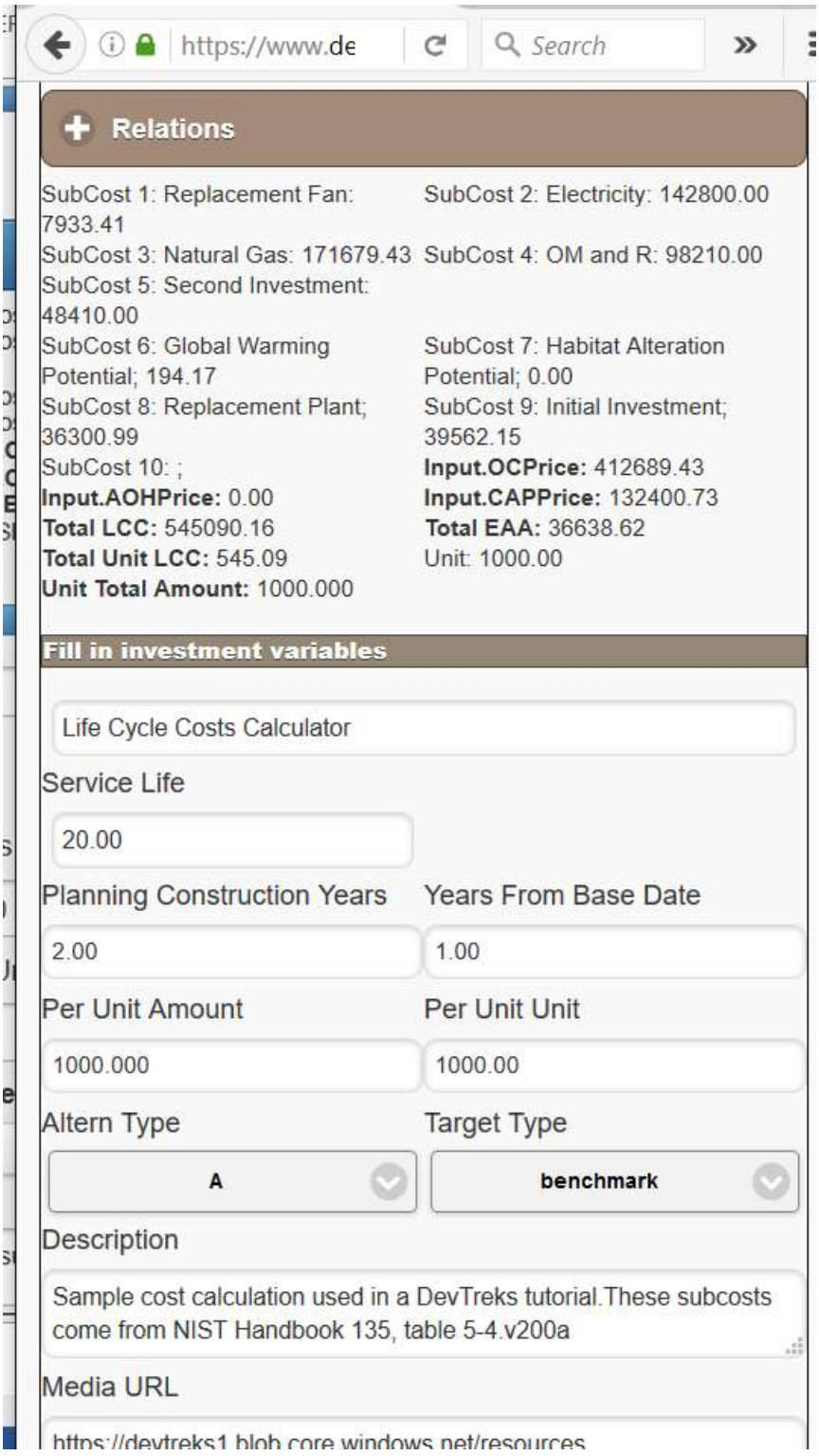
Price Basis Type: The type of price used to calculate SubCosts or SubBenefits. Options include none, market, list, contracted, government, production, copay, premium, incentive, penalty, fee, engineered, and consensus. When possible, use market prices.

Salvage Value: Used with an Escalation Type of spv and Service Life Years > 0 to calculate a discounted salvage, or residual, value. Also used with an Escalation Type of caprecovery and DiscountYears > 0 to calculate an annual capital recovery cost for operating budgets.

Total Cost or Benefit: Not a data entry field. Shows the total LCC cost or LCB benefit after calculations are run.

Unit Cost or Benefit: Not a data entry field. Shows the total LCC unit costs or LCB unit benefits after calculations are run.

The following image shows that Step 3 of LCA calculators contain project-related properties that are used to aggregate Step 2's SubCosts or SubBenefits:



These properties are defined as follows:

Service Life: The life span of the Input or Output.

Planning Construction Years: Number of years in the planning and construction period. Also known as the preproduction period.

Years from Base Date: The base date is the Input or Output's date. Enter an integer that specifies the specific year within the Planning Construction Years when the Input is installed or Output's revenue received. The NIST reference uses examples that are installed in 1 year and given a value of 1 for this property. A project with a Planning Construction Years greater than 1 would insert whichever year within the period when the Input is actually installed.

Per Unit Amount: An amount used to derive per unit costs. For example, a 1000 ft2 (m2) house would use a value of 1000.

Per Unit Unit: A unit used in per unit costs. For example, a 1000 ft2 (m2) house would use a value of ft2 (m2).

Alternative Type: Type of alternative used in the comparison of different Inputs or Outputs. Options include A, B, C … Other base elements use NPV calculators to set this property.

Target Type: This property supports setting goals and targets for Inputs and Outputs. The Benchmark option is used to define a baseline, or benchmark, Input or Output. The Actual option is used to define the actual results for an Input or Output. The Full Target and Partial Target options are used to carry out progress and goal-related analyses. Other base elements use NPV calculators to set this property.

Real and Nominal Interest Rates: Set using Step 2 of the calculators.

The results of running the calculators use the following properties:

Individual SubCost or SubBenefit: The total discounted cost or benefit derived from running the calculator.

Total Discounted Revenue, OC, AOH, and CAP prices: Sum of the discounted SubCosts or SubBenefits that will be added to base Input or Output prices. The Price Type property determines which price to update –either an Output's Revenue price or an Input's Operating Cost (OC), Allocated Overhead (AOH), or Capital (CAP) prices.

Total Life Cycle Cost: Sum of the Total OC, AOH, and CAP costs.

Total Equivalent Annual Annuity: Amortizes the life cycle cost over the service life years, using an equivalent annual annuity discounting formula.

Total per Unit Cost: Total Life Cycle Cost divided by the Per Unit Amount.

Per Unit Unit: Unit of measurement for the Total per Unit Cost.

D. Life Cycle Calculations

Life cycle calculations can include revenues, operating costs, allocated overhead costs, and capital costs in Capital or Operating Budget totals. In contrast, basic capital budgets (see the Capital Budget 1 tutorial) leave operating and allocated overhead costs completely out of the evaluation –in effect, discounted cash flow evaluations. Capital budgets usually account for capital costs by discounting their full cost and counting them as capital, rather than allocated overhead, costs. Operating budgets usually account for capital costs by allocating a portion of the full cost, generally an amortized portion, to allocated overhead costs (refer to the NPV tutorials for further explanation). DevTreks life cycle calculations can be carried out several ways:

1. **NIST-style Life Cycle Calculation**: This method follows the procedures detailed in the NIST 135 Handbook (1996). Complete capital budgets are completed for each 'preproduction' or 'planning and construction phase' year. All Inputs and Outputs in these budgets are calculated using DevTreks Life cycle Input and Output calculators. The Input and Output calculators compute all discounted, price escalated, totals. The budget's Net Present Value calculator just sums the Input and Output totals. Double discounting can be avoided in the NPV calculations by setting Input and Output dates equal to

Component, Operation, and Outcome dates, and by switching "off" discounting at the Time Period element of budgets.

2. **Cost and Return-style Life Cycle Calculation**: This method follows the procedures detailed in the Hallam et al (1999) reference (Task Force on Commodity Costs and Returns (2*****)). Although DevTreks Life cycle Input and Output calculators can still be used to compute SubPrices totals (such as power and water), the calculators' SubPrices are given a Discount Years property set to zero, and an EscalationType property set to none. The LCA calculators will set the base Input or Output Prices which can then be discounted using DevTreks standard Net Present Value calculators (see the Net Present Value 1 tutorial).
3. **Mixed NIST and Cost and Return-style Life Cycle Calculation**: This method uses both of the two previous styles. SubPrices that are capital costs can be computed using capital recovery options that calculate annual allocated overhead costs. Additional operating costs can be calculated by setting appropriate life cycle properties (set the Discount Years property to zero, set the EscalationType property set to none). Care is needed not to double discount the Inputs and Outputs when both Net Present Value and Life Cycle calculators are run (using Input and Output prices that have been set using the life cycle calculators).
4. **Unit Costs and Benefits**: DevTreks recommends that all base element Inputs and Outputs be calculated as unit costs and benefits. That allows the elements to be reused in multiple Components and Operations. The Input or Output quantity can be adjusted correctly when the elements are used in a specific structure (a Component or Operation). The Input and Output examples that follow were required to match their associated NIST reference, so their quantities appear to be related to a specific structure. We discourage this practice unless the resultant cost or benefit can be interpreted as a reusable unit cost or benefit.

Choose whichever style best meets your needs. Closely examine the examples below and experiment with additional techniques. This version limits the display of SubCosts and SubBenefits to the first 10 summary items encountered. The summation is carried out using the

"Label" property of each SubCost or SubBenefit. Although only 10 items are displayed, the total cumulative costs and benefits will be for the total number of SubCosts or SubBenefits being aggregated.

E. Life Cycle Cost (LCC) Input Calculator 1

This calculator carries out life cycle cost calculations using methods that are explained in NIST Handbook 135 and some additional methods that support general budgeting. Up to 10 'SubCosts' (i.e. electric, power, taxes …) can be included in the calculations. Unlike domain-specific calculators (i.e. Agricultural Machinery), this calculator does not automatically calculate repair, water, power, capital recovery, or other costs. Instead, the user must enter prices and quantities for each 'SubCost' and the calculator will then compute discounted costs. Recurring costs can be calculated using uniform, linear, or geometric growth types or the techniques explained in the NIST Handbook 135 reference. The calculator updates the base Input's OCPrice, AOHPrice, and CAPPrice with the calculated composite costs, but does not change their units or amounts. These examples demonstrate that environmental impacts can be included as SubCosts or SubBenefits (**3***).

Example 1. NIST-style Building Reconstruction LCC (see NIST 135 Handbook table 5-2)

The following image (US NIST, 1996) displays the LCC calculations that will be carried out in this example. Real discount rates, with constant money, are used to discount costs.

Table 5-2 summarizes the input data and calculations for the Base Case: the relevant amounts in base year dollars (column 2), the year of occurrence (column 3), and the appropriate discount factors (column 4). Column 5 shows the calculated present-value cost for each cost category and their sum, the total LCC for the Base Case.

Table 5-2
Data Summary for Conventional HVAC Design: Base Case—Simple Example

Cost Items (1)	BaseDate Cost (2)	Year of Occurrence (3)	Discount Factor (4)		Present Value (5)=(2)x(4)
Initial investment cost	$103,000	Base date	already in present value		$103,000
Capital replacement (fan)	$12,000	12	SPV_{12}	0.701	$8,412
Residual value	($3,500)	20	SPV_{20}	0.554	($1,939)[a]
Electricity: 250,000 kWh at $0.08/kWh	$20,000	annual	FEMP UPV^*_{20}	15.13	$302,600
OM&R	$7,000	annual	UPV_{20}	14.88	$104,160
Total LCC					**$516,233**

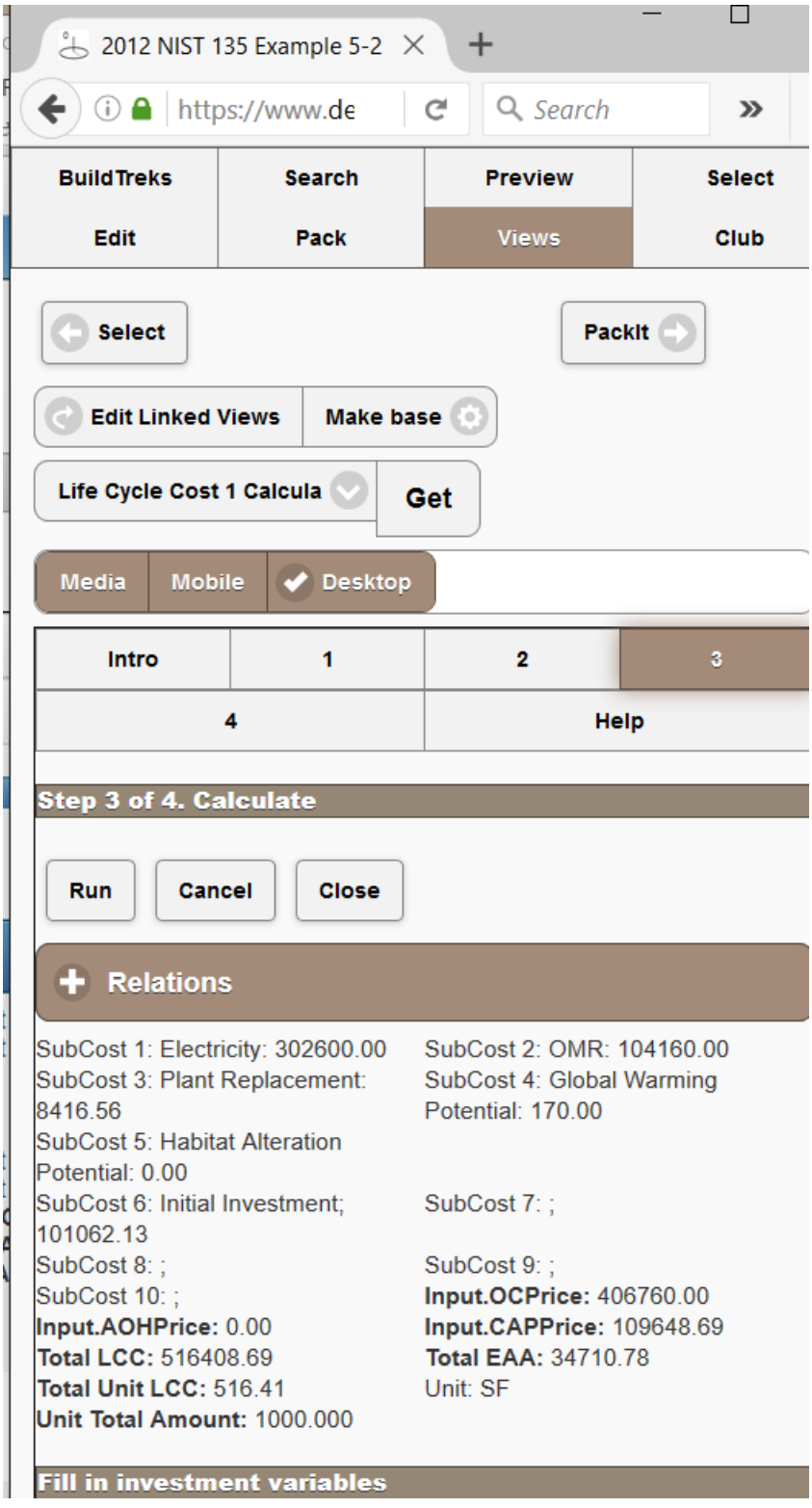
[a] The residual value is subtracted from the LCC.

In this example, the LCC of **$516,233** for the conventional design serves as a baseline against which the LCC of the energy-saving alternative system will be compared.

Input URIs (4*)

https://www.devtreks.org/buildtreks/preview/commercial/input/2012 NIST 135 Example 5-2/2147397445/none/

https://localhost:5001/buildtreks/preview/commercial/input/2012 NIST 135 Example 5-2/2147409725/none/


2012 NIST 135 Example 5-2
https://www.de
Search
BuildTreks
Search
Preview
Select
Edit
Pack
Views
Club
Select
PackIt
Edit Linked Views
Make base
Life Cycle Cost 1 Calcula
Get
Media
Mobile
Desktop
Intro
1
2
3
4
Help
Step 3 of 4. Calculate
Run
Cancel
Close
Relations
SubCost 1: Electricity: 302600.00
SubCost 2: OMR: 104160.00
SubCost 3: Plant Replacement: 8416.56
SubCost 4: Global Warming Potential: 170.00
SubCost 5: Habitat Alteration Potential: 0.00
SubCost 6: Initial Investment; 101062.13
SubCost 7: ;
SubCost 8: ;
SubCost 9: ;
SubCost 10: ;
Input.OCPrice: 406760.00
Input.AOHPrice: 0.00
Input.CAPPrice: 109648.69
Total LCC: 516408.69
Total EAA: 34710.78
Total Unit LCC: 516.41
Unit: SF
Unit Total Amount: 1000.000
Fill in investment variables

SubCost 1:

$302,600.000 (Electricity, Total Cost 1) = (250,000 (Amount 1, kWh) * $0.08 (Price 1, per KwH)) * 15.13 (discount factor: 20 years, 3%, FEMPUPV)

$302.60 (per SF, Unit Cost 1) = $302,600.000 (Electricity, Total Cost 1) / 1,000 SF (Per Unit Amount)

SubCost 2:

$104,160.000 (OMR, Total Cost 2) = (1 (Amount 2, annual) * $7,000.00 (Price 2, per year)) * 14.88 (discount factor: 20 years, 3%, UPV)

$104.16 (per SF, Unit Cost 1) = $104,160.000 (OMR, Total Cost 2) / 1,000 SF (Per Unit Amount)

SubCost 3 (**4***):

$170 (Global Warming, Total Cost 3) = 8,500 (Global Warming Potential) kg CO2 equivalents * $0.02/kg carbon* 0 Discount Factor (3%, 0 year from base date)

A market price for carbon was found and therefore dollar values could be determined for this impact. Since the impact has a Price Type of 'capital'. This cost is added to Total Discounted Capital Costs.

SubCost 4 (**4***):

$0 (Habitat Alteration, Total Cost 3) = 0.60 (Habitat Alteration Potential) TE Species Count equivalents * $0/HAE

A market price for Habitat Alteration Equivalents could not be found, so they are priced at $0. Impacts without prices are used in cost effectiveness evaluations. Note that market prices for

some types of wildlife may be available (this might make an interesting calculator or subalgorithm).

SubCost 5:

$8.416.56 (Plant Replacement, Total Cost 5) = $12,000.00 (Plant Replacement Cost) * 0.701 (discount factor: 12 Repl Years From Base Date, 3%)

SubCost 6:

$101.062.13 (Initial Investment, Total Cost 6) = $103,000.00 (Initial Investment Cost) * 1 (discount factor: 0 Discount Years) – ($3,500.00 (Salvage Value) * 0.554 (discount factor: 20 years Service Life + 0 Planning Construction Years, 3%) * -1)

Discounted Total Costs:

$109.648.69 (Input.CAPPrice) = $101.062.13 (Initial Investment, Total Cost 6) + $8.416.56 (Plant Replacement, Total Cost 5) + $170 (Global Warming, Total Cost 3)

$0.00 (Input.AOHPrice) = $0.00

$406,760.00 (Input.OCPrice) = $302,600.000 (Electricity, Total Cost 1) + $104,160.000 (OMR, Total Cost 2)

$516.408.69 (Total LCC) = $109.478.69 (Input.CAPPrice) + $0.00 (Input.AOHPrice) + $406,760.00 (Input.OCPrice)

$516.41 (Total Unit LCC) per SF = $516.408.69 (Total LCC) / 1,000 SF (Per Unit Amount)

$34.710.76 (Total EAA) = $516.408.69 (Total LCC) / x (equivalent annual annuity discount factor: 20 years, 3%)

$34.71 (Total Unit EAA) per SF = $34.710.76 (Total EAA) / 1,000 SF (Per Unit Amount)

Example 2. NIST-style Building Reconstruction LCC (see NIST 135 Handbook table 5-4)

The following image (US NIST, 1996) displays the LCC calculations that will be carried out in this example. Real discount rates, with constant money, are used to discount costs.

Table 5-4
Data Summary for Conventional HVAC Design: Base Case—Complex Example

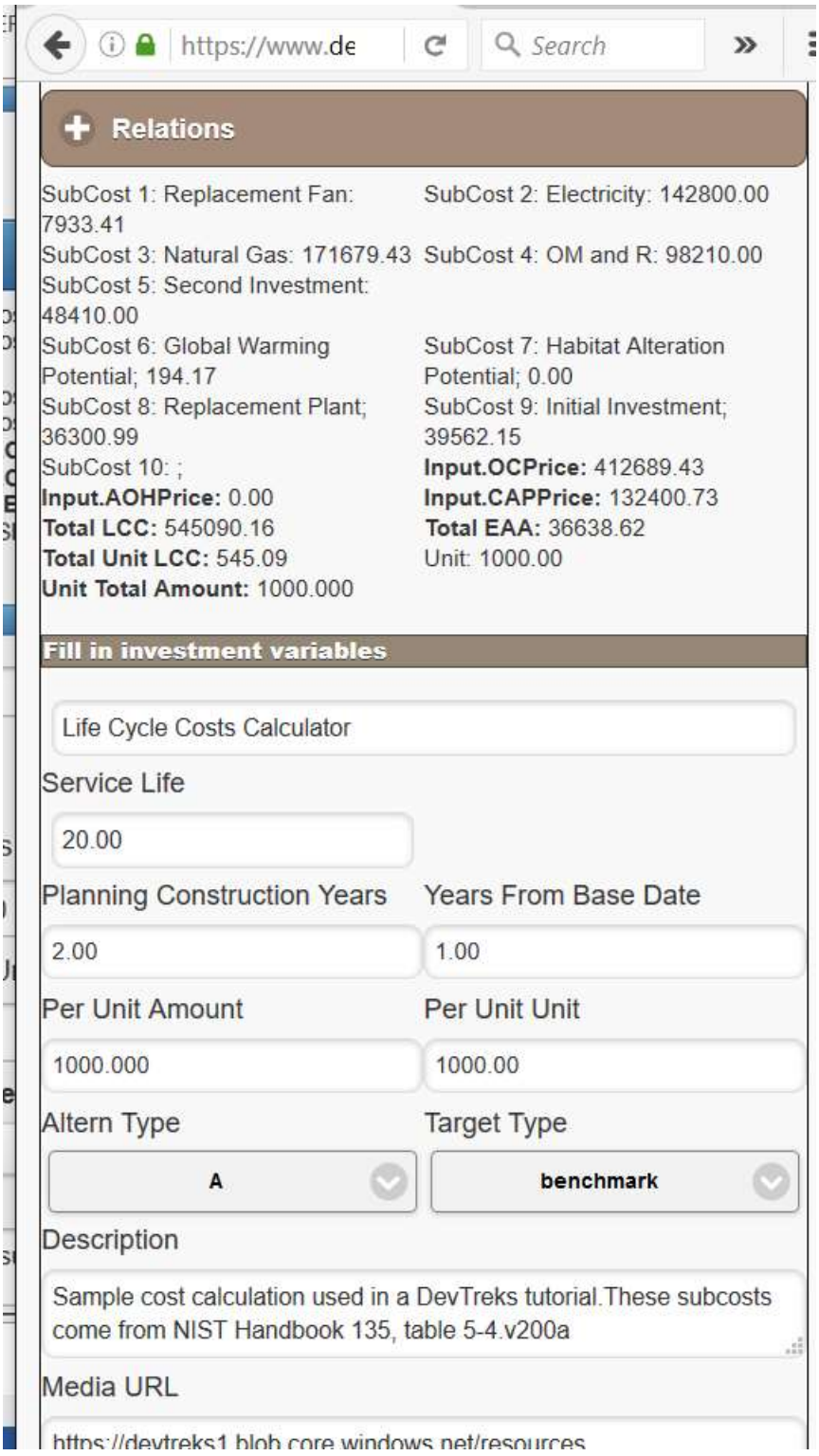
Cost Items	Base Date Cost	Year of Occurrenc (from Base Date)	Discount Factor		Present Value
(1)	(2)	(3)	(4)		(5)=(2)x(4)
Initial Investment Cost: 1st Installment at midpoint of construction	$51,500	1	SPV_1	0.971	$50,007
2nd Installment at beginning of service period	$51,500	2	SPV_2	0.943	$48,564
Capital replacement (fan)	$12,000	14	SPV_{14}	0.661	$7,932
Capital replacement (plant)	$60,000	17	SPV_{17}	0.605	$36,300
Residual value	($20,000)	22	SPV_{22}	0.522	($10,440)
Electricity 125,000 kWh at $0.08/kWh	$10,000	annual	FEMP UPV*	14.28	$142,800
Natural Gas 1700 GJ at $5.93/GJ (≈1800 MBtu)	$10,080	annual	FEMP UPV*	17.03	$171,662
OM&R	$7,000	annual	UPV	14.03	$ 98,210
Total LCC					**$545,035**

When costs are phased in during the P/C period, the **base date** of the study and the **service date** do not coincide as they did in the previous example. Operational costs usually begin at the service date but must be discounted to the base date. To calculate the correct UPV factor when the service date is later than the base date, you subtract the UPV factor for the P/C period (two years in this example) from the UPV factor for the entire study period (22 years). This procedure is described in detail in chapter 3, section 3.2.3. In this example, the discount factor for calculating the present value of the electricity cost at a discount rate of 3 percent, for region 3, commercial sector, is derived as follows: Deduct from the FEMP UPV* factor for 22 years (16.21) the FEMP UPV* factor for 2 years (1.93) to get 14.28. The UPV* factor for commercial natural gas and UPV factor for non-fuel OM&R costs are derived in a similar fashion.[3]

Input URIs (4*)

https://www.devtreks.org/buildtreks/preview/commercial/input/2012 NIST 135, table 5-4/2147397446/none/

https://localhost:5001/buildtreks/preview/commercial/input/2012 NIST 135, table 5-4/2147409726/none/


https://www.de
Search
Relations
SubCost 1: Replacement Fan: 7933.41
SubCost 2: Electricity: 142800.00
SubCost 3: Natural Gas: 171679.43
SubCost 4: OM and R: 98210.00
SubCost 5: Second Investment: 48410.00
SubCost 6: Global Warming Potential; 194.17
SubCost 7: Habitat Alteration Potential; 0.00
SubCost 8: Replacement Plant; 36300.99
SubCost 9: Initial Investment; 39562.15
SubCost 10: ;
Input.OCPrice: 412689.43
Input.AOHPrice: 0.00
Input.CAPPrice: 132400.73
Total LCC: 545090.16
Total EAA: 36638.62
Total Unit LCC: 545.09
Unit: 1000.00
Unit Total Amount: 1000.000
Fill in investment variables
Life Cycle Costs Calculator
Service Life
20.00
Planning Construction Years
Years From Base Date
2.00
1.00
Per Unit Amount
Per Unit Unit
1000.000
1000.00
Altern Type
Target Type
A
benchmark
Description
Sample cost calculation used in a DevTreks tutorial.These subcosts come from NIST Handbook 135, table 5-4.v200a
Media URL
https://devtreks1.blob.core.windows.net/resources

SubCost 1:

$7,933.41 (Replacement Fan, Total Cost 1) = (1.0 (Amount 1, each) * $12.000.00 (Price 1, per each)) * 0.661 (discount factor: 14 years, 3%, SPV)

$7.93 (per SF, Unit Cost 1) = $7,933.41 (Replacement Fan, Total Cost 1) / 1,000 SF (Per Unit Amount)

SubCost 2:

$142,800.000 (Electricity, Total Cost 2) = (125,000 (Amount 2, kWh) * $0.08 (Price 2, per KwH)) * 14.28 (discount factor: 20 years, 3%, FEMPUPV)

$142.80 (per SF, Unit Cost 2) = $142,800.000 (Electricity, Total Cost 2) / 1,000 SF (Per Unit Amount)

SubCost 3:

$171,679.43 (Natural Gas, Total Cost 3) = (1700 (Amount 3, GJ) * $5.93 (Price 3, per GJ)) * 17.03 (discount factor: 20 years, 3%, FEMPUPV)

$171.68 (per SF, Unit Cost 3) = $171,679.43 (Natural Gas, Total Cost 3) / 1,000 SF (Per Unit Amount)

SubCost 4:

$98,210.00 (OMR, Total Cost 4) = (1 (Amount 4, annual) * $7.000.00 (Price 4, per year)) * 14.03 (discount factor: 20 years service life plus 2 years planning construction years, 3% discount rate, uniform escalation type)

$98.21 (per SF, Unit Cost 4) = $302,600.000 (OMR, Total Cost 4) / 1,000 SF (Per Unit Amount)

SubCost 5:

$48,410 (Second Investment, Total Cost 5) = (1 (Amount 5, each) * $51,500.00 (Price 5, per each)) * 0.943 (discount factor: 2 years, 3%, SPV)

$48.41 (per SF, Unit Cost 5) = $48,410 (Second Investment, Total Cost 5) / 1,000 SF (Per Unit Amount)

SubCost 6:

$194.17 (Global Warming, Total Cost 6) = 10,000 (Global Warming Potential) kg CO2 equivalents * $0.02/kg carbon * .971 Discount Factor (3%, 1 year from base date)

SubCost 7:

$0 (Habitat Alteration, Total Cost 7) = 0.03 (Habitat Alteration Potential) TE Species Count equivalents * $0/HAE

SubCost 8:

$36,300.99 (Plant Replacement, Total Cost 8) = $60,000 (Plant Replacement Cost) * 0.605 (discount factor: 17 Repl Years From Base Date, 3%)

SubCost 9:

$39,562.15 (Initial Investment, Total Cost 9) = $51,500.00 (Initial Investment Cost) * .971 (discount factor: 1 Discount Years, 3%) + (-$10.440 (Discounted Salvage Value))

-$10.440 (Discounted Salvage Value) = $20,000.00 (Salvage Value) * 0.522 (discount factor: 20 Service Life + 2 Planning Construction Years, 3%) * -1

Discounted Total Costs:

$132.400.73 (Input.CAPPrice) = $7,933.41 (Replacement Fan, Total Cost 1) + $48,410 (Second Investment, Total Cost 5) + $194.17 (Global Warming, Total Cost 6) + $36,300.99 (Plant Replacement, Total Cost 8) + $39,562.15 (Initial Investment, Total Cost 9)

$0.00 (Input.AOHPrice) = $0.00

$412,689.43 (Input.OCPrice) = $142,800.000 (Electricity, Total Cost 2) + $171,679.43 (Natural Gas, Total Cost 3) + $98,210.00 (OMR, Total Cost 4)

$545.090.16 (Total LCC) = $132.400.73 (Input.CAPPrice) + $0.00 (Input.AOHPrice) + $412,689.43 (Input.OCPrice)

$545.09 (Total Unit LCC) per SF = $545.090.16 (Total LCC) / 1,000 SF (Per Unit Amount)

$36.638.62 (Total EAA) = $545.090.16 (Total LCC) / x (equivalent annual annuity discount factor: 20 years, 3%)

$36.64 (Total Unit EAA) per SF = $36.638.62 (Total EAA) / 1,000 SF (Per Unit Amount)

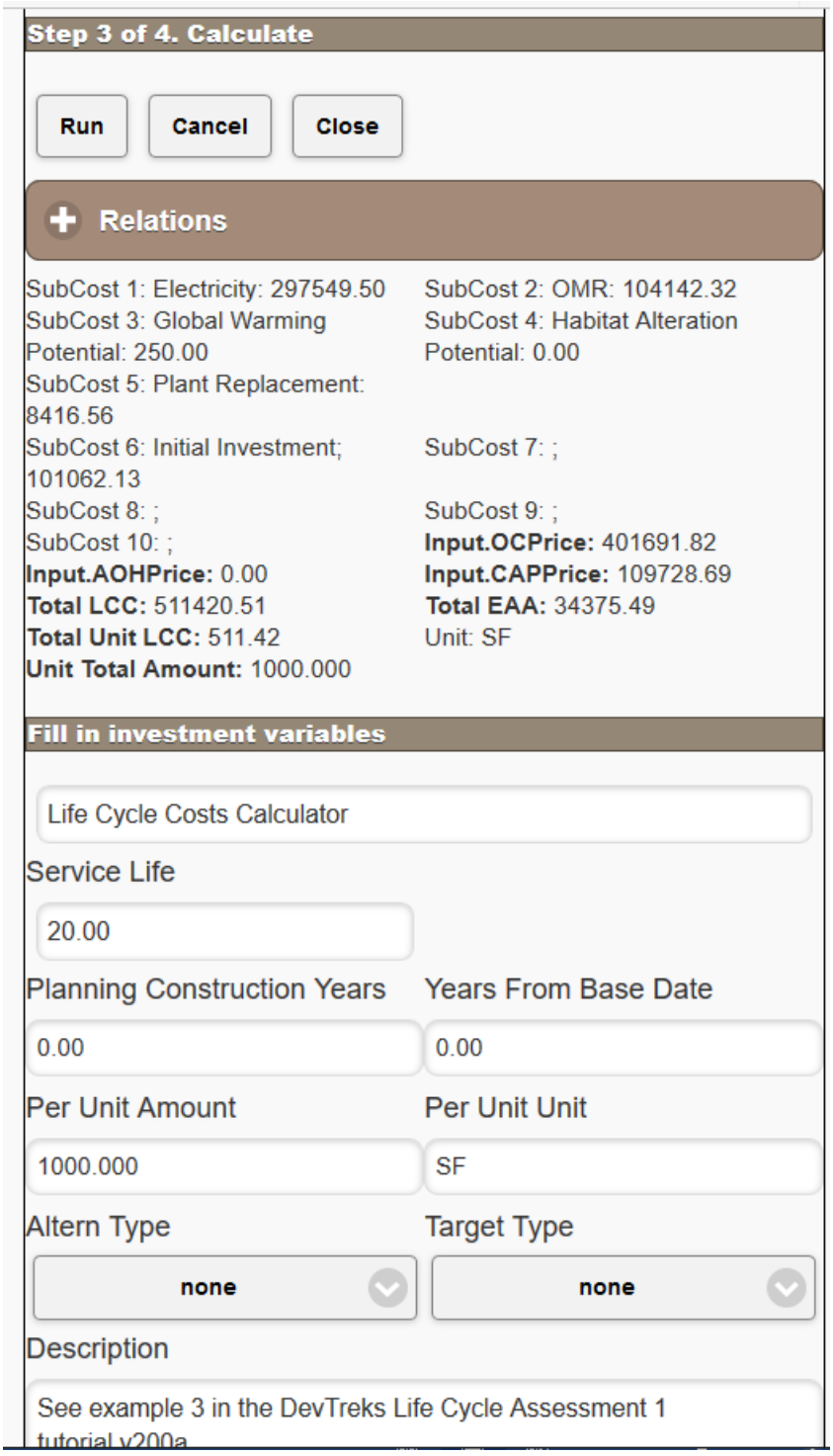
Example 3. Same as Example 1 but no FEMPUPV indexes

This example similar to Example 1 but replaces the NIST 135 price indexes with a uniform escalation type for electricity, and uses the upv option for OMR. The latter factor is new in 2.0.8 and differs from the uniform escalation rate technique by its use of the discount years, rather than the service life years + planning construction years. The escalation rate property is not used with uniform escalation types, but will be demonstrated with a linear escalation type in Example 4.

Input URIs (4*)

https://www.devtreks.org/buildtreks/preview/commercial/input/2012 Example 3, Uniform Growth/2147397444/none/

https://localhost:5001/buildtreks/preview/commercial/input/2012 Example 3, Uniform Growth/2147409727/none


Step 3 of 4. Calculate
Run
Cancel
Close
Relations
SubCost 1: Electricity: 297549.50
SubCost 2: OMR: 104142.32
SubCost 3: Global Warming Potential: 250.00
SubCost 4: Habitat Alteration Potential: 0.00
SubCost 5: Plant Replacement: 8416.56
SubCost 6: Initial Investment; 101062.13
SubCost 7: ;
SubCost 8: ;
SubCost 9: ;
SubCost 10: ;
Input.OCPrice: 401691.82
Input.AOHPrice: 0.00
Input.CAPPrice: 109728.69
Total LCC: 511420.51
Total EAA: 34375.49
Total Unit LCC: 511.42
Unit: SF
Unit Total Amount: 1000.000
Fill in investment variables
Life Cycle Costs Calculator
Service Life
20.00
Planning Construction Years
Years From Base Date
0.00
0.00
Per Unit Amount
Per Unit Unit
1000.000
SF
Altern Type
Target Type
none
none
Description
See example 3 in the DevTreks Life Cycle Assessment 1 tutorial v200a

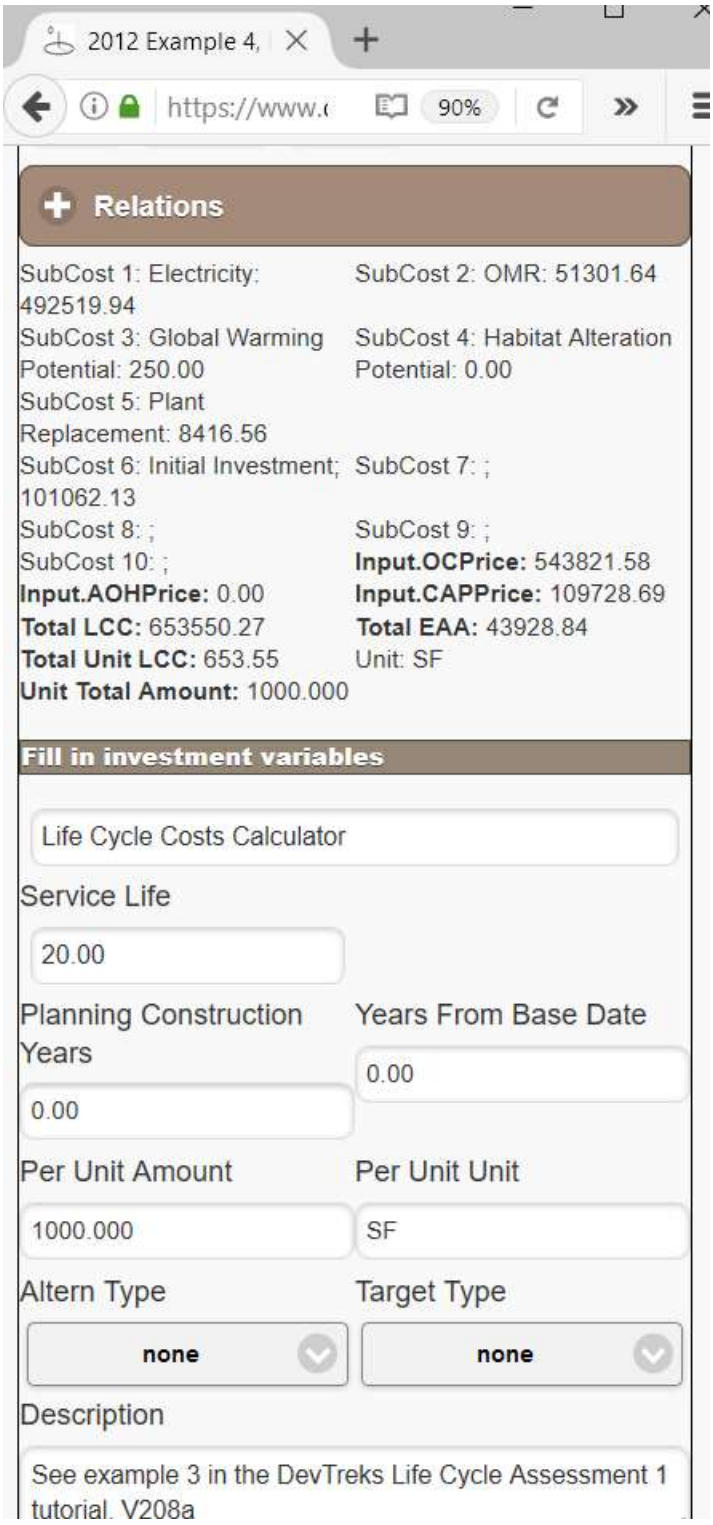
Example 4. Same as Example 3 but recurrent operating costs and linear escalating electricity cost

This example is the same as Example 3 but changes the OMR expense from annual to biannual and uses a 0.05 escalation rate with a linear escalation type for electricity.

Input URIs (4*)

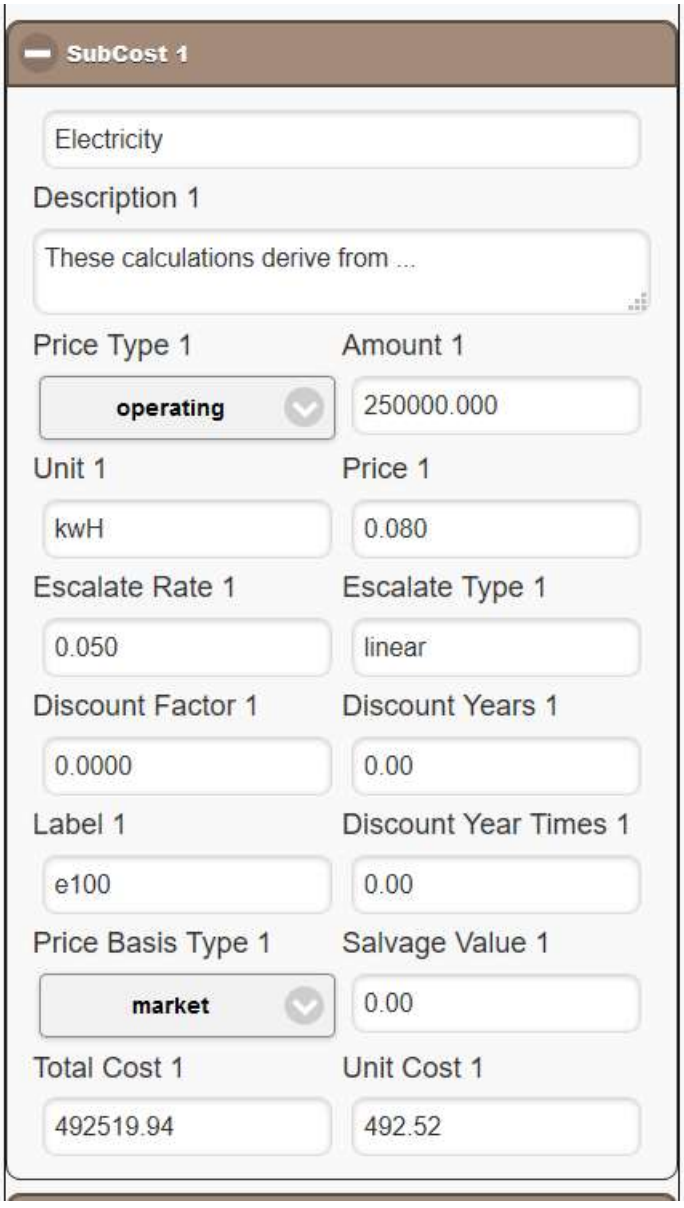
https://www.devtreks.org/buildtreks/preview/commercial/input/2012 Example 4, Recurrent Costs/2147397492/none/

https://localhost:5001/buildtreks/preview/commercial/input/2012 Example 4, Recurrent Costs/2147409776/none/


2012 Example 4,
https://www.
90%
Relations
SubCost 1: Electricity: 492519.94
SubCost 2: OMR: 51301.64
SubCost 3: Global Warming Potential: 250.00
SubCost 4: Habitat Alteration Potential: 0.00
SubCost 5: Plant Replacement: 8416.56
SubCost 6: Initial Investment; 101062.13
SubCost 7: ;
SubCost 8: ;
SubCost 9: ;
SubCost 10: ;
Input.OCPrice: 543821.58
Input.AOHPrice: 0.00
Input.CAPPrice: 109728.69
Total LCC: 653550.27
Total EAA: 43928.84
Total Unit LCC: 653.55
Unit: SF
Unit Total Amount: 1000.000
Fill in investment variables
Life Cycle Costs Calculator
Service Life
20.00
Planning Construction Years
0.00
Years From Base Date
0.00
Per Unit Amount
1000.000
Per Unit Unit
SF
Altern Type
none
Target Type
none
Description
See example 3 in the DevTreks Life Cycle Assessment 1 tutorial. V208a

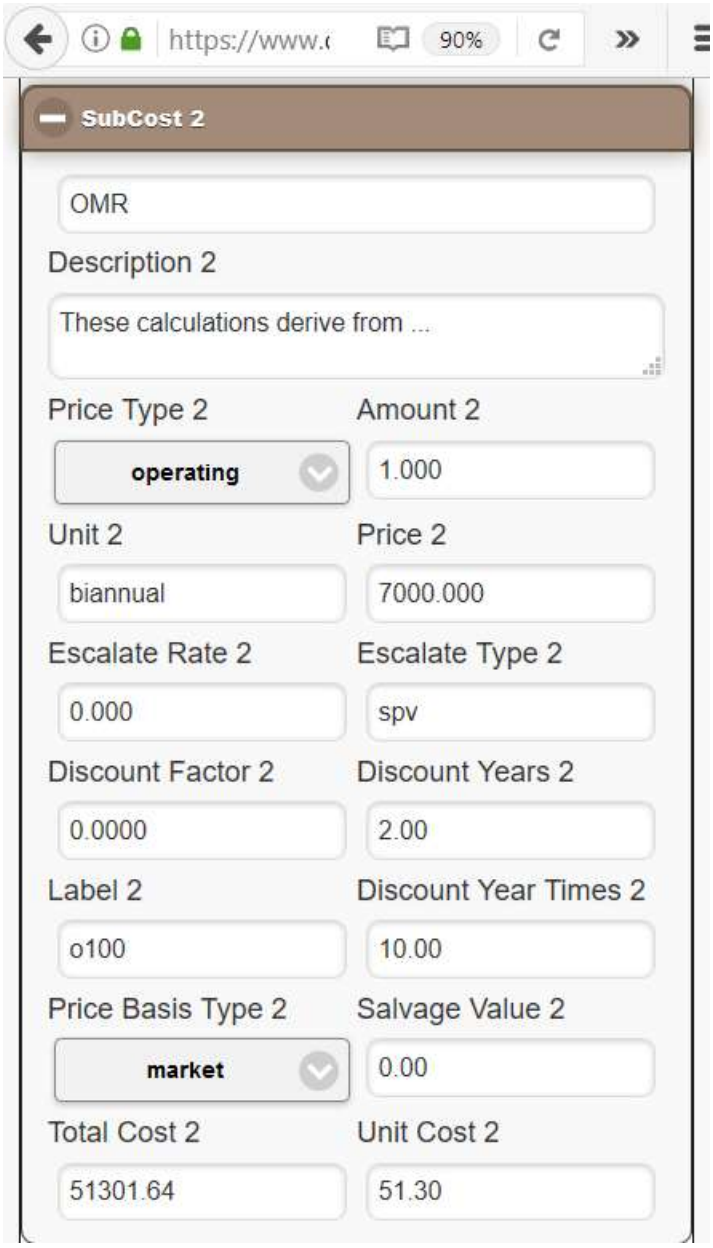
SubCost 1:

Electricity is calculated as escalating in a linear trend by setting the SubCost.EscalateType = linear and the SubCost.EscalateRate = 0.05. This example illustrates that even small linear or geometric escalation rates can result in extremely high costs.



SubCost 2:

OMR is the only difference and is calculated by setting the SubCost.DiscountYears = 2 and SubCost.DiscountYearTimes = 10. Every 2 years, for 10 periods, the annual cost is discounted. Contrast this cost with the upv escalation demonstrated in Example 3.



Example 5. Cost and Return-style Operating Budget Costs

This is the first example demonstrating how costs can be computed for Operating Budgets rather than Capital Budgets. Annual capital costs can be computed by setting the SubCost.EscationType property to “caprecovery”, the SubCost.PriceType property to aoh (Allocated Overhead), the SubCost.DiscountYears property to a value greater than one, and the SubCost.Salvage property value to an appropriate value. Additional operating costs can be calculated by setting the SubCost.EscationType property to “none” or “spv” (Single Present Value), the SubCost.PriceType property to oc (Operating Cost), and the SubCost.DiscountYears property to zero.

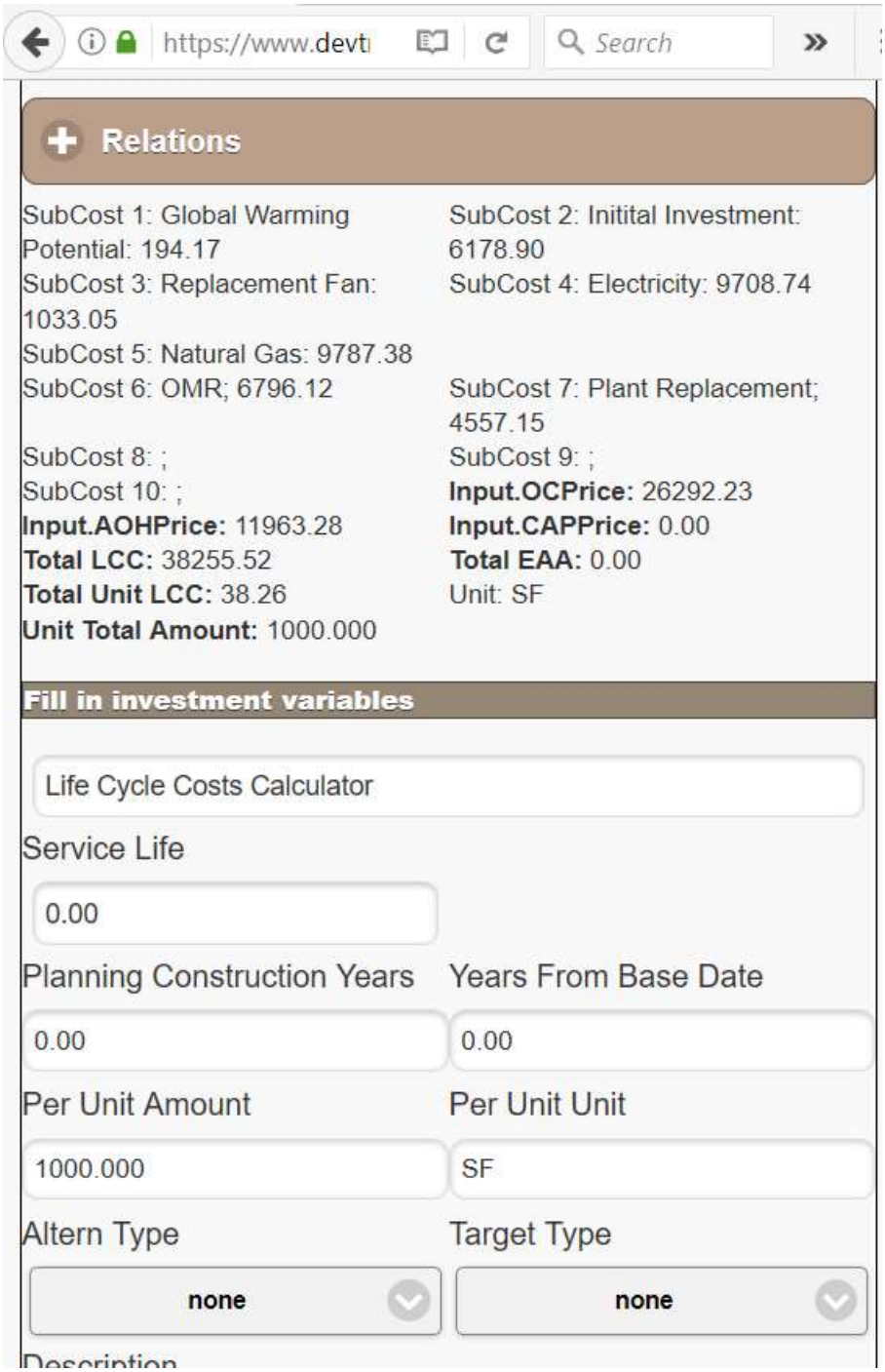
This example makes the following changes to Example 1:

- The Electricity, Natural Gas, and OMR costs are calculated as annual costs and discounted using the spv escalation type with a 1 year Discount Years.
- The Replacement Fan is calculated as an annual capital recovery cost. The annual cost is derived by: 1) setting the SubCost.EscalationType to caprecovery, 2) setting the SubCost.DiscountYears property to 14, 3) setting the SubCost.PriceType to aoh (allocated overhead), and 4) and setting the SubCost.SalvageValue to $500. Note that a cost per hour of Operation can be derived for the Fan by setting the SubCosts.Times property to a number greater than 1. The derived Capital Recovery Cost will be divided by the SubCosts.Times property when that property is greater than 1. For example, a fan with a Capital Recovery Cost of $100 that runs for 100 hours per year (SubCosts.Times) will have a final total of $1/hour allocated overhead cost (this technique is appropriate when the base Input has “hour” units).
- The Initial Investment and Second Investment are combined into a single SubCost ($103,000), with a Salvage Value of $20,000, and calculated as an annual capital recovery cost with 20 Discount Years.
- The Plant Replacement uses the capitalrecoveryspv option. First, the spv calculation is used with the Years from Base property to discount future capital costs to a present value. Second, the capital recovery calculation is used with (Service Life + Planning Construction Years) to calculate annual amortized costs.

Input URIs

https://www.devtreks.org/buildtreks/preview/commercial/input/2012 Example 5, Operating Budget Costs/2147397493/none

https://localhost:5001/buildtreks/preview/commercial/input/2012 Example 5, Operating Budget Costs/2147409778/none/



F. Life Cycle Benefit (LCB) Output Calculator 1

This calculator carries out life cycle benefit calculations using the same methods as the Input Cost Calculator. Instead of discounting a stream of costs, this calculator discounts a stream of

benefits. Up to 10 ‘SubBenefits’ (i.e. retail sales, rental income, revenue sharing returns, subsidies, incentives …) can be included in the calculations. Recurring benefits can be calculated using uniform, linear, or geometric growth types or the techniques explained in the NIST Handbook 135. The calculator can update the base Output’s Price with the calculated composite benefits, but does not change the units or amounts.

Example 1. AdHoc (NIST 135 does not include examples of Output calculations)

This adhoc example demonstrates that the Output calculator works the same as the Input calculator.

Output URIs (5*)

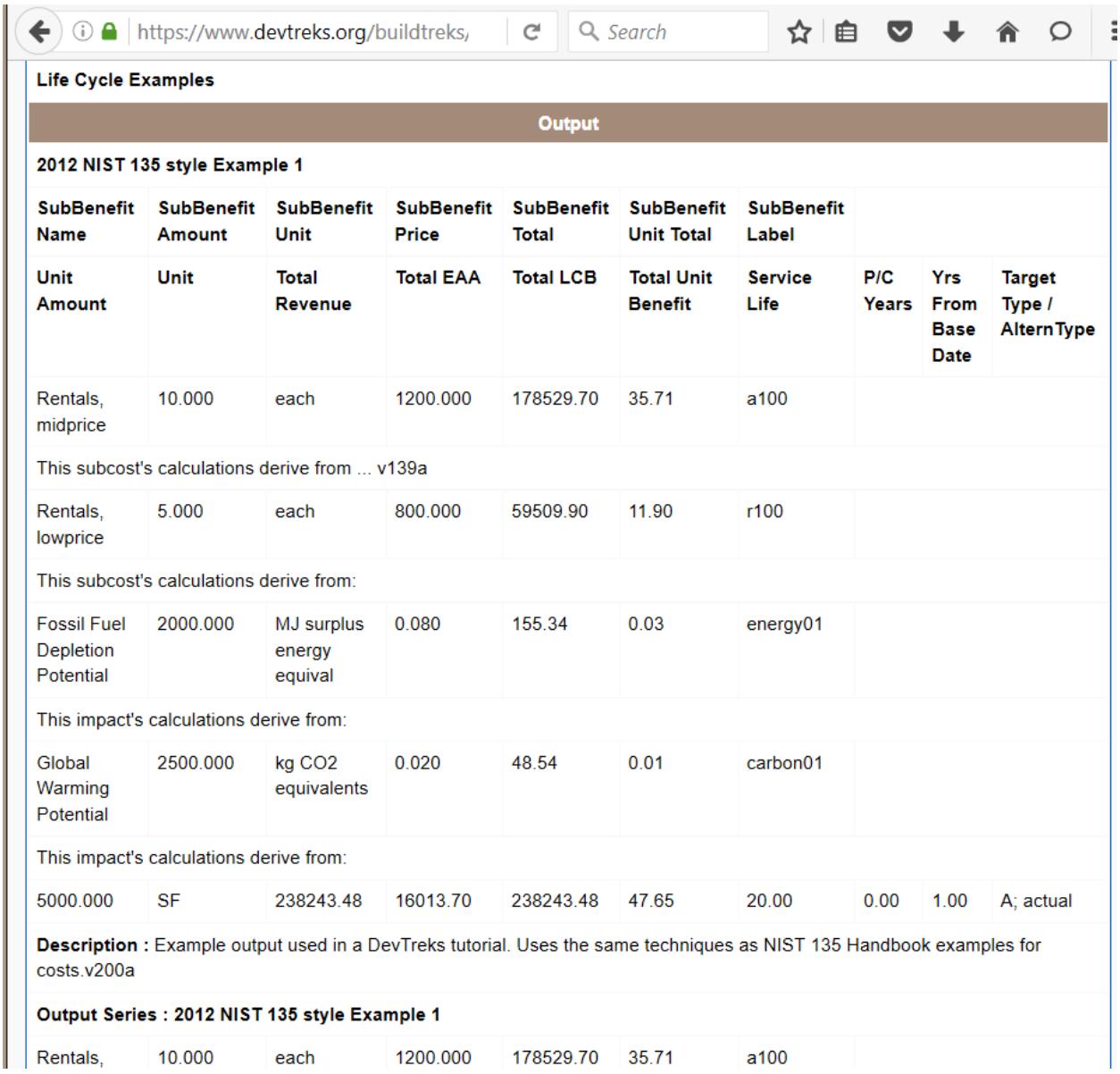
https://www.devtreks.org/buildtreks/preview/commercial/output/2012 NIST 135 style Example 1/2141223440/none/

https://localhost:5001/buildtreks/preview/commercial/output/2012 NIST 135 style Example 1/2141223440/none/

Benefit Details

Total Revenue : 238243.48	Total LCB : 238243.48
Total EAA : 16013.70	
SubBenefit 1 Name : Rentals, midprice	SubBenefit 1 Amount : 10.000
SubBenefit 1 Unit : each	SubBenefit 1 Price : 1200.000
SubBenefit 1 Total : 178529.70	SubBenefit 1 Unit Benefit : 35.71
SubBenefit 1 Description : This subcost's calculations derive from ... v139a	SubBenefit 1 Label : a100
SubBenefit 2 Name : Rentals, lowprice	SubBenefit 2 Amount : 5.000
SubBenefit 2 Unit : each	SubBenefit 2 Price : 800.000
SubBenefit 2 Total : 59509.90	SubBenefit 2 Unit Benefit : 11.90
SubBenefit 2 Description : This subcost's calculations derive from:	SubBenefit 2 Label : r100
SubBenefit 3 Name : Fossil Fuel Depletion Potential	SubBenefit 3 Amount : 2000.000
SubBenefit 3 Unit : MJ surplus energy equival	SubBenefit 3 Price : 0.080
SubBenefit 3 Total : 155.34	SubBenefit 3 Unit Benefit : 0.03
SubBenefit 3 Description : This impact's calculations derive from:	SubBenefit 3 Label : energy01
SubBenefit 4 Name : Global Warming Potential	SubBenefit 4 Amount : 2500.000
SubBenefit 4 Unit : kg CO2 equivalents	SubBenefit 4 Price : 0.020
SubBenefit 4 Total : 48.54	SubBenefit 4 Unit Benefit : 0.01
SubBenefit 4 Description : This impact's calculations derive from:	SubBenefit 4 Label : carbon01
Unit Amount : 5000.000	Unit : SF
Total Unit Benefit : 47.65	Service Life : 20.00
P/C Years : 0.00	Yrs From Base Date : 1.00
Target Type : actual	Altern Type : A

Description : Example output used in a DevTreks tutorial. Uses the same techniques as NIST 135 Handbook examples for costs.v214a



https://www.devtreks.org/buildtreks/ Search

Life Cycle Examples

Output

2012 NIST 135 style Example 1

SubBenefit Name	SubBenefit Amount	SubBenefit Unit	SubBenefit Price	SubBenefit Total	SubBenefit Unit Total	SubBenefit Label			
Unit Amount	**Unit**	**Total Revenue**	**Total EAA**	**Total LCB**	**Total Unit Benefit**	**Service Life**	**P/C Years**	**Yrs From Base Date**	**Target Type / AlternType**
Rentals, midprice	10.000	each	1200.000	178529.70	35.71	a100			
This subcost's calculations derive from ... v139a									
Rentals, lowprice	5.000	each	800.000	59509.90	11.90	r100			
This subcost's calculations derive from:									
Fossil Fuel Depletion Potential	2000.000	MJ surplus energy equival	0.080	155.34	0.03	energy01			
This impact's calculations derive from:									
Global Warming Potential	2500.000	kg CO2 equivalents	0.020	48.54	0.01	carbon01			
This impact's calculations derive from:									
5000.000	SF	238243.48	16013.70	238243.48	47.65	20.00	0.00	1.00	A; actual

Description : Example output used in a DevTreks tutorial. Uses the same techniques as NIST 135 Handbook examples for costs.v200a

Output Series : 2012 NIST 135 style Example 1

Rentals,	10.000	each	1200.000	178529.70	35.71	a100

SubBenefit 1:

$178,529.70 (Rentals-midprice, Total Benefit 1) = (10 (Amount 1, each) * $1,200 (Price 1, per each)) * 14.88 (discount factor: 1% uniform growth, 20 years, 3%)

$35.71 (per SF, Unit Benefit 1) = $178,529.70 (Rentals-midprice, Total Benefit 1) / 5,000 SF (Per Unit Amount)

SubBenefit 2:

$59,509.90 (Rentals-lowprice, Total Benefit 2) = (5 (Amount 2, each) * $800 (Price 2, per each)) * 14.88 (discount factor: 1% uniform growth, 20 years, 3%)

$11.98 (per SF, Unit Benefit 1) = $59,509.90 (Rentals-lowprice, Total Benefit 2) / 5,000 SF (Per Unit Amount)

SubBenefit 3:

$48.54 (Global Warming Potential, Total Benefit 3) = 2,500 (Amount 3) kg CO2 equivalents * $0.02/kg carbon * .971 (discount Factor: 1 years, 3%)

SubBenefit 4:

$155.34 (Fossil Fuel Depletion Potential, Total Benefit 4) MJ surplus energy equivalents = 2,000 (Amount 4) * $0.08/MJ * .971 (discount Factor: 1 years, 3%)

Discounted Total Benefits:

$238,243.48 (Output.Price) = $178,529.70 (Rentals-midprice, Total Benefit 1) + $59,509.90 (Rentals-lowprice, Total Benefit 2) + $48.54 (Global Warming Potential, Total Benefit 3) + $155.34 (Fossil Fuel Depletion Potential, Total Benefit 4)

$238,243.48 (Total LCC) = $238,243.48 (Output.Price)

$47.65 (Total Unit LCC) per SF = $238,243.48 (Total LCC) / 5,000 SF (Per Unit Amount)

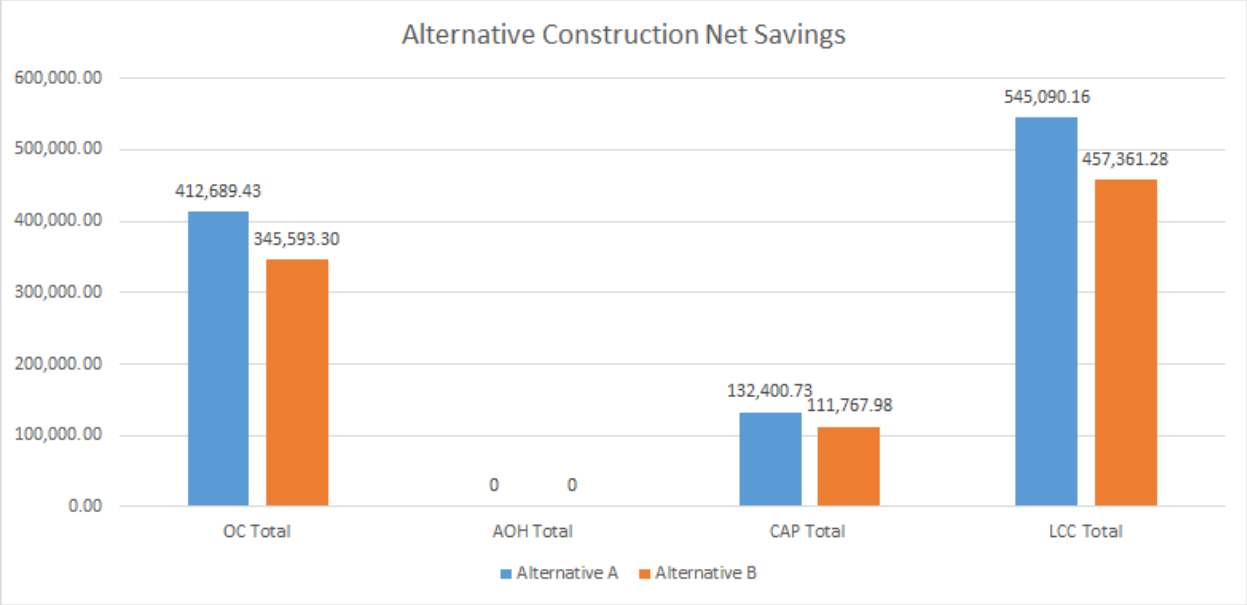
$16,013.70 (Total EAA) = $238,243.48 (Total LCC) / x (equivalent annual annuity discount factor: 20 years, 3%)

G. Other Life Cycle Calculations

Life cycle analysis can be used to quantify any life span-dependent costs and benefits. These analyses can be used in the fields of health care, human capital, environmental improvement, food production, safety efficacy, and disaster prevention/recovery. The Resource Stock Calculation 1 reference includes additional examples of natural resource stock Life Cycle Analysis. The Social Performance Analysis 2 (SPA3) reference includes examples of algorithms that carry out Life Cycle Impact Assessment, Product Life Cycle Analysis, Organization Life Cycle Analysis, Social Life Cycle Analysis, Hot Spots Analysis, and Cost Effectiveness Analysis. SPA3 demonstrates how to integrate life cycle calculations with population and machine learning algorithms.

H. Performance Measures and Multimedia support

The NIST 135 and GAO references contain examples of Performance Measures, such as Return on Investment or Estimated Cost at Completion, which can be used to reach decisions about alternative investments. The Performance Analysis tutorial contains several examples taken from those references. The Social Performance Analysis tutorial explains how to value the services generated by public goods using techniques such as Performance Monitoring, Impact Evaluation, Stakeholder Impact Analysis, and Cost Effectiveness Analysis. The examples include communication aids that help decision makers to decide among alternative investments, including the following graphs:



Reference Case Cost Effectiveness Results (Time Horizon = 200 years; Costs and QASYs Discount Rate = 3%; Escalation Type = none; CEA Threshold = 100,000; Confidence Interval = 80%;									
Alternative	**Most Likely Total Costs**	**Uncertainty Index**	**Most Likely QASYs**	**Uncertainty Index**	**Incremental Costs**	**Incremental Effectiveness (QASYs)**	**NMB**	**Incremental NMB**	**ICER (Inc Cost / Inc QASY)**
Stakeholder Group A Perspective									
No Mitigation and Adapt.									
AA	to be completed when data becomes available								
AB									
AC									
Natural Capital Care Perspective									
No Mitigation and Adapt.	21,000.00	4.00	16.50	4.50			1,629,000.00		
AA	23,100.00	3.50	18.98	2.50	21,000.00	18.15	1,874,400.00	245,400.00	1,157.02
AB	25,200.00	3.00	21.45	2.00	42,000.00	34.65	2,119,800.00	245,400.00	1,212.12
AC	26,250.00	4.25	21.45	4.50	63,000.00	51.15	2,118,750.00	(1,050.00)	1,231.67
Public Capital Care Perspective									
No Mitigation and Adapt.									
AA	to be completed when data becomes available								
AB									
AC									

I. Life Cycle Analyzers

The Life Cycle Analysis tutorial explains how to aggregate and analyze this reference's life cycle calculation data. Analyzers carry out summation, statistical, incremental change, and progress, analyses for all base elements.

Summary and Conclusions

Clubs using DevTreks can carry out basic life cycle calculations for a wide assortment of Inputs and Outputs. They can aggregate and analyze these calculations in a wider assortment of Operations, Components, Outcomes, Capital Budgets, and Operating Budgets. Clubs can tackle issues vexing their communities involving energy conservation, natural resources conservation, transportation improvement, food production, safety and disaster prevention effectiveness, health care expenditures, and human capital performance. Networks can build knowledge banks of benefit, cost, and performance data that can help future generations improve the sustainability of their lives and purses **(6*)**.

Footnotes

1. The NIST 135 reference uses examples of energy conservation to explain life cycle costs. Life cycle assessments are appropriate in any cost and benefit context, including health care, human capital, environmental improvement, food production, safety efficacy, and disaster prevention/recovery.
2. The Cost and Returns reference is explained in DevTreks' Net Present Value 1 tutorial.
3. Section F explains that environment impacts can be included in life cycle assessments. These impacts can be obtained from full life cycle environmental analyses. When possible, the impacts should be given dollar prices. These examples do not use escalated prices for the environmental impacts because research was not done to justify the escalation rate. Environmental indicators and their impacts can be tracked more thoroughly using DevTreks Monitoring and Evaluation (M&E) tools (see the M&E tutorials) or Resource Stock tools (see the Resource Stock tutorials). Version 2.0.8+ introduced several new algorithms for measuring Social Performance, including valuing the benefits of ecosystem services.
4. Use uniform sequences of SubCosts and SubBenefits when entering data. For example, if a Global Warming SubPrice is going to be included in all SubCosts, enter it in the same sequence position (first, third). That will allow the SubCosts and SubBenefits to line up uniformly when displayed in subsequent analyses (see the Life Cycle Analysis tutorial).

5. Version 2.1.4 testing concluded that the desktop view of these calculations is substandard and difficult to interpret. DevTreks recommends that the networks administering these types of calculations include software developers, data quality specialists, domain experts, and end user customers. As a small, software development ngo, with a serious distaste for administrative work, we assumed all of those roles. We recommend "doing it better". The Social Performance Analysis tutorials further explain that improvement in public goods-related IT has little to do with money.
6. The accompanying video tutorial explains why this statement is false –it's our responsibility to mitigate and adapt to climate change right now so that the quality of life for future generations is not wrecked.

References

U.S. Department of Commerce, National Institute for Standards and Technology. Handbook 135, Life-Cycle Costing Manual. 1996 Edition.

United States Department of Interior. National Parks Service. Cost Estimating Requirements Handbook. February, 2011.

United States Government Accountability Office. Applied Research and Methods. GAO Cost Estimating and Assessment Guide. Best Practices for Developing and Managing Capital Program Costs. March, 2009.

Hallam, Eidman, Morehart and Klonsky (editors). Commodity Cost and Returns Estimation Handbook, Staff General Research Papers, Iowa State University, Department of Economics, 1999

UNEP/SETAC. Guidelines for Social Life Cycle Assessment of Products. 2009 (primarily covers SLCA but also includes a section on LCC –they published a reference on this subject in 2011 but charge fees which means the reference has limited usefulness in the public goods context of DevTreks)

References Note

We try to use references that are open access or that do not charge fees.

Improvements, Errors, and New Features

Please notify DevTreks (devtrekkers@gmail.com) if you find errors or can recommend improvements.

Video tutorials explaining this reference can be found at:

https://www.devtreks.org/commontreks/preview/commons/resourcepack/Life Cycle Analysis 1/497/none/