INVENTING OUR ENERGY FUTURE

A TECTONIC SHIFT AHEAD

BY NATHAN P. MYHRVOLD /// ILLUSTRATION BY WARREN GEBERT

In recent years, billions of people have been rising out of poverty and participating more fully in the global marketplace. This is good news, but it has put the world in a tight spot. Economic prosperity is intimately linked to energy demand, and the elevation of billions of people to middle-class living standards seems destined to outstrip our existing energy infrastructure. To sustain economic progress, we must reinvent the ways in which we produce, distribute and use energy.

That is a rare and formidable challenge. The last time the world faced such a tectonic shift in its energy supply was about a century ago, when an industrializing world switched transportation fuels from carbohydrates — grain for work animals — to hydrocarbons — gasoline, kerosene and diesel; industry ramped up its use of coal, gas and oil; and electricity entered the picture as the dominant means of disseminating energy. The late 19th and early 20th centuries witnessed innovation in energy infrastructure to a degree that we haven't seen since.

Today, we need to do it again. Every city and village on the globe needs more energy, and our current mix of energy sources and current energy infrastructure is already struggling to keep up with the unprecedented demand. Oil production is flattening, despite recent record prices. Nuclear power plant construction is vexed by labor and supply bottlenecks, volatile fuel prices and economic and regulatory uncertainties. Plants, pipelines and transmission systems are increasingly difficult to site and expensive to build. These problems alone constitute a crisis, but the situation is made even worse by concerns about greenhouse gas emissions. Many of the tried-and-true methods of the past are no longer politically or economically acceptable. We need both brand-new sources of energy and radical changes in the way we use the old sources.

In other words, we need invention — and lots of it. New ideas are the only plausible way to meet future demand within the constraints we face. But who will invent our future energy infrastructure?

It isn't realistic to expect the energy industry to generate revolutionary thinking. Not that industries cannot transform themselves, because within the last few decades, established players in digital electronics, computing and the Internet have surprised all of us with a continuous stream of radical innovations. But the energy industry seems to lack such an entrepreneurial spark. It is old, mature and resistant to change.

That isn't meant as a criticism. Given the size and complexity of our energy system, we need mature operations that are dedicated to reliably powering the global economy. That is a gargantuan task in itself, however, and it is in some ways incompatible with the risks inherent in the creative pursuit of fundamentally new ideas.

What about the U.S. Department of Energy? Its national laboratories certainly have produced some terrific ideas. Their record of putting those ideas into practice is not as impressive. The computer revolution didn't come to us from the U.S. Department of Computing, after all. We shouldn't count on the transformative power of governments, because they are in some ways even less suited than mature companies are to stimulating groundbreaking innovations and steering them into widespread use. Government funding for basic research is unquestionably productive. But most government money for "energy research" actually goes either to a small set of players trying timid, incremental approaches or to earmarks aimed more at increasing local spending than at stimulating invention.

How about venture capital? In Silicon Valley, cleantech is all the rage today. Each month

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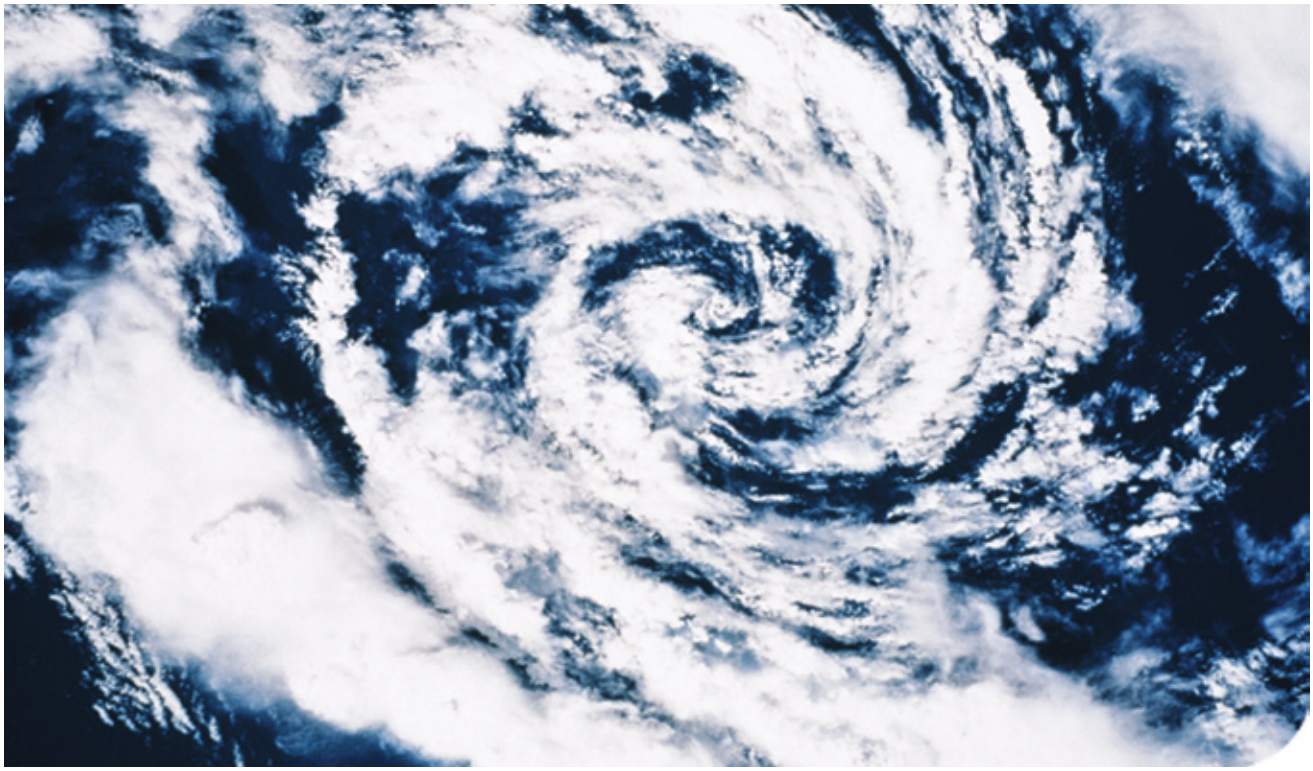

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sees dozens of startups founded to develop new energy technology. I expect a lot from these folks, but unfortunately they also face some structural problems. Venture capitalists expect rapid returns from fast-paced markets. They shy away from mature industries, particularly those that are regulated. As a result, nearly all venture capital investment in cleantech has gone to support solar, wind, cellulosic ethanol and other alternative sources of energy — all of them "green fields" that lack entrenched competitors.

We can use all the help we can get, so improvements in solar power and other renewables are absolutely welcome. But they are also absolutely insufficient to tackle more than a small portion of the problem, even if costs fall and investments rise far faster than expected, allowing us to wean them from the government subsidies they currently require. We will always need power at night and when the wind doesn't blow, power in our vehicles and power in many other situations and locations for which solar and wind are entirely unsuitable. It is not merely energy that we demand, but energy that can be transported by our ever-evolving grids where and when we need it. So while renewable sources are clearly part of the solution, they currently command a disproportionate amount of the IQ, inventor time, entrepreneurial activity and venture capital directed at energy advances.

We need to do a better job of focusing those resources where they can do the most good: in reinventing how we exploit the primary energy sources of coal, oil, gas and nuclear power. Hydrocarbons are too gritty and grimy to attract much attention in Silicon Valley. Universities do some work in these areas, as do some independent companies and one small national laboratory. But these fields are hardly hotbeds of invention. The sad fact is that more smart people wake up every day and go to work trading oil and gas futures than wake up to invent new technologies that will transform

Entrepreneurial Ferment

ROUTE 128 BECOMES ENERGY VALLEY EAST

BY PAUL KORZENIOWSKI

Massachusetts has often been known as Silicon Valley East. The state boasts the nation's second-highest concentration of high-tech workers: 86 out of every 1,000 private sector workers are in high tech, according to AeA, a high-tech trade association. Along its Route 128 corridor, successful technology firms, such as Digital Equipment Corp. and EMC, sprouted and employed tens of thousands. While high-tech remains an important component in its economy, the state has recently been turning its focus to a new market segment: energy.

The shift is evident in several ways. The state government has emphasized making the area more attractive to energy companies. Local universities have sponsored a number of energy initiatives. Venture capitalists are pouring money into energy startups, and some of these startups are sprouting their wings and moving from the concept phase to the delivery of their products.

The result is an influx of startup companies focused on addressing various energy challenges. "Generating capital for startup businesses is easier in the renewable energy sector today than in many other markets," said Rick Hess, CEO and president of startup Konarka. "Establishing that there is a need and a market for renewable energy is fairly easy." So easy in fact that many energy startups are finding needed capital. For example, the National Venture Capital Association said that nationally investments in clean-tech companies reached $1,754,490 by the middle of 2008, up from $996,700 through the first two quarters of 2007.

A number of factors are driving the growing interest in energy initiatives. "The high price of energy has become a hot topic in public discourse," said Marianne Wu, a partner at venture capital firm Mohr Davidow Ventures. Fluctuating energy prices have made it difficult for many enterprises to map out coherent short-term and long-term business strategies. As a result, more and more companies are looking to stabilize their energy costs.

In addition, climate change has become a hot button issue. At the turn of the millennium, debate centered on whether or not dirty energy was having an effect on the environment. Now, the focus has shifted to what can be done to clean up our energy sources.

Energy issues have caught fire around the globe, with Europe, Russia, Japan and China joining the United States in examining their energy policies. In a growing number of cases, government is offering energy businesses tax breaks and other incentives with the idea of sparking additional energy product and service development. Consequently,

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the futures of these industries. Inexpensive sequestration of carbon emissions from coal- and gas-fired plants are two of the signal technical challenges of our era, yet scant invention activity is devoted to these problems.

Nuclear power is in an even tougher spot. It requires extensive training and specialized knowledge. It is heavily regulated, and even though other forms of energy production cause more deaths and harm, nuclear has a special place in our fears. This situation creates an atmosphere so frightened of change that U.S. operators still use analog control rooms because the process to license a plant controlled by computers seems too intimidating. Nearly 30 years have passed in the United States without a single nuclear plant application being approved. And although that looks set to change soon, plants now in early development — and even much advanced nuclear research and development — reflect relatively minor incremental improvements. Since nuclear-generated electricity first went on line in the 1950s, far more innovation has occurred in automotive design than in nuclear plant design, not to mention the really fast-paced innovation that has occurred in computers and cell phones.

Amazingly, despite only modest incremental improvements, nuclear power still remains one of the best options for generating carbon-free electricity on a large scale. Imagine the far larger contribution it could make if we reinvented nuclear power technology in ways that solve some of the current drawbacks of nuclear plants, such as their uncertain fuel costs, the complexity of their core systems, the risks of proliferation, the inefficiency of the once-through fuel cycle and the consequent need for reprocessing. These are not impossible goals. My company and a few others are actively exploring inventions that address them.

But we need to attract far more of the effort of the world's inventors and entrepreneurs to solve these challenges. To do

venture capitalists recognize that when they fund an energy company, they are financing a firm with a global reach.

Because the need for new approaches to energy usage is clear, the Massachusetts state government has been taking steps to entice fledgling enterprises to set up shop within its borders. The Massachusetts Technology Collaborative is a state agency charged with bringing together leaders from industry, academia and government to advance technology-based energy solutions. The agency wants to help develop energy from wind, solar and other renewable resources, so Massachusetts can reduce its reliance on coal, oil and other fossil fuels.

In April, MTC contributed $5 million toward the building of a new research facility being developed by Massachusetts Institute of Technology and Germany's Fraunhofer Gesellschaft Institute, which operates more than 80 research facilities and has 12,700 scientists and engineers. The German enterprise is the largest European research lab focusing on solar technology, fuel cells and sustainable building materials.

The two organizations plan to build the MIT-Fraunhofer Center for Sustainable Energy Systems, which will focus on reducing the cost of solar energy over the next five years. Located adjacent to the MIT campus, the center, which has started off with about 60 employees, will have two labs focusing on building efficiency and prototype energy devices. A prototype lab will take advanced materials, such as electronics for the panels or encapsulated gel, and turn them into new or improved devices. A building efficiency lab will try to develop better building materials.

Similar state and academia partnerships have already borne fruit. A team of researchers at University of Massachusetts in Lowell, Mass., initially developed advanced solar cell technology for soldiers as part of a project funded by the state and the U.S. Army's laboratory in Natick, Mass. The research team determined that there were commercial options for the technology because the cells could be used indoors and outdoors under any weather condition.

The work eventually resulted in the founding of Konarka in Lowell. The company went from a research idea to a viable enterprise in 2001 with an initial investment from Zero Stage Capital, a Boston venture capital firm. Since then, the energy startup, which has 70 employees, has raised $104 million in private capital and $18 million in government research grants. With the money, Konarka has developed a series of fuel cells to serve portable power needs, with sizes ranging from 1/2 watt, 4 watts, 8 watts, and 30 watts.

Another energy startup drawing a lot of attention is A123 Systems, of Watertown, Mass. Founded in 2001, A123Systems' proprietary Nanophosphate technology was built on new nanoscale materials initially developed at MIT by materials science professor Yet-Ming Chiang.

A123Systems has raised a total of $102 million since inception. The company has more than 1,100 employees, and it has

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that, we'll have to improve the respect for intellectual property rights in the global energy industry. Inventors work on areas where they can expect a fair reward when their ideas are put to profitable use anywhere in the world; this hasn't always been the case in energy technologies. As more and more innovations in energy technology originate in emerging economies, those nations will realize that we all have a shared interest in using license fees to reward inventors, wherever they live. In the meantime, governments should make global IP rights enforcement a part of their long-term energy strategies, because it is a key prerequisite for rapid technological change.

Although respecting the rights of inventors is a necessary ingredient in the energy transformation, it isn't sufficient. We also need to see private companies playing a greater role in connecting inventors with the capitalists, plant manufacturers and utilities that will develop and deploy the new technologies. Along with making the market for inventions more open and transparent, these brokers can handle legal and business matters for inventors so that they can focus on what they do best and love most: inventing.

To surmount a technological challenge of this magnitude, we must deliberately invest as a society in invention in energy generation in every way possible. Even as we pursue breakthroughs in solar, wind, geothermal and related energy sources, we must reinvent our traditional sources to eke out more efficiency, curtail carbon emissions and make fuel stocks last through the transition to a new energy infrastructure.

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Nathan P. Myhrvold
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developed what it claims is the largest lithium-ion research and development team in the United States. To date, the startup has been pioneering a new kind of rechargeable lithium-ion battery that would be more powerful and durable than the batteries that are now used in hybrid cars. In addition, A123's batteries are being used in the consumer market, powering a new cordless line of Black & Decker's DeWalt power tools, such as hammer drills and circular saws

In August 2008, the energy company, which is not yet profitable, filed papers to raise about $175 million by going public. The capital will be used to expand its manufacturing and research facilities as well as pay back about $2.5 million in debt.

A123Systems' evolution underscores the growing symbiotic relationship between the area's high-tech and energy sectors. MIT, which helped spawn many of the Route 128 high-tech companies, has been aggressively moving into the energy sector. Each spring, the university sponsors an annual energy conference designed to outline problems and potential – and also to spawn ideas for new businesses. The academic institution has become the epicenter of Massachusetts' energy initiatives.

Many of its alumni are helping to forge this path. Gururaj "Desh" Deshpande is chairman of A123Systems. He co-founded Sycamore Networks in 1998 and Cascade Communications in 1991, two Massachusetts networking companies that played significant roles in developing devices needed to support the Internet. In addition, Dr. Deshpande serves as an advisor to MIT, and his donations have helped to build MIT's Deshpande Center for Technological Innovation, which helps to transform students' business ideas into new ventures.

The intersection between high tech and energy can be seen in the business plans of WindPole Ventures, a Lexington, Mass. startup. Company founder and CEO Stephen Kropper has held positions at high-tech firms Cable & Wireless, Martin Marietta, International Data Corp. and Equinox Corporation. He founded a real estate information services Web site, Domania.com, that was eventually sold to Lending Tree, which is now an IAC/Interactive Corp. holding. WindPole plans to create wind-powered electric generating facilities and use existing networks, such as cellular tower networks, to move it from place to place. The company's five-year target is to develop 300 megawatts of wind energy capacity.

Although the pairing of high-tech and energy businesses is becoming more common, it can be an odd couple. "There is the young, aggressive persona of the high-tech entrepreneur teamed with the older, more reserved manner of the corporate energy executive," noted MDV's Wu.

Despite the dichotomy, such alliances are expected to become more common in the future. As segments of the high-tech space, such as communications, mature, investors are on the lookout for new opportunities with energy emerging as an appealing option. That change already is evident along Route 128 in Massachusetts.

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