Life-Cycle Cost Analysis: Making Smart Decisions About Capital Improvements

A classic challenge for building owners is whether and how much capital to invest in energy-saving equipment or systems in order to reap long-term savings. Many types of financial analysis tools are available to help building owners, facilities managers and design teams make sound decisions about capital investments in new construction or building renovations or retrofits.

The Drawback of Simple Payback

Although simple payback is one of the easiest and most widely used methods for comparing the costs of similar systems or products, it promotes a distorted view of capital investments. Simple payback merely describes how long it will take, in months or years, for the investment’s energy savings (or other operational savings) to pay for the initial cost of the system. For example, if the system cost $1000 and reduced energy use by $200 annually, the simple payback would be five years ($1000/$200=5).

Simple payback provides a very rough estimate of whether the investment might be worthwhile, but its usefulness is limited. It does not address future savings and costs that occur after payback is reached, such as the costs of maintaining the system. It also does not differentiate between product alternatives that have different service lives.

Other economic measuring sticks for making investment decisions include first cost and internal rate of return. First cost is the least effective method, since the only factor it takes into account is the upfront cost of the product or system.

Internal rate of return (IRR) is the compound rate of interest that makes the present value of the savings over the period being considered equal to the present value of the investment-related costs. If the IRR of an energy-efficient design option exceeds a minimum expected return of other available investments—or in the case of borrowed money, the interest rate on the borrowed money—the energy-efficient design option is considered to be worthwhile. However, IRR-based decisions are solely dependent on the amount and timing of the project’s cash flow, and IRR can be unreliable when analyzing varying patterns of cash flow over time.

Getting a Handle on Profitability with Life-Cycle Cost Analysis

Life-cycle cost (LCC) analysis provides a far superior approach to analyzing investments in capital improvements. However, it is more complicated to calculate because it considers additional costs related to the investment’s long-term profitability.
Life-cycle cost analysis takes into account the total cost of owning, operating, maintaining and even disposing of the building, equipment or system over a given timeframe (usually the life of the building). These costs are typically expressed in terms of net present value (NPV), which is the net value of all costs and savings, expressed in today's dollars. NPV makes it possible to compare costs that occur at different points in time. It accounts for the time-value of money, recognizing the many ways building owners can spend or save their money compared to spending it on, for example, an energy efficiency upgrade.

Architects and engineers, as well as building owners and their representatives, use life-cycle cost analysis to analyze new construction investments and renovation or retrofit project alternatives. While life-cycle cost analysis is often used to calculate the cost effectiveness of energy-related systems or technologies, it can also be used to evaluate the cost effectiveness of any design option, such as roofing or flooring alternatives, assuming that reasonable costs can be established.

It is important not to confuse life-cycle cost (LCC) with life-cycle assessment (LCA). Life-cycle assessment is a holistic methodology that attempts to quantify the environmental impacts of a product (or a larger system such as a building) through all stages of its life, including extraction and processing of the raw materials used to make it, manufacturing or construction impacts, operation and maintenance, and eventual recycling or disposal. Life-cycle cost, on the other hand, addresses the cost effectiveness of capital investments in new construction or building improvements.

**Six Steps to Life-Cycle Cost Analysis**

Factors included in a typical life-cycle cost analysis include:

- Acquisition costs
- Financing costs (interest rate on a loan if capital is borrowed) or the likely rate of return for capital if it is not used to upgrade efficiency (if the capital is not borrowed)
- Energy savings
- Equipment replacement costs
- Operations, maintenance and repair costs
- Tax implications
- Impacts of inflation

Conducting a life-cycle cost analysis is more complicated than calculating simple payback. The basic steps can be broken down as follows:

1. **Gather basic financial data.** Gather relevant financial and economic data such as utility rates, projected energy and general inflation rates, discount rates, interest rates and financing terms.
2. **Estimate annual energy costs.** Estimate energy consumption and energy costs using a building energy simulation program, such as eQUEST (see below).

(continued from page 1)

Design and life-cycle cost methodologies. But Savings By Design does simplify the life-cycle cost analysis process by providing designers with a spreadsheet that gathers the analysis results into a consistent and convenient reporting format.

In addition, Energy Design Resources, the educational component of Savings By Design, offers two software programs that can be downloaded for free, eVALUator and eQUEST, as well as numerous case studies and design guides to help the building owners and design team make sound investment decisions. Find out more at www.savingsbydesign.com and www.energydesignresources.com.

This sample eVALUator screenshot shows a life-cycle savings of nearly $398,000 from an energy-efficiency investment that's only $17,550 more than the baseline investment. In this example, most of the savings come from productivity impacts.

(continued on page 3)
3. **Estimate first costs.** Estimate building construction costs using the most accurate information available.

4. **Estimate ongoing costs.** Include operation and maintenance costs, replacement costs and service life.

5. **Calculate life-cycle costs.** Calculate the life-cycle costs, for example present value of energy, construction and ongoing costs using discount factors that account for the time-value of money.

6. **Compare life-cycle costs.** Compare the life-cycle costs of each alternative. The alternative with the lowest life-cycle cost is the best economic option for the investor.

Software programs make these tasks easier. The Building Life-Cycle Cost (BLCC) program from the National Institute for Standards and Technology (NIST) is often used in federal projects (see sidebar at left). Energy Design Resources offers eVALUator, a financial analysis tool that simplifies the process of life-cycle cost analysis. eVALUator includes useful features such as the ability to consider differing perspectives (building developer versus a real estate management company, for instance) and the ability to consider the effects of an energy-efficiency measure on occupant productivity. To learn more about eVALUator, go to [www.energydesignresources.com/resource/131](http://www.energydesignresources.com/resource/131).

eQUEST, another program developed by Energy Design Resources, uses the same life-cycle cost methodology as BLCC. Besides calculating life-cycle costs, eQUEST is used to perform detailed building energy simulations to help the design team evaluate building design alternatives. For information about eQUEST, go to [www.energydesignresources.com/resource/130](http://www.energydesignresources.com/resource/130).

Once the design team has run the life-cycle cost analysis, they can use the results to make efficiency-related investment decisions, of which there tends to be three types. The first type of decision is a simple Go/No-Go decision: Should the investment—for example, an upgrade to the heating, ventilation and air conditioning (HVAC) system—be made or not?

A second type of decision is the optimum level of energy efficiency. With many design decisions, it is often a question of not just whether a feature or system should be upgraded, but by how much. For example, the energy code may require R-19 roof insulation, but the design team can use life-cycle costing to determine the optimum level of efficiency.

A third type of decision is the cost of quality. For example, should the design team upgrade to a more expensive but more efficient HVAC system, or should they stick with the less expensive system and perhaps use energy conservation strategies to achieve the same energy savings?

## The BLCC Methodology

The most common methodology and software for analyzing capital investments in buildings is the Building Life-Cycle Cost (BLCC) program developed by the National Institute of Standards and Technology (NIST). BLCC was designed to analyze energy and water savings but it is flexible and can accommodate any life-cycle cost analysis. The BLCC methodology is based on the following formula:

\[
LCC = I + Repl - Res + E + W + OM&R
\]

where
- \(LCC\) = Total LCC in present-value dollars of a given alternative
- \(I\) = Present-value investment costs
- \(Repl\) = Present-value capital replacement costs
- \(Res\) = Present-value residual value (resale value, scrap value, salvage value) less disposal costs
- \(E\) = Present-value energy costs
- \(W\) = Present-value water costs
- \(OM&R\) = Present-value non-fuel operating, maintenance and repair costs

Present value is the time-equivalent value of present or future cash flows as of the beginning of the base year, or the base date (usually the first day of the period being analyzed).

to evaluate whether it would be cost effective to increase the insulation to R-30 or R-38.

A third type of decision is the optimum combination of interacting measures. The design team needs to look at a number of alternatives and determine which should be used and in what combination. One simple example is the reduced heat gain that results from energy-efficient lighting fixtures; this will increase the building's heating requirements and decrease cooling requirements and thus must be considered when evaluating alternative lighting, building envelope and HVAC systems. A building energy simulation tool such as eQUEST allows design teams to evaluate the economic and energy impacts of these types of interdependent building features.

Building owners expect their design teams to provide answers to tough bottom-line questions about what systems or technologies to invest in, how much they cost and how much money they will save over time. Life-cycle cost analysis is an indispensable tool for meeting these expectations.

**Training Schedule**

Partial list of upcoming classes. For a complete list, visit each utility’s website.

<table>
<thead>
<tr>
<th>Date</th>
<th>Course</th>
<th>Time</th>
<th>Location</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb 1</td>
<td>Energy 101</td>
<td>8:30AM–12PM</td>
<td>Temecula</td>
<td>0</td>
</tr>
<tr>
<td>Feb 2</td>
<td>Advanced Lighting Technologies</td>
<td>8:30AM–12:30PM</td>
<td>CTAC</td>
<td>4</td>
</tr>
<tr>
<td>Feb 7</td>
<td>Boiler Basics</td>
<td>9AM–3PM</td>
<td>ERC</td>
<td>0</td>
</tr>
<tr>
<td>Feb 7</td>
<td>Fundamentals of EE Foodservice</td>
<td>9AM–12PM</td>
<td>San Diego¹</td>
<td>0</td>
</tr>
<tr>
<td>Feb 7</td>
<td>Basic Heating, Ventilation &amp; Air Conditioning (HVAC)</td>
<td>5:30PM–9:30PM</td>
<td>Yucaipa</td>
<td>0</td>
</tr>
<tr>
<td>Feb 7</td>
<td>2005 Title 24 Standards</td>
<td>8:30AM–3:30PM</td>
<td>San Diego²</td>
<td>5.5</td>
</tr>
<tr>
<td>Feb 8</td>
<td>Fundamentals of Electricity and Energy Efficiency</td>
<td>8:30AM–4:30PM</td>
<td>CTAC</td>
<td>0</td>
</tr>
<tr>
<td>Feb 14</td>
<td>Energy Efficiency Strategies in Cold Storages</td>
<td>8:30AM–12:30PM</td>
<td>CTAC</td>
<td>0</td>
</tr>
<tr>
<td>Feb 16</td>
<td>Boiler Water Treatment for Energy Efficiency</td>
<td>9AM–3PM</td>
<td>ERC</td>
<td>0</td>
</tr>
<tr>
<td>Feb 21</td>
<td>Tankless Water Heating</td>
<td>9am–12pm</td>
<td>ERC</td>
<td>3</td>
</tr>
</tbody>
</table>

**Training Locations**

<table>
<thead>
<tr>
<th>Location</th>
<th>Explanation</th>
<th>Phone</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTAC</td>
<td>SCE’s Customer Technology Application Center, Irwindale</td>
<td>(626) 812-7537</td>
<td><a href="http://www.sce.com/ctac">www.sce.com/ctac</a></td>
</tr>
<tr>
<td>San Diego¹</td>
<td></td>
<td>(858) 636-5726</td>
<td><a href="http://www.sdge.com/construction/ee_commercial_newconst_training.shtml">www.sdge.com/construction/ee_commercial_newconst_training.shtml</a></td>
</tr>
<tr>
<td>San Diego²</td>
<td></td>
<td>(858) 636-5726</td>
<td><a href="http://www.seminars.sdge.com">www.seminars.sdge.com</a></td>
</tr>
<tr>
<td>Temecula</td>
<td></td>
<td>(626) 812-7537</td>
<td><a href="http://www.sce.com/ctac">www.sce.com/ctac</a></td>
</tr>
<tr>
<td>Yucaipa</td>
<td></td>
<td>(626) 812-7537</td>
<td><a href="http://www.sce.com/ctac">www.sce.com/ctac</a></td>
</tr>
</tbody>
</table>

(continued from page 3)