

# INVENTING OUR ENERGY FUTURE

A TECTONIC SHIFT AHEAD  
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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 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 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 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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