Sustainability Essentials: Take 1

THE FALL — AND RISE — OF THE ENGINEER IN THE "GREAT SUSTAINABILITY DEBATE"

M. Bruce Beck

THE FALL — AND RISE — OF THE ENGINEER IN THE "GREAT SUSTAINABILITY DEBATE"

M Bruce Beck has recently published his Sustainability Concepts Paper. It took him nine years to complete, not to mention some 160 pages to express in writing. There was (and remains) just so much to be learned from Ecology, Economics, and the Social Sciences; so many planks to be set down for the conceptual platform on which then to build Engineering thinking for sustainability and sustainable development. But what now should Ecology, Economics, and the Social Sciences have to learn from Engineering?

It has been said — strictly as a matter of one engineer's opinion — that the two worst Presidents of the USA were both engineers. Should we conclude that, in a society beyond any technocracy, engineers are not intended to lead, but to follow, albeit in a superbly well organized and systematic manner? Like the proverbial sheep, should we gamble aimlessly about the field of Sustainability, to flock then meekly without dissent around some vision or task handed down by other superior beings?

There is a worthy strain of engineering that argues thus. Engineering design is about making decisions and pursuing strategies according to various criteria of what is the "single best" to be done in the face of a bundle of inevitable constraints. We have long been accustomed to dealing with constraints: on materials and their failure mechanisms, resources, costs, and the environment. So now, deafened by the chorus of calls for sustainability, just give us the social constraints, let us quantify them, expand our optimization program, and turn the handle once again, in anticipation of the utmost sustainable policies and designs "plopping" like clockwork out of the machine and into the hopper. Job done, systematically, optimally, and without fail — the quick engineering fix, as others all too readily have jibed.

Such a caricature of what engineers do plays into the hands of those more articulate, from economics, the social sciences, the law, ecology, politics, and so on, who led (and dominated) the great sustainability debate of the 1990s.

We engineers — who might otherwise never have questioned the orthodoxy of using well cleaned water to move our polluting biological residuals out of our households, office blocks, and public spaces — were brought up sharp in those heady days ahead of the new millennium. Optimizing the performance of such infrastructure was *not* self-evidently to be "doing good by the environment". This water in the Water Closet (WC) and our residuals were potentially a wholesale waste of resources and energy. Adding one to the other had comprehensively undermined our capacity for subsequent recovery of their embodied energy and resources.

In 1913, 40% of the dietary nitrogen of Paris's citizens had been symbiotically recycled as fertilizer onto the land around the city that grew the food for its and their sustenance. After the First World War, this exemplary symbiosis was severed, with the ever more complete installation of what today we would call Paris's (and the world's) conventional wastewater infrastructure. But this form of wet sanitation, sewerage, and sewage treatment — perfected by engineers over decades and centuries — has enabled us to lead healthy and productive lives in cities. One should not mess lightly with this supreme achievement.

And yet, a new vision was needed. It is that expressed in Box 1, a product (appropriately enough) of inter-disciplinary collaboration amongst a Chemist, an Engineer, and an Anthropologist. All 160+ pages of the Sustainability Concepts Paper are then an Engineer's transcription of what it might mean to respond to the challenge of such a vision, according to the Triple Bottom Lines of {environmental benignity}, {economic feasibility}, and {social legitimacy}.

There is something to be learned from engineers. They know a thing or two about control — and wouldn't they just! They know about the dynamics of unending change in the behavior of things. They know about the re-engineering of those dynamics to suit our needs, wants, and luxuries. They are the bringers of "smartness" in our infrastructure. They know about "tipping points" and "systemic risk". They know how to recover the signal from such colloquial noise. They know how to stabilize in the face of the ever-present threat of instability. They know how to manage in spite of uncertainty. And they call it closed-loop, negative (hence stabilizing) feedback — quite the opposite of open-loop conviction politics in the absence of any sensitivity to any kind of feedback. They know that we do not somehow decide once-and-for-all. They have even dared to propose, develop, and label a procedure of "Adaptive Community Learning" (*Take 6*). They know what adaptive control means: to steer and to probe at one and the same time, with one and the same policy decision for sustainability; thus to reduce uncertainty, hence to learn; hence to "steer to learn". Which is what psychologists praise as our acquiring personally and organizationally the high mental complexity of "leading to learn" (*Take 7*).

They know all this — we hope — as they stand yet humbly in the face of their inevitable ignorance of some facet of someone else's expertise, which expertise will surely be needed to get to grips with sustainable living.

"Arise, then, the self-confident Engineer!" It is time for Engineers and Engineering to play their vital, inimitable — and un-sheep-like — parts in the great sustainability experience of this new millennium.

Box 1

Grand challenges for engineering

Turning cities into forces for good in the environment

The world is becoming ever more populous and urbanized. Cities are inherently unmitigated environmental "evils"; with no extenuating circumstances; like bulls in china shops. Man's burden on the environment—woe, that it is—will continue to be piled upon woe. So runs the popular mind-set.

Yet things do not have to be this way, no matter how hard it may be today to conceive of cities as forces for good in the environment. Far from infrastructures having to take on the burden of compensating for the ills of cities, the two should "act" deliberately to contribute positively to enhancement of the environment around them. That is our grand challenge for engineering; and this is how we might begin to think of responding to the challenge.

In introducing their concept of the "urban ecological footprint"—massive, of course, for cities such as Paris, New York, and so on—William Rees and Mathis Wackernagel invite us to conceive of the city as a "large animal grazing in its pasture." We imagine that animal to be a bull. The "bull" of intense social and economic activity in the city is to be shod, we suggest, with the "padded athletic trainers" of re-engineered infrastructures and imbued with a technological deftness and intelligence sufficient for restoring the business of running the environmental "china shop" in which it charges about—indeed, profitably expanding the shop's operations.

The city, continuing the large grazing animal analogy, takes in its daily grass and daily water, while we, for readily understandable but increasingly unsustainable reasons, have engineered the return of the residuals of this metabolism to the air, water, and land environments surrounding the city. In the Global North, a good deal of the city's daily water is used to remove the residuals of its daily grass as wastewater so that citizens can lead healthy and productive lives. And much technological effort has been invested in treating that wastewater, not always to the better of the air, missing an opportunity to benefit the land, while not being a wholly unmitigated good for the water environment. In short, wastewater treatment in the Global North can end up shunting nitrogen into the atmosphere, to avoid fertilizing the aquatic environment, while we labor awfully energetically with the Haber-Bosch process to pull that nitrogen out of the atmosphere to produce industrial fertilizer.

How, then, can the built infrastructure be re-engineered to restore the natural capital and ecosystem services of the nature that inhabited the land before the city arrived there; how can it be re-engineered to enable the city to act as a force for good, to deliberately and positively compensate for the ills of the rest of man's interventions in nature? And how can cities of the Global South avoid adopting the same technological trajectory? Can they, as it were, "leapfrog" the Global North by foregoing the entire human-waste-into-the-water-cycle phase, and thereby end up one step ahead?

More profoundly, how can the engineering of city infrastructure be deployed expressly so that those at the bottom of the pyramid of dignified human development may be brought to a level where they care to engage in a debate over such a grand challenge for the next century—of cities as forces for good—beyond their desperate needs of survival for just today and tomorrow? ■

Further information This essay is part of a project by the US National Academy of Engineering to determine the Grand Challenges for Engineering during the next 100 years: www.engineeringchallenges.org

Professor Paul Crutzen (Nobel Prize for Chemistry), **Professor M. Bruce Beck**, and **Dr. Michael Thompson** are all Institute Scholars at IIASA. They also research at the Max Planck Institute for Chemistry, University of Georgia, and University of Oxford, respectively.

CFGnet
Cities as forces for good network

Contact us at info@cfgnet.org