The Engineer and the Ecosphere
Minding Nature, Changing Minds[1]

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Thank you for the honor and privilege of addressing the New York State Society of Professional Engineers. I'd like to start with a story and a tribute.

My dad—Edward Vitek—was an electrical engineer for 42 years He began his career at GE Schenectady, and spent most of it at Knolls Atomic Power Laboratory in Niskayuna, New York, doing I know not what, due to the military secrecy involved. He said it was an exciting time to be an engineer because the problems were big and so was the pile of money devoted to solving them. Educated at Johns Hopkins University, my dad is the classic engineer. He was always tinkering, and our home was filled with Heathkit build-it-yourself oscilloscopes, radios and televisions, as well as my dad's inventions, including the talking mailbox, an intermittent car windshield wiper device long before the commercial version, and a key holder design that eliminated the guessing game of choosing the right key. His dinner napkins were frequently scribbled with mathematical symbols and design sketches. He simply loved being an engineer, and he taught his children to find a career that they loved too. In retirement he worked tirelessly on a book that would explain calculus to engineers rather than to mathematicians.

He wanted one of his three sons to follow his career path, but none did (a funeral director, a telephone lineman, and a philosopher; there's probably a sitcom or reality show in there somewhere). At least I'm teaching at an engineering university. Sadly,

[1] This talk was the keynote address at the 2008 annual meeting of the New York Society of Professional Engineers in Syracuse, New York. For more information and a copy of a resource guide, contact Vitek@clarkson.edu

my dad suffered a number of what are euphemistically called “mini strokes” in the last few years, and his short and mid term memory systems are in a shambles. He just celebrated his 87th birthday.

When I told him that I was speaking to you, his eyes lit up and he went in to his long-abandoned home office and emerged with this: his PE membership plaque. He wanted me to tell you that he, too, is a professional engineer. I dedicate this talk to my dad, and to all those creative men and women who make engineering their profession and their vocation, and who are wonderfully dedicated to making the world a better place.

What might it mean when a philosopher is invited to address a society of professional engineers who have gathered to discuss technical matters that this philosopher could not possibly understand? I am increasingly invited to speak to organizations like this one; full of professional, highly competent, and practical people. What can I possibly offer them, and you?

I think it might be a sign of the times. We invite the philosophers in when things look really bad and the problems we face seem unsolvable with traditional methods, or are solvable only by addressing system-wide assumptions. After all, the big picture is presumably what philosophers are good at seeing. Is it possible that the big picture is in big trouble? Is it possible, for example, that $120/barrel oil is not just an economic indicator, but rather one signal among many of a system about to change?

I believe that the times really are changing, and in ways most of us do not welcome. I believe that we are living in a transition between worldview systems, the big systems that shape how we see the world and think about it, and that are embodied in our most deeply

held assumptions; all of the "isms" that operate nearly seamlessly in any culture and that are rarely challenged. Thankfully, large cultural transitions are infrequent, but they have occurred before in human history, and they can occur quite rapidly. In ecosystems these large changes are described as transitions from the K (or conservation phase) of a system to the release or Omega phase.[2] Like well behaved and quite comfortable members of the K phase of our worldview systems, we are reluctant to call for too much change, fearful of an unpredictable and disruptive Omega phase, and hoping instead that the systems that brought us here can also keep us in equilibrium. I am not optimistic.

As an applied or practical philosopher (I know, that sounds like an oxymoron), I try to avoid the dusty attic of our civilization's past and prefer instead to spend time down in its basement where, like the basements of our own homes, all of the social, political and technological systems are located, and that operate—or fail to operate—without our taking notice of them until it's rather late in the game. I've been down there now for two decades, and it seems to me that things are only getting worse, and ever more quickly.

I am also writing a book about the daunting social and cultural challenges we face in a world with too little carbon below the ground—in the form of oil and natural gas—and too much in the atmosphere—in the form of greenhouse gases, including carbon dioxide and methane. "Post-carbon" and "peak-carbon" are terms reflecting trends and discoveries indicating that the modern world will need to learn how to live without the vast pools of carbon energy that built and run it, and for which there is no equal. I live day-to-day with the exponential data of our times and they have made me a student of the boundaries and limits of both the living Earth and our human form.

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[2] See *Resilience Thinking: 'Sustaining Ecosystems and People in a Changing World.* Brian Walker and David Salt (Washington, DC: Island Press, 2006).

This work has brought me reluctantly to a perspective of which I am now convinced and to which I am fully committed. Our cultural Omega phase has begun. We are living in revolutionary times of rapid change and discontinuity.

I wish I could tell you that I was exaggerating in an effort to focus your attention this morning. When I was in the 10th grade my high school chemistry teacher, Mr. Rizzo, would frequently tell my classmates and me that we were the worst class he ever had. He finally admitted that he told every class, every year, that they were the worst class he ever had in order to motivate them; but that unlike those other classes, our class really was the worst.

Like Mr. Rizzo I honestly believe that we really do face a challenge of the sort that will be transformative. Most of us are familiar with the phrase "up a creek without a paddle." (The phrase is actually a bit more colorful than that.) I think the world and its inhabitants are up a creek—a post-carbon creek—**with** a paddle, the one that put us there in the first place. This paddle is the mindset of limitless expansion and consumption that we are unwilling to discard. This mindset won't get us out of our predicament and it actually makes matters worse. Meanwhile our boat—the living ark of Earth—is listing terribly.

What we must do instead is toss the paddle and, quite literally, begin to change our minds, our worldview, and our everyday lives. We must first dismantle some of the fundamental beliefs about ourselves and the world before these beliefs dismantle the world. And then we must learn how to function not just as individuals, but as whole civilizations on the only Earth we will ever know, a living, complex, and interconnected sun-powered ecosphere, complete with all of its, and our, limitations. This change of

mind is likely to require a lifestyle that is as inconceivable to us today as the invention of the modern factory or a heart transplant would have seemed to either the peasant or the professor of medieval Europe.

It is crucially important for the engineering profession to lead the way. You directly engage and transform the world. It's a risky job, but the benefits to humankind have been truly astonishing. But now the risks are becoming global in scope and potentially irreversible. The engineering mind that built the bridge across the river Tyne nearly one thousand years ago is not well equipped to build the ecological bridges necessary today and in the coming centuries.

When I say that we will need to change our minds I am referring to what might be called the intellectual DNA of the modern mind, a deep seated set of core beliefs that are assumed, rarely questioned, and built into the educational system from kindergarten to the Ph.D. These beliefs are at work in the labs and classrooms of every modern university in the world, and they are also with us when we are at the office, the mall or in our car or on our jet ski (or even in our composite kayak or canoe). These beliefs shape our expectations that high salaries and big houses will bring us happiness; and they cause us excitement about every new technological gadget.

Some of these beliefs have their earliest origins in ancient and well known stories about—of all things—theft: the theft of the knowledge of good and evil in the Garden of Eden by Eve and Adam, and the theft of fire by the Greek god Prometheus for the benefit of humankind.

In the Genesis creation story Eve and Adam are tempted by a "tree," which, some scholars claim, was not a tree at all, but rather a grass: wheat, one of the first edible wild

grasses to be cultivated by humans.[3] Scholars also point out that the first farmers used snakes to guard their granaries against hungry rodents. The temptation that the serpent and wheat grass granary presented to Eve, a name that means life itself, was for a more secure and plentiful life outside of nature's boundaries. And why wouldn't the first woman, and soon-to-be first mother, "steal" agriculture's promise of plentiful food and security for her offspring even if it meant, as the story tells us, more work for her husband and increased pain during childbirth for her and all women, no doubt a consequence of more and healthier, larger, babies?

We are told that the human couple was expelled from nature's garden, but it seems more likely that they left on their own accord—the original sin of willfulness—once they recognized their own powers to cultivate a grass that even today is the world's second largest cereal crop. More important is the warning they ignored about the danger of succumbing to this temptation to live outside of nature's boundaries; namely, that they "would surely die."

Despite that ominous warning, Adam and Eve and their offspring never looked back. Those first farmers in the Middle East's Fertile Crescent began a mining operation that continues to this day: the mining of high-energy carbon. In breaking the sod those early farmers were breaking from nature, living by their own wits, and appearing—at least temporarily—to exceed the boundaries and limitations that govern all life, and the Earth itself.

[3] See Evan Eisenberg's *The Ecology of Eden: An Inquiry into the Dream of Paradise and a New Vision of Our Role in Nature* (Vintage: 1999).

But it is a more recent historical period we call the Enlightenment that gave a modern voice to these beliefs. The Enlightenment claimed that human power and knowledge were no longer crimes against the gods, but rather the right of every human being. You know their names, in part because their ideas are still a crucial part of a modern college education: Galileo, Copernicus, Kepler, Descartes, John Locke, Thomas Hobbes, Francis Bacon, Voltaire, Isaac Newton, and Adam Smith. The Enlightenment produced revolutionary thinkers that freed human beings to embark on pursuits that had been forbidden or considered impossible: the control of nature; the creation of economies and technologies that went far beyond subsistence; individual freedom from oppressive governments, religions and family traditions; and a belief in human progress separate from the rest of life and largely unencumbered by moral and spiritual beliefs. Their names may seem dusty and distant, but their assumptions about the power of the human intellect to control and transform the world, and the seemingly infinite capacities of the earth to supply the goods necessary for human happiness, are our assumptions too. And these assumptions changed the world.

From 1750 to the present, and with continuous advances in science, engineering, technology, medicine and agriculture, the human population doubled three times, from 790 million to 6.6 billion, and counting. For the first time in human history, and perhaps the only time, it has doubled in a single lifetime: ours. The history books tell us about all of the personalities, discoveries and inventions that made possible this population growth and the advances of culture, but we probably know much less about the energy-rich carbon pools that fueled this population surge, and with it everything we associate with

the modern world. I mention them because energy is at the very center of all advanced civilizations, including our own.

The soil of the Fertile Crescent was the first carbon pool to be tapped twelve thousand years ago, and, as William Ruddiman writes in *Plows, Plagues and Petroleum*, it brought with it the first increases in human population *and* greenhouse gases—carbon dioxide and methane—released by the clearing of forests, biomass burning and irrigation, all common practices as early as seven thousand years ago.[4] The second high-energy pool—the stored carbon of the Earth's forests—furthered human dominance of the world and made the bronze and iron ages possible. Wood served as the preeminent energy source during the first 150 years of British settlement in North America and in what would become the United States.

The third carbon pool—coal—fired the industrial revolution and the exponential growth of the human population, and today remains a critical source of energy. In 2004 the world used over 6 billion tons of coal, and by 2030 the demand is projected to be almost 11 billion tons annually.

Oil and natural gas are our most recently tapped carbon pools, and together they fuel the global economy. Oil is currently consumed at the rate of 85 million barrels/day around the world, and the demand is expected to grow to 113 million barrels/day by 2020. The price has certainly grown. The world used 100 trillion cubic feet of natural gas in 2004, and is expected to need 150 trillion cubic feet by 2020. A good deal of natural gas is used in the Haber-Bosch process that turns atmospheric nitrogen into ammonia, an essential fertilizer that is now required for much of the world's depleted

[4] William Ruddiman's *Plows, Plagues, and Petroleum: How Humans Took Control of the Climate.* Princeton, NJ: Princeton University Press, 2005.

agricultural soils. Vaclav Smil calls the Haber-Bosch process the most important invention of the 20th century. Without it, he claims, 40 percent of humanity would not be alive today.[5]

Engineers know better than most that oil and natural gas are not just in our cars, planes and home furnaces. They are used to make insecticides, tires, trash bags, shampoo, cameras, food preservatives, anesthetics, upholstery, eyeglasses, credit cards, fertilizers, crayons, insect repellent, toilet seats, golf balls, antihistamines, guitar strings, toothpaste, tennis rackets, carpeting, artificial turf, heart valves, aspirin, and shaving cream. Our lives would be very different without oil and natural gas. Were we to also take away the coal, half of America's electricity would go with it.

Coal, oil, and natural gas are the primary feedstocks of our modern civilization just as the ideas forged in the Enlightenment are the primary feedstocks of our modern mind. Each feeds the other. And for those of us who have been alive these last fifty years in industrialized societies, particularly in America, it has been a wonderful ride, an amazing and blazing run on the carbon bank.

Paul MacCready, the visionary engineer and inventor of the first practical flying machine powered by a human being, has made a calculation that captures the enormity of our success. He estimates that ten thousand years ago human beings, plus their domestic animals, accounted for less than a tenth of 1 percent by weight of all vertebrate life on earth and in the air. Today, that percentage, including livestock and pets, is in the neighborhood of 98% of the weight of all vertebrate life on earth.[6]

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[5] http://www.oecd.org/dataoecd/52/25/36760950.pdf . See also Smil's *Enriching the Earth: Fritz Haber, Carl Bosch, and the Transformation of World Food Production*. Cambridge, MA: The MIT Press, 2001.

[6] From Daniel C. Dennett, *Breaking the Spell*.

We should probably excuse the Enlightenment revolutionaries for mistaking nature as infinite and infinitely malleable when humans were a scarce, weak species pursing their projects in the small clearings that culture made on our very sizable planet. But standing on their shoulders we find ourselves in a very different time and place. The Earth is not nearly as big and as impervious to harm as our predecessors thought, nor possessed of bottomless fuel tanks.

As the data continue to come in it appears that the processes driving our exponential growth may be at their peaks. And as with most exponential growth in biological systems—and it is a very large biological system—the Earth—that we are talking about here—what goes up exponentially usually comes down exponentially too. Our parents' generation rode this exponential wave to the top and it looks like our generation—and certainly our children's generation—will be the first to be riding down the other side of the peak, the first generation in what Wes Jackson calls "The Age of Rapid Depletion."

Here are some terrible and terrifying facts that give The Age of Rapid Depletion its name:

- In January 2007 The Bulletin of the Atomic Scientists moved its doomsday clock two minutes closer to midnight, "reflecting global failures to solve the problems posed by nuclear weapons and the climate crisis."
- Eight nations possess nuclear weapons, and two more are known to be working to acquire them.
- Current data indicate that atmospheric Carbon Dioxide, a greenhouse gas, is at a 650,000 year high.

- The latest report of the Intergovernmental Panel on Climate Change states that “there is a 90% chance humans are responsible for climate change," mostly due to the burning of fossil fuels. And among scientists, 90% confidence is a near certainty.
- The world’s leading petroleum geologists estimate that in less than a century the modern world has burned its way through half of the global supply of oil, and that the other half may be gone in as few as thirty years. Fifty four percent of the oil already consumed—a half trillion barrels—was consumed in the last 22 years alone. The numbers and predictions for natural gas are similar.
- The current rate of species extinction is being compared to the five known mass extinction waves. This sixth wave is caused by humans, not asteroids, and according to the Millennium Ecosystem Assessment Report, agriculture is the largest threat to biodiversity.
- Speaking of agriculture, it’s not just for food anymore. It’s taken less than two years for the corn-ethanol craze to trigger a worldwide hunger crisis that could affect 150 million people.
- Soil destruction now claims 24 million acres a year world-wide.
- One billion people lack access to fresh water. And more than 850 million people suffer from hunger and malnourisment.
- Two of the world’s most populous nations—China and India—are on the path to becoming two of the world’s largest economies. Their economic good fortune accelerates the rate of depletion worldwide.
- Human population growth continues to follow an exponential curve.

- It is estimated that there are currently 27 million slaves in the world, more than at any other time in human history. In 1850 a slave cost 40,000 of today's dollars. A slave can be purchased today for a mere $30. (Bales, 1999).[7]

That's a lot of facts and figures to process, and I would apologize for overwhelming you with them were it not my intention to overwhelm you with them. You, we, all of us, need to feel the enormity of the challenges that we face and to see the connections between them. In a world overcrowded with desperate people, the slave market, tragically, grows. Fresh water is scarce because of the demands of industrial agriculture to supply food to a global population that grows by 85 million people a year. The high demand for ethanol as an alternative to fossil fuels reaches further into the well: it takes three gallons of water to produce one gallon of ethanol. And a world made less stable by the high demand for energy becomes even more dangerous with nuclear weaponry. Meanwhile, hurricanes increase in intensity, and summer temperatures soar around the world.

OK, you say, but the Enlightenment mind—especially the engineering variety—can solve these problems with better technology and the march of progress. I am not so sure. What we commonly call "progress" has produced some of the very problems we expect progress to eradicate. Advances in agriculture and medicine have led to the exponential growth of the human population, and that has put increased demands on topsoil and fresh

[7] http://dawn-drupal.science.oregonstate.edu/facts

water. Technology has made more of the world's fossil fuels accessible, leading to increased consumption and an increase in atmospheric carbon.

Optimists talk about efficiency, but paradoxically efficiency leads to higher consumption. It's called Jevons Paradox, named after the man who demonstrated that as 19th century Great Britain became more efficient in its use of coal, it actually consumed more of it. Even if every car in the world was a hybrid, and every light bulb a compact fluorescent or LED, the continuing growth demands for cars and light bulbs worldwide would easily dwarf the savings. New technologies will help replace old technologies, but they will create unforeseen problems of their own. And they will take time to develop. The late Cornell physicist and Nobel Laureate Hans Bethe used to point out that no form of energy – from the draft horse to coal to petroleum to nuclear power – ever became a fuel for commonplace technology in fewer than fifty years. Sorry, there are no quick fixes on the energy front.[8]

Sustainability, now practically a household term, is starting to set things right and it does offer a path toward living well in a limited world. But in its current form it doesn't require enough from us. It is too laden with a near fundamentalist belief in technological fixes, still stuck in the old "the-Earth-is-a-machine" way of thinking. The problems it solves are inside the nearly invisible "isms" that shape how we see the world and think about it, and that are assumed and rarely challenged except in times of social upheaval. These larger systems are off the sustainability table. Corporate giants Toyota, GE and Wal-Mart, for example, are touted for their eco-efficiency initiatives, but their profit motives or their use of advertising to increase consumption of their products are rarely questioned. Al Gore's Nashville home is carbon neutral, but it's also ten thousand square

[8] See Smil: http://www.oecd.org/dataoecd/52/25/36760950.pdf .

feet in size. Without addressing deep structural changes in the larger systems, sustainability is like making one's Titanic first-class cabin water-tight at the first sight of water in the hallway. It might seem prudent at the time, but if the tear in the ship's fabric is big enough and if the ship is held together with thousands of sub-standard rivets (as historians now confirm[9]), you will still end up at the bottom of the North Atlantic.

Sustainability is a tad presumptuous too. The wise ones—Homo sapiens—have devoted 12,000 years to whittling away at the Earth's vital and sustainable forces, all the while mistaking human cleverness for nature's creative diversity and fertility, and now insisting that what the ecosphere has been providing all along is actually our job, and that somehow the great consumers of the Earth can now become its benefactors without having to sacrifice their high standard of living. If Earth had eyes they would be rolling.[10]

Central to the problems we face is our reluctance to see them as nothing more than temporary downturns or the usual up and down cycles of economics or climate. They are not. A barrel of oil—a mere forty two gallons—costs nearly $130, while a human slave can be purchased for a mere $30. Add another three billion people to the planet in forty years while simultaneously trying to cut CO_2 emissions by 80%. Find livelihoods, food, fresh water, and shelter, as well as education, health care, and stable governments for these numbers without causing species extinction, soil degradation, civil wars, nuclear wars, and mass migrations. Try running any of the world's major cities—their subways,

[9] http://www.nytimes.com/2008/04/15/science/15titanic.html?pagewanted=2&_r=1&ref=todayspaper

[10] If we want to get downright edgy in our definition we could say that what now goes by the name of sustainability is comparable to the good behavior of a reformed psychopath; self-diagnosed no less. Both admit that previous behaviors were anti-social, destructive, compulsive, without a broader perspective, and dangerous to others and self. Both require a radically new perspective as different from their previous lifestyles as to feel alien and unnatural. And both risk relapses into hold habits, and hence neither can be fully trusted in the long run.

waste water treatment plants, and transportation, lighting, and heating infrastructures for even a few days on low density solar and wind power.[11]

We will have to change our minds because nearly everything we believe about ourselves and the many talents that we possess are likely to further increase human population and consumption, to make life worse for millions—perhaps billions—of people worldwide, to increase species extinction, to extract from the earth more energy rich carbon than the earth can ever replace in a human timeframe, and to release more carbon into an atmosphere already too full of it. The Enlightenment mind and its technological fundamentalism have become dangerous liabilities in the 21st Century. We need to help usher in a new Enlightenment that values and protects human freedom and dignity while rejecting the beliefs that we can master the earth and treat it merely as our personal supermarket, playground, laboratory and dumpster.

Hard truths, once confronted, can change our lives for the better, especially when ignorance is no longer capable of providing bliss. And overwhelming challenges, when faced with strength and creativity, can be overcome.

The first steps toward changing our minds require us to upset our routines, to become curious again, and to imagine alternatives.

If you haven't already, acquaint yourself with Peak Oil, Ecological Footprints, Industrial Ecology, Embodied Energy, Biodiversity, the Precautionary Principle, Life Cycle Analysis, Jevons Paradox, Biomimicry, Carbon Neutrality, Micro Lending, The

[11] In 2005, the latest year for statistics from the US Energy Information Administration, coal, oil and natural gas accounted for eighty seven percent of the world's production of primary energy (460 quadrillion Btu's). Hydro and nuclear power accounted for six percent each, and geothermal, solar, wind, wood and waste electric power collectively accounted for about one percent. http://www.eia.doe.gov/iea/wepbtu.html

Genuine Progress Indicator, and Natural Systems Agriculture. These and other new terms and concepts are already making a difference, and they will help define what it means to be a professional engineer in the 21st century. Better yet, work to bring these and other important new concepts to the engineering profession, starting with the educational curriculum, and including the profession itself.

Your architect colleagues offer an inspiring example. The US Green Building Council, the source of the LEED (Leadership in Energy and Environmental Design) rating system, held a conference in 1995. It was attended by 135 people. In 2007, their "Greenbuild" conference had 40,000 attendees. That's the kind of exponential growth we need to encourage across the professions.

I strongly urge you to give sustainability a stronger voice in your Code of Ethics. In its present form the Code "encourages adherence to the principles of sustainable development." It is difficult to believe that this language is sufficient for the job ahead of us. Engineering historically has worked to give content to the formal ideas expressed in a society, from buildings and roads, to the myriad systems and products that define every age. The engineering profession must now be at the forefront of change, demanding it and creating it. Sustainability can no longer be "encouraged." It must become part of the cultural, social and technological operating systems. It **is** the operating system of the ecosphere. Once you really have this change of mind—that we live in a sun-powered ecosphere—the engineering code of ethics, engineering education, and engineering methods—will begin to reflect it. There's no better time than now.

From my perspective as a college teacher, it is the curriculum that most needs changing. Across departments and programs, the American university system still

prepares students for the 20th century rather than the 21st. From Accounting to Zoology, every major comes to the same thing: plunder studies. Engineering is particularly troubling. Were an alien explorer sent to Earth as an engineering student, the alien would conclude that engineering takes place on a lifeless planet. Calculus, physics, chemistry, and engineering science are the lion's share of the first two years of an engineering student's education, and there is in all of it nothing alive: no cells, organisms, soils, plants or animals. There is mass and acceleration, atoms and molecules, and plenty of derivatives, but no life and its complexity, no interconnectedness and organic variability.

It's only five years from now, but by the time my 12 year old son Ian is ready to study engineering—finally, an heir to my father's legacy—I hope that he will be required to study statistics, geology, biology, ecology, and engineering history. I hope too that his education prepares him to design and build products that resemble organisms more than they do machines. And I hope that he will be imbued with a new "safety factor" ethic that limits not just the failure of the designed product, but limits its capacity to fail the ecosphere as well. These changes won't come without the profession itself demanding them, without the engineering profession becoming a leader in this change of mind. Everything we do is done on a living planet.

It is so much easier to hope for a miracle. But our best and most realistic hope lies in embracing the revolution before us. With vigor and creativity we must help create the conceptual scaffolding necessary to build a new worldview; in the words of the American founder John Adams, "to start some new thinking that will surprise the world." Every category of human thought needs reorientation within the boundary conditions of our

sun-powered ecosphere. We need an ecospheric science, spirituality and economics; an ecospheric politics, education and technology; an ecospheric justice, history and architecture; an ecospheric engineering, agriculture, and philosophy; and ecospheric conceptions of rights, property and happiness. Here's a rough draft of our ecospheric "to-do" list.

- Reduce the industrialized world's carbon footprint eighty percent by 2050.
- Reduce human population eighty percent from its current level without famine, war, viruses or the loss of human dignity by 2110.
- Eliminate the automobile as a form of personal transportation.
- Create political and social systems that run on a solar economy.
- Revise the scientific method so that it more accurately balances the discovery of new knowledge with moral considerations and precaution.
- Devise viable models of happiness and success that do not require economic growth and increased consumption.
- Make the virtues of humility, cooperation, generosity, gratitude, kindness and thrift cool again, or hip, or bad, or the bomb, or whatever word or phrase you use to describe something really good and worth having.

When we change our minds powerful things begin to happen. The inconceivable becomes possible, and the possible becomes commonplace.

Wes Jackson changed his mind about how we grow food. For the last thirty years he and his colleagues at the Land Institute in Salina, Kansas have been working to transform the major food crops from annual monocultures into perennial polycultures; in other words, to turn the average corn field into an abundant, complex and resilient prairie of

food. Their efforts are featured in the August 2007 issue of *Scientific American* and are described in this way: "The challenge is monumental, but if these plant scientists succeed, their achievement would rival humanity's original domestication of food crops over the past 10 millennia, and be just as revolutionary." Jackson and his staff members recently made flour from a perennial prairie wheat grass grown at the Land Institute. They baked and ate the bread that resulted. It was a revolutionary moment, and perhaps the very first time in Earth's history that native prairie wheat grass produced an edible seed for human consumption. It happened last month.

Vandana Shiva changed her mind. Trained as a physicist, Shiva is described as "one of the world's most prominent radical scientists." She is the founder of a movement for biodiversity conservation and farmers' rights in India, and her studies have validated the ecological value of traditional farming and have been instrumental in fighting destructive development projects in India.

David Orr changed his mind. Not content to simply teach environmental studies, Orr single handedly raised $13 million dollars and brought together some of the world's best architects. Together they built the Adam Joseph Lewis Center for Environmental Studies at Oberlin College, one of the most sustainable educational buildings in the world. It frequently generates as much or more energy than it consumes.

Engineer and businessman Ray Anderson changed his mind about how to make carpet. As founder and CEO of Interface Carpet, a billion dollar company, Anderson decided fourteen years ago to change radically how his company would do business and

to make it "the first company that, by its deeds, shows the entire industrial world what sustainability is in all its dimensions: people, process, product, place and profits."[12]

There are countless more examples—thousands actually—of individuals and organizations that have decided to change their minds and directions.

This is the century where we get a couple of chances to move from the age of rapid depletion to something less rapid and less depleting. Ready or not we will be carried as in a river-current overrun with a spring thaw. We will steer our lives and cultures at first with more hope than effectiveness, and we will fret and worry a good deal. We should consider it an exciting time, filled with opportunities to think big thoughts and to imagine wonderful alternatives; to help create a worldview where humans can feel at home on an Earth that is very much alive, interconnected, filled with morally valuable species, and limited in terms of how much it can provide; where human ignorance about our living Earth will always exceed our knowledge; and where our curiosity promotes understanding—not subjugation—of the Earth's complexity, beauty and resiliency.

I encourage you as parents, community members and professional engineers to take seriously the enormity of the challenges before us, and to indicate by your words and deeds a willingness to change, and to demand change in the institutions that mean the most to you.

I'll end not with a philosopher's words, but with a poet's: T.S. Eliot.

We shall not cease from exploration
And the end of all our exploring
Will be to arrive where we started
And know the place for the first time.
Through the unknown, unremembered gate

[12] http://www.interfaceinc.com/who/founder.html

When the last of earth left to discover
Is that which was the beginning;
At the source of the longest river
The voice of the hidden waterfall
And the children in the apple-tree
Not known, because not looked for
But heard, half-heard, in the stillness
Between two waves of the sea.
Quick now, here, now, always—
A condition of complete simplicity
(Costing not less than everything)
And all shall be well and
All manner of thing shall be well
When the tongues of flame are in-folded
Into the crowned knot of fire
And the fire and the rose are one.[13]

[13] http://www.tristan.icom43.net/quartets/gidding.html