

# 39

## Energy-effective machinery can be self-financing (a case history)

Life-cycle costing is an effort to quantify the total owning costs of a system, subsystem, or component. Owning costs, in turn, can best be segregated into three basic components: 1) first cost or investment, 2) energy costs, 3) maintenance and service costs.

For many reasons the trend in product development in recent years has been to minimize first cost at the expense of the other two. However, with the recently accelerating increases in energy values and consciousness of the significance of maintenance and service costs, the trend is moving toward giving due consideration to these two components.

### Life-cycle costing revealing

A (mid-1975) experience in life-cycle costing was most interesting and revealing. In an existing plant, two absorption water chillers were to be replaced with two new centrifugal chillers. The preliminary designs were completed, including development of flow diagrams and complete detailed load and energy studies. At this point, it was decided to request proposals on the chillers, and specifications were written for life-cycle proposals.

To account for energy costs, the following energy cost impact features of the machines were considered:

- *Power impact*—From the refrigeration part load analysis, it was determined how many months a year both chillers would operate, how many months one chiller would operate, and how many months no chillers would operate. A formula was then developed

to provide a single number multiplier taking into account these demands established, the local utility demand rate, and present-day value of future dollars based on the owner's economic variables. The bidder would then simply multiply the full load compressor power (kW) requirement of the proposed unit by this compressor power multiplier to establish the power cost impact for the unit.

- *Compressor energy impact*—From the combination of the refrigeration energy analysis and the part load analysis, a formula was developed, linearizing the part load performance of the units, which provided a single number multiplier to be applied to the compressor power requirement at a single stated point of performance at less than full load. This formula took into account the calculated number of operating hours of each part load condition per year, the graduated commodity rate for the local utility company integrated with the other facility loads, and the present-day value of future monies as described above.

- *Water flow resistance impacts*—Similar single number multipliers were developed relating the pressure drops through the chillers and condensers, respectively, which considered the various parameters described, to be applied to the head loss for the chiller and product of head loss and flow rate for the condenser.

### Include maintenance contact

With calculation methodology currently available, the energy and part load requirements can be quantified quite accurately. Anticipated

maintenance and service requirements are, however, much more difficult (if not impossible) to quantify. Thus, it was decided that the only way to legitimately include this ingredient in the life-cycle proposal was to have each proposal include a full maintenance and service contract for an extended time by the manufacturer. The terms of the contract were specifically enumerated in the specification.

Each manufacturer was then requested to submit a proposal on a stated series or model of machine to comply with specific performance requirements. The information given was full load system capacity, piping configuration, single machine capacity, chilled water flow rate, entering and leaving chilled water temperatures, entering condenser water temperature, and anticipated total machine hours of operation per year. Each manufacturer was invited to submit additional proposals on any alternative units in its product line that could meet the performance specifications.

**Bid to include energy factors**

The bid form included two sections; the first was product cost and energy impact. For any unit proposed, the bidder stated the cost of the machines and cost of start-up services; then entered the compressor full load kW, multiplied by the power impact factor; and entered the product as a power life-cycle value. Similarly, the compressor life-cycle energy value, chiller pressure drop life-cycle energy value, and condenser value were entered. These six figures were then added, giving the total life-cycle cost of the respective unit.

The extended maintenance and service contract proposal constituted the second section of the proposal form. This cost, by previously determined formulation, was then converted to present-day investment dollars.

Six proposals were received. The results are shown in Fig. 39-1. The ordinate represents the amounts and the abscissa the proposals, starting with proposal 1, the lowest life-cycle cost, and extending to the sixth proposal, the highest life-cycle cost. The top curve is the life-cycle costs and the lower one is the first cost, including start-up service. (The first cost was adjusted as needed to account for difference in installation cost between various ma-

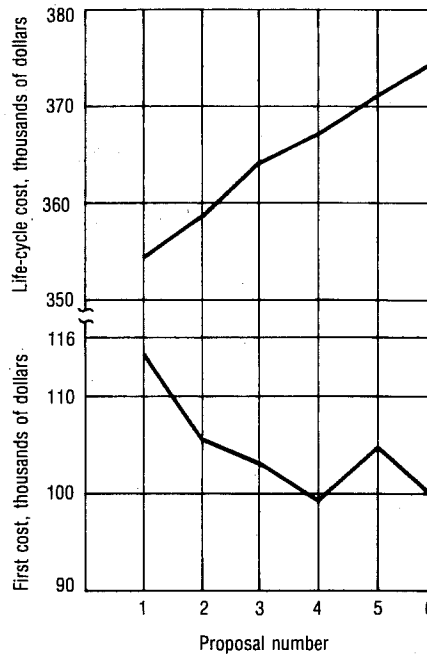


Fig. 39-1. Life-cycle and first cost versus bids received.

chines, such as insulation, field piping of ancillary devices, etc.) The impressive feature of the bids as revealed by the curves is the near-perfect divergence or inverse relation between first and life-cycle costs. It illustrates clearly that industry efforts at investment cost reductions have been at the expense of energy consumption and to a lesser extent, maintenance costs.

This methodology of purchasing major components, if not complete selection of systems, will go a long way toward quantifying decisions that were previously often made on the basis of judgment, but it is one more example of an ever-increasing maturity in the HVAC industry.

*Author's Note:* This chapter was originally published in December 1975. Subsequently, Chapter 40, which details the methodology, was published following additional experience with the technique. Approximately five years after the initial experience, the chiller manufacturers have responded by developing selection procedures to optimize the first cost versus energy-impact relationships of their units, and the divergence in the two curves shown in this chapter is becoming much less consistent.