# LIFECYCLE COSTING FOR DATA CENTERS:
# *DETERMINING THE TRUE COSTS OF DATA CENTER COOLING*

## Summary

Experts estimate that the average "design" life of a data center is 10-15 years. During that time, equipment will change three or four times. With each change of equipment comes more demand for power. And more power means more heat.

This makes evaluating cooling systems for the data center a significant challenge. Synchronizing technology equipment with power, floor space and proper cooling — and doing it all cost-effectively — takes serious analysis. Plus, with corporate budgets being scrutinized and squeezed, the need to justify return on investment is greater than ever.

Lifecycle cost analysis provides a tool that can be used to evaluate alternate cooling technologies to determine which will have the lowest lifetime costs. It is an economic tool that can be used to analyze the relative costs of technologies, which have been proven to be technically feasible in terms of capacity, availability and other factors.

Lifecycle cost analysis considers all the costs associated with acquiring, operating and disposing of equipment. This requires future costs to be projected, introducing some uncertainty into the process; however, because the same methodology and assumptions are used for each alternative, the results provide an accurate indication of the relative lifetime costs of the alternatives being considered.

Lifecycle cost analysis enables the organization to go beyond initial purchase price when evaluating cooling systems and base purchase decisions on the true costs of acquiring and operating the equipment over its expected life. Lifecycle cost analysis can help facilities managers, planners, engineers, designers and IT directors better understand and manage costs associated with running a mission-critical data center. Of course, the methodology is not limited to the corporate data center. It can be applied to a variety of environments that contain a highly concentrated load of electronic equipment, including large telecommunication switches, Internet service provider routers (ISPs), co-located server hosting facilities, and data storage facilities.

## What is Lifecycle Cost Analysis?

Lifecycle cost analysis (LCCA) is an economic method of project evaluation in which all costs of owning, operating, maintaining, and disposing of a project are considered important to the decision. It is the sum of present values of all costs over the lifetime of a project, product or measure, including:

- Investment costs
- Capital costs
- Financing costs
- Installation costs
- Energy costs
- Operating costs
- Maintenance costs
- Opportunity costs
- Disposal costs/salvage value

LCCA is particularly suited to assessing design alternatives that satisfy a required performance level, but that may have differing investment, operating, maintenance, or repair costs — and possibly different life spans. The result is generally expressed as the value of initial and future costs in today's dollars, as reflected by an appropriate discount rate.

It can be applied to any capital investment decision, and is particularly relevant when higher initial costs are traded for reduced future cost obligations; however, it is not a system for determining the total cost of a project. It should be used only to compare the costs of alternative ways to accomplish a goal in order to make a sound business decision about which option will provide the maximum benefit at the lowest cost.

LCCA also should not be confused with value engineering. Value engineering is a systematic procedure for analyzing the function of facilities, systems, equipment and other items so that anything that adds cost without contributing to function can be eliminated or modified. With value engineering, each element is scrutinized to determine if an alternative material, design or method could produce the same results at lower cost.

LCCA can be used as a tool for value engineering analysis. For example, an LCCA may show that an alternative with the lowest lifecycle cost does not have the lowest first cost because of lower operating costs. However, the first cost of the preferred alternative might exceed the project budget, eliminating it from consideration, regardless of lifecycle costs. If the value engineer can succeed at reducing the initial cost of the desired alternative, it can be used and the long-term cost-effectiveness of the project is optimized.

To be performed effectively, engineers, and project managers should:

* Allow ample time and budget for LCCA early in the project.

* Devote the appropriate time to data development without compromising other important projects.

* Carefully select areas that LCCA will be needed — the most expensive and major items should be considered first.

* Provide budget contingencies for items with higher first costs if the LCCA determines these alternatives are preferable.

## Why Perform A Lifecycle Cost Analysis?

Analyzing costs over the life of a facility or equipment is key to understanding return on investment and to making investment decisions based on true costs versus initial costs. Understanding cost drivers can also help control costs, especially in data centers where physical infrastructure expenses are often comparable to or larger than the cost of the technology being supported.

LCCA can also help ensure solid business decisions are made about design and sizing, location, replacing or making new purchases, interdependence of the data center with other systems or physical infrastructures, budget allocations, and overall priorities.

Properly performed, an LCCA can:

- Provide the most credible measure of the overall cost-effectiveness of design alternatives through its inherent systematic, rational and objective approach.
- Offer realistic data that can validate the chosen alternative.
- Determine ways to minimize the total cost of ownership.
- Supply data for future studies.
- Create cost-awareness and visibility, ensuring cost-consciousness.

## Lifecycle Cost Analysis and the Data Center

Data center design is complicated by rapid changes in technology and uncertainty about future capacity requirements. Lifecycle Cost Analysis can provide an objective approach to making informed decisions in the face of these complications.

Consider, for example, the changes that are occurring in power densities and the resulting heat generation in servers and communication systems. Power densities for rack servers has increased from 1-2 kilowatts per rack to 10 to 15 kilowatts per rack in recent years. With the emergence of blade servers, a single rack can now accommodate as many 60 servers, significantly changing the power and cooling requirements of the data center. As the Meta Group noted in a 2001 report:

> Driven primarily by rapidly increasing rack-mounted servers (being added at 45 percent to 55 percent annual rates) and storage, power-hungry hardware threatens many current data-center design specifications. Although a slower technology refresh cycle (at the expense of space) can push power upgrades out 12-18 months, these power and cooling problems will continue to plague designs.

In fact, the 2004 400-watts-per-square-foot requirement will again double by 2008, so designers must work this into longer-range facilities plans so that space can be fully used, as opposed to 40 percent to 50 percent utilization because of insufficient power and cooling.

This trend will have a significant impact on data center planning as engineers strive to weigh the higher initial costs of supplemental cooling against the increased floor space and energy costs required to cool high density systems with traditional approaches to cooling. Figures 1-6 show projected power and heat trends.

## Fundamentals of Lifecycle Cost Analysis

To derive the most value from an LCCA, it's important to understand a few fundamentals.

Time value of money

The foundation of an LCCA is the time value of money. Time adjustment is necessary because a dollar today does not have value equivalent to a dollar in the future. That is because money has real earning potential over time among alternative investment opportunities, and future revenues or savings always carry some risk. Thus time value can be viewed as shown below:

The time value of money is important when performing a cost analysis because typically the costs and benefits of a project or purchase are spread out over time.

Discounting

The time value of money is calculated using a discount rate. The mathematics of discounting is similar to, but the reverse of that used to calculate compound interest, and the discount rate is closely linked with the interest rate. Evaluating a project cash flow using the technique of discounting is called discounted cash flow (DCF) analysis.

Calculating the time value of money can be expressed as follows:

$$\text{Future Value} = \text{Present Value } (1 + \text{discount rate})^N$$

$$\text{Present Value} = \text{Future Value}/\ (1 + \text{discount rate})^N$$

Where: N = number of interest periods.

A change in the interest rate has only a minor effect on the LCCA because the same rate is applied to all alternatives being studied. It will influence the amount of the present value of each cash flow, but will not influence the relative position of two cash flows for the same period.

| | **Borrower** | **Investor** |
|---|---|---|
| Present | A dollar borrowed now requires repayment of more than a dollar in the future | A dollar invested now will yield more than a dollar in the future |
| Future | A promise to pay a dollar in the future can only be traded for less than a dollar now | A promise to pay a dollar in the future is worth less than a dollar now |

**Time value of money.**

Inflation
Inflation can also be considered in an LCCA because it affects the relationship between the present and future value of money. Inflation rates can be determined from historical data and financial forecasts. It is typically best to assume one rate of inflation for all alternatives. Three percent is a good standard based on history.

Total Cost of Capital
The total cost of capital can also be considered when performing an LCCA. The total cost of capital reflects the cost of using cash for capital projects versus other uses for that cash. Calculating this cost can be complex, so typically a standard percentage is used. This is also called an overall discount rate.

Lifecycle
Two time periods should be considered when doing an LCCA: the lifetimes of the alternatives being studied and the length of the analysis period.

For example, the generally accepted useful lifetime of HVAC equipment is 20 years. If the LCCA period is also 20 years, the analysis is straightforward. Replacement costs for equipment with useful lives shorter than the analysis period will need to be represented in the analysis, while equipment with longer lives than the analysis period will show some salvage value in the LCCA. For proper analysis, it is recommended that the analysis period not be shorter than the expected lifespan of the equipment.

## Performing a Lifecycle Cost Analysis

1. **Define objectives,** including results you hope to achieve, focus of the analysis, people affected or involved in the analysis, and specific criteria to measure the effectiveness of each alternative.

2. **Identify alternatives** that represent a wide range of solutions to the identified problem. Make sure that all alternatives are technically feasible in terms of capacity, availability and other relevant factors.

3. **Define assumptions,** both current and future, including analysis period, cost of capital, discount rate or interest rate, system boundaries (such as electrical, mechanical, water, and air, requirement of cooling systems in each alternative; limitations and boundaries may have an effect on an alternative's cost or viability).

4. **Document alternatives** to be considered in the analysis.

5. **Assess all costs** associated with each alternative, including:

   • Construction and procurement costs at the beginning of the analysis period (initial costs). Typical initial costs include:
   - Fees, real estate, financing and insurance costs.
   - Alteration and replacement costs such as demolition, renovation, equipment relocation, facility reconfiguration, including contractor costs.

- Equipment costs.
- Installation costs, including labor, project overhead, contractors' overhead, and profit. Consider also costs associated with project administration and engineering.
- Opportunity costs, sometimes called collateral costs. These are costs associated with one alternative but not another. For example, when evaluating data center cooling, the costs of data center shell should be considered if one alternative requires racks to be spaced further apart, or requires more data center floor space than the alternative. Floor space value usually does not depreciate; its salvage value is usually 100 percent of its present value. Opportunity costs also may include the following infrastructure costs:
  - Chilled water capacity
  - Electrical feeds
  - Controls
  - Fire sprinklers
- Disposal, demolition and other terminal costs as well as salvage values at the end of the analysis period. Typical terminal costs and salvage values include:
  - Alteration costs to convert a space to another use at the end of a specified time period, for example.
  - Salvage value of items whose economic life exceeds the analysis period; this value is a benefit, and is therefore recorded as a negative cost.
- Continuing costs of operation during the analysis period. Typical continuing costs include:
  - Energy: amount of power used per year and the unit costs of the power.
  - Salaries: salaries do not need to be included in an LCCA unless additional labor is needed to operate or maintain a particular alternative.
  - Maintenance: include cost for replacement items with service life less than five years, as well as costs for supplies and service contracts.
  - Financing, taxes and insurance: usually do not need to be included in an LCCA if they are the same for all alternatives being studied.
  - Equipment replacement costs for items with a service life less than the analysis period must be included.

When determining costs, do not include costs common to each alternative. An LCCA should be used only to provide a basis for comparison between alternatives. Also do not include costs incurred before the LCCA began.

6. **Calculate net present value.** To properly evaluate the alternatives, all costs and benefits have to be normalized to the same point in time. That is, capital costs and maintenance costs need to be comparable. To calculate net present value, costs and benefits are converted to either present value or annual value. Once the costs and benefits have been normalized, a comparison is performed by adding together the costs and benefits to arrive at a total cost.

7: **Calculate lifecycle costs** using the following method:

a. Add up all of the initial costs for each alternative being analyzed.

b. Add up the present value of all continuing costs described above for each alternative being studied. The estimated costs should be escalated to future value at the inflation rate, and then discounted back to present value at the overall discount rate (cost of capital).

c. Add up the present value of all terminal costs described above, and subtract the present values of all salvage values, also described above, for each alternative being studied. Estimated amounts for terminal costs and salvage values should be escalated to future value at the inflation rate, then discounted back to present value at the overall discount rate (cost of capital).

d. The total lifecycle cost is the sum of initial costs, plus the sum of continuing costs, plus the sum of terminal costs, minus salvage values. The annualized lifecycle cost is the total lifecycle cost divided by the number of years in the analysis period.

8. **Select an alternative**. Usually, this alternative is the one with the lowest lifetime costs. However, other criteria may also need to be considered, including risk minimization, ease of implementation, and other intangibles.

## LCCA in Action

### *Example for Data Center Cooling Equipment*

***Scenario:*** An existing relatively small data center with traditional raised-floor cooling will be updated to accommodate racks with a heat load of 6 kW/rack instead of the current 1 kW/rack. This gives an approximate heat load for the room of 330W/sq ft, including aisles and service space. Existing chilled water system in the building will be sufficient for the new racks.

For cooling of the data center, two different solutions are possible. Solution 1 is a system based on new technology and Solution 2 is a system based on traditional technology. The main differences are that Solution 1 is an overhead distributed cooling system that requires minimum floor space and is more energy efficient than Solution 2. The price (first cost) for Solution 1 is higher than the price for Solution 2.

When calculating lifecycle costs for the two alternative solutions, all costs unique to the alternatives must be included. In the example, the following assumptions have been used:

- Discount rate = 5%
- Analysis period = 15 years
- Project costs (fees, financing, etc.), alteration and replacement costs, terminal costs (disposal costs, salvage values, demolition costs) are considered to be the same for both the alternative solutions.

As seen in the example, the first cost (equipment, installation and opportunity costs) is higher for Solution 1 than for Solution 2. However, when a complete lifecycle cost calculation for the expected twenty year lifecycle of each system is calculated, Solution 1 is shown to be significantly less expensive than Solution 2.

## Conclusion

A Lifecycle Cost Analysis is a valuable tool for making informed choices about several competing alternatives, such as cooling equipment or other data center needs. Looking at purchases from both a present and future value can assist managers in planning, budgeting, and designing data center infrastructures. Finally, LCCAs can help maximize the value of an expenditure by taking into consideration all initial costs, direct costs, indirect costs and salvage values, giving managers a true perspective on the lifetime value of data center cooling systems.

| | **Solution 1** | **Solution 2** |
|---|---|---|
| Equipment cost [1] | $42,500 | $22,000 |
| Installation cost [2] | $2,800 | $1,000 |
| Opportunity cost [3] | $1,700 | $11,800 |
| Annual Maintenance cost [4] | $150 | $1,000 |
| Annual Operation (Energy) cost [5] | $8,600 | $21,500 |
| **Total Lifecycle Cost, Present value** | **$138,000** | **$268,000** |

Notes:
[1] Includes all hardware costs unique for the solution
[2] Includes all installation costs (material, labor, project overhead and contractors overhead and profit) unique for the solution
[3] Opportunity cost unique for the solution. Solution 1 is an overhead cooling solution that requires minimum floor space.
[4] Includes annual costs for maintenance of the solution during the analysis period.
[5] Includes annual costs for operation (energy) of the solution during the analysis period.

**Sample lifecycle cost analysis showing the difference in lifecycle costs between alternate cooling solutions.**

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