Technical Documentation: A how-to guide for the Smith College Proxy Carbon Life Cycle Cost Calculator

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SMITH COLLEGE

Welcome! The Smith College Proxy Carbon Life Cycle Cost Calculator is a tool designed to include climate impacts in the evaluation of present and future costs of projects on campus. At the request of the **Study Group on Climate Change**, this Excel tool was developed as part of the implementation of a proxy carbon price at Smith College .Thank you for your participation in this informed decision-making process!

This guide briefly describes the purpose of this tool and its potential applications. It also provides detailed instruction on how to use the Life Cycle Cost Calculator Excel spreadsheet. The guide includes an example of evaluating retrofit options for a residential house on campus. Additional resources in the appendix may be useful for completing a proxy carbon life cycle cost calculation.

Contents

Background

Many colleges and universities, including Smith College, have committed to carbon neutrality (zero net greenhouse gas emissions) to address the complex and urgent problem of anthropogenic climate change. Carbon dioxide emissions drive anthropogenic climate change, which poses social, economic, and ecological risks now and in the future. One source of carbon dioxide emissions is the combustion of fossil fuels to produce energy. This process has been studied extensively so it is possible to accurately estimate the amount of greenhouse gas emissions (hereafter, emissions) resulting from the production of energy, often using the unit of metric tons of carbon dioxide (or carbon dioxide equivalent).

For residential colleges and universities, most emissions derive from the operation of buildings because they need energy for heating, cooling, and electricity. Many buildings on campus are likely to remain in

use for years, so considering energy and emissions is crucial to making well-informed decisions in the construction process. This is especially true for institutions(like Smith) that have committed to reducing emissions or reaching carbon neutrality.

A proxy carbon price is a financial tool to internalize and acknowledge emissions, and thus thread climate impacts into decision-making. It is a *virtual* price, meaning it does not involve movement of financial resources between funds. A proxy carbon price can transform intangible carbon emissions into the common metric of money by multiplying expected emissions by the price in dollars per metric ton of carbon dioxide equivalent emissions. Essentially, decision-makers can sort options as if they actually had to pay a fee for every ton of carbon emitted without imposing a real cost.

A proxy carbon price is thus a way to integrate climate considerations into the bottom line and make the business case for emission reductions more tangible. This strategy is widely used in the business community to identify cost-effective emission reduction opportunities and to manage the risk of future carbon regulation or carbon commitments (CDP, 2017). As of 2018, over 1,300 firms, including Microsoft, Disney, Exxonmobil, and Shell, use carbon prices in financial decision-making (CDP, 2017).

A life cycle cost calculation (LCC) is a standardized approach to informing decisions that evaluates the present and future of costs of project alternatives (Testa, et.al, 2011). The overall goal of an LCC is to improve financial decisions over the long-term by considering both initial and operational costs. Typically, an LCC includes the time-discounted costs of the initial price, utilities (energy, water), operation, maintenance, and replacement price minus the projected residual value of a project over a study period (Harvard, 2017). The LCC method computes the net present value (NPV) of a project.[1] LCCs are particularly useful for projects where a substantial percentage of the total costs occur during operation (i.e. energy, maintenance) relative to initial market price (ASTM, 2017).

Since a large percentage of an institution's carbon emissions are associated with ongoing energy use, the LCC framework is an ideal way to incorporate costs associated with these emissions into financial analysis. Incorporating a proxy carbon price into the LCC illustrates the costs of carbon emissions (and/or future costs to the institution from carbon regulation) alongside other traditional financial costs.[2]

To perform the LCC calculation with the proxy carbon price it is best to use software that minimizes the time-intensive work of calculating financial variables across time. Using a standardized tool also makes it easier to compare and analyze across projects (including retrospective analysis). The Smith College Life Cycle Cost Calculator is an Excel tool that has the capability to include a proxy carbon price. This is of particular value when considering construction and renovation projects, which have long lifetimes and account for most institutional emissions. LCC tools can also be applied to specific purchasing decisions, like fleets. Finally, this tool can be used to find the most cost-effective energy conservation options—especially useful when vetting revolving green fund projects.

Because the LCC and proxy carbon price are both forward-looking, this tool can be integrated into campus utilities master planning.

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1. NPV measures the net savings (or costs) of a project relative to an initial condition, accounting for the both escalation in costs and the time value of money
2. A more in-depth approach is to conduct a life cycle cost assessment that includes upstream and downstream impacts (e.g. emissions from the supply chain and disposal). The overhead and data needs for such an analysis are significant.
3. It is possible to include emissions associated with construction, periodic maintenance, etc. or time-varying emissions in an LCC calculator but doing so would require modifications to the current Smith tool.

Life Cycle Cost Calculator Content

The first step to using the LCC calculator is to determine whether the tool is appropriate for your project. The Smith College Life Cycle Cost Calculator is currently designed to assist the user in selecting among several project alternatives that perform the same function and differ only in cost and carbon emissions. The tool also assumes that all carbon emissions occur during the operation of the project and are constant over time.[3]

If the LCC tool is suitable, the next step is to collect project data. To obtain the most accurate results, collect the best available data for the baseline "do nothing" case alongside the other options under consideration. A complete calculation would include the initial price, the replacement cost (and frequency), any anticipated operating costs including material, labor, and/or utility, and the expected lifetime of the project. Appendix A has a worksheet that can be used to collect and organize this data. The tool can be used with either rough estimates at the beginning stages of the project or detailed data after the completion of more thorough analysis/engineering.

The calculation can be performed without every point of data so long as the data inputs are consistent across options. However, calculations will not be as accurate if they are missing data. Small costs or those that are likely to be very similar across options are unlikely to change the results if omitted.

Input Tables Tab

Upon opening the Smith College Proxy Carbon Life Cycle Cost Calculator, go to the tab labeled "Input Tables" to begin a project analysis. The cells are color-coded for your convenience with data entry cells shaded green. The white cells will populate with calculations once the data has been entered into the green cells, so do not enter project data here.

At the top of the Input Tables tab there is a section with assumptions for the discount rate, carbon price, and the escalation rates for carbon, labor, and materials.

Assumptions	
Discount Rate	4%
Study Period	20
Proxy Carbon Price ($/MTCDE)	70
Carbon Price Escalation Rate	2.50%
Materials Escalation Rate	1.73%
Labor Escalation Rate	1.73%
Analysis Date	1/1/2018

Figure 1 Core Financial Input Assumptions in the LCC Tool

The prices, escalation rates, and greenhouse gas content of inputs are listed in the white cells in the Annual Consumption section.

Annual Consumption	Units	Base Price	Escalation Rate	Greenhouse Gas Content
Electricity Smith College Main Meter	(kWh)	$ 0.10	0.90%	0.00025
ISO-NE Electricity	(kWh)	$ 0.15	0.53%	0.00029
Transportaion Diesel	(Gallons)	$ 2.69	1.30%	0.00820
Transportation Gasoline	(Gallons)	$ 2.84	1.20%	0.00882
Smith College Chilled Water	(Ton-Days)	$ 2.00	3.10%	0.00487
Smith College Natural Gas	(MMbtu)	$ 1.26	0.90%	0.05317
Smith College Steam	(MMBtu)	$ 13.00	0.90%	0.07400
Northampton Water/Sewer	(Ccf)	$ 10.00	3.32%	0.00000
#2 Fuel Oil	(Gallons)	$ 2.70	3.50%	0.01031
#6 Fuel Oil	(Gallons)	$ 0.75	3.50%	0.01130
Unused A				
Unused B				
Unused C				
Unused D				
Unused E				
Unused F				

Figure 2 Energy prices and escalation rates in the LCC Tool (Note: actual values in tool may vary)

To maintain consistent analyses these assumptions should not be altered for individual projects. These variables may change over time and should be updated periodically by a governance committee to ensure accuracy based on best available data (see Adapting an LCC guide).

Project Title (should be unique)	Placeholder Data			Baseline	Alternative A	Alternative B
Project Type (please select)					Insulation	Insulation
Detailed Description	This is where you would enter brief details on project location, etc. Enter details about the alternatives to the right.					
Capital Costs						
Initial Investment				$0	$75,000	$100,000
Incentives						
Net Cost				$0	$75,000	$100,000
Expected Life						
Replacement Cost						

Figure 3 Entry of Project Costs in the LCC Tool

The names for each alternative in row 10 ("Baseline", "Alternative A", "Alternative B") should be changed to reflect the options under consideration. (See the Washburn House Pilot Project for an example.) The corresponding tabs should also be renamed to match these project names by double-clicking on the sheet name. It is essential that the names entered on row 10 match the tab names exactly or the spreadsheet will not work. Select a project category from the drop down menu on row 11 and enter a detailed description on row 12.

Investment and replacement costs should be entered in the capital cost section. The analysis can be performed without entering either replacement costs or expected life if these amounts will not vary significantly between alternatives, but the most accurate results will be obtained by entering values here, if available.

Most costs associated with each alternative are assumed to be associated with inputs that are used in fixed physical quantities each year of the project. These physical amounts should be listed in the Annual Consumption section of the sheet; note that these amounts must correspond with the units in column D.

Figure 4 Entry of Energy Usage in the LCC Tool. Some projects may only have one type of energy use (steam/electricity) while others may save multiple types.

Some projects will also involve labor or materials that occur at different points throughout the project lifetime. These amounts can be entered in the Year Specific Material Costs and Year Specific Labor Costs sections. Costs should be entered in current dollars; the spreadsheet will escalate and discount the values as appropriate to reflect the time at which the expenses occur. The current tool assumes that no carbon emissions are associated with these year specific costs.

Alternative Tabs

Once the data have been entered it is time to interpret the results. Each alternative has its own tab, and summary information for all alternatives is provided in the Results Comparison tab.

The summary information for each project includes several output metrics described below. Many of these are calculated with and without proxy carbon costs. Because each alternative is compared to the baseline, baseline outcomes are recorded at the top left of each tab.
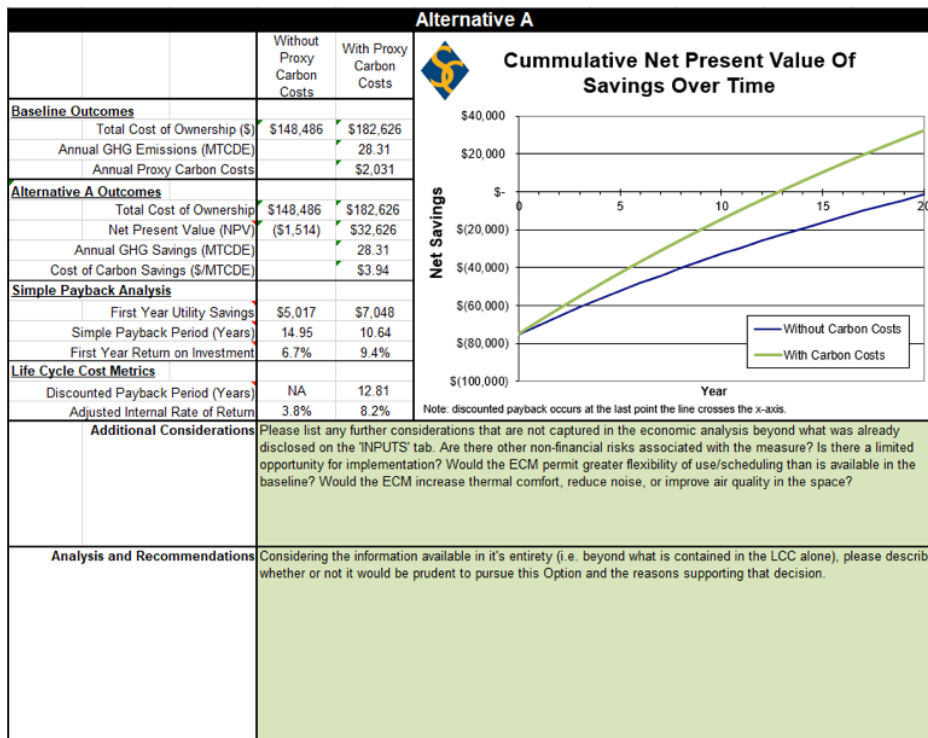

Figure 5 Sample 'Alternative A' Project Results in the LCC Tool

- Total cost of ownership (TCO) measures the life cycle cost of each option, escalated and discounted as appropriate. The TCO includes the utility, material, labor, maintenance costs along with the initial and proxy carbon prices, which are escalated and discounted, as appropriate. This is a single number that captures the total costs to the institution of selecting this option.

- Net present value (NPV) measures the net cost of this alternative relative to the baseline alternative over the life of the project. An alternative is cheaper for the institution than the baseline if NPV is positive.

- Annual GHG savings reports the reduction in emissions from this alternative relative to the baseline.

- Cost of carbon savings is a rough measure of the cost per ton of carbon saved by this alternative. A negative number indicates that the project saves money even before introducing the proxy price; the carbon reductions achieved by the alternative thus have an implicit negative cost. A positive number indicates that the project is more expensive without the proxy carbon cost; the number gives a rough measure of how much it will cost per ton to reduce the institution's carbon footprint using this alternative.

- The simple payback period compares annual savings from an alternative relative to the baseline against increased investment costs. It computes the number of years of savings that would be required to balance the investment cost, but does not consider changes in prices or the time value of money. Only costs included in the Initial Investment and Annual Consumption portions of the Input Tables tab are incorporated in this calculation.

- The discounted payback period is a more accurate measure of the time required to pay off an investment. This incorporates both escalation of costs and the time value of money; moreover, it accounts for the year specific labor and material costs entered in the Year Specific sections of the Input Tables tab.

The graph on the right of these tabs illustrates the accumulated savings for this alternative relative to the baseline, both with and without carbon costs. The discounted payback period is the time at which the alternative's savings become positive. The NPV of the project over 20 years is the height of the line at the far right edge of the graph.

The LCC calculator can only evaluate specific financial and carbon differences among alternatives. In many cases, different alternatives may have other variations that could influence decisions. Any additional important considerations or recommendations should be entered in the green cells below the graphs.

Below the summary information, the tab for each alternative contains detailed computations of annual utility and carbon costs. These calculations are derived from assumptions entered elsewhere in the spreadsheet and should not be altered.

Results Comparisons Tab

The Results Comparisons tab collects key outputs for each alternative in a single sheet to facilitate comparison.

	Baseline	Alternative A	Alternative B
Without Proxy Carbon Price			
Total Cost of Ownership	$146,972	$148,486	$129,394
Net Present Value (NPV)	$0	($1,514)	$17,577
Simple Payback Analysis			
First Year Utility Savings	$0.00	$5,017.25	$8,027.60
Simple Payback Period (Years)	NA	14.95	12.46
First Year Return on Investment	NA	6.7%	8.0%
Life Cycle Cost Metrics			
Discounted Payback Period (Years)	NA	NA	16.13
Adjusted Internal Rate of Return	3.8%	3.8%	5.8%
With Proxy Carbon Cost			
Total Cost of Ownership	$215,252	$182,626	$143,050
Net Present Value (NPV)	$0	$32,626	$72,201
Simple Payback Analysis			
First Year Utility Savings	$0.00	$7,048.14	$11,277.02
Simple Payback Period (Years)	NA	10.64	8.87
First Year Return on Investment	NA	9.4%	11.3%
Life Cycle Cost Metrics			
Discounted Payback Period (Years)	NA	12.81	10.37
Adjusted Internal Rate of Return	8.2%	8.2%	10.7%
Cost Breakdown			
Investment	$0	$75,000	$100,000
O&M	$0	$0	$0
Utility	$146,972	$73,486	$29,394
Carbon	$68,280	$34,140	$13,656

Figure 6 Sample Results Comparison Tab in the LCC Tool. Red parentheses indicate negative numbers.

Two graphs on stand-alone tabs are generated from these data that may be useful when preparing reports for key stakeholders and decision-makers.
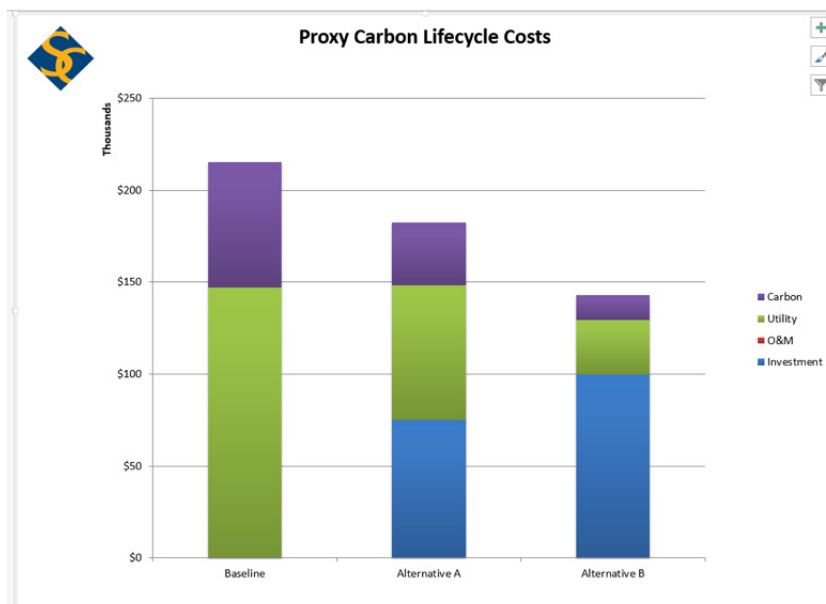

Figure 7 Sample Cost Breakdown Graph in the LCC Tool. There were no O&M costs entered for this example.

The 20 year proxy carbon life cycle cost graph ("Cost Breakdown Graph" Tab) is a bar chart that illustrates the initial cost, the operating cost, and the proxy carbon cost in net present value. This provides a helpful visualization of when and where the majority of the costs occur during operation (i.e. initial, operational, long-term climate impact). The cumulative costs incurred over time graph ("Cumulative Cost Comparison" Tab) compares the time path of the costs for each alternative. The discounted payback period occurs at the last point where the line for the option crosses the baseline.
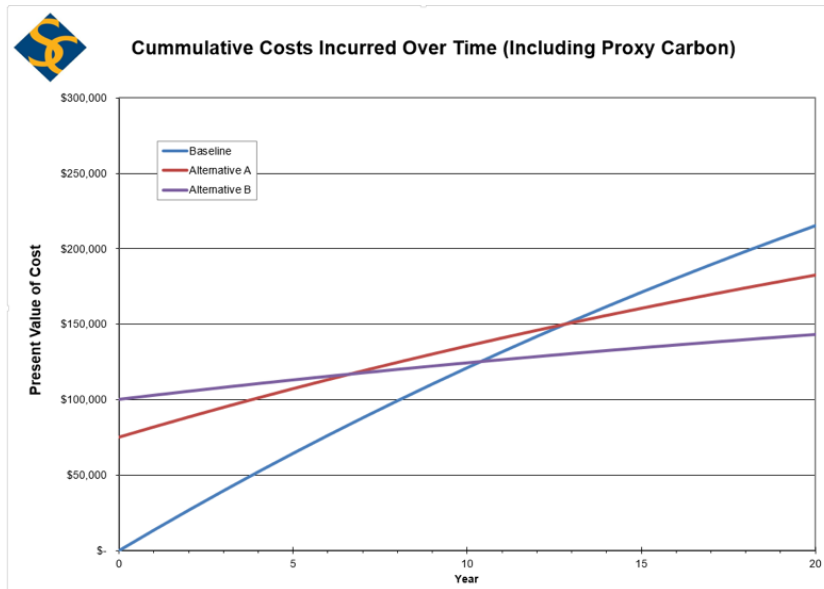

Figure 8 Sample Cumulative Cost Graph in the LCC Tool. The alternatives "pay back" when the cost line for the alternative crossed the costs for the baseline.

Adding or Removing Alternatives

The spreadsheet template includes sheets to calculate costs for the baseline and two alternatives. For projects that involve only one alternative to the baseline, the Alternative B sheet and columns can be deleted. Note however that once the Alternative B columns and sheets have been deleted, adding additional alternatives later will be more difficult.

For projects that involve more than two alternatives, the tool was designed to make additions relatively straightforward.

1. Make a copy of one of the two alternative sheets. (Do not copy the baseline sheet, as the formulas will not calculate properly). Give the new sheet a new name describing the new alternative. (Note: update the sheet name, NOT the title of the sheet in the black bar at the top of the sheet. The title is updated automatically when the sheet name is changed).

2. Go to the Input Table tab and insert a new column *between* two existing alternatives. (If the new column is to the right or to the left of the existing alternatives, the formulas will not update properly). Type the name of the new sheet in the title row of the new column. Make sure the names match exactly.

3. Go to the Result Comparison tab and insert a new column between the same two existing alternatives. (Again, if the new column is to the right or to the left of the existing alternatives, the formulas will not update properly). Type the name of the new sheet in the title row of the new column, again making sure the names match exactly.

4. The cost breakdown comparison graph will update automatically to include the new alternative. The NPV over time graph will need to have the new alternative added manually.

5. Go to the export tab and insert a new column between the same two existing alternatives. Highlight the entire column of data for an existing alternative, choose copy, and then highlight the new column and paste the formulas in place.

Example: Washburn House

This example is a rough estimate of the life cycle cost of two retrofit options for a residential house on the Smith College campus. This example only includes initial costs (construction materials and labor) and the energy costs for each option.

Perform the calculation using the following data:

The Washburn House retrofit pilot project used the proxy carbon life cycle cost calculator method to analyze three options: 1) Existing Baseline, 2) retrofit to seal the envelope of the building and prevent thermal convective loss, and 3) retrofit to seal the envelope and insulate the walls to improve the thermal blanket. The data for the proxy carbon life cycle cost calculation was collected and then entered into the Data Worksheet. *Note: the numbers used here are illustrative only.*

DATA WORKSHEET: WASHBURN HOUSE

Project Title (should be unique)	Washburn Retrofit					Baseline	Sealing	Sealing plus insulation
Project Type (please select)							Insulation	Insulation
Detailed Description	This is where you would enter brief details on project location, etc. Enter details about the alternatives to the right.							
Capital Costs								
Initial Investment						$0	$2,020	$13,570
Incentives								
Net Cost						$0	$2,020	$13,570
Expected Life								
Replacement Cost								
Annual Consumption	**Units**	**Base Price**	**Escalation Rate**	**Greenhouse Gas Content**		**Baseline**	**Sealing**	**Sealing plus insulation**
Electricity Smith College Main Meter	(kWh)	$ 0.10	0.90%	0.00025				
ISO-NE Electricity	(kWh)	$ 0.15	0.53%	0.00029				
Transportaion Diesel	(Gallons)	$ 2.69	1.30%	0.00820				
Transportation Gasoline	(Gallons)	$ 2.84	1.20%	0.00882				
Smith College Chilled Water	(Ton-Days)	$ 2.00	3.10%	0.00487				
Smith College Natural Gas	(MMbtu)	$ 1.26	0.90%	0.05317				
Smith College Steam	(MMBtu)	$ 13.00	0.90%	0.07400		645	537	428
Northampton Water/Sewer	(Ccf)	$ 10.00	3.32%	0.00000				
#2 Fuel Oil	(Gallons)	$ 2.70	3.50%	0.01031				
#6 Fuel Oil	(Gallons)	$ 0.75	3.50%	0.01130				
Unused A								
Unused B								
Unused C								
Unused D								
Unused E								
Unused F								

Figure 9: Sample data worksheet for a building insulation project.

Interpreting the Results

The baseline consumption of steam for heat is 645 MMbtu annually for an energy cost of $8,460, which is associated with about 48 metric tons of carbon dioxide equivalent (MTCDE) emissions. This amounts to a proxy carbon cost of $3,425 at the price used here (Figure 1). Over a 20-year period this results in approximately $123,917 in direct utility costs and $57,570 in proxy carbon costs. There is no initial cost for

this option because it assumes existing conditions. The total cost of ownership for the baseline scenario (including proxy carbon costs) is therefore $181,487.

The retrofit option to air-seal the windows, doors, and other parts of the building envelope would reduce the annual consumption of steam to 537 MMbtu, reduce annual utility costs by $1,417, and reduce annual carbon emissions by roughly 8 MTCDE. Selecting this option would save $18,729 over a 20-year period not including the proxy carbon cost. When the proxy cost is added, savings rise to $28,368. The discounted payback period without the proxy carbon price is about 1.5 years, well within the existing facilities practice of a 5-year payback period. The proxy charge reduces the discounted payback period to about 1 year. This option clearly makes financial sense, even without considering carbon costs.
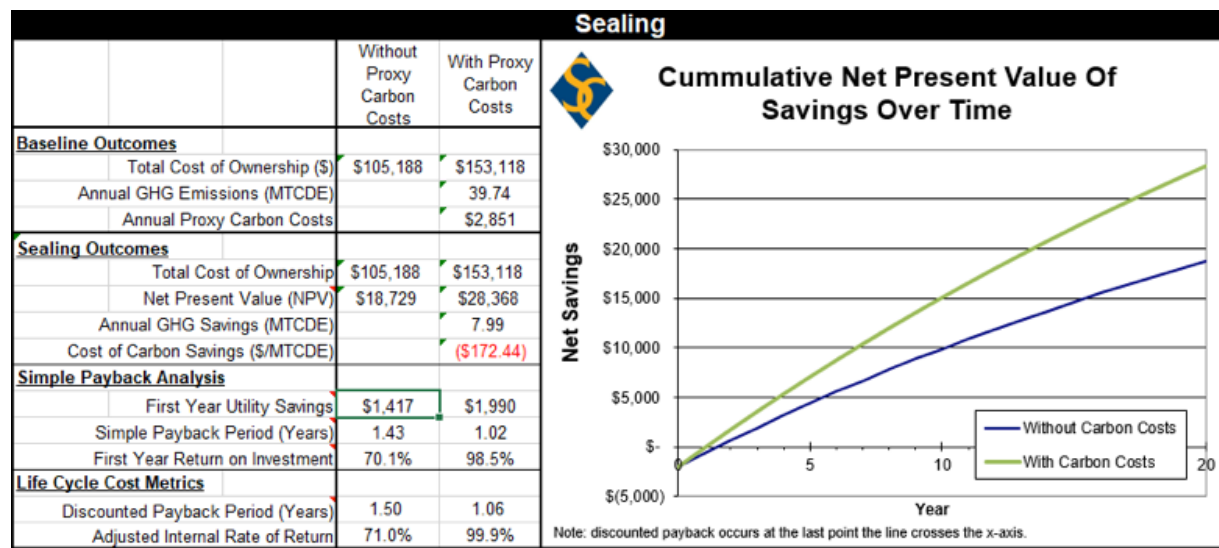

	Without Proxy Carbon Costs	With Proxy Carbon Costs
Baseline Outcomes		
Total Cost of Ownership ($)	$105,188	$153,118
Annual GHG Emissions (MTCDE)		39.74
Annual Proxy Carbon Costs		$2,851
Sealing Outcomes		
Total Cost of Ownership	$105,188	$153,118
Net Present Value (NPV)	$18,729	$28,368
Annual GHG Savings (MTCDE)		7.99
Cost of Carbon Savings ($/MTCDE)		($172.44)
Simple Payback Analysis		
First Year Utility Savings	$1,417	$1,990
Simple Payback Period (Years)	1.43	1.02
First Year Return on Investment	70.1%	98.5%
Life Cycle Cost Metrics		
Discounted Payback Period (Years)	1.50	1.06
Adjusted Internal Rate of Return	71.0%	99.9%

Cummulative Net Present Value Of Savings Over Time

Note: discounted payback occurs at the last point the line crosses the x-axis.

Figure 10 Sample output for a building insulation project – air sealing of doors and windows and other gaps.

The second retrofit option is a much deeper retrofit that will result in greater energy savings over time, but a higher initial cost. To seal the building and to insulate the walls would reduce the annual consumption of steam to 428 Mmbtu, reduce annual costs relative to the baseline by $2,846, and reduce carbon emissions by 16 MTCDE. Sealing the building and insulating the walls of Washburn House has an estimated initial cost of about $13,570. Selecting this option would save $28,120 over a 20-year period without considering carbon costs. The savings rise to $47,488 when proxy carbon costs are included. The discounted payback without the proxy carbon price is about 5.3 years, [discuss relationship to any Facilities payback period metrics at your institution]. Applying the proxy carbon price reduces the discounted payback period to less than 4 years, [discuss relationship to any Facilities payback period metrics at your institution].
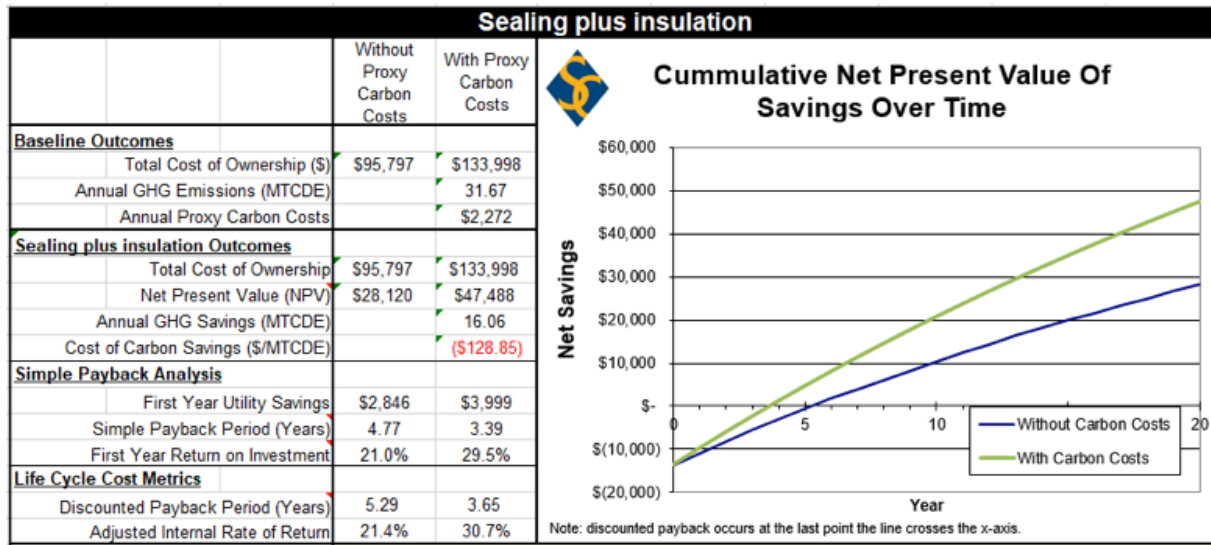
Sealing plus insulation

	Without Proxy Carbon Costs	With Proxy Carbon Costs
Baseline Outcomes		
Total Cost of Ownership ($)	$95,797	$133,998
Annual GHG Emissions (MTCDE)		31.67
Annual Proxy Carbon Costs		$2,272
Sealing plus insulation Outcomes		
Total Cost of Ownership	$95,797	$133,998
Net Present Value (NPV)	$28,120	$47,488
Annual GHG Savings (MTCDE)		16.06
Cost of Carbon Savings ($/MTCDE)		($128.85)
Simple Payback Analysis		
First Year Utility Savings	$2,846	$3,999
Simple Payback Period (Years)	4.77	3.39
First Year Return on Investment	21.0%	29.5%
Life Cycle Cost Metrics		
Discounted Payback Period (Years)	5.29	3.65
Adjusted Internal Rate of Return	21.4%	30.7%

Cummulative Net Present Value Of Savings Over Time

Note: discounted payback occurs at the last point the line crosses the x-axis.

Figure 11 Sample output for a building insulation project – air sealing of doors and windows plus insulation.

The proxy carbon life cycle cost calculation indicates that both retrofit options to seal the floors and insulate the windows have a total cost of ownership over a 20-year period that is less than the baseline because the savings in steam heat outweigh the upfront retrofit costs. The cost breakdown graph illustrates the 20-year total cost of ownership for each of the three options.
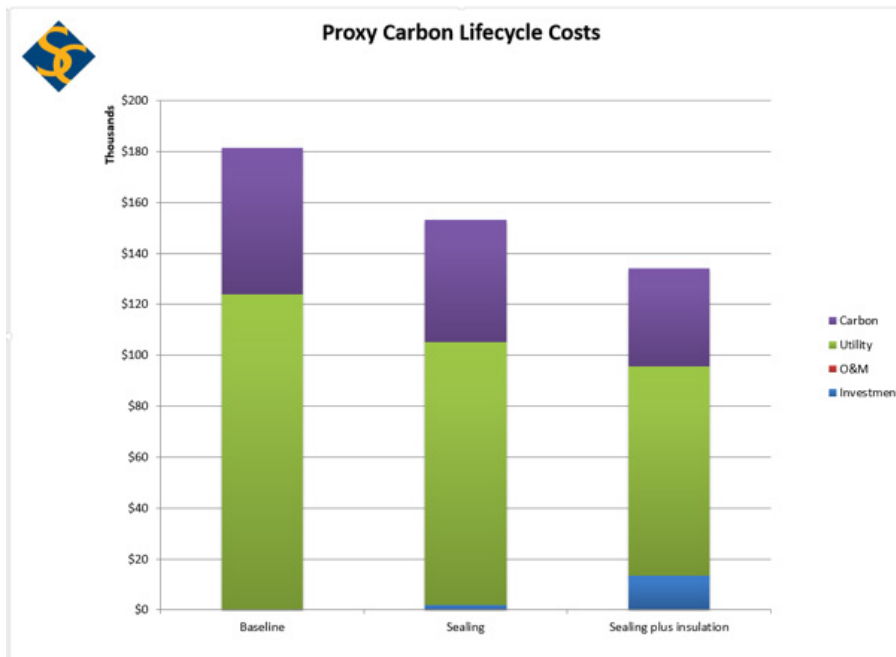

Figure 12 Sample total costs for a building insulation project.

The life cycle cost analysis, independent of the proxy carbon price, demonstrates a lower TCO for the two energy-saving retrofit options with respect to the baseline. The proxy carbon price also reduces the discounted payback period for both retrofit options.

Wrapping Up

Once you have analyzed your project with the tool, be sure to note which option you selected and, if it was not the one favored by the lowest total cost, note why you selected a different option. Be sure to save an archive copy of your analysis in the designated repository: [INSERT LOCATION]. Archiving past analyses is critical to understanding how well this process is working and can be used in research by students and faculty.

Acknowledgements

Thanks to the Smith College facilities and finance staff who provided input during the development of this tool. The tool design draws heavily on the Harvard Lifecycle Costing calculator available at https:// green.harvard.edu/topics/green-buildings/life-cycle-costing and the glossary has been adapted from their documentation. If you have feedback on this guide, please contact abarron@smith.edu.

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Glossary

These definitions were adapted from the Harvard Life-cycle Cost Calculator. Some of the definitions were modified for simplicity.

Adjusted Internal Rate of Return The Internal Rate of Return is similar to the Return on Investment, except that it accounts for all 20 years of the study period instead of only the first year. It examines the net escalated but undiscounted cash flows resulting from comparing the Baseline and an option case for each year:

(BASE Year Labor Costs + BASE Year Material Costs + BASE Year Utility Costs)—(ALT Year Labor Costs + ALT Year Material Costs + ALT Year Utility Costs)

As this measure compares the undiscounted cash flow, it is useful in determining the Discount Rate at which an option is revenue neutral compared to the Baseline. For example: assuming a Discount Rate of 4%, if an Alternate had an IRR of 4%, then the resulting 20-year NPV would equal $0. If the IRR is higher than the Discount Rate, then the project is NPV positive (i.e. it earns more money over 20 years compared to the an investment earning 4% a year). If the IRR is less than the Discount Rate, then the project is NPV negative (i.e. it earns less money over 20 years compared to an investment earning 4% per year).

Discounted Payback Period (years) This metric is similar to the Simple Payback Period in that it describes the amount of time it would take in years for the savings of Option A case to pay for the investment compared to the Baseline case. Unlike the Simple Payback Period, it factors in escalation and the

discounted value of each option. This is generally viewed as a more accurate representation of the length of time a project will become cost-neutral than the Simple Payback Period.

For projects that include a Baseline and an Alternate case with ongoing material or labor expenses—most projects—this cell refers you to the "Net Present Value Over Time" graph. The reason for this is that there may not be a single period in which the project becomes cost neutral, since material or labor expenses in later years may cause the Alternate to become NPV negative more often than once. If this is the case, the discounted payback period is the latest year that the line crosses the x-axis on the chart.

First Year GHG Savings This is the difference between the Baseline and Option A emissions stemming from utility consumption presented in Metric Tons of Carbon Dioxide Equivalent (MTCDE). The emission factors for each utility type can be found on the "Prices and GHG Details" tab. Emissions factors are assumed constant over the study period and are not escalated or discounted in any form.

First Year Return on Investment (%) The ratio of the first year savings divided by the difference in costs between the Baseline and an Option. This is the inverse of the Simple Payback Period. All prices are assumed constant, and maintenance, repair, and replacement material costs not included in the initial investment are not considered.

First Year Utility Savings The sum of the costs of each utility consumed by the Baseline minus the sum of the costs of each utility consumed by an option in a single year.

Simple Payback Period (Years) This metric examines only initial year costs and savings, and determines how long in years it would take for the initial investment to be repaid from utility savings. It assumes all prices would hold constant (i.e. there is no escalation of rates or discounting to present value). *Maintenance, repair, and replacement material costs not included in the initial investment are also not considered.*

20 Year Total Cost of Ownership (Variable Rates Only) This is the total cost to own an option over 20 years, escalated as appropriate and then discounted as appropriate. This is what it will cost to install, operate, and maintain the option over 20 years.

20 Year Net Present Value This is the total savings, in present dollars, for an option as compared to the Baseline. If this is positive, the option is less expensive to own when compared to the Baseline. If this is negative, the option is more expensive to own than that Baseline.

Appendix: Data Worksheet

COSTS	Unit	Baseline	Option A	Option B
Initial Total Cost	$			
Incentives	$			
Replacement Cost (if different from initial total cost)	$			
Expected Life	years			
Material one-time operating costs	$			
Labor one-time operating costs	$			

ANNUAL CONSUMPTION	Unit	Baseline	Option A	Option B
CHP Electricity (onsite)	kWh			
ISO-NE Electricity*	kWh			
Natural Gas	MMbtu			
Smith College Steam	MMbtu			
Smith College Chilled Water	Gallon			
Northampton Water/ Sewer	ccf			
Fuel Oil #4	Gallon			
Fuel Oil #6	Gallon			
Transportation Gasoline	Gallon			
Transportation Diesel	Gallon			

*Note: Absent a detailed analysis, assume a project will reduce purchased electricity.