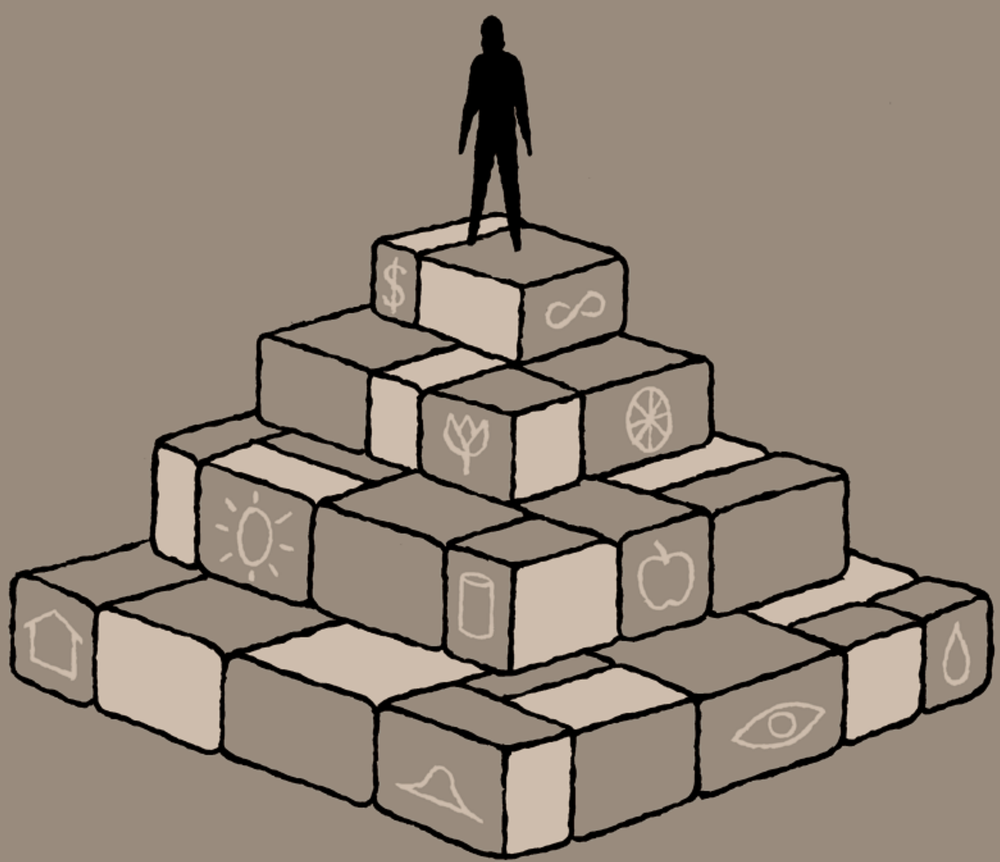
The Post Carbon Reader Series: Foundation Concepts

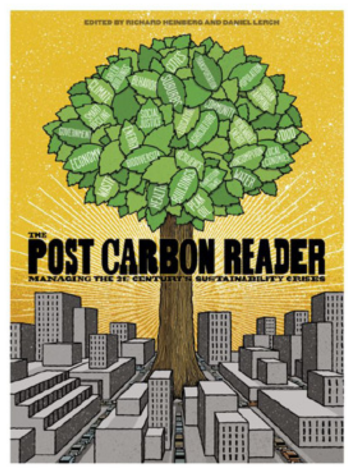
Beyond the Limits to Growth

By Richard Heinberg



About the Author

Richard Heinberg is widely regarded as one of the world's most effective communicators of the urgent need to transition away from fossil fuels. He is the author of nine books including *The Party's Over: Oil, War and the Fate of Industrial Societies* (2003), *Powerdown: Options and Actions for a Post-Carbon World* (2004), and *Blackout: Coal, Climate, and the Last Energy Crisis* (2009). He has authored scores of essays and articles, is featured in many documentaries, and has appeared on numerous television and radio programs. Heinberg is Senior Fellow-in-Residence at Post Carbon Institute.



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At some point in time, humanity's ever-increasing resource consumption will meet the very real limits of a planet with finite natural resources.

In 1972, the now-classic book *Limits to Growth* explored the consequences for Earth's ecosystems of exponential growth in population, industrialization, pollution, food production, and resource depletion.[1] That book, which still stands as the best-selling environmental title ever published, reported on the first attempts to use computers to model the likely interactions between trends in resources, consumption, and population. It summarized the first major scientific study to question the assumption that economic growth can and will continue more or less uninterrupted into the foreseeable future.

The idea was heretical at the time, and still is: During the past few decades, growth has become virtually the sole index of national economic well-being. When an economy grows, jobs appear, investments yield high returns, and everyone is happy. When the economy stops growing, financial bloodletting and general misery ensue. Predictably, a book saying that growth *cannot* and *will not* continue beyond a certain point proved profoundly upsetting in some quarters, and soon *Limits to Growth* was pilloried in a public relations campaign organized by pro-growth business interests. In reality, this purported "debunking" merely amounted to taking a few numbers in the book completely out of context, citing them as "predictions" (which they explicitly were not), and then claiming that these predictions had failed. The ruse was quickly exposed, but rebuttals often don't gain nearly as much publicity as accusations, and so today millions of people mistakenly believe that the book was long ago discredited. In fact, the original *Limits to Growth* scenarios have held up quite well, so much so that even the thoroughly pro-business *Wall Street Journal* printed a lengthy front-page reflection on that fact in March 2008.[2]

In any case, the underlying premise of the book is irrefutable: At some point in time, humanity's ever-increasing resource consumption will meet the very real limits of a planet with finite natural resources.

We the co-authors of The Post Carbon Reader believe that this time has come.

The Pivotal Role of Energy

During the past two centuries, an explosion in population, consumption, and technological innovation has brought previously unimaginable advances in health, wealth, transport, and communications.

These events were largely made possible by the release of enormous amounts of cheap energy from fossil fuels starting in the mid-nineteenth century. Oil, coal, and natural gas, produced by natural processes over scores of millions of years, represent far more concentrated forms of energy than any of the sources previously available to humanity (food crops, human and animal muscles, and simple windmills or water mills) and, with even basic technology, are comparatively easy to access. With this abundant energy available to drive production processes, it became possible to increase rates of extraction of other natural resources—as, for example, chain saws and powered trawlers could harvest timber and fish at rates previously unimaginable. Meanwhile, fuel-fed tractors enabled a relatively small number of farmers to support many specialists in industrial or commercial enterprises, leading to massive urbanization in nearly every country. Modern chemistry (largely based on organic compounds derived from fossil fuels) led also to modern pharmaceuticals—which, together with improved sanitation (likewise dependent on cheap energy), enabled longer life spans and growing populations.

And so, increased consumption of fossil fuels has produced both economic growth and population growth. However, a bigger population and a growing economy lead to more energy demand. We are thus enmeshed in a classic self-reinforcing ("positive") feedback loop.

Crucially, the planet on which all of this growth is occurring happens to be limited in size, with fixed stores of fossil fuels and mineral ores, and with constrained capacities to regenerate forests, fish, topsoil, and freshwater. Indeed, it appears that we are now pushing up against these very physical limits:

- The world is at, nearing, or past the points of peak production of a number of critical nonrenewable resources—including oil, natural gas, and coal, as well as many economically important minerals ranging from antimony to zinc.
- The global climate is being destabilized by greenhouse gases emitted from the burning of fossil fuels, leading to more severe weather (including droughts) as well as melting glaciers and rising sea levels.
- Freshwater scarcity is a real or impending problem in nearly all of the world's nations due to climate change, pollution, and overuse of groundwater for agriculture and industrial processes.

- World food production per capita is declining and the maintenance of existing total harvests is threatened by climate change, soil erosion, water scarcity, and high fuel costs.
- Earth's plant and animal species are being driven to extinction by human activities at a rate unequaled in the last 60 million years.

The exact timing of peak oil (the maximum point of global oil production) can still be debated, as can the details of climate science. Experts can further refine their forecasts for food harvests based on expectations for new crop varieties. Nevertheless, the overall picture is incontrovertible: The growth phase of industrial civilization was driven by the cheap energy from fossil fuels, and the decline phase of industrial civilization (now commencing) will be led by the depletion of those fuels as well as by environmental collapse caused directly or indirectly by the burning of coal, oil, and natural gas.

At the End of Abundance, on the Verge of Decline

Our starting point for future planning, then, must be the realization that we are living today at the end of

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the period of greatest material abundance in human history—an abundance based on temporary sources of cheap energy that made all else possible. Now that the most important of those sources are entering their inevitable sunset phase, we are at the beginning of a period of overall economic contraction.

Limits to Growth foresaw this inflection point nearly forty years ago. But the world failed to heed the warning; as a result, adaptation now will be much more difficult than would have been the case if growth had been proactively curtailed decades ago. Global leaders now face the need to accomplish four enormous tasks simultaneously:

1. *Rapidly reduce dependence on fossil fuels.* We must do this to avert worse climate impacts, but also because the fuels themselves will be more scarce and expensive. Ending our reliance on coal, oil, and natural gas proactively with minimal social disruption will require a rapid redesign of transportation, agriculture, and power-generation systems.
2. *Adapt to the end of economic growth.* This means reworking, even reinventing, our existing economic system, which functions only in a condition of continuous expansion. Banking, finance, and the process of money creation will all need to be put on a new and different footing.
3. *Design and provide a sustainable way of life for 7 billion people.* We must stabilize and gradually reduce human population over time, using humane strategies such as providing higher levels of education for women in poor countries. But even in the best case, this objective will take decades to achieve; in the meantime, we must continue to support existing human populations while doing a better job of providing basic services for those at the bottom of the economic ladder. We must accomplish this in the context of a non-growing economy and with a shrinking stream of resource inputs, and we must do it without further damaging the environment.
4. *Deal with the environmental consequences of the past 100 years of fossil-fueled growth.* Even if we cease all environmentally destructive practices tomorrow, we still face the momentum of processes already set in motion throughout decades of deforestation, overfishing, topsoil erosion, and fossil-fuel combustion. First and foremost of these processes is, of course, global climate change, which will almost certainly have serious impacts on world agriculture even if future carbon emissions decline sharply and soon.

Each of these four tasks represents an enormous challenge whose difficulty is multiplied by the simultaneous need to address the other three. The convergence of so many civilization-threatening planetary crises is unique in our history as a species.

Limits Are Unavoidable

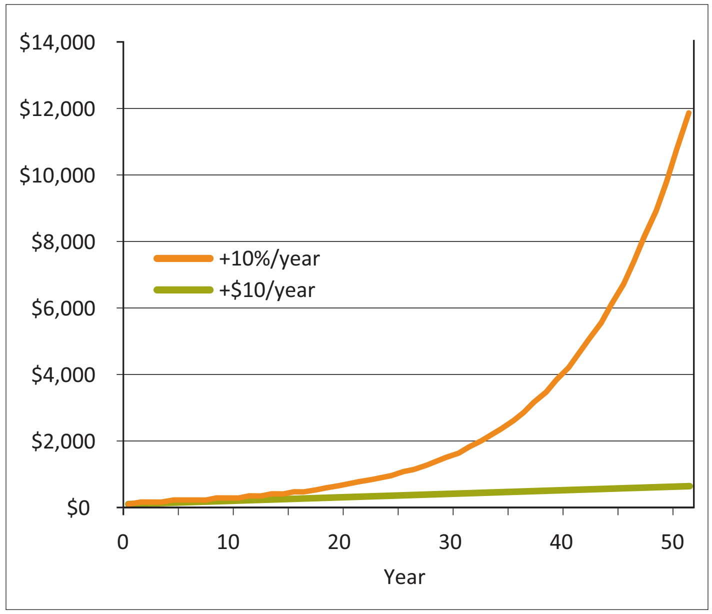
It is unpleasant and unprofitable to talk about limits to the human enterprise. Yet in principle, the argument for eventual limits to growth is comprehensible by nearly anyone.

Simple arithmetic growth is easy to understand. Imagine starting with $100 in a piggy bank and adding to it $10 every year—that's arithmetic growth. By the end of 50 years you will have $600. A debt or a problem that grows arithmetically is much simpler to deal with than one that grows *exponentially*—that's where the quantity expands by a certain percentage per unit of time. Start again with $100 in a piggy bank, but let it somehow magically grow by 10 percent per year, compounded, and the results are quite different: At the end of 50 years, you will have nearly $12,000, or over 20 times as much as yielded by arithmetic growth (figure 1.1). When discussing investments, exponential growth sounds like a very good thing, but when debts or problems grow in this way, calamity has a way of sneaking up on us.

If any quantity grows steadily by a certain fixed percentage per year, this implies that it will double in size every so many years; the higher the percentage growth rate, the quicker the doubling. A rough method of figuring doubling times is known as the rule of 70: Dividing the percentage growth rate into 70 gives the approximate time required for the initial quantity to double. If a quantity is growing at 1 percent per year, it will double in 70 years; at growth of 2 percent per year, it will double in 35 years; at 5 percent growth, it will double in only 14 years; and so on. If you want to be more precise, you can use the Y^x button on your calculator, but the rule of 70 works fine for most purposes.

Here's a real-world example: Over the past two centuries, human population has grown at rates ranging from

FIGURE 1.1
Exponential Growth Versus Arithmetic Growth



less than 1 percent to more than 2 percent per year. In 1800, world population stood at about 1 billion; by 1930 it had doubled to 2 billion. Only 40 years later (in 1975) it had doubled again to 4 billion; currently we are on track to achieve a third doubling, to 8 billion humans, around 2025. No one seriously expects human population to continue growing for centuries into the future.

In nature, growth always slams up against nonnegotiable constraints sooner or later. If a species finds that its food source has expanded, its numbers will increase to take advantage of those surplus calories—but then its food source will become depleted as more mouths consume it, and its predators will likewise become more numerous (more tasty meals for them!). Population "blooms" (that is, periods of rapid growth) are always followed by crashes and die-offs. Always.

Here is another real-world example. In recent years China's economy has been growing at 8 percent or more per year; that means it is more than doubling in size about every 9 years. Indeed, China consumes more than twice as much coal as it did a decade ago—the same with iron ore and oil. The nation now has four times as many highways as it did, and almost five times as many cars. How long can this go on? How many

Beyond a certain point, growth becomes more of a problem than an advantage. But economists generally don't see things this way.

more doublings can occur before China has used up its key resources—or has simply decided that enough is enough and has stopped growing?

Economists Tend to Ignore Environmental Limits

It makes sense that economies should follow rules analogous to those that govern biological systems. Plants and animals tend to grow quickly when they are young, but then they reach a more or less stable mature size. Beyond a certain point, growth becomes more of a problem than an advantage.

But economists generally don't see things this way. That is probably because most current economic theories were formulated during an anomalous historical period of sustained growth. Economists are merely generalizing from their experience: They can point to decades of steady growth in the recent past, and they simply project that experience into the future. Moreover, they have ways to explain why modern market economies are immune to the kinds of limits that constrain natural systems; the two main ones concern *substitution* and *efficiency*.

If a useful resource becomes scarce its price will rise, and this creates an incentive for users of the resource to find a substitute. For example, if oil gets expensive enough, energy companies might start making liquid fuels from coal. Or they might develop other energy sources undreamed of today. Economists theorize that this process of substitution can go on forever. It's part of the magic of the free market.

Increasing efficiency means doing more with less. In the United States, the number of inflation-adjusted dollars generated in the economy for every unit of energy consumed has increased steadily over recent decades.[3] That's one kind of economic efficiency. Another has to do with locating the cheapest sources of materials and the places where workers will be most productive and work for the lowest wages. As we increase efficiency, we use less—of resources, labor, or money—to do more. That enables more growth.

Increasing efficiency and finding substitutes for depleting resources are undeniably effective adaptive strategies of market economies. Nevertheless, the question remains open as to how long these strategies can continue to work in the real world—which is governed less by economic theories than by the laws of physics. In the real world, some things don't have substitutes, or the substitutes are too expensive, or don't work as well, or can't be produced fast enough. And efficiency follows a law of diminishing returns: The first gains in efficiency are usually cheap, but every further incremental gain tends to cost more, until further gains become prohibitively expensive.

Unlike economists, most physical scientists recognize that growth within any functioning, bounded system has to stop sometime.

But this discussion of limits has very real implications, because "the economy" is not just an abstract concept; it is what determines whether we live in luxury or poverty, whether we eat or starve. If economic growth ends, everyone will be impacted, and it will take society years to adapt to this new condition. Therefore it is important to be able to forecast whether that moment is close or distant in time.

Hence the *Limits to Growth* study and book. Its authors fed in data for world population growth, consumption trends, and the abundance of various important resources, ran their computer program, and concluded that the end of growth would probably arrive between 2010 and 2050. Industrial output and food production would then fall, leading to a decline in population.[4]

The Post-Carbon Transition

Already many farsighted organizations and communities see and understand this long-term trajectory of the human project and are experimenting with ways to satisfy basic human needs in a way that can continue into the indefinite future.

Alternative energy sources and greater efficiencies are important, but the post-carbon transition will not be limited merely to building wind turbines or weatherizing homes, for two key reasons: First, there are no alternative energy sources (renewable or otherwise) capable of supplying energy as cheaply and in such abundance as fossil fuels currently yield, in the brief time that we need them to come online. Second, we have designed and built the infrastructure of our transport, electricity, and food systems—as well as our building stock—to suit the unique characteristics of oil, natural gas, and coal. Changing to different energy sources will require the redesign of many aspects of these systems.

The post-carbon transition must entail the thorough redesign of our societal infrastructure, which today is utterly dependent on cheap fossil fuels. Just as the fossil-fuel economy of today systemically and comprehensively differs from the agrarian economy of 1800, the post-fossil-fuel economy of 2050 will profoundly differ from all that we are familiar with now. This difference will be reflected in urban design, land-use patterns, food systems, manufacturing output, distribution networks, the job market, transportation systems, health care, tourism, and more. It will also require a fundamental rethinking of our financial institutions and cultural values.

Leading the Transition

Our new historical moment requires different thinking and different strategies, but it also offers new opportunities to solve some very practical problems. Ideas from environmentalists that for decades have been derided by economists and politicians—reducing consumption, relocalizing economic activity, building self-sufficiency—are suddenly being taken seriously in households that can no longer afford to keep up with the consumerist treadmill.

Quietly, a small but growing movement of engaged citizens, community groups, businesses, and elected officials has begun the transition to a post-carbon world. These early actors have worked to reduce consumption, produce local food and energy, invest in local economies, rebuild skills, and preserve local ecosystems. For some citizens, this effort has merely entailed planting a garden, riding a bike to work, or no longer buying from "big-box" stores. Their motivations are diverse, including halting climate change, and promoting environmental preservation, food security, and local economic development. The essence of these efforts, however, is the same: They all recognize that the world is changing and that the old way of doing things, based on the idea that consumption can and should continue to grow indefinitely, no longer works.

Alone, these efforts are not nearly enough. But taken together, they can point the way toward a new economy. This new economy would not be a "free market" but a "real market," much like the one fabled economist Adam Smith originally envisioned; it would be, as author David Korten has said, an economy driven by Main Street and not Wall Street.[5]

Thus far, most of these efforts have been made voluntarily by exceptional individuals who were quick to understand the crisis we face. But with time, more and more people will be searching for ways to meet basic needs in the context of a shrinking economy. Families reliant on supermarkets with globe-spanning supply chains will need to turn more to local farmers and their own gardens. Many globe-spanning corporations—unable to provide a continuous return on investment or to rely on cheap energy and natural resources to turn a profit—will fail, whereas much smaller local businesses and cooperatives of all kinds will flourish. Local governments facing declining tax revenues will be desperate to find cheap, low-energy ways to support basic public services like water treatment, public transportation, and emergency services.

Elements of a transition strategy have been proposed for decades, with few notable results. Usually these have been presented as independent—sometimes even contradictory—solutions to the problems created by fossil-fuel dependency and consumerism. Now that "business as usual" is ceasing to be an option for mainstream society, these strategies need to be rethought and rearticulated coherently, and they need to *become the mainstream*.

What we need now are clarity, leadership, coordination, and collaboration. With shared purpose and a clear understanding of both the challenges and the solutions, we *can* manage the transition to a sustainable, equitable, post-carbon world, though the urgency of the need to fully and immediately engage with the transition process at all levels of society can hardly be overstated.

Endnotes

1 Donella Meadows, Dennis Meadows, Jorgen Randers, and William Behrens III, The *Limits to Growth* (New York: Universe Books, 1972).

2 A recent study by the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO) concluded: "[Our] analysis shows that 30 years of historical data compares favorably with key features of [the *Limits to Growth*] business-as-usual scenario." Graham Turner, *A Comparison of the Limits to Growth with 30 Years of Reality*, CSIRO Working Paper, June 2008, www.csiro.au/files/files/plje.pdf; Justin Lahart, Patrick Barta, and Andrew Baston, "New Limits to Growth Revive Malthusian Fears," *Wall Street Journal*, March 24, 2008.

3 The amount of energy, in British thermal units (Btu), required to produce a dollar of GDP has been dropping steadily, from close to 20,000 Btu per dollar in 1949 to 8,500 Btu in 2008. Praveen Ghanta, "U.S. Economic Energy Efficiency: 1950–2008," Seeking Alpha, January 10, 2010, http://seekingalpha.com/article/181818-u-s-economic-energy-efficiency-1950-2008.

4 The *Limits to Growth* scenario study has been rerun repeatedly in the years since the original publication, using more sophisticated software and updated input data. The results each time have been similar. See Donella Meadows, Jorgen Randers, and Dennis Meadows, *Limits to Growth: The 30-Year Update* (White River Junction, VT: Chelsea Green, 2004).

5 David Korten, *Agenda for a New Economy: From Phantom Wealth to Real Wealth* (San Francisco: Berrett-Koehler, 2009).

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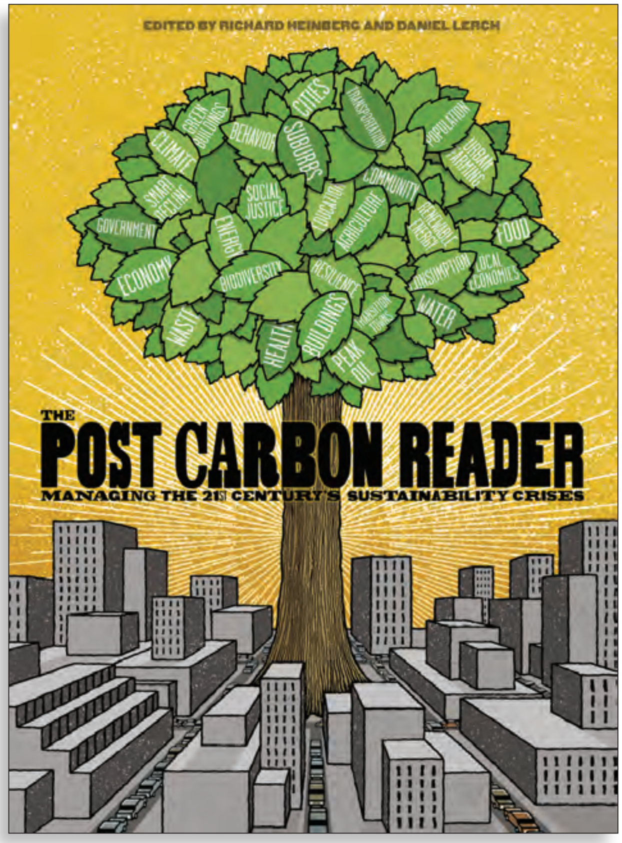

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The Post Carbon Reader

Managing the 21st Century's Sustainability Crises

Edited by RICHARD HEINBERG and DANIEL LERCH

In the 20th century, cheap and abundant energy brought previously unimaginable advances in health, wealth, and technology, and fed an explosion in population and consumption. But this growth came at an incredible cost. Climate change, peak oil, freshwater depletion, species extinction, and a host of economic and social problems now challenge us as never before. *The Post Carbon Reader* features articles by some of the world's most provocative thinkers on the key drivers shaping this new century, from renewable energy and urban agriculture to social justice and systems resilience. This unprecedented collection takes a hard-nosed look at the interconnected threats of our global sustainability quandary—as well as the most promising responses. *The Post Carbon Reader* is a valuable resource for policymakers, college classrooms, and concerned citizens.

Richard Heinberg is Senior Fellow in Residence at Post Carbon Institute and the author of nine books, including *The Party's Over* and *Peak Everything.* **Daniel Lerch** is the author of *Post Carbon Cities.*

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