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Sustainable Santa Barbara Program

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Life-Cycle Cost/Benefit Analysis Guidelines

Introduction

This section provides guidelines for economic analysis of proposed capital expenditures. The goal is to accurately assess costs and benefits on a life-cycle basis, based on the following principles:

- Life-cycle analysis considers up-front costs and costs over the life of a project to get a complete view of a project's economic feasibility. It is useful in evaluating capital expenditures aimed at reducing annual operating costs (such as energy conservation measures). It also helps avoid decision making based solely on a comparison of initial capital costs.

- For projects with relatively short equipment or facility life (up to five years) a "simple payback" analysis is usually sufficient. Simple payback is calculated by dividing the total capital cost by the net annual savings generated by the project. The result is the number of years until the investment is paid back, not including interest costs, inflation, or real price increases. Longer term projects can benefit from a more detailed economic life-cycle analysis that includes these factors.

- These guidelines aim to quantify the *direct* economic costs and benefits of a project. Many decisions involve *indirect* costs and benefits that are not addressed here, but can be significant. For example, an investment in energy efficiency involves capital and maintenance costs as well as reductions in energy costs. Separate from this, and more difficult to quantify, are indirect benefits associated with environmental protection, local control over energy sources, and the retention of money within the local economy. These guidelines are intended to provide a complete and realistic view of direct costs and benefits, which would be a part of a decision making process that may also include a more qualitative assessment of indirect costs/benefits.

Terminology

A few economic concepts are important to address accurately and consistently as a part of life-cycle cost analysis:

> Inflation: Dollars of future years are expected to have lower purchasing power than today's dollars. This means care is needed in comparing costs or benefits that occur in different years of an economic analysis. As discussed below, inflation is sometimes factored out of an economic analysis to make it simpler.

When inflation is applicable to a particular analysis, an assumed annual inflation rate of 3% is appropriate, based on the period of 1986 to present.

Time Value of Money: Separate from the effects of inflation, money has value over time. This is why one can expect to earn an investment return that is greater than the rate of inflation. This increment in excess of inflation is referred to as the "real" interest rate. The City earns about 5% on its invested reserves, so a 3% inflation rate suggests a real interest rate of about 2%.

Opportunity Cost: If money is used to fund a project, it is not in the bank earning interest. This means that the use of the money is a cost of doing the project and must be included in the analysis. This cost continues until the money used on the project is repaid, with interest, through cost savings generated by the project.

Present Value and Discounting: Due to inflation and time value, a $1,000 cost (or benefit) that occurs in the future does not have the same value as a $1,000 cost (or benefit) today. To accurately compare costs and benefits that occur at different points in the future, they are typically adjusted to their equivalent value in the present. The adjusted values are referred to as the "present value." Costs and benefits that will occur in a given year are combined to get the net cost or benefit for that year. The net amount is then "discounted" back to present value based on an interest rate that reflects the value of money over time. This rate is called the "discount rate" and is equal to the organization's rate of return on investments. For example, if an organization typically earns 5% on its money, the present value of a $3,000 savings that occurs 10 years from now would be about $1,842. So, for this very simple example, one could justify spending up to $1,842 today to save $3,000 in year 10. (This example is based on "nominal dollars," as discussed below.)

The discounted net cost/benefit is called the "net present value" (NPV). NPV's for each year of an economic analysis are added together to get the "cumulative NPV" of a project. If cumulative NPV is positive, the project is cost effective. An investment in energy efficiency is said to have a "discounted payback period" equal to the number of years for savings to offset project cost to the point where the cumulative NPV equals zero. Sometimes it is valuable to create separate cash flows for the two different alternatives and compare the cumulative NPV for each one.

Constant Dollars vs. Nominal Dollars

Economic analysis can be done using "constant dollars" or "nominal dollars." The constant dollar approach is to express all values in dollars of a specified year. By using constant dollars, inflation is taken out of the analysis. Recurring annual costs only change to the extent there is "real" price escalation. If there is no escalation, then annual costs remain the same each year in constant dollars. The discount rate includes only the "real" portion of the interest rate.

The "nominal dollar" approach expresses values in terms of the dollars of the year in which they occur, so inflation is included. Recurring annual costs include inflation, so they grow each year due to inflation, as well as any "real" price escalation. The discount rate includes inflation as well as the "real" interest rate. Either approach is valid as long as the use of either constant or nominal dollars is consistent for all inputs to the calculation. For simplicity, these guidelines focus only on the nominal dollar approach to economic analysis, but it is important to evaluate all assumptions to determine whether they are based on constant or nominal dollars.

Real Price Escalation:

Inflation is the upward movement of prices in general and, consequently, the declining purchasing power of the dollar. Some commodities are subject to price increases in excess of the general rate of inflation, due to increasing scarcity, increasing demand, or other factors specific to that commodity. The increment is referred to as the "real" price escalation. Energy costs are widely considered to have the potential for real price increases.

For commercial sector electricity in California, long-term historical price data indicates an average annual real price increase of 0% to 1%. Greater increases are possible, but to maintain a conservative assumption for economic analysis purposes, a 1% real price escalation is appropriate. With 3% inflation included, this yields a projected annual electric cost increase of about 4% in nominal terms.

For commercial sector natural gas in California, long term price data suggest an historical annual real price escalation rate of about 2%. Projections for the future show price spikes in the near term followed by a period of declining prices in real terms, with a net result of about 0% real price increase through 2030. These projections include some assumptions that may be optimistic, so the historical 2% real price escalation rate for natural gas may be appropriate for use in economic analysis. This would yield a projected average annual natural gas increase of about 5% when inflation is included (i.e. in nominal terms).

Sensitivity Analysis:

An economic analysis is really only an estimate of how a given project will pencil out, based on a set of assumptions as to project costs, inflation, escalation, and savings generated by the project. Sensitivity analysis involves modifying key variables in the analysis to see how much the outcome is affected. For example, a project might look cost effective with an assumption of annual maintenance costs at .5%, but not if maintenance costs were 1% per year.

Discounted Cost/Benefit Procedure

The following procedure is for economic analysis of long term projects, reflecting initial capital cost, annual costs and savings, any real price escalation, and the value of money over time. It is for use with the worksheet in Exhibit 1 and analyzes the economic value of a defined project compared to the status quo. The worksheet uses a "nominal dollar" approach, meaning that all costs and benefits are expressed in terms of dollars in the year in which they occur.

1. Define the Project: Describe the project specifically, including equipment sizing, type of technology, and other relevant factors to distinguish this project from other possible alternatives. Include any costs that are not a direct part of the project, but will be incurred as a result of the project. Assign an option name that describes the option being analyzed.

2. Assumptions: Adjust assumptions at the top of the worksheet, as necessary, to reflect the analysis you want to perform.

3. Identify Capital Costs: These are all the up front costs needed to implement the project, including design, engineering, land acquisition, environmental analysis and design review, permitting, construction, and project management. Take credit for any costs that are avoided as a result of doing the project.

4. Identify Annual Costs/Benefits: Include recurring costs for annual maintenance, periodic capital maintenance/replacement costs for components that have a shorter life than the period of economic analysis, and the savings generated by the project. If there are costs that are avoided as a result of doing the project, include them as benefits in each year in which they would be avoided, adjusted for the effects of inflation.

5. Analyze Results: When all information is entered, evaluate the results of the analysis. A project with a positive cumulative net present value is considered cost effective. A negative net present value indicates the project is not cost effective. Perform sensitivity analysis by varying key assumptions to see how much it changes the results.

Exhibit 1: Cost/Benefit Analysis (Nominal Dollars)

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Project Name: **Sample Project**

Description: **Sample Energy Conservation Project**

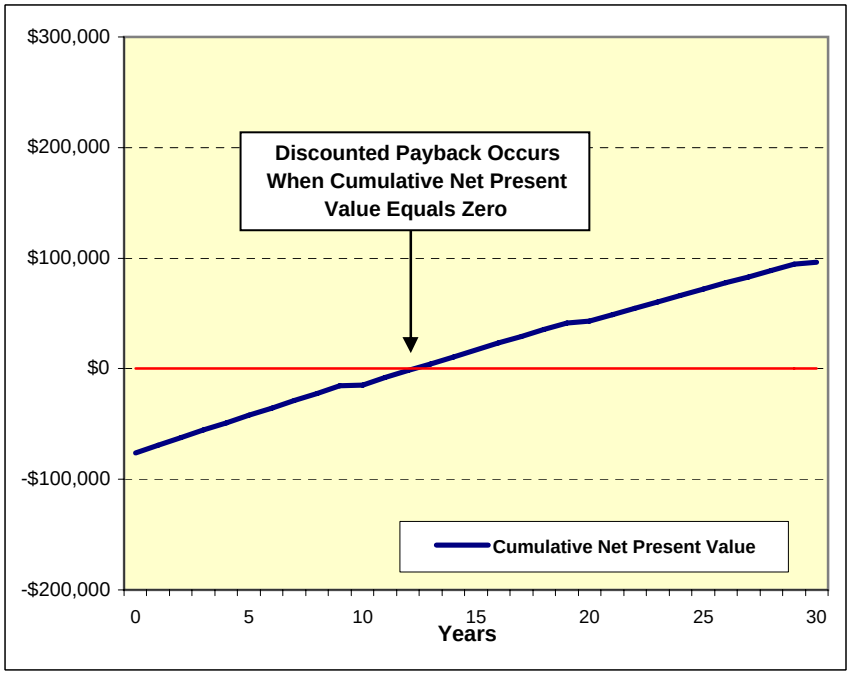
Option: **Option A**

Assumptions

Discount Rate:	5.0%
Inflation Rate:	3.0%
Real Energy Escalation Rate:	1.0%
Total Annual Energy Increase Rate:	4.0%
Annual Energy Savings:	$ 8,500

Project Cost Information

Design/Permitting:	$ 10,000
Construction Contract:	$ 75,000
Project Management	$ 10,000
Other Capital/Initial Costs:	$ -
Contingency:	$ 11,250
Gross Capital Cost:	**$ 106,250**
Total Rebates:	$ 30,000
Net Capital Cost:	**$ 76,250**
Annual O&M Costs:	$ 1,200
Capital Maintenance Costs:	$ 6,500
Capital Maintenance Interval (yrs):	10



	Costs		Benefits		Present Value Analysis			
	Capital Costs (initial cost & periodic capital replacement costs)	Annual Operation & Maintenance Costs	Energy Savings	Other Savings	Net Savings/ (Cost)	Present Value Factor	Present Value	Cum. Net Present Value
0	$ 76,250				$ (76,250)	1.0000	$ (76,250)	$ (76,250)
1		$ 1,200	$ 8,500		$ 7,300	0.9524	$ 6,952	$ (69,298)
2		$ 1,236	$ 8,840		$ 7,604	0.9070	$ 6,897	$ (62,401)
3		$ 1,273	$ 9,194		$ 7,921	0.8638	$ 6,842	$ (55,559)
4		$ 1,311	$ 9,561		$ 8,250	0.8227	$ 6,787	$ (48,771)
5		$ 1,351	$ 9,944		$ 8,593	0.7835	$ 6,733	$ (42,038)
6		$ 1,391	$ 10,342		$ 8,950	0.7462	$ 6,679	$ (35,359)
7		$ 1,433	$ 10,755		$ 9,322	0.7107	$ 6,625	$ (28,734)
8		$ 1,476	$ 11,185		$ 9,710	0.6768	$ 6,572	$ (22,162)
9		$ 1,520	$ 11,633		$ 10,113	0.6446	$ 6,519	$ (15,643)
10	$ 8,735	$ 1,566	$ 12,098		$ 1,797	0.6139	$ 1,103	$ (14,540)
11		$ 1,613	$ 12,582		$ 10,969	0.5847	$ 6,414	$ (8,127)
12		$ 1,661	$ 13,085		$ 11,424	0.5568	$ 6,361	$ (1,765)
13		$ 1,711	$ 13,609		$ 11,898	0.5303	$ 6,310	$ 4,544
14		$ 1,762	$ 14,153		$ 12,391	0.5051	$ 6,258	$ 10,803
15		$ 1,815	$ 14,719		$ 12,904	0.4810	$ 6,207	$ 17,010
16		$ 1,870	$ 15,308		$ 13,438	0.4581	$ 6,156	$ 23,166
17		$ 1,926	$ 15,920		$ 13,995	0.4363	$ 6,106	$ 29,272
18		$ 1,983	$ 16,557		$ 14,574	0.4155	$ 6,056	$ 35,328
19		$ 2,043	$ 17,219		$ 15,177	0.3957	$ 6,006	$ 41,334
20	$ 11,740	$ 2,104	$ 17,908		$ 4,064	0.3769	$ 1,532	$ 42,865
21		$ 2,167	$ 18,625		$ 16,457	0.3589	$ 5,907	$ 48,772
22		$ 2,232	$ 19,370		$ 17,137	0.3418	$ 5,858	$ 54,631
23		$ 2,299	$ 20,144		$ 17,845	0.3256	$ 5,810	$ 60,441
24		$ 2,368	$ 20,950		$ 18,582	0.3101	$ 5,762	$ 66,202
25		$ 2,439	$ 21,788		$ 19,349	0.2953	$ 5,714	$ 71,916
26		$ 2,513	$ 22,660		$ 20,147	0.2812	$ 5,666	$ 77,582
27		$ 2,588	$ 23,566		$ 20,978	0.2678	$ 5,619	$ 83,201
28		$ 2,666	$ 24,509		$ 21,843	0.2551	$ 5,572	$ 88,773
29		$ 2,746	$ 25,489		$ 22,743	0.2429	$ 5,525	$ 94,299
30	$ 15,777	$ 2,828	$ 26,509		$ 7,903	0.2314	$ 1,829	$ 96,127