

# LIFE-CYCLE COSTING METHODS FOR POST-FRAME BUILDINGS

**S**everal previous articles in *Frame Building News* have discussed green building in relation to post-frame construction. *Green building* is “the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building’s life cycle from siting to design, construction, operation, maintenance, renovation and deconstruction” (U.S. Environmental Protection Agency, 2014). The advantage of green building is that buildings tend to be more energy-efficient and cause fewer concerns about indoor air quality. A recent study on green office buildings found that the design of an office building significantly affected workers’ health and productivity (World Green Building Council, 2014). Post-frame buildings already make efficient use of material resources, as previously demonstrated in a white paper available from the National Frame Building Association (2010).

## Life Cycle

One of the central concepts of green building is the *life cycle* of a structure. To create a building that is truly resource- and energy-efficient, the process of its creation—from design to construction to operation to deconstruction or demolition—must be analyzed.

For example, let’s think about a building constructed by a local government. The local government is probably under a high level of financial scrutiny, so pressures for a low initial cost for the building are high. Sometimes buildings that are lower cost than alternatives may contain hidden costs: higher utility bills, for example, or more frequent maintenance needs. When the total costs of the building for the *entire period of building operation* are considered, the initial low-cost option may not prove to

be the lowest-cost option.

A helpful tool would be able to predict the overall costs associated with a building throughout its life. This is really an extension of the *net present value* concept that many of us saw in economics or business classes. By taking the costs of a building and placing them all into current funds (2015 dollars), we are able to make a better comparison of the cost of a building project.

## Life-Cycle Costing

Life-cycle costing (LCC) is a method to determine the entire cost over a product’s intended life cycle. For buildings, the main factors considered are initial cost, operating costs and maintenance or repair costs. LCC is an economic assessment, but it can involve detailed energy modeling of the structure. LCC does not include environmental impacts of the building and is not currently included in any of the green building certification systems. The main use for LCC is as a purchasing tool used for predicting the expected costs of a structure rather than focusing only on the initial construction costs. Comparisons can be made between alternative materials for the structure (input as cost and energy needs), and changes in the energy use and operation of the structure can be estimated to aid in understanding the cost comparisons.

LCC is used by many government organizations, including the U.S. military, the U.S. Forest Service, and state Departments of Transportation. These organizations want to ensure that funds are being used to achieve the most cost-effective results for the public good. These groups are also looking to minimize long-term costs, rather than focusing only on the initial cost of the building.

The U.S. Forest Service has published a document titled *Life-Cycle Cost Analysis*

*for Buildings Is Easier Than You Thought* (USDA, 2008) to explain the reasoning for LCC and educate Forest Service personnel on how to conduct an LCC analysis. The simplest form of an LCC analysis is expressed by the equation below, where the life-cycle cost of the building is composed of the initial cost plus the replacement cost minus the residual cost of the building at the end of its service life plus the cost of operations, maintenance and repair (OM&R) throughout the entire service life of the building.

$$\text{LCC} = \text{Initial Cost} + \text{Replacement Cost} - \text{Residual Cost} + (\text{Operations, Maintenance and Repair Costs})$$

Although this equation looks simple, estimating many of these parameters can become complex and is subject to economic markets, which have demonstrated great volatility in the last several years. Many assumptions about future economic trends, including inflation, depreciation rate, interest rates and energy prices, must be made. The OM&R costs of a structure are subject to the geographic location, construction of the building envelope, amount and type of insulation in the structure and type of construction.

The Forest Service article lists a series of LCC computer models that incorporate all or some of the conditions described above to help produce values to estimate the life-cycle cost of a building. Most of the models include assumptions about the economy. The type of building construction may be used as an input for some programs, while others may inquire only about the costs associated with initial purchase and recurring energy costs. These programs will need an energy analysis or similar estimate of energy performance to be completed

on the structure. Assumptions of economic performance are tied to the Federal Energy Management Program or Circular A94 from the Office of Management and Budget of the White House. More complex LCC models tend to yield more accurate results; however, the accuracy of the data and the accuracy of predictions used will ultimately govern the accuracy of the LCC results.

### A Word of Caution

The old phrase *caveat emptor*, “buyer beware,” still applies. LCC is an estimate of the cost and should not be taken as the *actual* cost. Predictions of economic trends, such as energy prices and real estate viability, are included, as discussed above. Given the economic developments of the past 10 years, we should all be aware of just how volatile the market can be. If LCC is used for comparison of several alternatives, then the effect of outside economic pressures is minimized as long as similar assumptions are used for different alternatives.

The power and strength of the LCC analysis are in its ability to compare several alternatives.

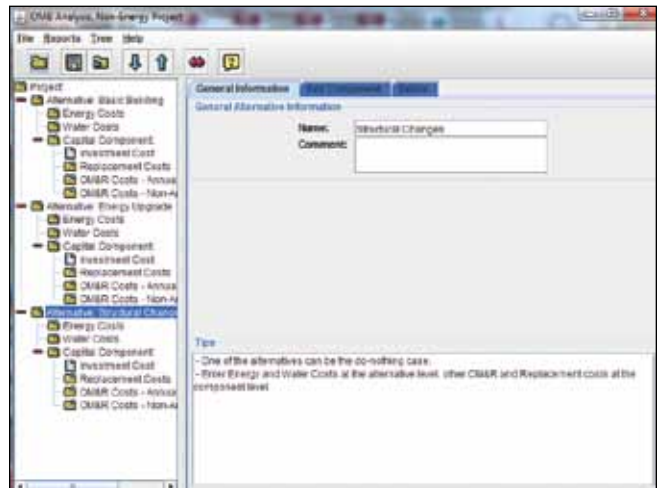
LCC is only a tool to help owners make economic decisions about buildings. It is still the responsibility of the owner to ensure that the building performs as stated and receives proper maintenance and repair over time.

### Life-Cycle Costing Programs

The Building Life Cycle Cost program is available from the U.S. Department of Energy at [www1.eere.energy.gov/femp/information/download\\_blcc.html](http://www1.eere.energy.gov/femp/information/download_blcc.html). The program is free for downloading after completion of a short survey. Versions of the program are available for use on Windows, Mac OS X, or Linux computers. The BLCC Version 5.3 was used for the example problems discussed below. Another resource for LCC methods and BLCC operation is *National Institute of Standards and Technology Handbook 135, Life-Cycle Costing Manual for the Federal Energy Management Program* (Fuller & Petersen, 1996).

The BLCC program covers a series of different project types, including buildings, energy and water projects and military projects. The program incorporates many of the current economic projections from the Federal Energy Management Program or Circular A94. Creating a project involves creating a file for the LCC, which asks for the name of the project, state, study period (total life of project), and several options for end-of-year and mid-year discounting. This is the main screen of the file—and what is saved. The next step is to create a series of alternatives for comparison.

From the “Add Alternative” screen, the alternative is created. **Figure 1** is a screenshot of the BLCC 5 program, showing three alternatives denoted by the file directory tree on the left side. For each alternative, there are three input categories: energy costs, water costs, and capital component. Under “Energy Costs,” you are allowed to choose the type of energy, amount used per year and price, as well as demand charges or rebates that could be applied. Energy options include electricity, distillate fuel (#1 and #2), residual fuel oil (#3, #4, #5), natural gas,



**FIGURE 1.** Screen shot of the BLCC 5 program

liquefied petroleum gas and coal. More specific choices of fuel are also provided.

The “Water Costs” category allows for indication of usage and disposal in summer and winter, with appropriate prices for each season. Schedules for price escalations and anticipated usage changes are also provided.

The “Capital Component” includes the investment, replacement, and OM&R costs. The investment cost includes the initial cost, annual rate of increase, expected service life and the residual factor when the building’s life has ended. A worksheet allows for cost-phasing of the project if needed. The replacement cost screen includes the same items shown on the investment cost screen. OM&R costs are separated into annual and non-annual costs. Both types of OM&R costs include the amount and annual rate of increase.

One advantage of the BLCC program is that a partial analysis can be conducted with as much or as little information as is available. This also allows simpler processing of alternatives. For instance, if the difference between two alternatives involves only energy costs, the water costs or OM&R costs do not have to be included for one to understand the difference between the alternatives.

### Life-Cycle Costing Building Examples

The following examples are presented for illustrative purposes only to demonstrate the ability of the LCC program and to increase understanding of the general trends associated with building alternatives. Every building and every situation are unique, and special care should be exercised to create the best prediction possible. The models given below should be able to be recreated within the BLCC program, given the information below.

The input parameters for the LCC examples are shown in **Table 1**. This analysis was constructed for a building site in Illinois. A study period of 60 years was considered. Five building alternatives were created for this location. The “Base” case

**TABLE 1.** Life-Cycle Costing Building Examples

INPUTS	"BASE" CASE	"GREEN BUILDING" CASE	"GREEN BUILDING ENERGY CHANGE" CASE	"LOW INITIAL COST" CASE	"LOW INITIAL COST, LOW BUILDING LIFE" CASE
Initial Cost	\$200,000	\$230,000	\$230,000	\$175,000	\$150,000
Annual Rate of Increase	2%	2%	2%	2%	2%
Expected Life	60 years	60 years	60 years	60 years	25 years
Residual Value Factor	15%	15%	15%	5%	5%
Building Maintenance	\$7,000/year, 2% annual increase	\$5,000/year, 2% annual increase	\$5,000/year, 2% annual increase	\$10,000/year, 2% annual increase	\$10,000/year, 2% annual increase
Electricity, \$0.10/kWh	15,000 kWh	10,500 kWh	1,000 kWh	21,000 kWh	21,000 kWh
Natural Gas, \$0.0915/kWh			9,500 kWh		

of the building had a cost of \$200,000 and a yearly electric consumption of 15,000 kWh. An OM&R cost of \$7,000 per year with a 2 percent annual increase was used. The building life is 60 years.

A "Green Building" case is offered on the basis of the author's experienc-

es with green building performance. Typically, green buildings certified by LEED (Leadership in Energy and Environmental Design) achieve an energy savings of approximately 30 percent. Although some studies do not show an initial cost increase, residential con-

struction costs observed by the author increased 10–15 percent, so the initial cost of the building was \$230,000, or 115 percent of the "Base" case. With the reduction in electricity use of 30 percent, a reduction in OM&R costs of \$2,000 per year was also predicted. A



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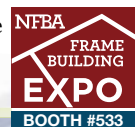


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**TABLE 2.** Life-Cycle Costing Building Examples: Results of Analyses

	"BASE" CASE	"GREEN BUILDING" CASE	"GREEN BUILDING ENERGY CHANGE" CASE	"LOW INITIAL COST" CASE	"LOW INITIAL COST, LOW BUILDING LIFE" CASE
Initial Cost	\$200,000	\$230,000	\$230,000	\$175,000	\$150,000 + Replacement 1 \$187,204 + Replacement 2 \$233,634
Energy Consumption	\$75,563	\$52,894	\$ 67,488	\$103,186	\$103,186
OM&R Costs	\$556,847	\$397,748	\$397,748	\$795,495	\$795,495
Residual Value @ End	-\$51,057	-\$58,715	-\$58,715	-\$14,892	-\$21,042
<b>Total Life-Cycle Cost</b>	<b>\$781,353</b>	<b>\$621,927</b>	<b>\$636,520</b>	<b>\$1,058,790</b>	<b>\$1,435,713</b>

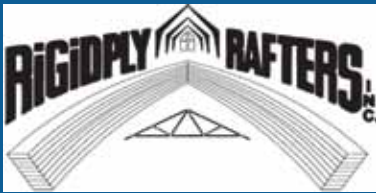
residual payback of 15 percent of building cost was assumed at the end of the building life.

Another use of LCC methods is to examine the effects of changing building components other than the structure system. In the "Green Building Energy Change" case, the effect of changing the

power system from electricity to natural gas is explored. This case assumes that 1,000 kWh of electricity are still used, with the remaining 9,500 kWh supplied by natural gas. A natural gas price of \$11.65/1,000 ft<sup>3</sup> was assumed, giving a price of \$0.0915/kWh.

The next case, the "Low Initial Cost"

case, represents a building that costs only \$175,000 but may not contain the same levels of insulation as the "Base" case and requires more electricity (21,000 kWh per year) and a greater OM&R cost (\$10,000 vs. \$7,000). The residual payback at the end of the building life was reduced to 5 percent.



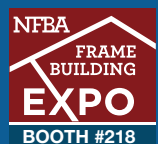
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The last case, the “Low Initial Cost, Low Building Life” case is identical to the “Low Initial Cost” case, except that the initial cost is even less, \$150,000, but the building lifetime is reduced to 25 years. This case may represent a non-engineered building.

The results of the LCC analyses for building examples provided in Table 1 are shown in **Table 2**. For the “Base” case, the total cost of the building over the 60 years of service is \$781,353. This includes the initial cost, energy use, OM&R and the residual payback at the end. Note that the majority of costs were related to the OM&R over the life of the project.

The “Green Building” case—with the highest initial cost of all examples—produced the lowest life-cycle cost of \$621,927. The cost savings over the “Base” case were due to the reduction

in both energy and OM&R costs. This example has been used in green building marketing, where a higher initial cost can actually lead to a reduced total cost, or annual cost, of the building. The “Green Building Energy Change” case had a life-cycle cost of \$636,520, which was similar to but slightly higher than the “Green Building” case. For this particular situation, the change in energy sources may not be efficient or may provide little benefit, even though the fuel cost of natural gas was less at the beginning of the study period.

The “Low Initial Cost” case has a life cycle cost of \$1,058,790, greater than the “Base” case and “Green Building” cases. The increase in energy and OM&R costs contributed to the difference in cost. For the “Low Initial Cost, Low Building Life” case, the life-cycle cost was 1,435,713, which was more than double the green

building life-cycle costs. The increase in costs was due to the 25-year life of the building, which needed to be replaced twice during the 60-year timeframe of the study, as well as differences in energy and OM&R costs.

## Conclusions

Life-cycle costing is a tool that can help demonstrate the economic case for post-frame buildings by evaluating costs over the life of the structure, rather than focusing on initial costs. Life-cycle costing is especially helpful when making the case for increased energy efficiency or decreased OM&R costs. The examples of LCC buildings shown here illustrate that careful consideration of all costs over the life of the building are needed for a full understanding of the economic differences in building options. **FBN**

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## References

- Fuller, S. K., & Petersen, S. R. 1996. *National Institute of Standards and Technology Handbook 135. Life-Cycle Costing Manual for the Federal Energy Management Program*. Washington, D.C.: U. S. Government Printing Office. Retrieved from [www.nist.gov/customcf/get\\_pdf.cfm?pub\\_id=907459](http://www.nist.gov/customcf/get_pdf.cfm?pub_id=907459)
- National Frame Building Association. 2010. *Putting the 'Green' Into Post Frame Construction: Accounting for Post Frame Construction in Green Building Certification Systems*. Retrieved from [www.nfba.org/uploads/files/Putting\\_the\\_Green\\_Into\\_Post\\_Frame\\_Final2.pdf](http://www.nfba.org/uploads/files/Putting_the_Green_Into_Post_Frame_Final2.pdf)
- U.S. Department of Agriculture. 2008. *Life-Cycle Cost Analysis for Buildings Is Easier Than You Thought*. 0873-2839-MTDC. Missoula, MT: USDA Forest Service, Missoula Technology and Development Center.
- U.S. Environmental Protection Agency. 2014. *Green Building: Basic Information*. Retrieved from [www.epa.gov/greenbuilding/pubs/about.htm](http://www.epa.gov/greenbuilding/pubs/about.htm)
- World Green Building Council. 2014. *Health, Wellbeing and Productivity in Offices: The Next Chapter for Green Building*. Retrieved from [www.worldgbc.org/activities/health-wellbeing-productivity-offices/](http://www.worldgbc.org/activities/health-wellbeing-productivity-offices/)

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