ANNALS OF DESIGN

# THE INVENTOR'S DILEMMA

*An eco-minded engineer discovers the limits of innovation.*

BY DAVID OWEN

A professor who taught Saul Griffith at M.I.T. described him as "an invention engine."

ILLUSTRATION BY SEAN MCCABE, PORTRAIT REFERENCE BY ED QUINN/CORBIS

In 2004, while Saul Griffith was a Ph.D. student at the Massachusetts Institute of Technology, he won a thirty-thousand-dollar award that is given each year to a student who has shown unusual promise as an inventor. Griffith was an obvious candidate. Neil Gershenfeld, one of his professors, described him to me as "an invention engine," and said, "With Saul, you push 'Go' and he spews projects in every imaginable direction." The judging committee was especially impressed by a device that Griffith had created to custom-manufacture low-cost eyeglass lenses, intended primarily for people in impoverished countries.

Traditional lensmaking is a process involving thousands of costly molds. Oversized lens blanks are cast in plastic, and then technicians grind and polish them to match individual prescriptions. Griffith told me, "I wanted to make a machine that would negate the need for that entire factory—to let you print the lenses on demand." So he built an inexpensive desktop device with which a minimally trained operator could turn a fast-hardening liquid into a finished lens in a few minutes. The machine had a single, universal mold, with an adjustable metal ring—like a tiny springform cake pan—between a pair of flexible membranes, whose degree of convexity or concavity could be controlled by a simple hydraulic system. "Literally with only those two inputs—the shape of your boundary condition and the pressure—you can define an infinite number of lenses," Griffith explained. That year, he won a five-hundred-thousand-dollar MacArthur Fellowship—a "genius grant"—and the MacArthur judges cited the eyeglass invention as having "the potential to change the economics of corrective lenses in rural and underserved communities around the world."

But winning prizes turned out to be easier than changing the world, and Griffith's lens printer has never found a market. "It turned out that we were solving the wrong problem," he told me recently. "A lens factory is expensive to build and equip, but once you've got one you can make lenses cheaply, and then you can deliver them anywhere in the world for a dollar or two in postage." In effect, Griffith's invention addressed a problem that had been solved years before, at lower cost, by Chinese labor and global shipping. The real problem with eyeglasses in the developing world isn't making lenses, he told me; it's testing eyes and writing accurate prescriptions for people with little or no access to medical care—a matter of politics and economics rather than technology.

Griffith is still an invention engine. His many current projects include an electricity-assisted cargo-carrying tricycle, an inexpensive form of insulation inspired by origami, and an unconventional method of generating power with wind. But his thinking has been deeply influenced by what might be thought of as the cheap-glasses conundrum: the inadequacy of addressing complex societal issues with technological ingenuity alone. Nowhere is this problem more apparent than with his main preoccupation these days: energy use and global warming. The world's most urgent environmental need, he has come to believe, is not for some miraculous-seeming scientific breakthrough but for a vast, unprecedented transformation of human behavior. That conviction makes him doubly unusual: an extraordinarily innovative engineer who is trying to think his way around the limits of innovation.

Griffith has an athletic build and a scruffy beard. His hair, which is reddish brown, is usually an omnidirectional mess, and he often looks as though he had dressed from the bottom of the laundry pile. He was born in Sydney, Australia, in 1974. His father is a retired professor, and his mother is an artist and printmaker. He grew up, he says, "in the corners between my father's tools and my mother's studio."

He warned me that he despises clichéd descriptions of inventors' childhoods—taking things apart to find out how they work, blowing things up and setting them on fire—but that's the kind of childhood he had. He built a helicopter powered by fireworks attached to its rotors, and when he was six or seven he spent most of a summer trying to replicate Batman's grappling hook, and eventually succeeded in hoisting himself onto the roof of his house. He said, "That was probably the first time I noticed in myself the obsessive-compulsive, I-will-solve-this-problem gene, or whatever it is." When he was a little older, his obsession with mechanics became more acute. While drinking a glass of milk, he began to consider the complex neuromuscular choreography involved in lifting the glass to his mouth, and was so overwhelmed that he spilled the milk. A similar reflection drove him from golf, which he played at a very high level as a teen-ager but abandoned after having a paralyzing vision of the mechanical preposterousness of the golf swing.

At the University of Sydney, in the late nineteen-nineties, Griffith became an environmental activist, helping to organize a number of protests. For his master's degree, he worked on combining recycled fabrics and plastic waste into structural building materials, and his research brought him into close contact with Sydney's waste stream and the vast amount of paper it contained. (Worldwide, paper constitutes between a third and a half of the contents of landfills.) That got him thinking about alternatives to conventional printing. He read about a paperless technology that was being developed at M.I.T.'s Media Laboratory: electronic ink, the low-energy text-display medium that is used today by the Amazon Kindle and several other digital readers. Griffith decided he wanted to work on it.

By the time he got to Cambridge, in 1998, the fundamental work on electronic ink was over, but he participated in the final stages, and Joseph Jacobson, a co-founder of the company E Ink, became his thesis adviser. Griffith's Ph.D. research involved machines that assemble and replicate themselves, based on information contained in their components—a concept known as "programmable matter." Such machines function in a manner roughly analogous to the growth of living things, which build themselves, cell by cell, in accordance with rudimentary instructions contained within each nucleus. Griffith created puck-size plastic components that could fasten themselves to one another in specific ways, and then set them in motion on an air-hockey table. Random collisions on the table, over periods of hours, caused the components to join together and to correct their own assembly errors.

Griffith was a noticeable figure at M.I.T. He travelled everywhere by bicycle and carried his laptop and his books in a pizza-delivery bag. "He looked like a madman, and his office looked like a madman's office," Sherry Lassiter, a program manager at the university, told me. "But out of that came the most amazing, thoughtful projects." Griffith encountered what he described to me as an "unlimited resource"—lasers, electron microscopes, vacuum chambers, a device called a water-jet cutter, and quantities of Lego bricks, a staple in the Media Lab and one of Griffith's favorite prototyping materials. Griffith told me, "I don't think most students get full utility from M.I.T., but if you learn where all the dumpsters are, and what labs are open on what nights, it's just this incredibly fertile environment for doing your own stuff."

As he tinkered, Griffith became a prime exemplar of "maker culture"—a community of sophisticated do-it-yourselfers who view hardware in the same provisional way that computer hackers view software, and who believe that making, modifying, and repairing things can be an antidote to throwaway consumerism. There was a playful quality to his research. He built a compact electricity generator that a user operated by swinging it around his head, an idea inspired by the bull-roarer, a ceremonial musical instrument used by Australian Aborigines. He built a machine that turned digital designs into three-dimensional objects made of chocolate. During a trip home to Australia, he saw some kitesurfers, and when he returned to Cambridge he and several friends decided to build their own boards and kites in various M.I.T. labs. They developed their surfing technique by trial and error, and became familiar with Boston-area emergency rooms. A video of one of their wind-related adventures ("The Stoopid Thing," on YouTube) shows one of the group riding a kite-powered wakeboard while another hangs from the kite itself, nearly a hundred feet above the water.

After Griffith received his Ph.D., in 2004, he moved to California, and, with half a dozen friends, most of them from M.I.T., attempted to reproduce the creative environment of graduate school. They founded an independent research-and-development company, which they called Squid Labs. ("I think we chose the name because squids have good eyesight and large brains, and are good at solving puzzles.") They rented a warehouse, adopted the slogan "We're not a think tank, we're a do tank," and acquired much of their laboratory equipment for little or nothing, through Craigslist. To save money, Griffith and his future wife, Arwen O'Reilly, lived in the warehouse's attic.

Squid Labs quickly became very productive. Griffith and his colleagues worked on an old M.I.T. invention of his, electronic rope, which contains sensors that detect changes in load, and in 2005 it was selected by *Time* as one of the twenty-five best inventions of the year. They built a power supply for the so-called hundred-dollar computer, on a grant from the nonprofit organization One Laptop per Child, which supplies inexpensive computers to children in developing countries. They worked on solar roadways, which are streets paved with photovoltaic panels. They invented a programmable, spoke-mounted L.E.D. safety-lighting system for bicycles. They founded a Web site—Instructables.com—that is a compendium of user-described do-it-yourself projects. The hundreds of projects outlined on the site include building a wireless charger for low-power electrical devices, turning a pair of aluminum crutches into a trailer that you can pull behind a bicycle, and making a computer mouse from the corpse of a real mouse.

The most potentially significant Squid Labs project is a wind-energy company called Makani Power. Griffith and his friends had a preëxisting interest in wind power, and they were also influenced by the work of Miles L. Loyd, who, in 1980, demonstrated the feasibility of generating electricity with turbines mounted on unpowered aircraft flying at an angle to the wind. Griffith explained, "The strongest, steadiest winds are at altitudes that are higher than you can reach with a conventional turbine. So the question is: how do you get access to that energy? There are various reasons that we're unlikely to ever build towers that tall, so you have to start thinking about flying turbines of some description. That was the basic idea behind Makani."

Makani's headquarters are on the Oakland side of San Francisco Bay, at what used to be the U.S. Naval Air Station in Alameda. The base closed in 1997 and was declared a Superfund site two years later. Today, it consists of unused runways, crumbling streets, empty parking lots, and post-apocalyptic-looking semi-abandoned buildings. Makani occupies the old air-traffic-control building and tower, at the southeast corner of the runway complex, as well as an adjacent building. Makani's research is directed by another Squid Labs alumnus, Corwin Hardham—Griffith was the company's president but is no longer involved on a daily basis—who met me on the front steps and led me into a large room. We stepped over wings, fuselages, rotors, turbines, circuit boards, and other components, and looked on as half a dozen young men and women tinkered with prototypes at various stages of assembly or disassembly. Makani's staff, like that of every other venture with which Griffith has been associated, defies common stereotypes about the physical fitness, body-mass index, and solar exposure of high-level nerds: almost all the company's employees are accomplished athletes. Hardham, before earning his Ph.D., at Stanford, considered becoming a professional windsurfer.

Hardham led me through a computer room, where one of Makani's employees was working on a simulation program, and into the building next door, which the company uses as a workshop. He showed me what looked like a large model airplane, with an eighteen-foot wingspan. "We mount the turbines on a rigid wing and fly the wing around in circles, and transmit electricity back to the ground through the tether that connects the wing to the ground," he said. Attached to each of the prototype's wings was an electricity-generating turbine about half the size of a coffee can, and each turbine had a propellerlike rotor just over a foot long. On the prototype we were looking at, Hardham said, the two turbines combined, at peak production, produced approximately twenty kilowatts, or enough to power about ten modest American houses. A utility-scale version would be larger—with a wingspan of roughly a hundred feet, or half that of a Boeing 777—and would have a peak generation rate of a megawatt, or enough to power five hundred houses.

We returned to the main building, and Hardham showed me a video of a recent test flight. In it, a prototype was attached to a cable and flying very rapidly in a circle at thirty degrees to the ground. By flying across the wind, the prototype was able to move significantly faster than the wind's speed—in fact, five or six times as fast, Hardham said—thereby increasing its generating power. Griffith told me that a full-scale Makani-type installation would look "like a wind farm," and that, like other wind farms, it would most likely be situated at some distance from densely populated areas, perhaps above agricultural land or the ocean. "You'll just have a bunch of very large kites, flying in circles all day, two thousand feet above the ground," he said.

The electrical output of a typical tower-mounted wind turbine is limited by structural factors: lengthening the blades increases their weight and their surface area and, consequently, their vulnerability to destructive stresses. But a small kite can sweep the same area, and it doesn't need a tall, heavily reinforced steel tower to hold it up. "One way to imagine how all this works is to picture the blades of a conventional wind turbine going around in circles," Hardham said. "Now imagine erasing all of that turbine except for the tip of one of the blades. Now imagine tying a string to that tip. What that gives you is a kite flying in circles—and that's essentially what we do. Because we've eliminated the tower and the blades, we're no longer constrained to sweeping a small, tight-diameter circle or to flying close to the ground. We can move our circle up

## THE SCAR

So long gone had I been
that when I returned
I did not know me, the one

who called—warily, through the trees,
as I approached like a thief or a
ground mole—*Who is it*?
I saw her whiten in the doorway,
she could have been my cousin.

*Linda, is that you*?
That's what I answered.

From the lintel she took me in, the length
of me, with my one good eye.
Nearing her, I was a worm on end, an indigent.

That was when I knew I had arrived.
The last step is the longest, impassably long, now I will always
be twinned, wanting
to not know returning.

—*Susan Wheeler*

into the sky, where the wind is better, and we can enlarge it so that the swept area is huge."

Google's philanthropic arm, Google.org, invested ten million dollars in Makani in 2006 and an additional five million in 2008, making it the company's biggest financial backer. (Griffith and Don Montague, a professional wind- and kitesurfer, met Google's founders, Sergey Brin and Larry Page, on a sailboat ride, and have taken them on excursions on a variety of wind-powered vessels of their own design.) Google is interested in energy mainly because the company's server farms, along with the rest of the Internet, use a huge and rapidly growing amount of power. Searching, accessing, and storing an ever-increasing volume of Web pages, family snapshots, e-mails, old books, tweets, "cloud" applications, humorous videos, television shows, feature films, pornography, and everything else that can be found online requires electricity, and most of that electricity is currently generated by burning coal. The Internet's energy and carbon footprints now probably exceed those of air travel, Griffith told me, perhaps by as much as a factor of two, and they are growing faster than those of almost all other human activities. In February, the federal government made the decision to allow a Google subsidiary to participate directly in energy markets, on an equal footing with utilities.

In 2007, Google announced an initiative it called Renewable Energy Cheaper Than Coal, or RE<C. The price of coal is environmentally significant because coal is the cheapest and most abundant of the fossil fuels, and no genuine transition to renewable energy will be possible without doing something to eliminate that market advantage, either by increasing coal's price—through carbon taxes or other regulatory schemes—or by developing renewable energy sources that can compete with coal directly on price alone. The first approach is likely to be a political impossibility; the second may be a technological one. But Griffith and Hardham believe that Makani's approach, by generating power more efficiently than conventional turbines, could narrow the difference.

Yet moving Makani or any other innovative energy company beyond the prototype stage represents a tremendous challenge, Griffith told me. The speed with which software-based activities and Web innovations catch on—text messaging, eBay, Twitter—has encouraged a public perception that transformative technological change takes place almost instantaneously. But hardware is slower than software. Electronic ink was a fully realized technology by the late nineteen-nineties, but getting from that point to the Kindle took most of a decade, and its share of the global reading market is extremely small. (Printing on paper, after all, still exists, and now Steve Jobs is clearly hoping that the iPad—which uses more energy than an electronic-ink device—will turn the Kindle into landfill.) "Even if I came to you tomorrow with the perfect energy idea," Griffith said, "the reality is that to go from that idea to doing utility-scale power generation would be a minimum cost of entry of a hundred million dollars, and a minimum lead time of five to ten years." That puts any such project well beyond the reach of rational venture capitalists, or even of a well-capitalized and highly motivated company like Google. In 2007, Congress created an agency to invest in high-risk energy research, and in 2009 it was allocated four hundred million dollars in stimulus funds. But most of its awards have been relatively small, and their impact has been spread across many fields and concepts, and a number of the grants have gone into research areas, such as batteries, that were already heavily funded by other parts of the federal government or by private industry.

Makani is developing a tantalizing and possibly important approach to wind-energy production, but the company's next step is by no means clear—partly because the global recession and a steep drop in energy prices have weakened any public sense of urgency about renewable energy, and partly because no obvious financial mechanism exists to take a company like Makani from prototype to industrial implementation. News reports about energy research can create the impression that our power problems are just about licked, and on numerous fronts. But the reality is different.

Squid Labs, despite its promising initial burst of activity, lasted little more than three years. One problem was what might be thought of as the difference between graduate school and the real world. Electronic rope, Griffith told me, remains "sort of a technology waiting for the right application," and solar roadways turned out to be "a terrible idea." ("In theory, solar roadways look great—let's just cover all the roads with solar cells—but it's a very energy-intensive way to build a road, and you're unlikely to get that energy back.") The Squid Labs enterprises that did make money, among them Instructables and the bicycle safety lights, caused problems


*"In the ring, kid. We want you to take a fall in the ring."*

of a different kind, because the partners who started them left to run them. Then, in addition to everything else, the global economy imploded, making grants and venture capital harder to come by.

Those experiences didn't destroy Griffith's enthusiasm for private laboratories, however. "It's not an easy thing to do and survive at," he told me, "and, over time, the temptation is to become a very vanilla consulting company. But in the heyday of American invention there were a lot of private labs, like Edison's and Tesla's, back before universities became the only places to do research." He recently founded a scaled-down successor, called Other Lab, with two partners, James McBride and Jonathan Bachrach.

Other Lab occupies a storefront in a low, modern building in an industrial neighborhood of San Francisco near Potrero Point. When I visited, Bachrach let me in, then propped the door open with a gallon jug of wood glue. An old wooden kayak was hanging from the ceiling, and bicycles, bicycle parts, and bicycle tools were everywhere. Griffith seems to operate on the principle that excessive orderliness is inefficient, and that neatly putting things away is more time-consuming, in the long run, than searching through piles. Among his few concessions to conventional housekeeping are half a dozen salvaged library card-catalogue cabinets, the drawers of which he has repurposed as (non-alphabetized) storage units for thousands of small parts: strap clips, eyelets, resistors, microcoils, standoffs, shackles, hose clamps, bearings, springs, washers, cleats, skate hardware.

Parked near the door was the prototype for an electricity-assisted tricycle, an ongoing Other Lab project. It had a yellow barrel-like enclosure mounted in front for hauling cargo. That morning, the cargo had consisted of Huxley Griffith, Saul and Arwen's infant son. During Griffith's ride to work, rain had caused a short circuit in the wiring near the trike's battery, and a cloud of gray smoke had emerged from under Huxley's seat. "There was this hissing sound, and I had to pull him out and try to stamp out the fire," Griffith said. Huxley had reacted placidly to the crisis, as though, at eight months, he was already accustomed to life as the child of an inventor.

The trike is typical of a number of Griffith's recent inventions, in that he designed it to address a perceived environmental issue in his own life—dependence on automobiles—while also hoping eventually to find a market for it. "The hypothesis is that, by being completely selfish and solving all my own energy problems, I will find some general solutions that other people will like, too," he said. The trike also presents an energy problem of its own. Its battery—which can provide about a kilowatt-hour of power on one charge, or enough to give the trike a range of about fifty miles, assuming the rider pedals half the time—costs a thousand dollars, or as much as the rest of the components combined. "So, effectively, energy storage doubles the cost of the bike," Griffith said. "It's the entire problem of electric vehicles and hybrids." No battery comes anywhere close to holding energy as efficiently as the fuel tank of a car. ("Unfortunately," Griffith told me, "the difference between the world's best battery and gasoline, in terms of energy storage per kilogram, is not a factor of ten; it's more like a factor of hundreds or thousands.") This is a critical issue, because the most abundant renewable-energy resources are intermittent—the sun sets; the wind stops blowing—and so rely on some form of stockpiling.

"The French, during the night, store energy from their nuclear power plants by pumping water uphill," Griffith said, "and then that water is used to generate power hydroelectrically the next day, when demand is high again. So that's like a huge battery. But there's an issue of what's known as round-trip efficiency. Most energy-storage systems have round-trip efficiency of about eighty per cent, meaning that you lose twenty per cent as you store the energy and then retrieve it. So in order for wind and solar to work we also need to do storage at enormous scale."

He rummaged around on a large table in one of Other Lab's two workrooms, and showed me a heavy black iron device the size and approximate shape of a small loaf of bread. It had a hand crank, which he turned. "This is a power supply for an old telephone, circa 1920," he said. "It's almost a century old, but it still works. If you put your tongue on there, it will throw you across the room. And you could keep it working, conceivably, for another two hundred years." Cell phones can't do that, because they depend on energy-storage components called electrolytic capacitors, which deteriorate over time, and because their batteries become useless after a finite number of charging cycles. "Technology optimists would say, O.K., we'll invent a better battery and better electrolytics," Griffith said. "But the possibilities for big improvements probably aren't that great, and, besides, there's a better way to solve the problem, which is to fundamentally rethink the design of the object, along with the sociology and the behavior around it. Example? Hand-crank your cell phone." This is the cheap-glasses conundrum in a slightly different form. The real problem with cell phones isn't technological; it's cultural. Coveting slightly fancier models, we abandon flawlessly functioning devices after just a year or two, long before their components have degraded.

Other Lab's most visible project is a Web site called WattzOn, which is a collection of tools for estimating and reducing personal energy consumption. The idea came to Griffith one day while he was stuck at home with the flu, and occupied himself in bed by brooding about the inefficiencies of his existence. At WattzOn, you can create a pie chart that represents the energy you consume in all aspects of your life, including your flying, driving, and eating, and the energy that went into manufacturing your possessions. When the project began, Griffith told me, his own average rate of energy consumption was at least eighteen thousand watts—the equivalent of keeping a hundred and eighty hundred-watt light bulbs burning all the time. (One watt is a joule per second.) He has now reduced his energy use, mainly by driving and flying less, to a rate of about eight and a half thousand watts—a bit less than what he figures to be the American average, but still roughly five times the global average. "My life now is a laboratory experiment to determine how you live at twenty-five hundred watts," Griffith said.

It's a goal that he is nowhere close to achieving, but when I visited his home, a small rented two-bedroom house in San Francisco's Mission District, about two miles from Other Lab, the living room was full of signs of environmental tinkering. He described the building as "a thermodynamic nightmare"—Griffith has since bought and moved into a slightly more energy-efficient house close by—and he had been pondering domestic heat loss through building materials. Taped to the inside of a sliding glass door was a sheet of yellow construction paper that Griffith had folded, in an origami-like fashion, into a crude prototype of a recent insulation idea. The folds in the paper created air pockets, which significantly slowed the flow of heat through the glass, as Griffith had determined with a thermal camera.

Recently, Griffith said, he had been studying statistics on energy use around the world, and had identified countries whose residents use relatively little energy yet still enjoy a high quality of life. "They are typically countries, like Portugal, that built their infrastructure before the availability of cheap coal and oil," he said. "Their houses are small and have thick walls and small windows, and they heat only one or two rooms. There are enormous clues about efficiency to be found in the way we used to do things, before energy was essentially free. Think about drapes in France and England in the eighteenth and nineteenth centuries. Just by iteration, those people stumbled across an incredibly clever design, three-layer curtains, which functioned like a fantastic retrofit insulator for windows."

Such low-tech ideas are crucial to forming viable environmental strategies, Griffith believes, because implementing more complicated technologies—like building the solar roadways that Squid Labs worked on, or manufacturing electric cars for all the world's drivers—would consume natural resources and generate greenhouse gases at unsustainable rates. Griffith pointed out that he could greatly improve his house's energy performance by replacing all its aluminum window frames (which conduct heat so readily that they act like highly efficient heat exchangers between his living room and his back yard) with ones made of wood (which is a decent insulator). But the cost of replacing those windows would be so high that the payback period would be twenty years or more.

"When environmentalists and politicians talk about other climate solutions, very few of them talk about the cost, in carbon terms, of creating the new infrastructure they're advocating," he explained. "If I were building a house from scratch, I could totally design a thermodynamically amazing, almost zero-energy house—but a huge amount of energy would go into building it, just in the materials, and right now most of that energy would come from burning fossil fuels."

The human race, Griffith has estimated, currently consumes energy at an average rate of approximately sixteen trillion watts, or sixteen terawatts—the equivalent of a hundred and sixty billion hundred-watt light bulbs burning all the time. Capping greenhouse gas at a level that climatologists hope may be consistent with a global temperature increase of only two degrees Celsius would necessitate replacing all but three of those sixteen terawatts with energy generated from a combination of the most promising renewable and non-carbon-based sources: photovoltaics, solar thermal, wind, biofuels, geothermal, and nuclear fission. And doing that, Griffith said, would require building the equivalent of all the following: a hundred square metres of new solar cells, fifty square metres of new solar-thermal reflectors, and one Olympic swimming pool's volume of genetically engineered algae (for biofuels) every second for the next twenty-five years; one three-hundred-foot-diameter wind turbine every five minutes; one hundred-megawatt geothermal-powered steam turbine every eight hours; and one three-gigawatt nuclear power plant every week. Such a construction program, he told me, is at least theoretically achievable, but the practicalities are daunting. The design, approval, and construction of nuclear power plants in the United States typically takes years, and fewer than three dozen new plants are being built or planned.

"Right now, everyone sees climate change as a problem in the domain of scientists and engineers," Griffith told me. "But it's not enough to say that we need some nerds to invent a new energy source and some other nerds to figure out a carbon-sequestration technology—and you should be skeptical about either of those things actually happening. There are a lot of ideas out there, but nothing nearly as radical as the green-tech hype. We've been working on energy, as a society, for a few thousand years, and especially for the last two hundred years, so we've already turned over most of the stones." Such considerations help explain Griffith's focus on ways in which affluent societies can make dramatic reductions in energy use without reducing their perceived quality of life—a challenge that involves wrestling with human nature as well as physics. He once tried to determine at what point in history his ancestors would have been consuming energy at a rate that he believes would be sustainable by humanity today, and calculated that, even in 1800, Americans used energy (mostly by burning New England forests) at a rate close to double that of the average global citizen in 2010.

Realizations like that one are partly responsible for the note of pessimism that enters his voice when he talks about these issues—a change from his M.I.T. days. He said, "In the past, friends have told me, 'You're like the manic-depressive without the depressive—you're just always happy and manic.' So they're all a little worried about me at the moment, because when I talk about these things I sound a little less than optimistic."

Shortly after we first met, Griffith told me, "I know very few environmentalists whose heads aren't firmly up their ass. They are bold-facedly hypocritical, and I don't think the environmentalism movement as we've known it is tenable or will survive. Al Gore has done a huge amount to help this cause, but he is the No. 1 environmental hypocrite. His house alone uses more energy than an average person uses in all aspects of life, and he flies prodigiously. I don't think we can buy the argument anymore that you get special dispensation just because what you're doing is worthwhile." Griffith includes himself in this condemnation. He said, "Right now, the main thing I'm working on is trying to invent my way out of my own hypocrisy." ♦