Life-Cycle Cost Analysis

Engineers and other business decision makers often perform complicated analyses to develop detailed owning and operating costs (think of energy simulations or in-depth construction cost estimates), yet make final decisions based on simple economic tools such as "simple payback." This method only works if an alternative has a short or long payback period compared to some baseline. It does not account for inflation; the cost of borrowing money; variations in periodic costs and savings; salvage value; future one-time costs to maintain or repair equipment; nor opportunity costs. Most importantly, simple payback omits an important benefit; it does not account for savings that occur after the initial equipment cost is recouped (e.g. savings after the simple payback period).

After all of the hard work is done developing accurate owning and operating costs–including installation costs, annual energy costs, maintenance costs and other recurring costs–economic decisions should be based on a comparably robust economic tool such as Life-Cycle Cost Analysis (LCCA). As the name implies, LCCA looks at more than just the first costs and savings that occur up to the time of simple payback, it looks at all costs and benefits that occur over the project's lifetime. It also accounts for variations in the magnitude and timing of recurring costs. By ensuring that all economic factors have been considered, LCCA reduces financial risk and affords decision makers with a more definitive picture of the relative benefits and costs of alternatives.

LCCA is based on the time value of money, which recognizes a dollar today is worth more than a dollar a year from now. The future value F of an amount P invested today at interest rate i is $P(1+i)$. After two years, the investment will be worth $P(1+i)^2$, and after n years, F equals $P(1+i)^n$.

The same formula can be inverted to determine the present value P of a payment F that will be made n years in the future: $P = F/(1+i)^n$. This equation is the heart of the LCCA method. Essentially, the life-cycle cost of a project is determined by totaling up the present value of all future payments associated with it. The life-cycle cost is equal to the amount of capital that must be invested today to make all of the future payments at the time they are required. In the LCCA method, the rate at which an investment could earn interest is called the discount rate because it is the rate used to discount future payments to present value.

Chapter 36 of the 2007 ASHRAE Handbook HVAC Applications Volume includes a simple example of this analysis. A municipality is evaluating two methods of providing chilled water for cooling an office building–Alternative 1, to purchase chilled water from a central chilled water utility service in the area, and Alternative 2, to install a conventional chiller plant. Since the municipality is not a tax-paying entity, the evaluation does not need to consider the impact of taxes.

The first-year price of the chilled water utility service contract will be $65,250 per year, and is expected to increase at a rate of 2.5% annually.

Alternative 1: Purchase chilled water from utility

	Year										
	0	1	2	3	4	5	6	7	8	9	10
First costs		$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
Chilled water costs		$65,250	$66,881	$68,553	$70,267	$72,024	$73,824	$75,670	$77,562	$79,501	$81,488
Replacement costs		$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
Maintenance costs		$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
Net Annual Cash Flow		$65,250	$66,881	$68,553	$70,267	$72,024	$73,824	$75,670	$77,562	$79,501	$81,488
Present Value of Cash Flow		$60,417	$57,340	$54,420	$51,648	$49,018	$46,522	$44,153	$41,904	$39,770	$37,745
						Year					
		11	12	13	14	15	16	17	18	19	20
First costs		$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
Chilled water costs		$83,526	$85,614	$87,754	$89,948	$92,197	$94,501	$96,864	$99,286	$101,768	$104,312
Replacement costs		$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
Maintenance costs		$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
Net Annual Cash Flow		$83,526	$85,614	$87,754	$89,948	$92,197	$94,501	$96,864	$99,286	$101,768	$104,312
Present Value of Cash Flow		$35,823	$33,998	$32,267	$30,624	$29,064	$27,584	$26,179	$24,846	$23,581	$22,380
20-year Life Cycle Cost	$769,283										

The expected life of the chiller and cooling tower, which will cost $220,000, is 20 years. A major overhaul ($90,000) of the chiller is expected to occur in year ten. Annual costs for preventative maintenance ($1,400), labor ($10,000), water ($2,000) and chemical treatments ($1,800) are all expected to keep pace with inflation, which is expected to average 3% annually over the study period. The annual electric cost ($18,750) is expected to increase at a rate of 5% per year. The municipality uses a discount rate of 8% to evaluate financial decisions. Assuming a study period of 20 years, which option has the lowest life-cycle cost?

The tables shown compare the two alternatives. Note that for Alternative 1, the only cost is for the chilled water contract. The cost in year two, $66,881, is 2.5% higher than in year one to account for inflation. To determine the present value of the year two payment, the discount rate of 8% is used per the given formula $[F/(1+i)^n=P]$ or $66,881/(1+0.08)^2=$57,340. The present values of the other payments are calculated in a similar manner.

Alternative 2 includes the immediate (year zero) cost of purchasing and installing the chiller, as well as the cost of energy and maintenance, and the major plant renovation required in year 10. The present value of each payment is calculated using the discount rate as above.

For the values provided, alternative 1 has a 20-year life-cycle cost of $769,283 and Alternative 2 has a 20-year life-cycle cost of $717,100. Therefore, Alternative 2 is the more attractive option in this example.

Alternative 2: Install chiller and tower

	Year										
	0	1	2	3	4	5	6	7	8	9	10
First costs	$220,000	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
Energy costs		$18,750	$19,688	$20,672	$21,705	$22,791	$23,930	$25,127	$26,383	$27,702	$29,087
Replacement costs		$-	$-	$-	$-	$-	$-	$-	$-	$-	$90,000
Maintenance costs		$15,200	$15,656	$16,126	$16,609	$17,108	$17,621	$18,150	$18,694	$19,255	$19,833
Net Annual Cash Flow	$220,000	$33,950	$35,344	$36,798	$38,315	$39,898	$41,551	$43,276	$45,077	$46,957	$138,920
Present Value of Cash Flow	$220,000	$31,435	$30,301	$29,211	$28,163	$27,154	$26,184	$25,251	$24,354	$23,490	$64,347
						Year					
		11	12	13	14	15	16	17	18	19	20
First costs											
Energy costs		$30,542	$32,069	$33,672	$35,356	$37,124	$38,980	$40,929	$42,975	$45,124	$47,380
Replacement costs											
Maintenance costs		$20,428	$21,040	$21,672	$22,322	$22,991	$23,681	$24,392	$25,123	$25,877	$26,653
Net Annual Cash Flow		$50,969	$53,109	$55,344	$57,678	$60,115	$62,661	$65,320	$68,099	$71,001	$74,034
Present Value of Cash Flow		$21,860	$21,090	$20,350	$19,637	$18,951	$18,290	$17,654	$17,042	$16,452	$15,884
20-year Life Cycle Cost:	$717,100										

Some available resources for LCCA:

ASHRAE: www.ashrae.org/lifecycle

NIST Office of Applied Economics: www.bfrl.nist.gov/oae/oae.html

ACTIVE ASTM STANDARD: E2204-05 Standard Guide for Summarizing the Economic Impacts of Building-Related Projects
www.astm.org/cgi-bin/SoftCart.exe/DATABASE.CART/REDLINE_PAGES/E917.htm?L+mystore+s

ACTIVE ASTM STANDARD: E917-05 Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems
www.astm.org/cgi-bin/SoftCart.exe/DATABASE.CART/REDLINE_PAGES/E2204.htm?L+mystore+s

Current volume of ASTM building standards:
www.astm.org/cgi-bin/SoftCart.exe/BOOKSTORE/COMPS/198.htm?L+mystore+s+1191620252

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Produced by ASHRAE Technical Committee 7.8, Owning and Operating Costs.