Optimizing Operational and Performance Efficiency in the Engineering Design of Systems — *"It Takes a Village"*

By Don Voigt, PE

"A building owner generally spends nine times more to build a facility than to design it; thirty times more for O&M than for design; and 460 times more to pay the people that will work in the facility (over its useful life) than was spent on the design." [1]

Efficiency – a word uniformly appreciated but often misunderstood. And, we all agree, efficiency is uniformly highly valued. In engineering circles, efficiency, generally, refers to conservation of resources through efficient and effective use of products and processes.

Yet, human nature does not always lend itself to consistent performance of efficiency. This treatise explores the how and why of improving efficient use of energy. We will consider the human elements of engineering—focused on efficiency as a final objective.

Unlike other commodities (like gold bullion, for instance) energy is not directly seen nor readily stored. It is, rather, a quantity which is consumed or transformed into other forms (First Law of Thermodynamics). Efficiency implies a well-engineered rate of consumption of energy—or, a careful transformation of one form of energy into another (such as epitomized by an electric vehicle). A learned engineering design trait which, often, falls prey to "convenient" or "easy."

In the area of engineering design, efficiency is an appreciated form/factor. After all, our patrons of design—Archimedes, Newton, and Liebnitz, Michelangelo, Volta—all strived for efficiency in their approaches to innovation…always searching for the quintessential laws governing scientific projects.

Today, engineers approach designs or construction with the intent of providing efficient designs and implementation of projects.

Yet, all of us fall prey to “convenience.” And, to what I’ll call elementalism—designing “inside of our box,” so to speak. Examples abound – from misapplied pumps to inappropriate software for design of the next widget.

How does this happen, in an age of hyper information, where specific answers to specific questions are only a “Google search” away? Two potential answers include: 1.) “silo” design mentality and 2.) an acquiescence to low (competitive) initial cost. Each of these falls through our review processes when the reviewer is focused on “design for function” vs. “design review for lowest life cycle cost of the system.”

Designs need to begin with the end in mind—as Steven Covey’s aphorism postulates. For designers, the end must include:

1. Total cost of ownership
2. Total impact on world environments
3. The effect of this design on the system—be it the direct related elements/structures or the world we live in and how people will be affected (Scott Johnson of CH2-Hill).

“Designs need to consider the entire system - to be efficient” – Scott Johnson, PhD, CH2M

Total cost of ownership spreads all costs (including impact costs on related systems) to the owner/buyer. Of course, the automobile is the common example of this—using initial purchase cost as only a fraction of the total cost of ownership—when factoring in fuel costs, maintenance costs, and resale (salvage) “cost.”

Likewise, total impact on world environments for an auto will include CO_2 emanation, impact of the manufacturer’s facility on world environments and final disposal or reuse capability. Such factors should give rise to the X-generations’ fascination with electric self-driving Uber/van concepts which are emerging in world markets. Such a concept meets/hits on all cylinders (a word which is likely to be forgotten or lost in coming decades).

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And, the need to consider “systems’” effects of our product or process is so often lost in the focus on our own device/concept. Commonly known as “silo effects”—where elements or discrete portions of a complex system may be an optimum for the individual silo but in complete disparity with the overall system. Draper Kauffman Jr. has written a wonderful text titled “Systems 1—An Introduction to Systems Thinking” —highly recommended reading. Among his postulations is this:

“Everything is connected to everything

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else. Life is lived in a complex world system where all of the subsystems overlap and affect each other. The common mistake is to deal with one subsystem in isolation, as if it didn't connect with anything else. This almost always backfires as other subsystems respond in unanticipated ways."

So, given the complex interrelatedness of our designs/products/processes, what can we, as the individual designer/engineer, do to improve upon the process and bring harmony to the overall system?

1. Begin with a mission/vision—one which encompasses the diversity of the use and user alike. For without such a stated mission/vision, we wander, lacking focus and lacking a comprehensive perspective.
2. Begin with a charrette—whether your project is a new corporate headquarters or a new air conditioner—charrettes invite a broad cross section of perspectives—from concept inventor to end user and all elements of construction between.
3. Embrace/seek feedback—from beginning to end. Feedback loops—both plus and minus—help evolve systems into an optimal format. Continue the feedback process (from benchmarking in equipment operational costs to customer surveys in service businesses) so that systems can be improved and continue to evolve. Don't fight positive feedback —support negative feedback (example: don't poison pests, support their predators, instead).
4. Everything is connected to everything else. Real life is lived in a complex world system where all the subsystems overlap and affect each other. This is true in both micro and macro evaluations of design implications.

And, know that in the end there are no simple solutions. To quote, again, Dr. Kauffman: "Real life systems are big, messy, complicated things, with problems to match. Genuine solutions require careful thought for their effect on the whole system. Anyone who tries to sell you a simple answer—"all we have to do is…and everything will be perfect!"—is either honestly dumb, dishonest or likely, running for office."

References:

[1]*Systems One: An Introduction to Systems Thinking*, Dr. Draper L Kauffman Jr. Stanford Research Institute

About the Author:

Don Voigt, PE, received Bachelors and Masters Degree in Mechanical Engineering from Marquette University. He entered the field of water treatment as an equipment applications engineer and founded Energenecs Inc.—a systems engineering consulting firm in Midwestern USA. In 2008, he divested of Energenecs and founded an equipment efficiency consulting firm in Fort Myers—Engineered Equipment Integration Inc.

He has chaired several engineering-related professional organizations (including chair of Wisconsin's American Water Works Association group). He is current chair of the FES Energy Committee.

In addition to his professional activities, Don has been a supporter of the American Water Works Association's "Water for People" group. As such, he has been active in traveling to Guatemala in a team effort in providing water to undeveloped rural Villages.

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