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Evaluate New Machinery Purchases Using Life Cycle Costing Tools

By Fred K. Geitner, P. Eng.

Capital costs of new projects attract the most attention of both management and vendors. However, it must be recognized that operating and maintenance (O&M) expenses are also as significant. Unfortunately, evaluating the total cost of ownership of a plant asset on a common basis with the capital cost is difficult: so managers tend to give priority to initial cost. In extreme cases, the potential O&M costs might not be considered at all when specification and purchasing decisions are being made and are driven only by initial capital cost and schedule considerations. Consequently, poor reliability and performance of our machinery equipment do not show up until the plant is actually up and running.

Less expensive systems are more likely to have inferior materials, poor workmanship, and weaker designs. Designers frequently do not elect to use redundant equipment because it is "too expensive," even though averting lost production by providing spare machinery, for example, may pay for the initial cost many times over.

Life Cycle Costing (LCC) is a promising evaluation tool that makes it possible to compare alternatives by quantifying the long-term outlook. In refinery and petrochemical plant operations, for instance, maintenance and downtime costs often exceed the initial equipment cost. LCC identifies and quantifies project costs over the life of the project. It includes future costs of O&M, downtime, production losses, replacement, decommissioning, and incremental operating costs associated with material choice, and initial costs.

Life cycle costing has always been applied in an intuitive way in the form of cost-benefit deliberations. The main value of a formal LCC is that it quantifies life cycle elements in a uniform manner so that their relevance can be established and receive appropriate attention. LCC should be applied as early as possible in the life of a project to achieve the greatest benefit.

Unreliable equipment causes a significant loss in production and waste. However, reliability is frequently a fuzzy concept to project engineers, and they often do not know how to address it. By using LCC, the use of more reliable equipment can be justified using a credible analysis approach that is acceptable to accountants and business planners.

Increasing the useful lifetime of any system costs money and involves trading against other benefits. Figure 1 provides a simple illustration of such trade-offs. It shows that life cycle costs and benefits depend on good design integration and support. Hardware is only one factor in the overall picture.

Upcoming Training Courses held in our NJ offices

- Course 1510, *Mechanical Design of Process Plant Equipment,* February 1-4, 2011
- Course 607, *Design and Maintenance of Aboveground Atmospheric Storage Tanks* February 23-25, 2011
- Course 1615, *Maintenance Practices for Improved Plant Profits,* March 2-4, 2011

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Work Highlights

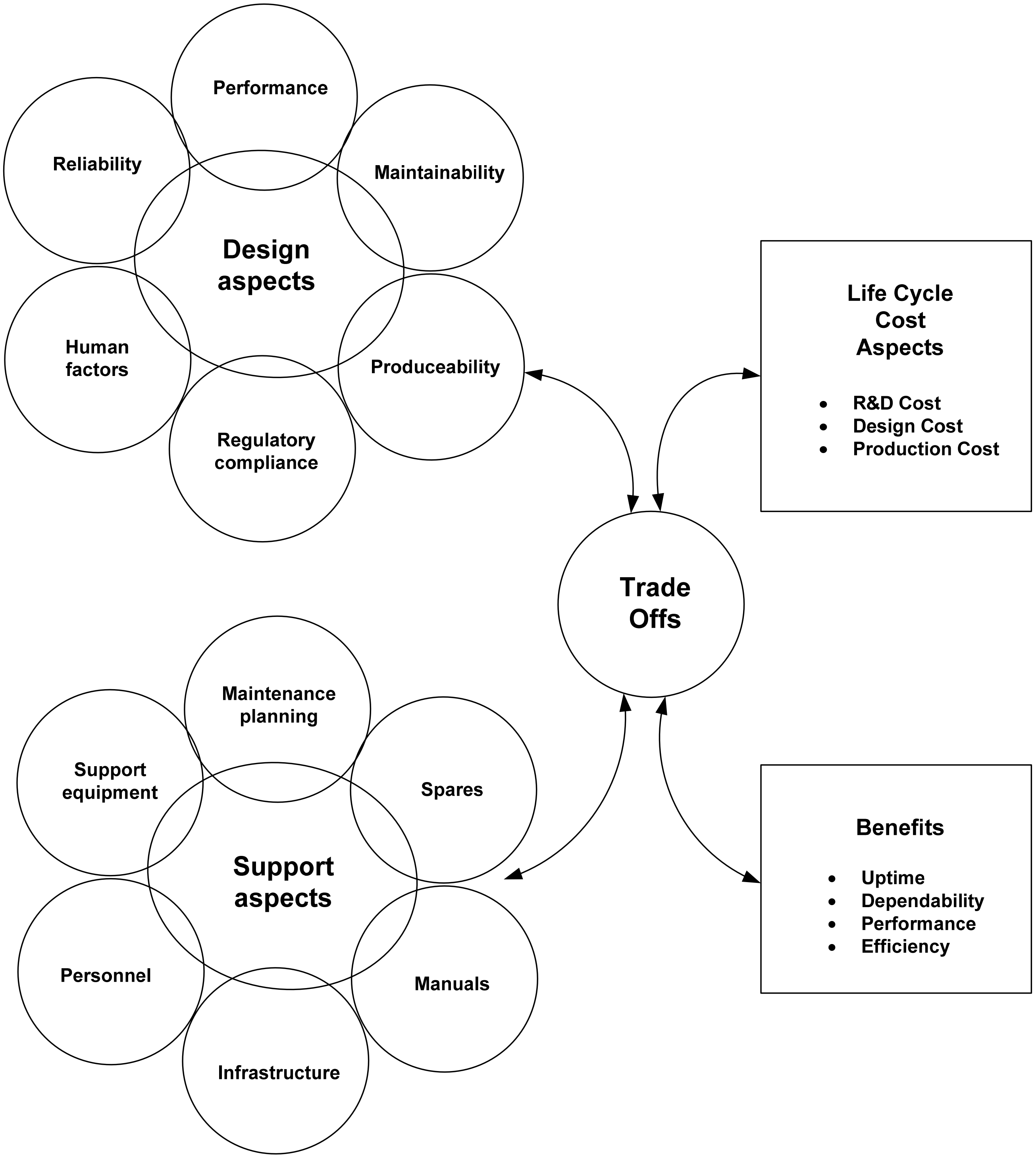
Process, Operations, & Safety

Provided a number of hydrotreating unit performance modeling and revamp screening assessments for a major licensor.

During a unit turnaround, provided process and mechanical advice on refiner's observed FCC Regenerator air grid deformation, and provided an assessment of its cause and approach for timely rectification.

Provided emergency turnaround consultation on risk assessment of client's proposed FCC modifications.

Figure 1 - Life Cycle Costing Trade-offs[1]



In general, a LCC analysis follows the 12 basic steps listed in Table 1. The relative importance of each of these steps, and hence their level of application, will vary according to the requirements of a particular LCC analysis.

Table 1

STEP 1:	Define the problem.
STEP 2:	Identify feasible alternatives. Engineering must produce preliminary designs of multiple configurations that are expected to meet the objectives. This stage eliminates unworkable solutions. The concern here is with meeting performance parameters.
STEP 3:	Consider alternatives and the system requirements. This is the first look at operations and maintenance. Identify and categorize the life cycle activities. If nothing else, this activity raises awareness that reliability is a parameter in the design process.
STEP 4:	Analyze the total lifetime of potential events for the physical asset. Include in these events all applicable future activities associated with research, development, production, construction, installation, commissioning, operation, maintenance, and disposal. In the analysis, identify all resources required during the lifetime of the asset. Group the identified events, activities, and resources into major LCC elements, and then break them down into sub-elements. This activity has been refined into what is known as the cost-breakdown-structure, CBS. Note that all abbreviations used are defined in Table 2.
STEP 5:	Set up a model to define the cost factors and estimating relationships. These factors and relationships include items such as hourly labor rates, profit margins, and fuel-consumption rates.
STEP 6:	Work up the cost of each of the life cycle elements. The previously determined cost estimating factors and relationships are applied to cost models for each of the elements.
STEP 7:	Account for inflation and learning curves. Set the accuracy required in the calculated life cycle cost. Inflation will have strong effects on the life cycle cost of today's physical assets.
STEP 8:	Discount all the estimated costs to a base period. Discounting yields a common basis for financial comparison by removing the effects of time differences. The process is based on finance mathematics and uses the concepts of sinking fund, present value, and capital recovery.
STEP 9:	Identify the high-cost contributors. There are facilities in which one or two costs overwhelm all the others. This is a shortcut to concentrate on such items, because they promise the highest payoff.
STEP 10:	Calculate the final LCC using an appropriate cost model. In many cases, this is likely to entail a straight summation of the cost breakdown elements. In most cases, the model should include a sensitivity analysis. Sensitivity analysis consists of evaluating the results predicted by a model (mathematical or other) upon changing one or more input variables.
STEP 11:	Perform a risk analysis. The LCC technique can be useful when applied to situations that consider alternative decisions on a cost basis. These are basically trade-offs. A few typical situations are: • Balancing the relative levels of reliability and maintainability for a given piece of machinery or asset against a desired level of availability. • Deciding on the most cost-effective maintenance policy for sub-elements of a given asset. The usual choices are: predictive, preventive, or run to failure. • Deciding which asset to procure when faced with two or more that will satisfy all specified requirements.
STEP 12:	Recommend a solution. LCC can be applied to assist in the logical management of an asset, even without looking at alternatives. Examples of this approach are: • Identifying the exact subsystems where design simplification and cost control will produce major cost reduction and longer life cycles. • Establishing a more accurate budget for the actual project. • Understanding the inner workings of a machine or asset. This sets up a more effective management organization and better control procedures.

The following is a simple example of an LCC tool used in sensitivity analysis (Table 1, Step 10). Frequently, it is not obvious what repairs on process equipment really cost. Consider a population of centrifugal pumps which are important elements in pipeline, refinery, and petrochemical plant operations. Long-term records show that the MTBR of these pumps is 25 months. We want to find the equivalent capital cost of the repairs. The life of a pump is assumed to be 15 years. This calculation discounts annual repair costs back to the date of purchase. Other data from the operation are: MTTR = 5 d; C_G = \$7,500; i = 6.5%; C_Y can be calculated as follows:

The present value of the repair costs, C_{PV}, can be determined by looking up the present value factor as a function of interest rate, years of life, and annual costs. This example employs the PV function in Microsoft Excel.[2]

$$C_{PV} = \mathrm{PV}\ (\text{rate, years, } C_Y\ )$$

$$C_Y = \frac{8{,}760 \times C_G}{\left[(\mathrm{MTBR} \times 30.4 \times 24) + (\mathrm{MTTR} \times 24)\right]}$$

$$C_Y = \frac{8{,}760 \times 7{,}500}{\left[(25 \times 30.4 \times 24) + (5 \times 24)\right]} = 3{,}578$$

$$C_{PV} = \mathrm{PV}(0.065,\ 15,\ 3{,}578) = \$33{,}643$$

Our sensitivity analysis now has a basis. Look for the benefits that could be derived from attempting to reduce repair costs. Evaluations will compare purchasing a more expensive and hence (hopefully) more reliable pump or by making repairs more efficiently and hence less costly.

Finally, many reliability professionals are talking about Life Cycle Costing today. Frequently, that is where this subject remains – in the talking phase. A few basic and simple administrative procedures can help to familiarize plant personnel with LCC concepts. However, to implement LCC practices, a company policy must be established.

Table 2 – Abbreviations

C_G	Average repair cost, \$
C_{PV}	Present value of costs, \$
C_Y	Annual repair costs, \$
i	Current interest rate, dimensionless (decimal form)
MR&O	Maintenance, Repair & Overhaul
MTBR	Mean time between repairs, mo
MTTR	Mean time to repair, d

References

1. Bloch, H.P. and Geitner, F.K., *Maximizing Machinery Uptime*, Elsevier – Gulf Publishing, Amsterdam – Tokyo, 2006.
2. Microsoft Corp., Excel Ver. 5.0, Help Function PV. Redmond, Wash., 1997.
3. Bloch, H.P., *Improving Machinery Reliability*, 3rd ed., Gulf Publishing Co., Houston, TX, 1998.
4. Galster, D. and Geitner, F.K., *Using Life Cycle Costing Tools*, CHEMICAL ENGINEERING, pp. 80-86, Feb. 2000.
5. *Pipeline and Gas Technology Magazine, June 2005*

About the Author

Fred K. Geitner has over 40 years experience in design, maintenance, operation, and troubleshooting of machinery used in process plant and transmission pipeline applications. Registered Professional Engineer in the Province of Ontario, Canada. Expert witness for rotating and reciprocating process machinery and advises and teaches in the field of process machinery reliability improvement and maintenance. Worked as an engineering consultant for a major natural gas transmission company in Germany where he was involved in machinery technology liaison work (gas turbines and compressors) between pipeline companies in the newly independent states of the former Soviet Union and the German firm.

Please contact Vince Carucci (vcarucci@carmagen.com) if you'd like more information on Carmagen's expertise in this area.

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For more information, please contact Pat Terry at pterry@carmagen.com.