RMI LCCA Tool
User's Guide

version 0.92

1820 Folsom Street | Boulder, CO 80302

303.245.1003 | www.rmi.org

October 2010

1 ACKNOWLEDGEMENTS

The RMI LCCA Tool was developed with funding from Rocky Mountain Institute's Commercial Building Retrofit Initiative. The following staff at Rocky Mountain Institute were involved in its development:

Aaron Buys, Lead Developer
Kendra Tupper, Project Manager
Caroline Fluhrer, Content Support

Additional thanks to all beta testers for their valuable feedback.

2 TABLE OF CONTENTS

3 OVERVIEW

3.1 ABOUT

This life cycle cost analysis tool was designed to be used by building design professionals (architects, engineers & energy modelers) who have little or no previous experience with financial analysis. The goals in its development were:

1. **Transparency** – Make it as clear as possible how the financial calculations are being done. This has been accomplished by keeping the tool open source. The user can see all the in-cell calculations, as well as all of the user-defined functions and sub-routines that are used.
2. **Simplicity** – Make it easy enough to do that someone with no prior LCCA experience can use the tool. This has been accomplished by utilizing a step-by-step method in which the user starts with the basics and moves on to more detailed information.
3. **Flexibility** – Give users experienced in LCCA the ability to modify and adapt the tool as they see fit. This is done by creating an open source tool within a framework with which most design professionals are familiar – Excel.

3.2 COMPATIBILITY AND SAVING THE FILE

The tool was developed in Microsoft Windows XP SP3 using Office 2007. The file has been saved down to Excel 97-2003 compatibility to provide greater usability. All efforts have been made to avoid compatibility errors, but because the program uses VBA sub-routines, problems may occur due to library locations. These problems occur when Excel is updated and the path of a VBA library is changed. This can be fixed by correcting the path by going to the VBA editor (Alt+F11), choosing Tools/References, selecting the library which has been modified and browsing to find the correct path.

Additionally, when using Excel 2007, the workbook must continue to be saved as 97-2003 compatible (.xls) as opposed to a 2007 version (.xlsx).

3.3 OTHER TOOLS AND EDUCATIONAL MATERIALS

This tool was developed by Rocky Mountain Institute (RMI) in conjunction with several other software tools and educational materials with the same goal in mind. These other tools and materials include:

- A full day energy modeling training workshop covering modeling fundamentals, best practices for quality control, use of the 90.1 Performance Rating Method, and strategies for effectively utilizing energy modeling throughout the building life cycle.

- Content development for the BEMbook energy modeling wiki hosted by the International Building Performance Simulation Association (IBPSA) located at http://bembook.su-per-b.org/index.php?title=Main_Page
- A DOE-2.2 model manager, which streamlines parametric runs in DOE-2.2 based modeling software
- EMIT (Energy Model Input Translator), which translates typical design data into energy model input data.

The LCCA tool along with current and future tools can be found at http://www.rmi.org/rmi/EMIT-LCCA-ModelingTools.

4 GUIDE TO LCCA STEPS

The tool is structured in a step-by-step manner. The following is a description of each step with some tips and tricks along the way. See section 5 for a glossary of terms.

4.1 STEP 1: PROJECT INFO

The first step involves entering basic information about the project for which you are performing an LCCA. When you click "Step 1: Project Info", the form in Figure 1 appears. The following information is required at this time:

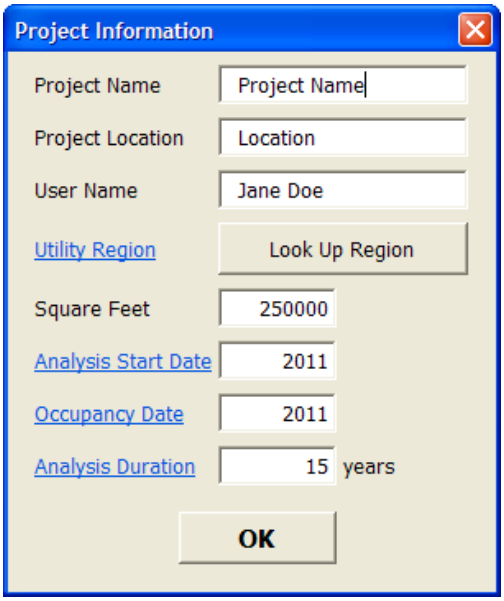

Figure 1. Step 1: Project Information Form

Project Name: The name of the project, which will appear on output reports.

Project Location: The location of the project, which will appear on output reports.

User Name: The user may enter their name, which will appear on output reports.

Utility Region: The user can click "Lookup Region" and will have the option of either entering a zip code or choosing from a list of regions on a map of the United States. These regions are defined by the EPA eGrid program (www.epa.gov/egrid) and are used to determine the equivalent CO_2 emissions due to electricity production in the region.

Square Feet: The total square footage of the building for which the analysis is being done. Information is for output report purposes only, although it may be reference in any cell by using the variable name *ProjectArea*.

Analysis Start Date: The year in which your analysis starts. This is typically the year in which construction begins, although may be any year the user chooses.

Occupancy Date: The year in which the building is first occupied. This date is used as a default for the start of utility use, and has no effect on the calculations.

Analysis Duration: The length of the analysis period. This value may be any number from 1 to 50 years. The duration starts at the analysis start date, so if the analysis must be 25 years from the start of occupancy and construction lasts for 2 years, then this value should be 27 years.

Once all the information has been entered, click OK and move to step 2.

4.2 STEP 2: GLOBAL INPUTS

This step is where discount, inflation and escalation rates are entered. See the glossary for more information on these. In addition, the user selects which utilities will be used in the analysis and can adjust the CO_2 emission rates for each utility. When the user clicks "Step 2: Global Inputs" the form in Figure 2 pops up.

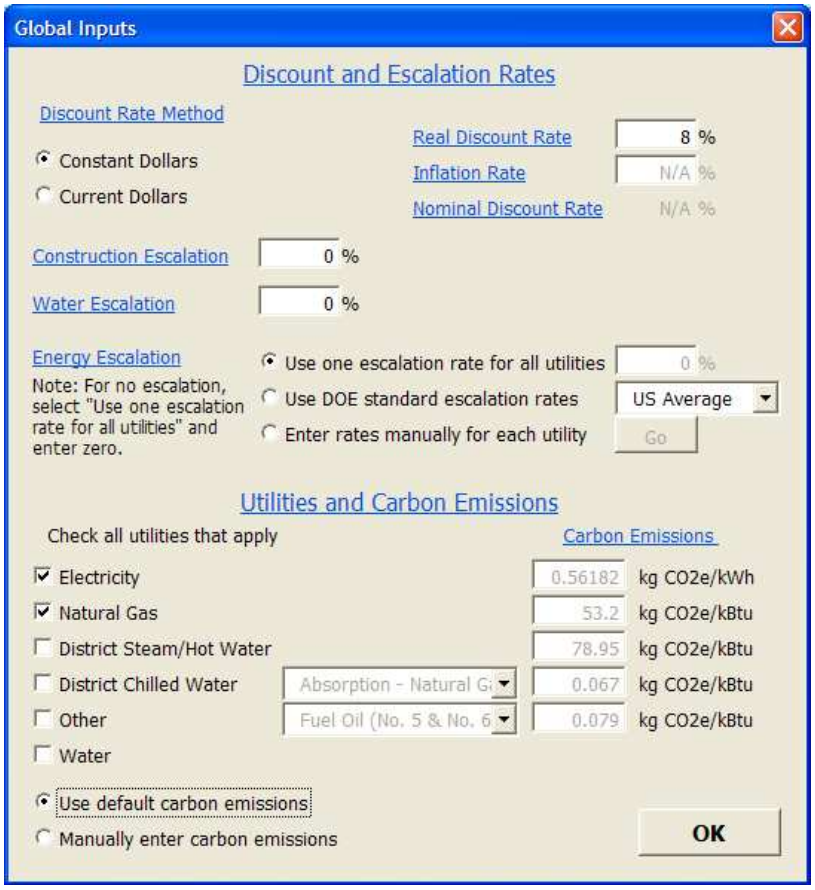

Figure 2. Step 2: Global Inputs Form

In this form, the user may enter the following information:

Discount Rate Method: The user chooses either constant dollars or current dollars. The constant dollar method ignores inflation, while the current dollar method accounts for inflation.

Real Discount Rate: The real discount rate is the rate at which future costs are discounted to the present. If constant dollars are chosen, the real discount rate is equal to the nominal discount rate. This rate is typically set by the project's owner/funder as a targeted rate or return.

Inflation Rate: The inflation rate is the rate at which the price of goods and services increases annually. This rate is only used when current dollars are selected. The nominal rate is then calculated using the following equation:

$$n = (1+d)(1+i) - 1 \qquad \textbf{Equation 1}$$

where n is the nominal discount rate, d is the real discount rate and i is the inflation rate. The nominal rate is the rate used in the workbook to discount all cash flows to present dollars.

Escalation Rates: Escalation rates are rates at which the price goods and services increase annually above inflation. This tool lets you account for escalation of capital costs (construction escalation) and utilities. DOE projected escalation rates for energy sources are built in and may be used by selecting the "Use DOE standard escalation rates" radio button and selecting the state where the project is located from the drop down list to the right.

Utilities: The user should select from the list all utilities to be analyzed. Only selected utilities will show up on forms in following steps.

Carbon Emissions: You may choose to use the default carbon emission factors, which are based on EPA data, or you may choose to enter your own custom rates.

After completing step 2, click OK and go to step 3.

4.3 Step 3: Baseline Utility Data

Step 3 is the first instance where energy model outputs or other energy use data is required. In this step, utility use and cost data must be input for the baseline building. The baseline should be carefully defined to provide the most insightful benchmark for the energy efficiency measures. For new buildings, the baseline may be an ASHRAE 90.1 compliant building. For an existing building, the baseline may be current utility use and costs.

When the "Step 3" button is clicked, the form in Figure 3 appears.

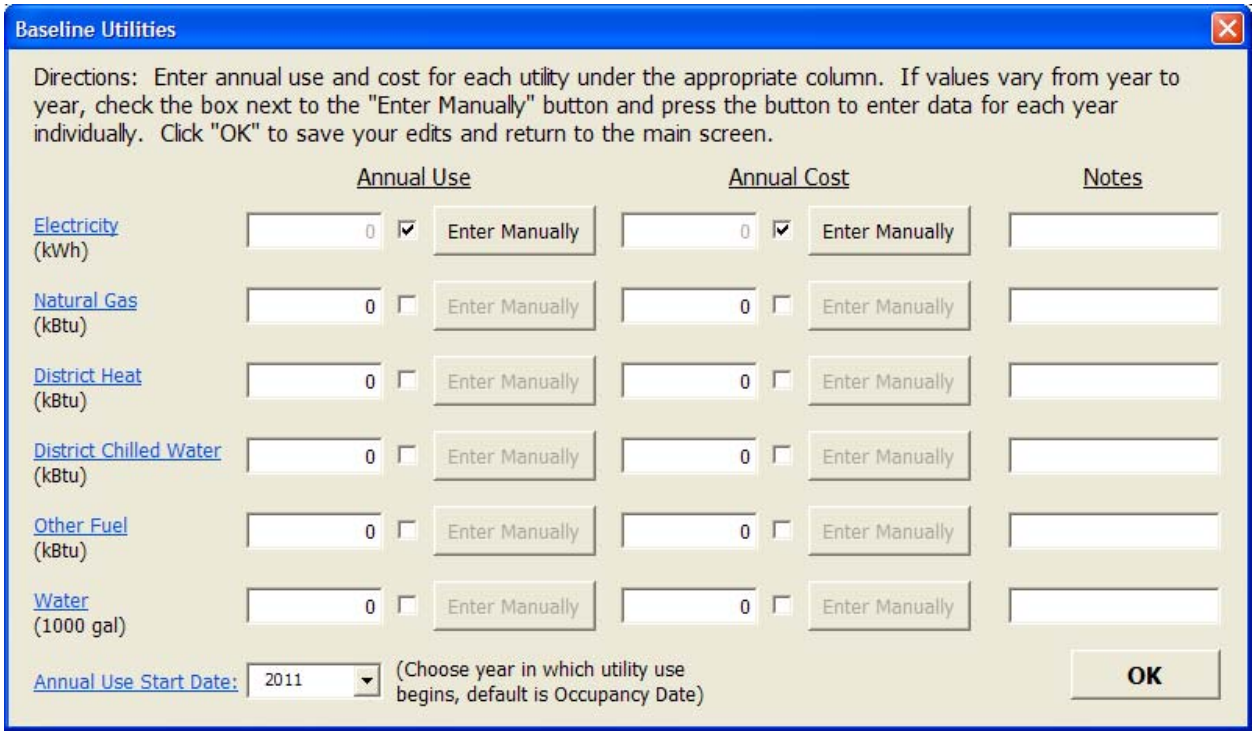

Figure 3. Step 3: Baseline Utility Data Form

This form allows you to edit the annual use and cost for each utility, as well as add notes on the data. If the annual use or cost is not constant over the life of the building, you may click the check box next to the input box and click the adjacent "Enter Manually" button to enter the data for each year separately. The manual entry option is available for most data inputs in the tool. When the button is clicked, the form in Figure 4 appears.

The manual entry form is automatically populated with one input box for every year of the analysis period. You can enter the values for each year separately, or you may use the default value function located in the lower right corner to populate every box with a default value and then change only the years that deviate from the default. When you are done, click the save button to return to the baseline utility form.

You can also choose the year in which the utility data should begin (**Annual Use Start Date**). This input gives you the opportunity to delay the utility use while the building is under construction. This value defaults to the **Occupancy Date** entered during Step 1: Project Information.

Once you have entered baseline values for each applicable utility, click OK and continue to step 4.

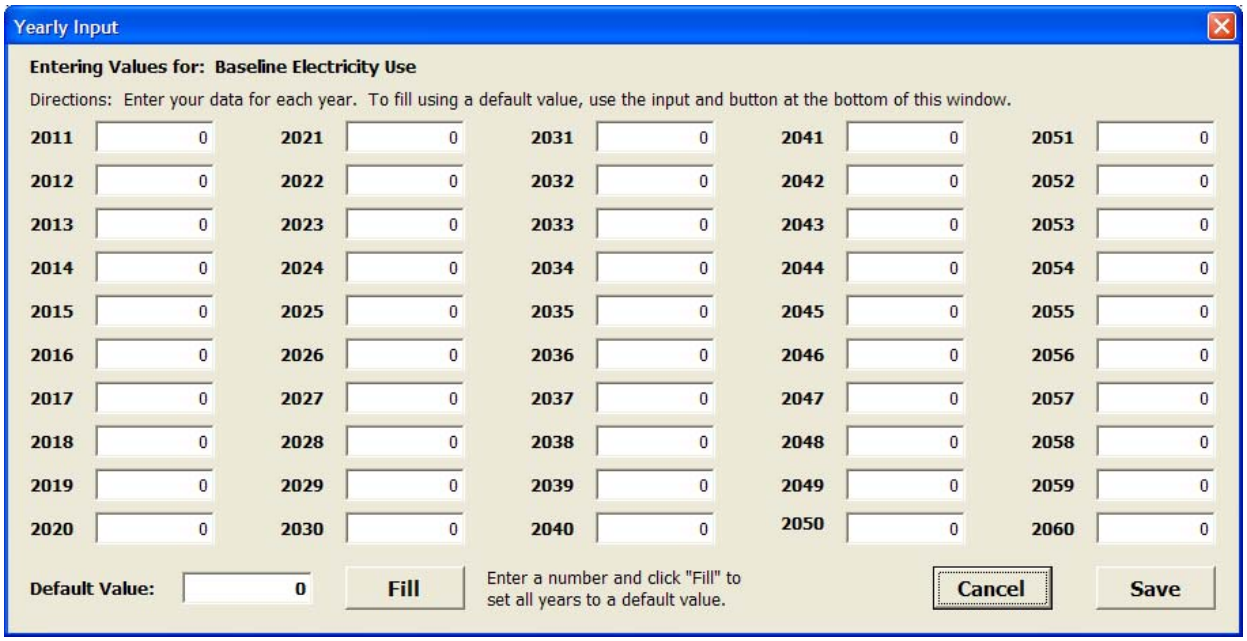

Figure 4. Manual Entry Form

4.4 Step 4: Add/Edit/Delete Measures

Step 4 is where you enter all energy efficiency measures for the project. Start by clicking the "Step 4: Add/Edit/Delete Measures" button. From here you may choose to add, edit or delete a measure. Each of these options is described in detail below.

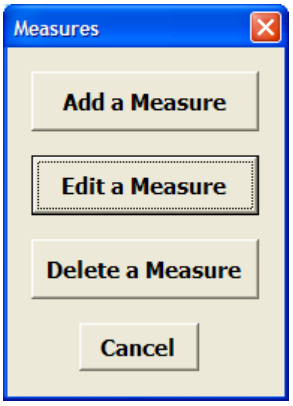

Figure 5. Add/Edit/ Delete a Measure

4.4.1 Adding a Measure

When you select "Add a Measure," you will be prompted to enter a name for the measure along with any notes and a description of the baseline for the measure (see Figure 6).

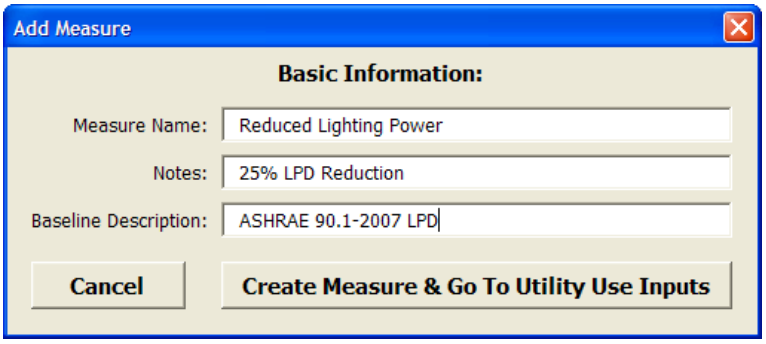

Figure 6. Add Measure Form

After entering this information, click "Create Measure". The tool will automatically add an entry in the "Measure Data" tab for the measure you have just created and a form will pop up for you to enter utility data for the measure. This form is nearly identical to the form in Figure 3 and requires all of the same data.

Utility data entered in this form should be absolute utility use and cost for the measure, not utility savings for the measure.

The next step is entering capital and marginal costs for the measure (see Figure 7).

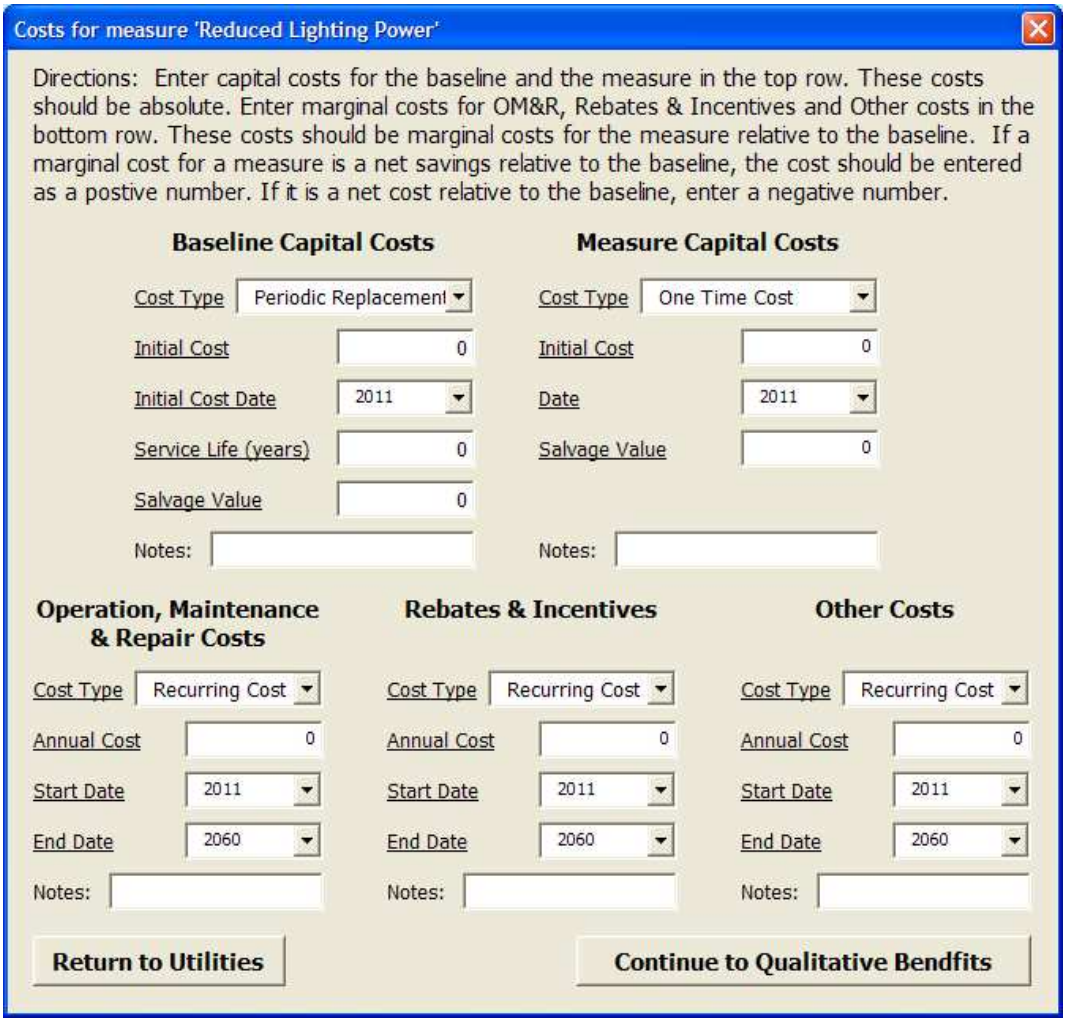

Figure 7. Measure Costs Form

The two costs in the top row are absolute capital costs for the baseline and measure:

Baseline Capital: Baseline capital costs include the equipment and installation costs for the baseline system which the measure is intended to replace. The simplest option for entering capital cost is the "One Time Cost" option. Simply enter the initial cost, adjust the date the cost is incurred if necessary and enter any salvage value.

If the baseline system's expected life is less than the length of the study, be sure to account for replacement by selecting the "Periodic Replacement" option in the Cost Type drop down. You may also copy baseline costs from a previous measure by selecting "Copy from Previous" under Cost Type.

Measure Capital: Measure capital costs include all equipment and installation costs for the measure itself. All of the same options from the **Baseline Capital** input are available for measure capital except "Copy from Previous".

The next three costs in the bottom row are marginal costs for the measure relative to the baseline. This means that costs should be entered as either positive or negative numbers depending on whether the measure results in a net savings or net cost relative to the baseline.

Operation, Maintenance & Repair (OM&R): OM&R costs should account for any difference in planned equipment operating, maintenance or repair budgets between the baseline and measure.

Rebates & Incentives: Rebates & Incentives include any tax credits or utility rebates that are associated with implementing the measure. A useful database for these incentives can be found at http://www.dsireusa.org/.

Other Costs: This is a catch-all category for the user to enter any costs that do not fall under any of the previous categories. At this time, there is not an option to create additional cost categories, so all miscellaneous costs should be summed up and entered under this category.

Once you have completed the costs, click "Continue to Qualitative Benefits" to move on to the final step of the "Add a Measure" process. This will take you to the Qualitative Benefit form (Figure 8).

Qualitative benefits are advantages of measure to which a quantitative dollar amount cannot be assigned. This form affords you the opportunity to record these advantages for consideration. Four common benefits are listed for you, but you may also record your own in the space below. These benefits are often ignored in a conventional LCCA because they cannot be incorporated into typical financial metrics. However, they could be the deciding factor between two measures with similar metrics.

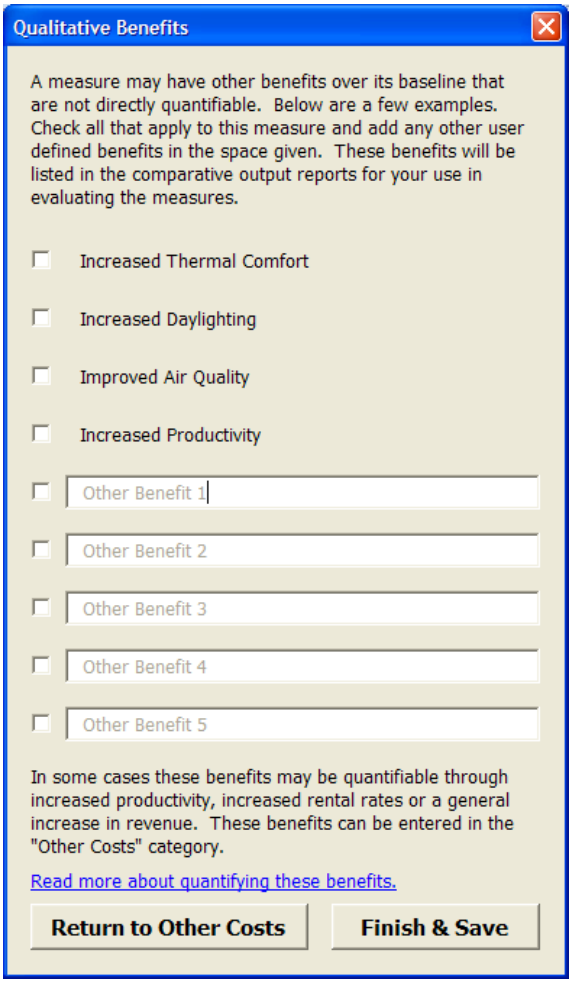

Figure 8. Qualitative Benefits Form

Once the qualitative benefits have been entered, click "Finish & Save".

4.4.2 Editing a Measure

Now that you have created a measure, you may wish to edit it. When you select "Edit a Measure" you will be asked to select a measure to edit from the list of measures that have already been created. Once you have selected a measure, you will see the form in Figure 9.

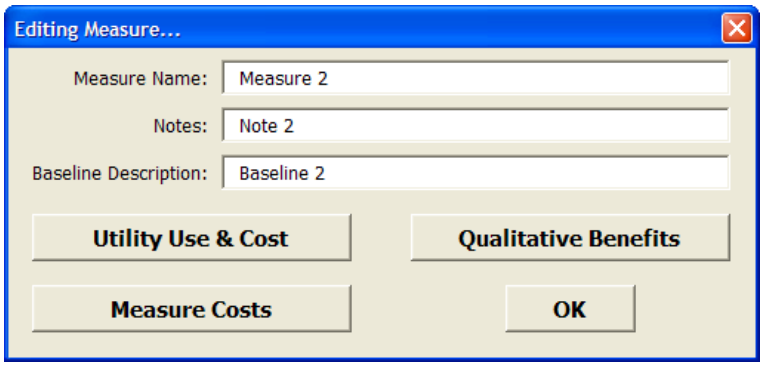

Figure 9. Edit Measure Form

From this dialog box you may edit the measure name, notes and baseline description. You may also choose to edit the utility data, costs or qualitative benefits by clicking on the buttons at the bottom of the window. Clicking any of these three buttons will bring up the same forms which were used to add the measure.

You may also edit measure data directly in the "Measure Data" tab, or you may edit measure name, notes and baseline description in the "Measure Summary" tab.

4.4.3 Deleting a Measure

You may need to delete a measure during your analysis. To do so, select "Delete a Measure" from the Add/Edit/Delete dialog box. Select the measure you wish to delete from the dialog box that appears. You will be asked to confirm that you want to delete the measure. If so, select "Yes" and the measure will be deleted. Be careful when deleting a measure, because there is no way to retrieve the measure once it has been deleted.

4.5 Step 5: Measure Output Reports

After entering your efficiency measures, you may want to compare measures or look at a summary of financial indicators for a specific measure or measures. This step gives you the option to view or create five different reports:

Cash Flow vs. Time: This report gives you the opportunity to plot discounted cash flow over the analysis period for any combination of measures. The plot shows the

accumulated net present value for each measure at each year. See Figure 10 for an example.

NPV Bar Graph: This report compares the NPV of selected measures on a bar graph. See Figure 11.

NPV vs. Carbon Reduction: This report plots the NPV for each selected measure against that measure's total carbon reduction. The best location for a measure on this graph is toward the upper right (maximum NPV with maximum CO_2 reduction). See Figure 12.

Summary LCC (FEMP Standard): This is a text report designed to mimic the summary LCC report from the BLCC5 software. See Table 1 for an example.

Measure Financial Metrics: This report is a summary for all measures of typical financial metrics such as net present value, discounted payback period, savings to investment ratio and adjuster internal rate of return. In addition, energy and CO_2 savings are also listed. See Table 2.

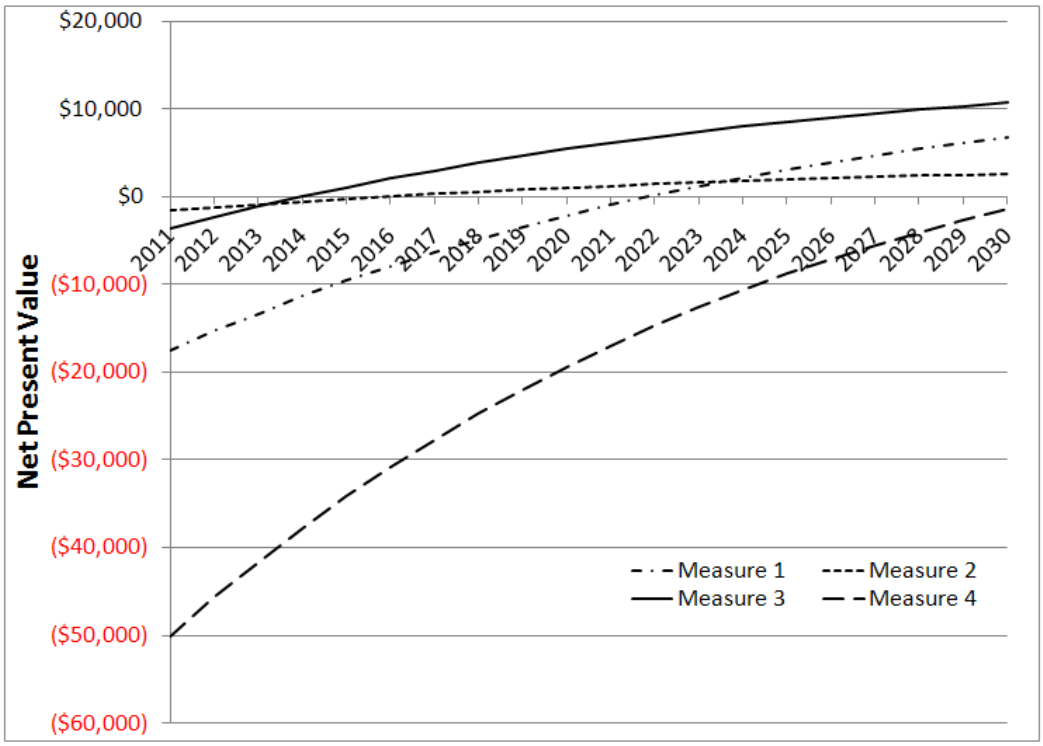

Figure 10. Cash Flow vs. Time Example

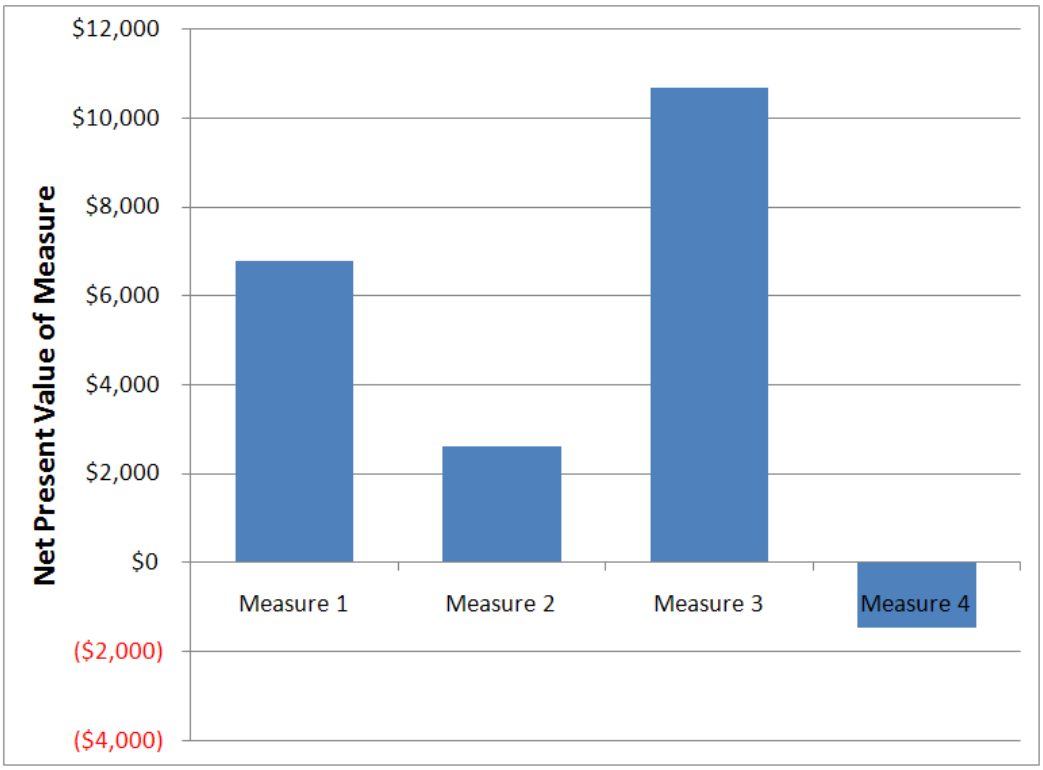

Figure 11. NPV Bar Graph Example

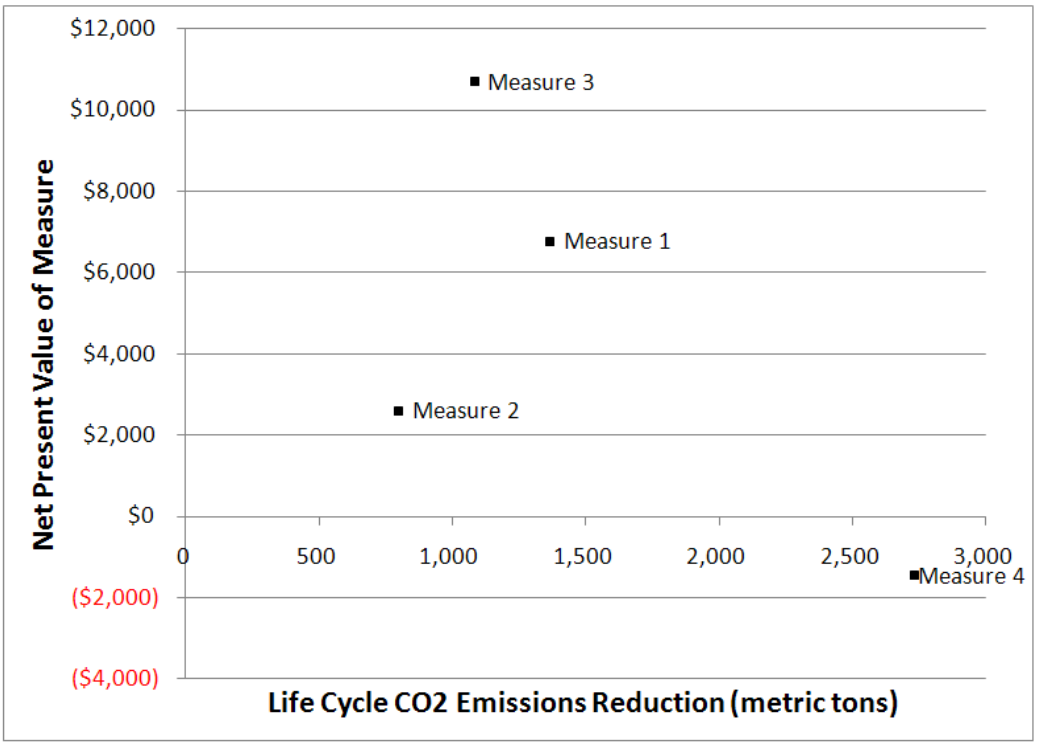

Figure 12. NPV vs. Carbon Reduction Example

Table 1. Summary LCC Example

Project Name:	Project Name	**Discount Rate:**	8%
Project Location:	Location	**Inflation Rate:**	N/A
User Name:	Jane Doe	**Nominal Rate:**	8%
		Escalation Type:	DOE/NIST
Base Year:	2011		
Occupancy Date (Service Date):	2011		
Study Length:	20 years		

Measure 1			
Notes:	Note 1		
Baseline Description:	Baseline 1		
	Present Value	**Annual Value**	**Qualitative Benefits:**
Baseline Initial Capital Costs	$50,000	$5,093	
Baseline Salvage Costs	$0	$0	
Measure Initial Capital Costs	($70,000)	($7,130)	
Measure Salvage Costs	$0	$0	
Net Measure Energy Costs	$26,775	$2,727	
Net Measure Water Costs	$0	$0	
Net Measure OM&R Costs	$0	$0	
Net Measure Rebates & Incentives	$0	$0	
Net Measure Other Costs	$0	$0	
Total	$6,775	$690	

Table 2. Measure Financial Metrics Example

Measures	Notes	Baseline Description	Net Present Value	Discounted Payback Period	Savings to Investment Ratio	Adjusted Internal Rate of Return	Energy Use Reduction		CO2 Emissions Reduction	
							MMBtu	%	Metric Tons	%
Measure 1	Note 1	Baseline 1	$6,775	11.88	1.339	9.87%	1365.2	15.47%	224.73	18.27%
Measure 2	Note 2	Baseline 2	$2,604	5.93	2.302	13.63%	800.0	9.06%	42.56	3.46%
Measure 3	Note 3	Baseline 3	$10,689	3.98	3.138	16.13%	1082.6	12.27%	133.64	10.87%
Measure 4	Note 4	Baseline 4	($1,450)	NEVER	0.974	7.83%	2730.4	30.94%	449.46	36.54%

4.6 STEP 6: ADD/EDIT/DELETE BUNDLES

A bundle is a combination of individual energy efficiency measures. The purpose of bundling is to evaluate the synergistic benefits of measures. This practice supports integrative design and allows for more cost-effective measures to absorb the cost of measures that do not "pay for themselves," leading to a more efficient design with more qualitative benefits. Bundling measures also often leads to downsizing mechanical systems because a specific collection of measures can greatly reduce heating and cooling loads.

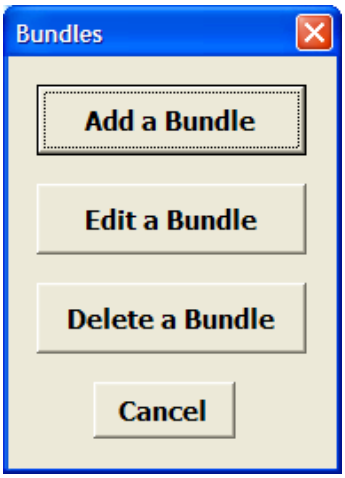

Figure 13. Add/Edit/ Delete a Bundle

When you click on "Step 6: Add/Edit/Delete Bundles," you will see the dialog box in Figure 13. To create a bundle, click "Add a Bundle" and you will see the Add a Bundle form (Figure 14).

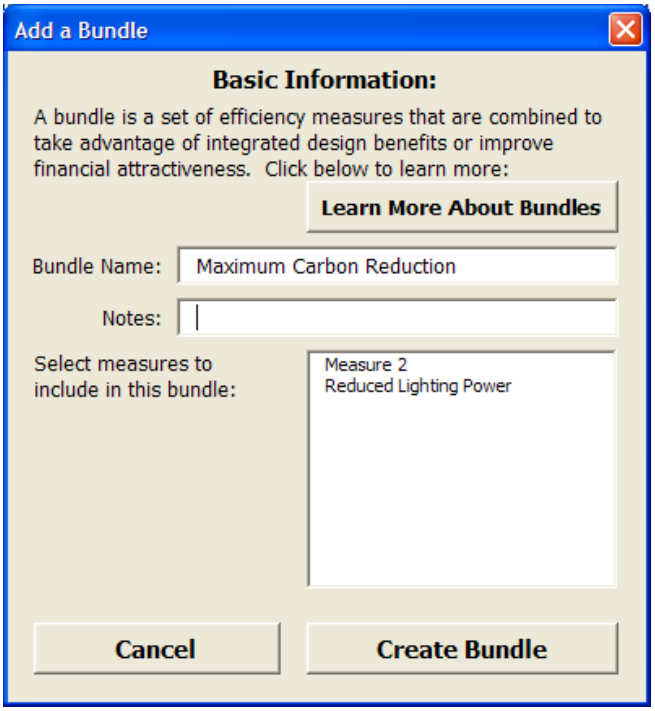

Figure 14. Add a Bundle Form

From this form, you may name the bundle and insert any notes. Then, select all the measures you would like to bundle and click "Create Bundle." A bundle will be created by summing up all costs from each measure in each category. This process assumes that no measures interact with each other – that is, all savings from each measure are fully realized when the measures are combined.

Of course, this assumption is not necessarily true. As mentioned above, oftentimes the mechanical systems can be downsized when several measures are combined. Therefore, after making a preliminary bundle of measures, you should resize the mechanical systems, and re-evaluate the energy operating cost savings and capital cost of the bundle. This re-evaluation will not require as much as effort as was required to create the initial estimates, because you can combine measures with relative ease using parametric runs in energy modeling software and revise the initial cost estimates without much added effort.

Once you have created your bundles, you may edit and delete them in the same manner in which measures are edited and deleted. See Section 4.4.2 and 4.4.3 for details on these processes.

4.7 Step 7: Bundle Output Reports

Once you have created your bundles, you may create the same reports as are available under step 5. See Section 4.5 for a summary and examples of these reports.

4.8 Step 8: Sensitivity Analysis

This function is not yet available.

5 Glossary

The following is list of terms used in the tool and their definitions or descriptions.

Utility Region: For projects inside the United States, enter the four-letter eGrid acronym for the region where the building is located. Click "Show Map" for a map of all U.S. regions. For projects outside the United States, enter the name of the country where the building is located. This input will inform the default carbon emissions values used in the analysis.

Analysis Start Date: This is the year in which the first cash flow of any type (usually capital cost) will occur. Note that this year will also be the reference year if constant dollars will be used.

Occupancy Start Date: Enter the year in which the building will first be occupied. This can also be thought of as the analysis start date plus the expected construction time. This date is used as a default start date for annual costs for energy, but otherwise has no effect on the analysis.

Analysis Duration: Enter the length over which the life cycle cost analysis will be conducted (e.g. the number of years for which you want to account for cash inflow or outflows). For federal projects, this is 40 years from occupancy (per EISA 2007). For private sector projects this typically ranges from 5 – 15 years. Because this is such a critical input, it should be discussed with and agreed upon by the client project manager.

Discount Rate Method: For the analysis, you can choose if you'd like to use "constant dollars" or "current dollars." If you choose constant dollars, the value of a dollar is kept constant throughout the analysis. This means the analysis will not account for inflation and a real discount rate will be used. If you choose current dollars, the value of the

dollar changes over time to account for inflation. If this option is selected, a nominal discount rate will be used.

As an example, if the analysis is done using constant dollars, everything will be in the reference year (e.g. 2011) dollars. Thus, a chiller that might cost $500k in 2010 will also cost $500k in 2011 dollars in 2015 (unless you think the actual cost of the item will change above or below inflation). If the analysis is done in current dollars, the chiller will cost say $537k in 2015 in 2015 dollars (due to inflation).

Because the LCC method discounts everything back to the present year, the use of constant versus current dollars will not affect the total LCC, though it will affect the SIR and IRR values. Thus, this is an input that should be discussed with the client project manager, as some clients will prefer to include inflation and some will not.

It should be noted that inflation is not the same as the time value of money. Even if inflation is ignored in the analysis, $10 today is still worth more than $10 five years from now. This is because you could take that $10 today, invest it, and have more than $10 in five years. If you received the $10 in five years, you would have no opportunity to have more than $10. Thus, money is always worth more today than tomorrow. This fact is accounted for by the real discount rate.

Real Discount Rate: The real discount rate is the rate at which future costs are discounted to the present. Essentially the real discount rate accounts for the time value of money (that money today is worth more than money tomorrow). For example, at a real discount rate of 5%, a cost of $100 incurred in 2012 would equal $95 in 2011, and a cost of $100 incurred in 2013 would equal $90.25 in 2011 ($100*(1-.05)^2$). If you chose constant dollars as your discount rate method, which means you are excluding inflation, then you need only enter a real discount rate. If you want to include inflation, you should use the nominal discount rate.

Nominal Discount Rate: If you chose current dollars as your discount rate method, then the nominal discount rate will be used to account for both the time value of money and for inflation when calculating present value. This number is automatically calculated from the real discount rate and the inflation rate according to the formula:

$$d_{nominal} = (1 + d_{real}) \times (1 + i) - 1$$

Inflation Rate: If you chose current dollars as your discount rate method, you must enter an inflation rate. The inflation rate is the average rate at which the purchasing power of a unit of currency decreases each year. For example, at an inflation rate of 1%, $100 in 2011 equals $101.01 in 2012 equals $102.03 in 2013.

Construction Escalation: The rate at which real construction costs increase each year above and beyond inflation. For example, if you know steel prices are headed up or that

there will be a shortage for the next 3 years for wind turbines, you should account for that here.

Water Escalation: The rate at which the real cost of water increases each year. Because the cost of utilities does not generally match general inflation, this is the If you chose constant dollars as your discount rate, then this should be a real rate. Otherwise it should be a nominal rate.

Energy Escalation: The rate at which real energy costs increase each year. This rate can be constant for all utilities, constant at different rates for each utility or vary annually by utility. NIST releases energy price forecasts for the next 30 years for several different energy sources in their annual supplement to Handbook 135.

Utilities and Carbon Emissions: In this section, check the boxes next to each utility that you would like to account for in your analysis. If necessary, select the type of utility.

Carbon Emissions: This is understood as the carbon content of each utility, in appropriate units. It is recommended to use the default carbon emissions, which are provided by the EPA and EIA. However, if you know the carbon emissions for your area and wish to enter them, you may do so.

Baseline Utility Use: The baseline utility use is the consumption of utilities for your baseline building. Examples of a baseline building include historic utility data, an ASHRAE 90.1-2007 building energy model, a baseline model that meets federal requirements for fossil fuel requirements, or specific baseline systems. It is up to you to define your baseline building and ensure that all alternatives correctly reference that building.

Measure Utility Use: On the following forms that allow you to enter information for individual energy efficiency measures, you should enter information as if just this one measure and no other measures were implemented. Later, in the process you can choose to "bundle" measures together and adjust these inputs accordingly.

Electricity: Total annual electricity use for your baseline building in kWh. This can be taken from a building simulation model, determined from an energy model, or be based upon actual utility bills.

Natural Gas: Total annual natural gas use for your baseline building in kBtu. This value should include natural gas used for heating, on-site electricity production (i.e. cogeneration), cooling (i.e. absorption chilling), cooking, or any other use.

District Heat: Total annual purchased district heat for your baseline building in kBtu. This should be entered as site energy. The default CO_2 emission factor for district heat adjusts for source efficiency.

District Chilled: Total annual purchased district cooling for your baseline building in kBtu. This should be entered as site energy. The default CO_2 emission factor for district heat adjusts for source efficiency.

Other Fuel: If other fuels such as heating oil, coal, or weapons grade plutonium are used in the baseline building, please enter them here.

Water: Total annual water use for your baseline building in US Gal/year.

6 FREQUENTLY ASKED QUESTIONS

What is this workbook for? This workbook is intended to assist project teams make recommendations about cost-effective bundles of energy efficiency measures that maximize energy savings through the application of life cycle cost analysis (LCCA).

What is LCCA? As defined by NIST, LCCA "is an economic method of project evaluation in which all costs arising from owning, operating, maintaining, and ultimately disposing of a project are considered to be potentially important to that decision."[1] Because LCCA considers all relevant cash flows over a specified period of time and accounts for the time value of money, it estimates the total cost-effectiveness of project alternatives better than simple payback or first cost.

How long does it take to do this analysis? Using this spreadsheet should only take a few hours. Collecting the necessary inputs, thinking about how to create bundles, and discussing outputs with clients typically takes weeks or months.

What kinds of outputs does it generate?

Provided with the necessary inputs, this spreadsheet will provide the life cycle cost, net savings (compared to other alternatives or a baseline), savings-to-investment ratio, adjusted internal rate of return, and simple payback for individual measures and for bundles of measures. The project team should determine the decision-making process and metrics prior to beginning the analysis.

What inputs are required?

Core inputs include energy use, energy cost, operations & maintenance costs, and capital costs. However, any other desired cost or benefit (e.g. rebates, increased revenue, white tag credits) can be included in the analysis. Because LCCA is useful in deciding amongst alternatives, these types of inputs will be required for each baseline or measure that will serve as an alternative.

[1] NIST Handbook 135, Section 1.1

7 REFERENCES

2007 ASHRAE Handbook-HVAC Applications