Appendix P-6: Life Cycle Cost Supporting Information

Compliance with Legislation
State legislation identifies two different measures for evaluating the performance of new and existing buildings:
1. Section 16B.325 requires in part that the guidelines "focus on achieving the lowest possible lifetime cost for new buildings...";
2. Minnesota Laws 2001, Article 1, Ch 212,Sec.3. Benchmarks for Existing Public Buildings requires a comprehensive plan to maximize energy efficiency in existing public buildings "through conservation measures having a simple payback within ten to 15 years."

How are proposed projects to be evaluated in order to best ensure compliance with these requirements?
- The first requirement references a more comprehensive analysis, an analysis that strives to achieve the lowest possible lifetime cost for a proposed new building. This lifetime cost analysis requirement can be the source of some confusion because of varying definitions and interpretations and the math needed to complete the calculations. The materials in the following section are intended to serve as an introduction to this type of comprehensive analysis.
- The second requirement for energy efficient projects in existing buildings with a simple payback within ten to 15 years is simple enough, but in its simplicity it fails to recognize some important considerations. Some alternative measures that can be used in addition to the simple payback calculation are discussed below.

Why Discounting?
The process of converting streams of benefits and costs over time in the future back to an equivalent "present value" is called discounting. If the costs and the benefits (i.e. energy cost savings) of a particular proposal occur in the same time period the analysis is quite simple. If you were trying to pick the most cost effective choice between 2 rental cars for a weekend the analysis would be quite straightforward. If a hybrid rents for $50 a day and gets 50 MPG and a more traditional compact rents for $40 a day and gets 22 MPG, it is easy to envision the analysis. The most cost effective choice will depend on how many miles you expect to drive and the cost of gasoline. You might have some difficulty quantifying other considerations (i.e. you like or don't like the looks of the hybrid), but you could weigh such preferences against the least costly alternative. Does it make the choice easier or harder? How big a economic penalty are you willing to pay to support your styling preference?
But what if the costs and benefits are spread out over time? The same simple calculations don't work very well since we all have a "time value of money". If you are deciding which car to buy and the hybrid costs $24,000 and the traditional compact costs $21,000, how do you compare them? The extra $3,000 is a current expenditure while the gas savings will be spread over the years. Most people would not consider the hybrid to be the same cost as the traditional car if it saved exactly $3,000 in gasoline costs over 10 years. You would require more future savings than that to compensate for the fact that the benefits are spread over so many years. And what about maintenance and repairs? How will they compare? To properly compare these two alternatives you would need to convert costs and benefits to comparable Present Values and complete a "life-cycle cost analysis".

Discounting and Present Values

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Discounting and Present Values are perhaps best understood as the reverse of compound interest. If you have $100 and invest it at 5% interest compounded annually for 10 years, it will grow by more than $50 over 10 years because of compounding. It will grow to $105.00 at the end of year 1, $110.25 in year 2, $115.76 in year 3, and so forth until in totals $162.89 at the end of year 10. Calculating a Present Value amounts to reversing the compounding process in order to answer the question, "What amount received today would have the same utility to me as $162.89 received ten years from now?" If my discount rate is 5%, the answer will be calculated to be $100.

Just as the interest rate is central to determining the total amount accumulated over the investment period, so the choice of discount rates drives the Present Value calculation. In the above example, if my discount rate were 8% instead of 5%, the $162.89 received in year 10 would have a Present Value of only $75.45. The choice of discount rates is very important to the validity of an analysis, overshadowed only by the critical importance of being consistent with the choice of discount rates throughout an analysis.

Federal Energy Management Program Guidance

The Federal Energy Management Program's Guidance on Life-Cycle Cost Analysis Required by Executive Order 13123 provides some useful definitions and guidance. "Section 707 of Executive Order 13123 defines life-cycle costs as *"...the sum of present values of investment costs, capital costs, installation costs, energy costs, operating costs, maintenance costs, and disposal costs over the life-time of the project, product, or measure."*

"Life-cycle cost analysis (LCCA) is an economic method of project evaluation in which all costs arising from owning, operating, maintaining, and disposing of a project are considered important to the decision. LCCA is particularly suited to the evaluation of design alternatives that satisfy a required performance level, but that may have differing investment, operating, maintenance, or repair costs; and possibly different life spans. LCCA can be applied to any capital investment decision, and is particularly relevant when high initial costs are traded for reduced future cost obligations."

The FEMP guidance goes on to explain the need for time adjustments , defines the life cycle cost formula, and discusses application of life cycle cost analysis. Included in the FEMP guidance are some important comments on the shortcomings of a simple payback analysis. These sections of the FEMP guidance are quoted below.

Time Adjustments

Adjustments to place all dollar values expended or received over time on a comparable basis are necessary for the valid assessment of a project's life-cycle costs and benefits. Time adjustment is necessary because a dollar today does not have equivalent value to a dollar in the future. There are two reasons for this disparity in value. First, money has real earning potential over time among alternative investment opportunities, and future revenues or savings always carry some risk. Thus an investor will require a premium or extra return for postponing to the future the spending of that dollar. Second, in an inflationary economy, purchasing power of money erodes over time. Thus a person would demand more than a dollar at some future time to obtain equivalent purchasing power to a dollar held today.

The process of converting streams of benefits and costs over time in the future back to an equivalent "present value" is called discounting. A discount rate is used in special formulas to convert future values. When future values are expressed in current (nominal) dollars, where inflation is included in the future values, a market (nominal) discount rate is used. It takes into account both inflation and the earning potential of money over time. When future values are expressed in real (constant dollar) terms, where general price inflation has been stripped out, a real discount rate is used. It takes into account only the earning potential of money over time. Both approaches yield identical results as long as you use real

discount rates in discounting constant-dollar future amounts and market discount rates in discounting current-dollar future amounts.

Choices among energy-savings projects can be made either by estimating for each alternative project a stream of life-cycle costs and savings relative to a "base case," and computing the net present value (NPV) of that stream (looking for the maximum NPV), or by calculating the present value of each project's life-cycle cost, and choosing the alternative (including "do nothing") that yields the minimum present value life-cycle cost (PVLCC.)

Life-Cycle Cost Formula
To find the total LCC of a project, sum the present values of each kind of cost and subtract the present values of any positive cash flows such as a resale value. Thus, where all dollar amounts are converted to present value by discounting, the following formula applies:
Life-cycle cost = first cost + maintenance and repair + energy + water+ replacement - salvage value. Eventually, when additional considerations for values such as worker or occupant productivity and community or social values can be assessed and calculate with more certainty, they will be incorporated in the model as well. At this time, however, there are too many variables and little conclusive data associated with these topics to make them part of the standard calculations. However, Appropriated Agencies may want to consider the cost benefits of worker productivity improvements within their own models and use those as additional factors when considering the overall outcomes for net present value.

Applications of LCCA
Projects may be compared by computing the LCC for each project, using the formula above and seeing which is lower. The alternative with the lowest LCC is the one chosen for implementation, other things being equal.

The LCC method can be applied to many different kinds of decisions when the focus is on determining the least-cost alternative for achieving a given level of performance. For example, it can be used to compare the long-term costs of two building designs; to determine the expected savings of retrofitting a building for energy or water conservation, whether financed or agency-funded; to determine the least expensive way of reaching a targeted energy use for a building; or to determine the optimal size of a building system.

In addition to the LCC formula shown above, there are other methods for combining present values to measure a project's economic performance over time, such as Net Savings, Savings-to-Investment Ratio, Adjusted Internal Rate of Return or Discounted Payback.

Note on Discounted Payback (DPB) and Simple Payback (SPB)
Discounted Payback (DPB) and Simple Payback (SPB) measure the time required to recover initial investment costs. The payback period of a project is expressed as the number of years just sufficient for initial investment costs to be offset by cumulative annual savings. DPB is the preferred method of computing the payback period for a project because it requires that cash flows occurring each year be discounted to present value to adjust for the effect of inflation and the opportunity cost of money. The SPB does not use discounted cash flows and therefore ignores the time value of money, making it a less accurate measure than the DPB. In practice, the DPB or SPB is used to measure the time period required for accumulated savings to offset initial investment costs. Any costs or savings incurred during the remainder of the project life-cycle are ignored. The DPB and the SPB are therefore not appropriate

measures of life-cycle cost effectiveness and should be used only as screening tools for qualifying projects for further economic evaluation.

Analyzing a Proposed Project

- It is very likely that any entity proposing a significant state funded project will have the resources needed to prepare a discounted cash flow analysis of the project. Such an analysis, typically prepared with a software program such as Excel, will detail all of the initial costs of design and construction and then project future annual operating and maintenance costs, utility costs, replacement costs, and the residual value of the building and equipment. If these future costs are presented in current dollars in each year (showing the impact of inflation), they are then discounted back to the present using a nominal discount rate (a discount rate that recognizes inflation.) If future costs are expressed in constant dollars (not adjusted for inflation), then they are discounted back to the present using a real discount rate. (For example, FEMP discount and inflation rates, valid for energy and water conservation and renewable energy analyses conducted between 4/1/2004 and 3/31/2005 are: 3% Real Discount Rate, 4.8% Nominal Discount Rate, and a 1.75% Inflation Rate.) The initial costs and the discounted future costs are the summed to provide the discounted present value (discounted cost) of the proposed project over its life cycle. By completing a life cycle cost analysis of different options under consideration and then comparing the discounted present value of each, it is possible to work towards identifying the building option that has the lowest possible lifetime cost.