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Methodology to Adapt and Update a Life Cycle Cost Calculator for Your Institution: A Step-by-Step Guide

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Breanna Jane Parker and Dr. Alexander R. Barron, September 5, 2018

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Contents

Executive Summary

This guide provides a methodology for adapting a life cycle cost (LCC) calculator to your institution. An LCC calculator can be used to examine the present and future costs of any expenditure and can include a proxy carbon price in its analysis. Adapting an existing tool saves time and resources when compared to building from scratch. It also provides the most accurate information by accounting for specifics of context, such as energy costs and the greenhouse gas emission rates of energy sources, which vary by region.

This guide outlines a five-step process for adapting an LCC calculator to match your institutional context. Step one is identifying all assumptions and utilities that may be needed to complete a life cycle cost estimate (e.g. electricity, central plant steam). Step two is collecting the data for all identified utility rates and assumptions. Step three is preparing the tool for the data update. Step four is entering institutionally specific variables into the calculator. Step five is updating the tool with the best available data to maintain accuracy.

Selecting a Life Cycle Cost Calculator

Before starting to adapt an LCC calculator, it is a good idea to do see whether one already exists for the geographic region of your institution or for an institution with a similar energy delivery structure. For example, both Swarthmore and Smith College have developed tools with different regional values as inputs (the mid-Atlantic and New England, respectively). If an LCC calculator does not already exist for

your geographic region, then you can select an LCC calculator template to adapt. A publicly-available and open-source option especially suitable for large campuses is the Harvard Life Cycle Cost calculator, which can be found on their sustainability website and has the capacity to include a carbon price. The Smith College Proxy Carbon LCC Calculator, originally adapted from the Harvard tool, is simplified for institutions with a single central steam plant. It has also been revised to highlight carbon-related aspects of any decisions in its output, to allow adaptation to multiple comparison cases, and to allow easy exporting of data for later analysis.

Five-Step Adaptation Process

Step 1: Identify the Variables

The first step is to identify all of the variables that should be adapted to complete an LCC calculation. There are three types of variables within the calculator that should be adapted: fuel/utility costs, greenhouse gas emissions rates, and financial assumptions. Greenhouse gas emission rates result from the combustion of fossil fuels to produce utilities (e.g. steam, electricity). These are used to apply the proxy carbon cost. The financial assumptions are used to manage future costs by escalating costs and savings over time and then discounting them to the net present value. It is therefore necessary to identify both escalation and discount rates.

To identify the fuel and utility costs and emission rates, consider the sources of energy used to operate the institution. For simplicity, start with electricity and any major campus energy sources (e.g. central steam), then add other variables as needed. For a complete catalog of all fuel and utility costs and greenhouse gas emission rates, identify any sources that are purchased or produced on-site. For example, Smith College identified grid purchased electricity (from ISO-NE, the local electricity generating region), on-site electricity/on-site steam, fuel oil #2, fuel oil #6, water/sewer, chilled water, and transportation gasoline and diesel.

Financial assumptions are standard assumptions used to conduct financial analysis, plus any information used to implement an internal carbon price. The general assumptions for the LCC are discount and escalation rates of the identified fuel/utilities, as well as materials, maintenance, and labor. This would include any internal carbon price and the escalation rate for the cost of carbon (if used).

Step 2: Collect the Data

The second step is to collect the data for all identified fuel and utility costs, greenhouse gas emission rates, and assumptions for your institution. It is essential to be organized and thorough as the quality of internal variables determines the accuracy of modeling the life cycle cost of a financial decision. Section 2A describes data that can be collected internally; Section 2B describes data that can be collected externally. To assist in the organization and record-keeping of data for internal variables: use Appendix A for the fuel and utility cost and escalation rate data, and Appendix B for the greenhouse gas emissions data.

SECTION 2A: INTERNAL DATA COLLECTION

Fuel and utility cost variables that are specific to an institution should be collected for the present (or most recently available) year. For example, Smith College collected institutional data on the cost of electricity and steam that was produced on-site at the combined heat and power plant as well as the water/sewer and chilled water rates.

The escalation rate should be calculated because costs are likely to increase over time due to inflation and changes in the market prices. An escalation rate is an estimate of the change in the price of a good or service over a given period of time. There should be unique escalation rates for the fuel, utility, labor, and material costs. If your institution has current working assumptions for any escalation rates (i.e. wage increase, electricity rates), then these can be the default value for the LCC. This is the simplest option. When existing rates are not available, the escalation rate should be calculated using U.S. Energy Information Administration (EIA) or institutional data. The U.S. EIA publishes an Annual Energy Outlook with an online tool to that projects costs into the future; this can be used to determine an escalation rate.

To calculate an escalation rate from historical institutional data, use the escalation rate formula, derived from the formula to calculate compound interest, where P_2 is the present value, P_1 is the past value, t is the time period between P_2 and $P_1,$ and e is the escalation rate over the given period of time:

$$P_2 = P_1 (1+e)^t$$

$$\frac{P2}{P1} = (1+e)^t$$

$$\left(\frac{P2}{P1}\right)^{1/t} = 1+e$$

$$Escalation\ rate = \left(\frac{P2}{P1}\right)^{1/t} - 1$$

It is important to select a time period that captures changes in market prices. Smith College selected five years to calculate the escalation rate estimates as a longer rate would have captured a period before a major shift in natural gas markets. Be sure that all your prices are in the same year's dollars (adjusted for inflation).

Greenhouse gas emission rates depend on the source of energy generation. All greenhouse gas emissions rates should be in metric tons of carbon dioxide equivalent emissions. If your institution does not record and report greenhouse gas emissions, then the University of New Hampshire's Campus Carbon Calculator or the Greenhouse Gas Protocol are possible resources to obtain greenhouse gas emission rates (see Appendix B). It is important to consider any special cases where the greenhouse gas emissions may differ from a standardized rate. For example, the Smith College fleet uses B-20 diesel, which has different costs and emission rates than traditional diesel fuel. These small differences can have a significant impact over the long-term and, if unaccounted for, can distort decision-making, especially for institutions that use a proxy carbon price.

Institutions with a combined heat and power plant on site should calculate the greenhouse gas emission rates for its outputs of electricity and steam. The dual output creates a challenge of attributing greenhouse gas emissions to each on-site utility. One useful resource for this calculation is the "Allocation of Emissions from a Combined Heat and Power (CHP) Plant" document created by the Greenhouse Gas Protocol.

SECTION 2B: EXTERNAL DATA COLLECTION

Utility and fuel costs vary by geography and year. It is also important to consider if any special subsidies or hidden costs may impact fuel costs or utility rates. Many institutions use the following variables that can be collected from the U.S. Energy Information Agency (EIA) databases: commercial electricity, natural gas, distillate fuel oil #2, residual fuel oil #6, transportation gasoline and diesel. EIA databases are

updated annually and, to varying degrees, contain national, regional, and state-level data. Appendix A provides a table with hyperlinks to the U.S. EIA databases and a column to record the data necessary for the LCC variables. Fuel and utility costs should be in dollars per unit of energy.

The U.S. EIA also projects costs for some utilities and fuels in the Annual Energy Outlook interactive table (Appendix A). These can be used as escalation rates for the following variables: propane, distillate fuel oil #2, residual fuel oil #6, natural gas, and purchased electricity. These are updated annually with projections out to 2050 (as of 2018).

Emissions rates for electricity vary significantly by region depending upon the fuel sources used to generate the electricity. EPA's Emissions & Generation Resource Integrated Database (eGRID) can be used to get a regional estimates of emissions rates (Appendix C).

Step 3: Prepare the Calculator

The third step is to prepare the calculator for the data update.

FOR THE HARVARD LCC TOOL

1. Relabel all columns to align with the variable names of the institution on the relevant tabs (e.g. "Price GHG Detail, Details_Baseline, Details_Alt A, and Details_Alt B." on the Harvard LCC).
2. Highlight extra columns and change the font to a light gray. This will signal that these columns are unused, but will keep them functional in case another variable is necessary later.
3. Change the labels for the assumptions on the tab, "Inputs" in Row 67.

FOR THE SMITH LCC TOOL

1. Relabel the utility inputs to align with the variable names at the institution in the Input Tables tab.
2. Label any remaining rows as unused. This will signal that these rows are unused, but will keep them functional in case another variable is necessary later on. These changes will be reflected throughout the LCC tool.
3. Change the labels for the assumptions on the tab "Inputs" in Row 67.

As a final touch, add your university or college logo.

Step 4: Enter the Data

The fourth step is to enter the institutionally specific variables to adapt the calculator.

FOR THE HARVARD LCC TOOL

Data for each assumption are entered in the "Inputs" tab in Row 67 in the Harvard LCC tool. Data for the utility rates are entered in the "Price GHG Detail" tab. Enter greenhouse gas emission utility rates data in Row 9 of the appropriate column under "GHG." This should be a constant value, regardless of year. Then, enter the data for the financial utility rates in Row 9 of the appropriate column under "Total Rate." This entry represents the total cost and savings of the project. The "Variable Only" column can be enabled if a portion of the cost and savings of the project will impact the overall institutional budget. If the "Variable Only" case is true, then enter the "Component of Total Rate" in Row 6. The financial utility rates should increase annually due to the escalation rate.

FOR THE SMITH LCC TOOL

All assumptions are located on the Inputs Tables Tab. You may want to lock the cells with the key assumptions so that they are not accidentally changed by analysts using the tool once it has been developed.

Step 5: Update the Calculator

The LCC calculator is most effective and accurate when the internal data are accurate and up-to-date. It is thus important to establish a period over which regular updates occur; a person or team should be explicitly responsible for this. Data from the Energy Information Agency are updated annually, making annual updates possible. Harvard University also updates internal data annually. Absent resources to update the tool annually, the institution can select an update period that accommodates its capabilities.

Optional Additional Steps

These steps get you up and running, but the tool can be refined in consultation with the staff who use it. Possible changes include:

- Removing unused macros
- Developing versions for different time scales
- Adding or changing the interface and graph outputs (see Smith College version)
- Adding a data export tab for later analysis (see Smith College version)

Note

If you found this guide useful, please email **abarron@smith.edu**. We also welcome your feedback on ways to improve this document.

Appendix A:
Fuel/Utility Cost and Escalation Rate Data Resources Table

Variable	Cost	Unit: ($/Unit)	Escalation Rate (%)	Suggested Source
Commercial Electricity				**U.S. EIA** -national
Natural Gas				**U.S. EIA** -national
Transportation Gas				**U.S. EIA** -regional
Transportation Diesel				**U.S. EIA** -regional
Distillate Fuel Oil #2				**U.S. EIA** -national
Residual Fuel Oil #6				**U.S. EIA** -national
Labor				**Bureau of Labor Stats** or Institutional
On-site Electricity				Institutional
Steam for Heat				Institutional
Water/Sewer				Institutional/Local
Chilled Water				Institutional

Appendix B: GHG Emission Data Resources Table

Variable	Emission Rate	Unit: (MtCO2e/unit)	Suggested Source
Commercial Electricity			**EPA eGRID** (Appendix C)
Natural Gas			**UNH Campus Carbon Calculator**
Transportation Gas			**UNH Campus Carbon Calculator**
Transportation Diesel			**UNH Campus Carbon Calculator**
Distillate Fuel Oil #2			**UNH Campus Carbon Calculator**
Residual Fuel Oil #6			**UNH Campus Carbon Calculator**
On-site Electricity			Institutional CHP: **GHG Protocol**
Steam for Heat			Institutional CHP: **GHG Protocol**
Water/Sewer			Institutional
Chilled Water			**UNH Campus Carbon Calculator**

Appendix C: Estimating Emissions for Purchased Electricity

Estimating carbon emissions associated with electricity from the grid can be challenging. EPA's **Emissions & Generation Resource Integrated Database (eGRID)** provides convenient, if approximate, estimates of the carbon emissions associated with electricity generation in a number of sub-regions (see map below). The estimates in the table below represent the carbon emissions associated with "non baseload" electricity—that is, electricity generation used to meet changes in demand. This is a reasonable proxy for the emissions associated with changes that may occur from implementing individual energy efficiency measures. The table below contains values for 2016 (the most recent data as of 9/2018), but ongoing shifts in generation mix mean that it may be useful to check for updated values on a regular basis.

Map of eGRID Subregions

USEPA, eGRID February 2018

Crosshatching indicates that an area falls within overlapping eGRID subregions due to the presence of multiple electric service providers. Visit Power Profiler to definitively determine the eGRID subregion associated with your location and electric service provider.
http://www.epa.gov/energy/power-profiler
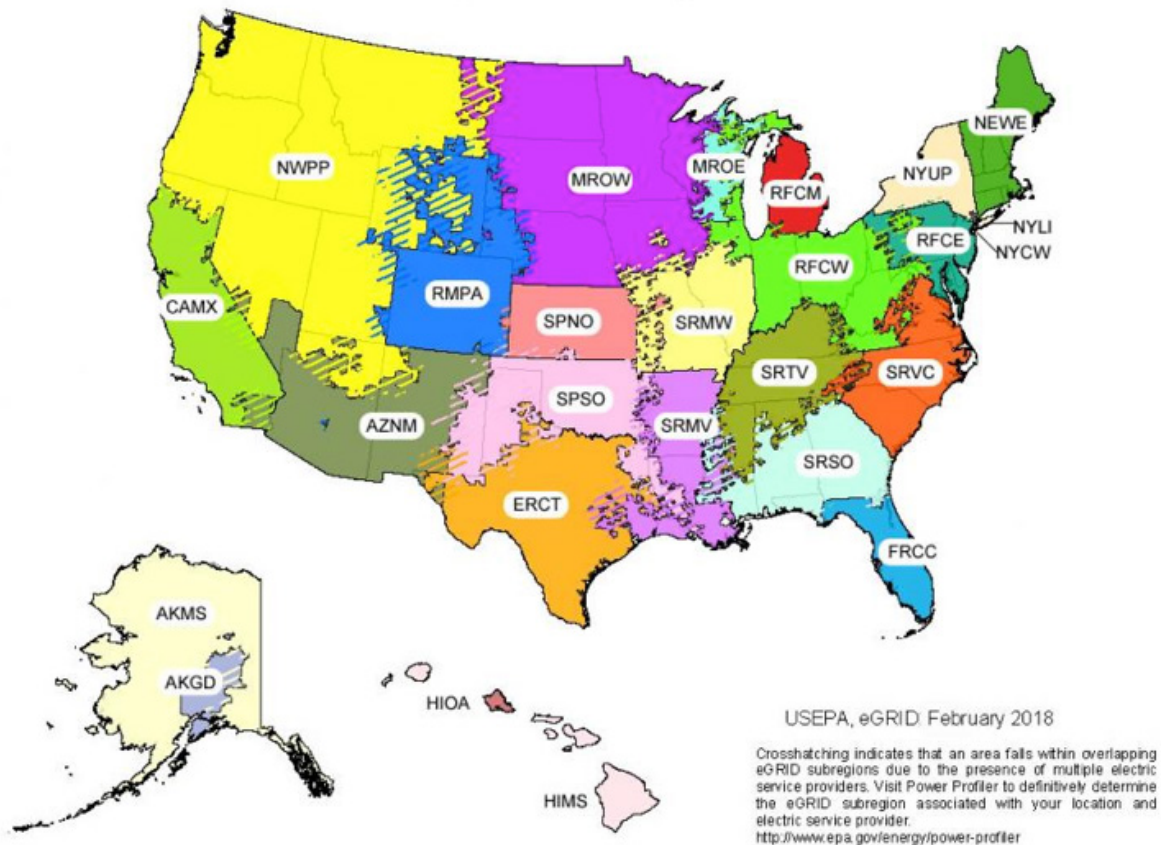
EPA eGRID subregion	2016 Non-Baseload Emissions Rate (metric tons CO2e/MWh)
ASCC Alaska Grid	0.624
ASCC Miscellaneous	0.698
WECC Southwest	0.631
WECC California	0.429
ERCOT All	0.639
FRCC All	0.541
HICC Miscellaneous	0.699
HICC Oahu	0.748
MRO East	0.794
MRO West	0.832
NPCC New England	0.445
WECC Northwest	0.696
NPCC NYC/Westchester	0.482
NPCC Long Island	0.608
NPCC Upstate NY	0.464
RFC East	0.654
RFC Michigan	0.824
RFC West	0.883
WECC Rockies	0.770
SPP North	0.909
SPP South	0.758
SERC Mississippi Valley	0.540
SERC Midwest	0.892
SERC South	0.663
SERC Tennessee Valley	0.802
SERC Virginia/Carolina	0.649

(Source: **EPA eGRID 2016 data** SRNBC2ER variable)