

# Imagine a University

Amory B. Lovins, Cofounder and Chief Scientist  
Rocky Mountain Institute  
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University of North Carolina Energy Leadership Challenge  
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Historians note that the United States Navy, and earlier the British Royal Navy, led the great energy transformations in the civilian sector, from sail to coal to oil to nuclear, and now to efficiency, advanced biofuels, and for expeditionary use, modern renewables. Naval culture also holds lessons for us civilians about leadership.

Thirteen years ago, I was explaining to some Flag officers how Naval leadership could speed America's journey off oil so we needn't fight over oil. I first showed how we can optimize buildings as whole systems for multiple benefits, not isolated components for single benefits, and thus make very big energy savings cost less than small savings. As I was then shifting from buildings to cars, the committee chairman stopped me. Vice Admiral Joe Lopez was one of two people in the history of the Navy who rose from enlisted seaman to four-star Admiral. At the time he was the most powerful 3-star in the Pentagon: he owned the Navy's budgets, programs, planning, personnel and facilities. He turned to his exec, said what I'd just told them about buildings was very interesting, and added, "Find out who are all the architect and engineering firms we've hired in the past 20 years that never told us any of this, and make sure they never work for us again." I thought to myself, "Gee, I like this dude!"

Then the Admiral and I, together with a bold civilian Naval leader named Cheryl Kanderas, had a conversation that boiled down to something like this: "Mr. Lovins, I suppose you know who's good at this 'integrative design' you're describing?" "Yes, Sir, most of them." "Can you get a suitable group of them here in the next two weeks? Because then we'll put them around a big table with our best designers. Together we'll redesign a big building we've just designed, so we have something to compare it with. Then we'll build it your way and measure it, and if it does what you say, we have \$6 billion worth of construction we'll do that way next year, and \$7 billion the year after that, and we want you to indoctrinate our top 250 designers." "Yes, Sir!" So everyone moved out smartly and transformed how the Navy designed buildings.

A year later, Admiral Lopez called me back and said, "We've done eight buildings your way now, and they do what you said they would. Write me a report card—I want to know what to improve next."

I tell this story to our private-sector CEO clients in the hope they'll all get that good.

Now let me tell you a new Naval story about this difference between leadership and management. At the end of World War II, our Navy faced a tsunami of innovation along with drastically shrinking budgets, so it stood up the General Board to greatly accelerate innovation. Today, in the same conditions, the Chief of Naval Operations has stood up a similar group, on which I serve, for the same purpose. But CNO also read a recent article in *Small Wars Journal* by a young lieutenant, Ben Kohlman, who described how the junior officer corps is full of entrepreneurs bubbling with disruptive thinking but discouraged by a rather impermeable command structure that doesn't reward, expect, develop, or even assess their creativity and innovation. So Ben assembled a national network of such disruptive-thinking junior officers, and they recommended how best to use their talents. CNO liked that, told Ben to find and bring more like him, met with them immediately...and turned them into his Rapid Innovation Cell, reporting straight to him and tasked to turn the Navy upside-down.

How many \$150-billion-a-year organizations do you know whose head reaches down to their *lowest* level of leadership to find and empower the fresh, untrammelled thinking needed to reinvent the institution? That takes guts and vision.

Universities today have the same opportunity that CNO saw in Lt. Kohlman's team. After all, experts see few options; beginners see many options. That wonderful gift called "beginner's mind" lets intensely curious young people with sharp tools pierce complex problems with uninhibited, yeasty imagination.

Naval Lieutenants are doing that—and so can your students. Before they get their creative prickles worn down and their boldness beaten out of them, before they lose their beginner's mind, they can help design and build our new and retrofit buildings, our landscapes, our food systems, our water and waste systems, everything on campus, all hooked together in their complex web of interrelationships with community and planet. They'll do better and learn more if they help lead our next wave of systemwide improvements than if they just study how we've always done things before.

Congratulations! You're already on the right path with your buildings—your most obvious big opportunity. You're saving some \$241 million on the UNC system's energy costs just in the past decade! Last year alone, your resourceful facilities folks saved \$63 million worth of energy at your 17 campuses. Your system's annual energy bill started last calendar year at about \$290 million and ended it at \$227 million, even though energy prices are headed up. Here at ASU, you increased your floor-space 39% over the past decade, yet your electricity use went up less than a third that much, you used 30% *less* total energy per square foot (vs. 20% for the whole UNC system), you eliminated all your nearly one million gallons a year of fuel oil and most of the propane, and you used one-fourth less water.

That's a terrific start. But many opportunities remain, and they keep expanding, so any campuses that are still lagging have even juicier opportunities now than they

had last year. In lights, windows, draftproofing, insulation, controls, drivesystems, chillers, boilers, pumps, fans, electronics, kitchen equipment, practically everything, efficiency technologies keep improving faster than we can install them. That's why a well-designed negawatt costs two-thirds less today than it did three decades ago.

Some campuses use more energy than others because they have more labs and data centers. Conventional wisdom says there's little they can do. Conventional wisdom is wrong again. Last year I mentioned the old CalTech lab we cost-effectively retrofitted to save over 70% of its energy—including 50–60% for the supposedly sacrosanct lab equipment, with the scientists' enthusiastic collaboration. Each fume hood, using as much energy as five houses, can save upwards of 80% while increasing lab safety.

It's the same for IT. An ultrareliable supercomputer at Los Alamos nine years ago used 7–8 times less energy, yet cost 3–4 times less to own and run. RMI's latest data-center design would save about 95% of its energy and half its capital cost. And at the Packard Foundation, re-specing supposedly efficient Energy Star office equipment saved half its energy with the same cost and performance. So let's go render wasted energy out of these big old hogs until there's nothing left but the squeal. And rather than bemoaning all the power-hungry electronic gizmos students bring to their dorm rooms, let's send with their acceptance letters an order form offering attractive bulk-buy prices for the most energy-efficient models of all the popular gadgets. Participants might even share the savings on campus electric bills.

Often we save more energy if we see the larger pattern that connects. If you invest more energy in a rapid spin cycle so your washing machine wrings more water out of wet clothes, you can save 70 times more energy in the dryer than the faster spin uses—but you must consider both machines together. An air-assisted shower uses electricity to get you very wet with a trickle of hot water—but that's only 1–2% as much electricity as a regular showerhead needs to heat 4–8 times more water. My home's Swiss cookstove saves two-thirds of its energy by redesigning not its electric-resistance elements or its controls but its *pots*.

So with all this low-hanging fruit mashing up around our ankles and spilling in over the tops of our waders, where are we headed with the UNC system's \$227 million annual energy bill over the coming decades? Not to \$100 million, not to \$50 million, but to *negative costs*. Our buildings will run their meters backwards more than not, because once they use only a small fraction of their original energy, as they surely can and will, it'll become convenient and cost-effective to make them self-powered, singly or in clusters and neighborhoods, by gradually attaching solar power—in rigid modules, flexible and stick-on surfaces, or even power-producing façades that replace building skins altogether. In good sites, many other renewables will pay too.

At the rate some campuses are going, soon you'll start to encounter the same issue as the Fort Collins municipal utility in Colorado: 15% of its service territory is putting up net-zero-energy buildings, and if the utility continued to charge by the kilo-

watt-hour, those buildings would pay zero revenue. That's why that utility, with our help, will soon test a new kind of tariff where the utility and the customers pay each other for the value of the services they exchange. If a small municipal utility can invent such a national and global model, why can't New River Light and Power, the unique municipal utility owned by the ASU Foundation? Before its bulk power purchase contract expires in about another eight years, how much electricity could it save, or produce onsite? And why not, as the military is doing now, rearchitect the local grid, at essentially no extra cost, into a network of resilient microgrids so key loads work even if the grid goes down—just as in my own house? This approach can protect our vital power supplies from storms on earth or in outer space, from physical or cyber-attack, from any kind of mishap—greatly increasing the security of our families, communities, and all of North Carolina.

It may sound unduly adventurous to jump right into renewable power, the natural partner of modern energy efficiency. But projects across North Carolina are already showing sound financial returns today, even for supposedly costly solar power. If China can add more electric generation last year from non-hydro renewable power than from all coal and nuclear plants combined, why can't we do that here?

These design choices are not rocket science. They're about rearranging our mental furniture, re-minding ourselves so we can design mindfully, capturing many benefits from each expenditure. So imagine a university that does this *everywhere, all the time*, and not just in physical plant but *throughout its operations and pedagogy*. That could free up even *more* than the billion dollars your system aims to save on energy costs over 20 years —money we can turn from dead-loss overhead into innovation and instruction.

If we walk out the door of most of our buildings, we're in parking lots. These huge expanses, a third to a half of many cities' total area, are generally covered with "asphalt"—as designer Bill McDonough points out, two words assigning blame. Asphalt is a form of petroleum pitch—the goeey stuff just above the bottom of the refiner's barrel. America buys a billion dollars' worth of this nasty stuff every year to bind aggregate into black pavement that broils in the sun. Let me expand my brief mention last year of what that means. Radiant heat roasts you as you get out of your car. Superheated air forms more smog and bakes the buildings, straining their air-conditioners. Your car's inside surfaces get hot enough to burn your skin, so the air-conditioner, big enough for a house, runs flat out trying to pull the temperature back down, making the engine dirtier and less efficient, thus turning more fuel into pollution. Big daily temperature cycles quickly degrade the asphalt. And its dark surface soaks up light, so the lawyers demand ever brighter night security lighting—temporarily blinding departing drivers so they run into something and can sue you anyway. And all this uses more energy, making the climate even hotter!

You needn't be an engineer, a farmboy gearhead, or a housewife to see what's wrong with this picture. Let's try an integrative design choice that saves money, improves comfort and safety, and teaches better. You guessed it—*light-colored pavement*, de-

scribed in USEPA's 2005 *Cool Pavement Report*. Made of asphalt or bioasphalt from crop wastes and term papers or concrete or grass pavers, you make its upper surface light-colored, so all those bad effects run backwards. Light pavement stays tens of degrees cooler in the hot sun, keeping people, cars, and buildings cooler. Cool pavement lasts much longer. It reflects light for night security, saving lighting energy. Fewer light fixtures, reflecting off brighter surfaces with new LED designs, can let you can see better with just 1/100<sup>th</sup> of a watt per square foot—a 98% saving.

Next, you can cheaply build power sockets right into the lightpoles so electric cars can plug in a smart cable, integrating battery or fuel-cell vehicles into the electric grid so their distributed storage helps the grid accept varying solar and windpower. Mobile metering with communications and billing built into the car or the cable let drivers sell valuable services back to the grid, making a few bucks' profit by charging their car overnight—or far more by selling back power on a hot afternoon. Or you can put solar-power awnings over the parking area. That keeps the cars cool, protected from hail and bird droppings, and recharged during the day by solar energy that would otherwise overheat the cars. Pervious pavements can also shrink or eliminate costly stormwater infrastructure.

Parking lots are where we store, 96% of the time, a two-ton steel machine that's our biggest household asset except a home (if we own one). Each parking space can cost tens of thousands of dollars to build, plus maintenance, but often those costs are socialized, not recovered from users. And what do we do with the automobiles we park? Four percent of the time, for an hour a day, they move us between the widely scattered places where we live, work, study, shop, pray, and play. All this converts each year \$1 billion worth of oil, the rotted remains of primeval swamp goo, into a weaker and more volatile economy, fewer jobs, and a more dangerous world, raising our automobiles' cost to \$3 billion a day—plus dirty air, climate change, illness, degraded lands and waters and wildlife, and a less admired and less independent nation.

Yet these bad choices are not fate. We can instead design smart-growth communities that put us already within a five-minute walk of where we want to be. That's generally cheaper to build and more profitable for the developer, with higher quality of life, stronger neighborhoods and families, and happier, healthier people. Are all our campuses designed like that? Not yet—but they should be.

What else can students observe when they look around, really see what's going on, and keep asking "Why?" until they understand root causes? One of my Dartmouth students in 1982 moved the napkin dispensers from the cafeteria line onto each table, so folks took only the napkins they needed—seven-eighths fewer. Another student dramatically reduced food waste by plotting on a big graph, set up where you picked up your tray, the total amount of food turned back to the kitchen uneaten. If that graph kept falling past certain targets, every student with a meal ticket would be entered in a lottery to win a free meal ticket for next semester. This created social

pressure that gradually rightsized eyes to match stomachs. And now we know from social science that behavior drives attitude, not the reverse.

**[Omit if short on time:** The solar-powered BigBelly™ Solar trash compactor, whose 100-fold-more-energy-efficient crusher design lets it use solar power to compact trash by fivefold, then radio the crew to say when it needs emptying, costs far more than a simple trashcan, but produces such huge system benefits—starting with slashed collection costs—that in Philadelphia, the first 500-bin test was found to save \$10 million net over the first decade. Reduced collection can also free up workers for recycling instead of landfilling, creating even more value.

Why are we throwing away all that trash anyway? I was once out back of a Walmart store with a top executive, looking at Dumpsters full of all the packaging he'd paid for twice—once to buy it and again to throw it away.. He asked what to do about it. I suggested he put it on the trucks heading back to his suppliers who'd sold it to him, and tell them he wasn't going to pay for it next time—go figure it out. They did. They designed out lots of superfluous packaging. They redesigned products to do more work with less stuff, like the way P&G switched to concentrated detergents: why package and transport water when the customer already *has* water?

That redesign process starts in the head of each student. Still another of my Dartmouth students, who went on to become a fine prep-school headmaster, persuaded a few dozen students and faculty to join him in carrying around a big transparent plastic bag containing everything they threw away that week. The Sunday *New York Times* was the first to go. Soon their consciousness and their lives had irreversibly changed. How *little* stuff can we throw away? I once met a retiree who'd gotten down to three grams a month—basically just hearing-aid batteries.

How much room is there for a university to wring out wasted stuff? Well, it's a microcosm of the whole U.S. economy, which extracts, processes, uses, and throws away about 20 times your body weight per person per day. Only 1% of that flow gets into durable products, only a fiftieth of which come back to create more value, so the whole system is about 99.98% pure waste. Fixing it has got to be one of the biggest business opportunities on the planet, and you each own your piece of it. But systematically combining the four principles of natural capitalism—radical resource efficiency, systematically designing out waste and toxicity, adopting new business models that reward doing more and better with less for longer, and reinvesting some of the resulting savings back into natural capital, the kind of capital we're shortest of—can turn that waste into profit, harm into benefit, and an ever more impoverished society and ecology into RMI's vision of a world thriving, verdant, and secure, for all, for ever. At natcap.org you can download free our 14-year-old business book *Natural Capitalism* and its "*CliffsNotes*" summary from *Harvard Business Review*. They'll remind you how, in practically every part of your operations, to make this transformation as natural as breathing, so you can't even imagine why you'd ever have done it any other way.]

What's the right goal for every kind of waste—lost energy, lost materials, lost water, lost time, extra process steps, needless movement, poor quality, making anything nobody wants or nobody has asked for yet? The right number is *zero*. And then you keep going to make your campus and your whole local economy positively regenerative, giving back more than it takes, adding more value than it loses.

Along the way, some big investments we now take for granted may disappear. We hook up buildings to costly remote infrastructure via pipes and wires for six reasons: electricity, fuel, potable water, sanitation, stormwater, and telecommunications. But today we have equal or better onsite solutions for probably all six. If we combined them, we'd probably need no exterior pipes and wires, no pouring money into holes in the ground and covering it up. We could get more flexible siting and cashflow, probably lower construction cost, lower total cost, and no need to pay for decades for that costly remote infrastructure—power plants, water plants, sewage-treatment plants. Instead, we could integrate renewable microgrids and wireless networks with roofwater capture, uninvent wastewater, and turn nutrients into food and flowers. But if centralized remote infrastructure is becoming obsolete, why are we still designing buildings so they need it?

To be sure, such a big changes require thought. Do you find thought scary or exhilarating? Or maybe both? Isn't that why we have universities? And *who* can design something so radical? I'll bet that together, your students, staff, and faculty can!

But this needs not only engaging students in cutting-edge, hands-on projects, not only teaching and practicing integrative design in every aspect of our work, but also a far more fundamental and challenging shift. It needs us to tear down the ancient walls that fragment our pedagogy, put blinders on our imagination, and hobble our achievement.

To borrow from an article I wrote a few years ago for *Harvard Magazine*, the world's big problems are often *caused* by narrow, reductionist solutions. Yet the whole, as Aristotle noted, is different from the sum of its parts. We need people with a vision across boundaries, harnessing hidden connections so the cause of solutions is solutions—solving, or better still avoiding, not just one problem but many, without making more.

Problems created by narrowly trained people walled into a discipline require solutions by “un-disciplined” people educated in the disciplined habit of linking supposedly disparate learnings, and hence primed to ask very different questions. Yet holism is scarce because universities put too many obstacles in its way due to academic tribalism, fear that a broad education can't be deep, and a solicitous urge to shield students from exuberantly transdisciplinary impulses.

My two undergraduate years at Harvard encountered these obstacles. I therefore exploited and invented loopholes so I could study, often in research and grad cour-

ses, in a dozen eclectic disciplines ranging from geology to law to linguistics, just as earlier I'd delved in physical sciences, music, classics, and math. Yet this wonderful intellectual playground also had ogres. The College's administration plugged loop-holes not just behind me but also ahead of me, blocking access to the education I sought.

Continuing to study widely without a Concentration, they warned, was too risky to allow. I asked, Isn't this a great *University*? Yes, they said, but for your own good we require focus. Can't I choose how to spend my own time and money? No. So since they weren't customer-friendly, halfway through I transferred to Oxford as a graduate student to study whatever I wanted. (That worked until 1971 when I wanted to do a doctorate in energy—not yet an academic subject two years before the Arab oil embargo—so I resigned as an Oxford don to do energy anyway. Two years later they understood why energy was important. Now they have professors of energy.)

So I subversively advise students that if their studies are so disparate their advisors can't discern a pattern and don't see how this subject is related to that one, they're probably on the right track. Go wild. Mix thermodynamics with Chinese art history with cultural anthropology with evolutionary biology with aerospace engineering and you'll learn how to learn. You may even find missing links and hidden treasure.

I tell students the big dark secret that a smart, motivated person can learn as much about almost any discipline in six months as most (not all!) practitioners know. I encourage them to roam uninhibited across the entire range of learning, leaping the fences and walking on the grass—and if they discover a mysterious cave that learning has missed, go spelunking. I mention that at ten universities, I've taught only subjects I've never formally studied. I reveal that my line of work requires picking up about two new disciplines a year, so after decades, everything reminds you of something.

If you learn and live that way so you're broadly educated, knowing enough about lots of things and something about almost everything, then you'll be equipped to meet the toughest challenges of our time and tackle those big gnarly problems created by overspecialization. You'll also become a better person, have a more fulfilling career, do more good, and have more fun, because you'll be following your passion and doing what is necessary.

So imagine a university that reunites dis-integrated learning and takes E.O. Wilson's *Consilience* seriously; where the fences fall into disrepair; where a rich mycelium organizes around grand challenges; where dropouts like me, if any, are asked why they left so the institution can improve; where all responsible students, anywhere, at any level, on any track, can freely choose *all* their studies; and where integration is prized above reductionism. That is what the world needs.

Universities are where we play the long game and make the long bet. Universities steward not just millennia of precious learning but also civilization's painfully



learned focus on excellence, on continuous improvement, on intelligent trial and error. These are the tools we need to tenaciously transform ourselves over generations and to respond flexibly to ever-changing needs. We know from biology and history that the most durable organisms and institutions and societies are not the strongest or the smartest but those that learn fastest and adapt most gracefully.

There is no better place than our campuses to sustain this long view, public purpose, and rigorous insistence on quality. Any students who enter without these three attributes should leave with them. And since you're dealing with young people, the best way to get this across is not by telling them about it but by *doing* it, *yourself*, *with them*. As a heavily paraphrased Chinese proverb says: Tell me, I forget; show me, I remember; involve me, I understand. And, to add one more step: Help me engage and teach others, I grow, we all learn faster, and we all succeed together.

This is what you have the opportunity and responsibility to create, offer, and evolve. Agile initiatives like the NSF-funded IDEXlab, which is reorganizing this campus's undergraduate building-sciences studies around the principles of integrative design, are a great start—and I understand that all those Solar Decathlon students had job offers before they even left the Washington Mall! The students learn experientially, often in “studio” sessions that mimic real design situations with students as designers, teachers as design-firm principals, maybe even actors from the theater department playing building owners or financiers. And at NCA&T, design students for their capstone project actually designed the retrofit of an existing campus building to use zero net energy.

We need more efforts like these, all over the UNC system. We need more flexibility from the State to allow competition so you smart facilities professionals can get the permission and the revolving-fund finance you need to save the taxpayers more money sooner. We need all you smart administrators to keep busting barriers, developing metrics, driving performance, learning quickly from successful failures, and celebrating and reinforcing success. Biomimetic inventor Stephen Dewar said, “For every vision there is an equal and opposite revision.” To refine both, we must rapidly build momentum in the direction we know we need to go.

So as we wonder in the bewilderment together, seeking better ways to create citizens, I end, as I began, with a Naval quotation that my colleague Chris Lotspeich (who's here today) spotted aboard an *Aegis* cruiser. It was from science-fiction writer Robert A. Heinlein, a 1920 graduate of the Naval Academy, who wrote: “A professional naval officer should be able to change a diaper, plan an invasion, deliver a speech, butcher a hog, design a building, write a sonnet, balance accounts, build a wall, set a bone, comfort the dying, take orders, give orders, cooperate, act alone, solve equations, analyze a new problem, pitch manure, program a computer, cook a tasty meal, fight efficiently, and die gallantly. Specialization is for insects.”

In the arts of peace as in the profession of arms, what we must do isn't *just* about improving our physical plant; it's even more about exploring and expanding our

mental capacities and our cultural competencies. As institutions of higher learning, we need to select, advance, reward, and reinforce administrators, faculty, staff, and above all students who can take off their old departmental and disciplinary shackles, escape or span or demolish their comfortable silos, and reorganize their studies, teachings, and learnings around what our society needs to survive and thrive.

That need to prevail against increasingly long odds is why we're all here. And that's what I'm confident your leadership and perseverance can achieve. Just imagine such a *University*—and then make it so.

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