WANTED:
Masters of Elegant Frugality

THE STRATEGIES USED BY CHEMICAL ENGINEERS TO ACHIEVE EFFICIENT DESIGNS may vary, but they probably reflect the methodologies we learned in engineering school. So, it is only natural that we use them almost intuitively in the work place. We pride ourselves on the fact that we are able to solve any problem with our skillset. But this may come back to haunt us if there's a better way to get the same results.

Suppose that while reviewing the specs for a recent project, you realize that a simple rearrangement of logistics would have eliminated much of the engineering rework performed to meet the client's requests? What prevented you from seeing the forest through the trees? Impeded your ability to think outside the box? Whatever the reason, the engineers at Rocky Mountain Institute (RMI) are on a mission to eliminate the myopic mindset and master the art of efficiency.

In light of John Chen's guest editorial (p. 5) about the future role of ChEs in society, you might say that RMI is demonstrating one of them. E-mail your thoughts and comments to cepedit@aiche.org.

Rita D'Aquino, editor

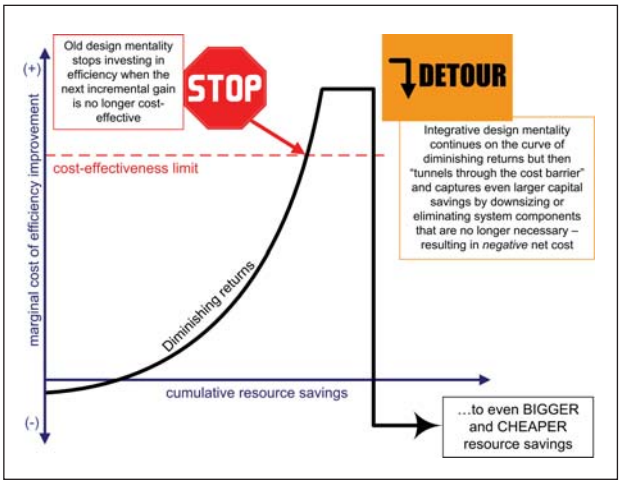
The first Industrial Revolution increased productivity by 100 times because adequate human resources was no longer the rate-limiting step to progress. In the Next Industrial Revolution, the scarcity of natural resources will be our greatest challenge, requiring a collective effort to be more efficient. As chemical engineering continues to accelerate economic progress, its most valuable practitioners will be those whose integrative design skills create radically greater resource productivity at ever-lower costs.

Whole-system engineering — optimizing an entire system for multiple benefits, not isolated components for single benefits — can make very large, even order-of-magnitude, savings cost *less* than the savings achieved by capturing the interactive effects between design components (Figure).

Rocky Mountain Institute (RMI; Snowmass, CO), an entrepreneurial non-profit organization, explored this potential in *Natural Capitalism*. Since then, RMI's engineers have helped firms in 28 industries redesign nearly $30-billion-worth of diverse facilities. In retrofit cases, they achieve energy savings of 30–60% with a return on the investment (in efficient design) of a few years. New-facility savings are 40–90% with *lower* capital costs.

To ensure that designs are done correctly the first time, RMI is introducing engineers to new approaches to problem solving, which are essential to securing long-term efficiency. RMI wants to reform engineering pedagogy and practice to benefit engineering students, teachers, practitioners, clients and stakeholders.

Most of these redesign techniques simply identify and avoid the errors perpetuated in leading engineering textbooks. For example, designers learn to optimize pipe size to minimize pumping-energy costs. But they ignore the avoidable capital cost of the pumping equipment. Consider a European engineering firm that specified 14 pumps using a total of 70.8 kW. Fresh thinking cut pumping power to just 9.7 kW — 86% less, with lower capital costs and better performance — thanks to two changes in design mentality.



Rather than reaching the lower-cost destination along the curve, designers should use integrated design to go there directly.

First, small pipes and big pumps were replaced by larger pipes and smaller pumps. Traditional optimization compares the cost of fatter pipe with the value of the saved pumping energy, but ignores the size, and, hence, the capital cost of the pumping equipment needed to overcome pipe friction. Doubling the pipe diameter decreases the friction, the pumping-equipment size and the equipment cost by nearly 32-fold in this fifth-power relationship. Yet, the capital cost of fatter pipe increases as only the *second* power of diameter, roughly.

Second, the new pumping system was designed using backward thinking — laying out the pipes first, then locating the equipment they connect. Typical pipe runs twist and turn to hook up equipment that is far apart, facing the wrong way, mounted at the wrong height, etc. This raises friction by about three-to-six-fold. Optimal piping systems — fat, short, and straight — require training for pipefitters to learn how to lay out pipes for low friction, and new CAD software.

Good design is about optimizing, and the optimal solution often solves problems you didn't even know you had. For example, the redesign above yielded additional benefits — such as faster construction, simpler maintenance — that were not anticipated.

To help find, exploit, and propagate such opportunities, RMI is developing a casebook on Factor 10 Engineering (10xE; www.10xE.com). Several dozen cases spanning a wide range of engineering disciplines and applications are arranged in facing columns to contrast whole-system with dis-integrated design methods and results.

This effort needs gifted partners. We know they're out there. Please help us find them. If you or other engineers embrace this way of thinking and have a compelling case-study of radical efficiency (preferably with lower capital cost) that you'd like to share, please write us at casebook@10xE.com.

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