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Life Cycle Cost Analysis

This white paper will outline the benefits of using full life cycle cost analysis (LCCA) for making mechanical, electrical and plumbing infrastructure decisions. It will include two case studies; one involving the HVAC system at a 500,000 square foot hospital expansion, the second involving cogeneration units for a large healthcare complex. The goal will be to become familiar with the information used in life cycle analysis and how to interpret the results, and to understand their sensitivity to assumptions.

The life cycle cost is the overall cost of a system over the life of the facility or the system considering all related costs, and includes construction, operation, and maintenance. Life cycle analysis is becoming more prevalent in the design industry, particularly as capital is further constrained by the recent economic downturn. More now than ever, projects need to be evaluated to consider the financial impacts and feasibility.

Many factors must weigh in on mechanical, electrical and plumbing high level system decisions. While upfront costs are very important, the overall comparative cost of each system over its life or the life of the hospital must be a major consideration. Too often these long term costs are not taken into consideration when the owner and architect/engineer team are trying to cut construction costs, but it can make a huge impact to the operating costs of a facility. In today's volatile economy, low overhead is paramount to a hospital's survivability.

Healthcare engineers are faced with important decisions on a daily basis that require understanding of capital and operational impacts. Performing a life cycle cost analysis is an effective tool to be used in the decision making process.

In many instances, life cycle cost analysis goes hand in hand with sustainable design goals, and is used as a tool to evaluate the financial feasibility of a "Green" engineered system. Reducing the energy use of healthcare facilities is in the forefront for every facility manager; however, if the additional cost of the system cannot be justified to the people providing the money, the system will most likely not make it into the final design. A life cycle analysis during early design can provide the financial justification for a more expensive, yet ultimately more sustainable, MEP system.

Life cycle cost analysis takes into account many factors, including the following:

- Initial construction costs
- Maintenance and operating costs including re-commissioning
- Energy costs, including time of use costs, for electric and gas utilities
- Square footage costs for equipment of differing sizes

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- Acceptable return on investment
- Equipment expected life and replacement costs

These costs can be assumed using good cost estimation techniques combined with experience. It is extremely important for the facility manager and engineer to understand and have confidence in these numbers.

Much tougher to estimate, is what will happen in the future. Since the analysis must look into the future, many assumptions must be made, including the following:

- Electrical/Gas cost inflation
- Material cost inflation
- Labor rate inflation

These factors can sometimes be difficult to obtain or assume, and it is important to understand the effect of incorrect assumptions on the overall outcome. No one knows exactly what electric utility rates or material cost will be in the future, but using good historical data and understanding the analysis' sensitivity to changes in these assumptions can provide the facility management with the tools to make an educated decision.

By looking at the sensitivity of the analysis for variables and assumptions, we get a better idea of the risk in making those assumptions and the implications of fluctuations in the variables. If the sensitivity of a component such as future electricity rates in significant, we will want to take that into account when drawing conclusions on the results.

The output of a life cycle cost analysis has two parts: a net present value (NPV) of each option over its life, and a payback period. The NPV is the entire value over the course of the system's life in today's dollars, taking into account increases in factors such as energy and maintenance costs and a return on investment if the capital was used somewhere else. Payback refers to the length of time it will take to make up the additional up-front costs of a system given its decreased operating and maintenance costs.

NPV and payback are useful metrics for comparing investment alternatives or justifying capital expenditures. In comparing several investment alternatives, the NPV metric allows us to normalize the options to create a meaningful comparison. Typically, we will select the alternative with the greatest NPV, unless there are other intangibles that are not part of the cost analysis. Payback can be used to evaluate alternatives, but is also useful when evaluating and scheduling capital expenditures as well as estimating when the return on investment will occur.

Looking at two different case studies where life cycle cost analysis was used it is evident to see the benefit of the exercise. The first case study involves the HVAC system at a 500,000 ft^2 hospital expansion, while the second study looked at the decision to utilize a cogeneration plant to provide power, chilled water, and steam to a large medical campus.

In considering the design components of the mechanical system for a 500,000 ft^2 hospital expansion, we performed a lifecycle cost analysis to inform the design and evaluate the most cost effective solution. The analysis consisted of:

- Energy modeling of proposed systems – An energy model was created to reflect the geometry/building constructions of the building and also to simulate the mechanical systems.
- Evaluation of energy conservation measures (ECM's) – The energy model was used to evaluate the impact of several system alternatives, or ECM's.
- Cost estimation of the ECM's – a cost analysis was performed to quantify the initial capital cost implications of the ECM's
- Life Cycle Cost Analysis (LCCA) – A LCCA was performed using the energy model, cost estimation, and general assumptions.
- Results and analysis – An evaluation of the LCCA analysis was performed, including a sensitivity analysis to understand the implications of the assumptions. The results of the analysis were presented to the client, who ultimately went with the team's recommendations of the system based on the results that has the potential to save more than 30% of the facility's energy consumption over the baseline design.

In the second case, we look at a large healthcare campus, with two hospitals, multiple medical office buildings, and a prominent medical school. With such a large amount of space, with a large utility usage, it seemed that a cogeneration central utility plant could be a possible life cycle cost savings.

The cogeneration plant would supply electricity, steam, hot water, and cooling to the campus, replacing some of the operational costs associated with utility gas and electricity. But is the capital investment worth the operational cost savings?

The building loads were derived to initially size the system. Load metering and analysis, and study of each building's utility records, helped to determine a proper load usage chart. This indicated the differing loads depending on the time of day or season, and would set the basis of our analysis.

With the building loads in tow, the size of the plant is chosen, which sets the output in electricity and steam, and the input in water and some kind of fuel. We can also estimate the construction cost once the system is sized, and by talking to manufacturers and other facility engineers, the operation and maintenance annual costs can be determined.

As the factors start to add up, the assumptions just get started. How much will utility rates increase annually over the life of the cogeneration plant? Or labor and material costs? Using historical data and published projections, utility, labor, and material cost inflation can be estimated to facilitate the analysis.

A sensitivity analysis of the variables is performed to understand the implications of the assumptions and the effect of forecast inaccuracies.

The LCCA resulted in a payback period for the proposed system which was greater than the owner would accept. Also, the sensitivity of the analysis with respect to gas and electricity process increased the risk that forecast inaccuracies would further increase the payback period. Therefore, the facility decided not to pursue a cogeneration solution.

As we have shown, life cycle cost analysis can be an effective tool for helping facility management in evaluating mechanical, electrical, and plumbing alternatives. In order for it to be effective, careful consideration should be given toward making assumptions and how the sensitivity of the results to these assumptions can significantly affect the financial feasibility of a particular solution.