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RMI Solutions NEWSLETTER

10XE

"Factor Ten" and the Nonviolent Overthrow of Bad Engineering

By Andrew Kean

Each year, Rocky Mountain Institute attracts a handful of devoted young engineers. Many are looking for alternatives to typical engineering practice, characterized by rushed or copied design and excessive resource consumption, pollution, and costs. Often from the best engineering schools in the United States, they recognize that whole-system design, a concept used throughout RMI's research and consulting practice, is a sensible, money-saving approach to technical challenges.

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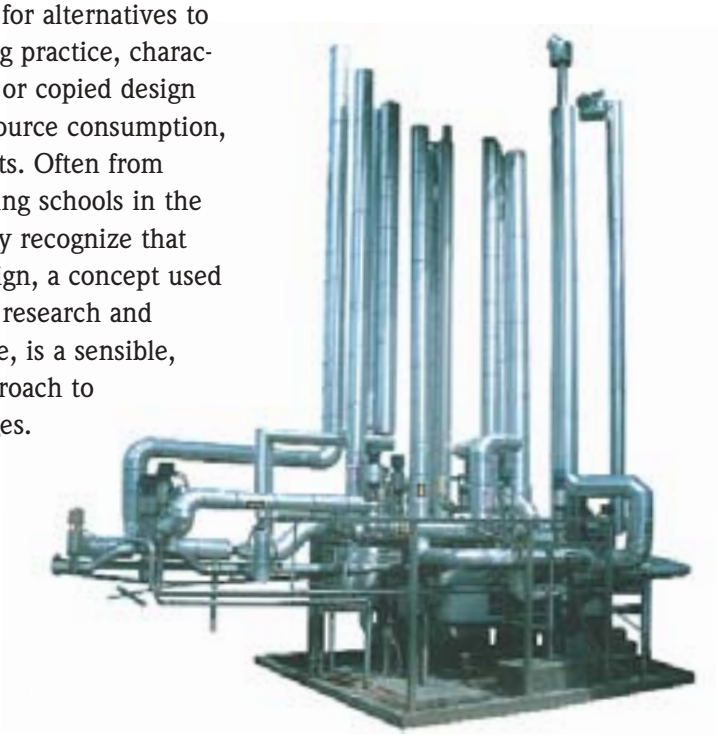

Engineering-as-usual not only reduces the ability of future generations to meet resource needs; it's also a root cause of many present-day environmental, political, and economic problems. Conversely, increased resource productivity—wringing the same or more services from less energy and fewer materials—reduces our ecological footprint, creates wealth and employment, and increases global equity and security. RMI believes whole-system design is the key to advanced resource productivity, and can often reduce its capital cost to zero or less. RMI's technical experts do this routinely in our work to make major corporations radically more efficient, so why can't we create the tools to equip the next generation of engineers (and retread existing ones) to do it right the first time?

Last fall, RMI kicked off Factor Ten

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What's Inside...

10XE

"In today's environment, innovation and technological breakthroughs more likely are driven by convergence—where disciplines intersect... once-singular fields now collaborate, with sometimes surprising, and always interesting, results."

Dr. Shirley Ann Jackson
President, Rensselaer Polytechnic Institute

Engineering (a.k.a. "10XE"), a four-year program to develop and introduce pedagogic tools on whole-system design for both engineering students and practicing engineers. The focus is on case studies where whole-system design boosted resource productivity by at least tenfold, usually at lower initial cost than traditional engineering approaches.

Whole-system design optimizes an entire system to capture synergies. The concept is straightforward, but implementation is not trivial. It requires creativity, good communication, and a desire to look at causes of problems rather than adopting familiar solutions—and it requires getting to the root of the problem: education. Like the engineering profession itself, engineering education is often compartmentalized, with minimal consideration of systems, design, sustainability, and economics. It stresses analysis over synthesis. The traditional design process focuses on optimizing components for single benefits rather than whole systems for multiple benefits—thereby "pessimizing" the system. This, plus schedule-driven repetitis (i.e., copy the previous drawings), perpetuates inferior design. Whole-system design, on the other hand, offers competitive advantage by revealing better, simpler solutions.

Whole-system design has already proved its value in industrial engineering. More than half the world's electricity turns electric motors. The largest use of electric motors is pumping. In 1997, a major carpet manufacturer was building a factory in Shanghai. One heat-transfer loop was designed to use fourteen pumps totaling 95 horsepower. Using whole-system design that RMI's Amory Lovins brought from Lee Eng Lock in Singapore, Dutch engineer Jan Schilham cut the power use by 92 percent to just 7 horsepower by using fat, short, straight pipes rather than skinny, long, crooked pipes. Thanks to smaller motors and pumps, total capital cost went down.

RMI isn't the only organization concerned about the state of engineering education and practice. In an effort to improve the design abilities of engineers, the Board of Direction of the American Society for Engineering Education has recommended that "engineering faculty should use systems approaches, including interdisciplinary teams, to teach pollution prevention, life cycle analysis, industrial ecology, and other sustainable engineering concepts." The Accreditation Board for Engineering and Technology requires a major design experience to include most of the following considerations: economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political. These organizations agree with Dr. Shirley Ann Jackson (the president of Rensselaer Polytechnic Institute) that "in today's environment, innovation and technological breakthroughs more likely are driven by convergence—where disciplines intersect... once-singular fields now collaborate, with sometimes surprising, and always interesting, results." Clearly,

RMI *in the news*

RMI Kicks Off '04 Lecture Series

RMI's popular series of Aspen-area lectures ("RMIQs")* will be returning this year with at least three events. The first lecture will take place 17 February at the Given Institute in Aspen, 5:30–7:00 p.m. Founder and principal of RMI's Green Development Services **Bill Browning, Hon. AIA,** will lecture on "Big and Green" architecture, and describe why big architecture is increasingly going "green." **Dr. John Todd** will be the featured speaker at our second RMIQ lecture (also at the Given Institute, 5:30–7:00 p.m.) on 24 March. One of the pioneers of biological design, John is the inventor of the "EcoMachine," a device that naturally removes pollutants from water. Finally, this summer, RMI CEO and Cofounder **Amory Lovins** will present RMI's latest research on specific ways to end the United States' addiction to oil. "Winning the Oil Endgame" will be presented at Paepcke Auditorium in Aspen; date and time to be announced. Watch RMI's website (**www.rmi.org**) for more details on these and other upcoming events.

**RMIQ is shorthand for RMI's Quest for Solutions.*

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demand for whole-system design and 10XE is high. And these educators aren't the only ones behind it. The William & Flora Hewlett Foundation has funded RMI's planning efforts thus far, and two private firms have already agreed to provide considerable support in the future.

While whole-system design can enrich far more engineering disciplines than it now does, getting 10XE principles widely adopted will require RMI to sustain a complex multi-year campaign. It starts by understanding the current state of engineering education and practice worldwide, defining case-study criteria, collecting initial cases, and recruiting expert practitioners. A charrette-format "summer study" will then collect, write up, and refine the most vivid, memorable, high-brain-Velcro case studies. A first draft of the casebook will next be developed and field-tested with both engineering educators and practitioners. Following revision, a second version will be developed and disseminated through a series of steps engaging both academic leaders and engineering firms. The ultimate "demand-pull" driving both engineering schools and firms will come from major customers—like many of RMI's industrial clients—who need whole-system engineers for their business success.

Firms that apply 10XE will gain competitive advantage, hire more practitioners and recent graduates with 10XE experience, and increase those employees' market value. Progressive educators will adopt 10XE quickly because of the economic and environmental advantages, but less progressive educators are likely to change only when forced by their graduates' difficulty finding jobs. Thus, demand from industry for a different way of doing engineering will prompt change even by those satisfied with the status quo.

The success of this ambitious effort will require international collaboration, so the Institute has teamed up with The Natural Edge Project (see **www.naturaledgeproject.net**). It helps to develop robust frameworks, operational methodologies, and best practices for sustainability, chiefly in the Asia-Pacific region.

Our several dozen Factor Ten Engineering case-studies, spanning the range of engineering disciplines and applications, will optimize whole systems, achieve ten times better resource productivity with no loss of service, have lower first and operating costs, tunnel through the cost barrier, and demonstrate simple, elegant solutions. Whole-system design principles used by RMI's Green Development Services already integrate building orientation, envelope, lighting, and equipment to use an order of magnitude less energy with short or negative payback times.

RMI's casebook will tell many such stories, contrasting their design logic and calculations with traditional ones, side-by-side in two columns. Our goal is to ensure that the reader will never do it the old way again (at least without wincing)—and will run out and tell every engineer within earshot about the great new way to do design.

By the time most designs have been completed, but before they're built, about 80 percent of their lifetime economic and ecological costs have already been determined. It is thus a wise investment in our future to help re-wire the mindsets of engineers worldwide to focus on resource efficiency up front (all the really important mistakes are made on the first day). Making whole-system design the new norm is challenging, but that's what the past twenty-two years have been preparing us for. Through Factor Ten Engineering, Rocky Mountain Institute expects to improve engineering education and practice in the service of a more secure, just, prosperous, and life-sustaining world.

Dr. Andrew Kean, until recently a Berkeley-educated mechanical engineer with RMI's Education Team, has now migrated to our frequent partner Rumsey Engineers in Oakland, Calif.