How to kick-start new energy technologies

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The world desperately needs innovation in energy technologies — but those innovations are unlikely to happen by themselves. A three-year study by a team of researchers based at MIT has now identified a suite of policy and investment strategies that could accelerate innovation in the United States, helping to meet our growing energy needs affordably and reliably, reducing carbon emissions and alleviating insecurity over energy supplies.

The conclusions of that study are detailed in a new book — Unlocking Energy Innovation (MIT Press, 2012) — by Richard Lester, the Japan Steel Industry Professor of Nuclear Science and Engineering at MIT, and David Hart, a professor of public policy at George Mason University. The project was supported by a grant from the Doris Duke Charitable Foundation.

The study, carried out at the MIT Industrial Performance Center and involving faculty and students from nine MIT departments, concluded that fundamental changes are needed in the U.S. energy-innovation system. Without systematic, transformative changes, Lester says, we are unlikely to succeed either in averting the worst economic and environmental consequences of climate change or in achieving a secure, affordable and reliable energy supply.

“Innovation doesn’t just emerge out of thin air,” Lester says, but requires a productive ecosystem, including public and private research laboratories; small and large firms; financial intermediaries ranging from huge banks to individual “angel” investors; schools, community colleges

and universities; and local, state and federal agencies.

“We face a very big innovation challenge over the next few decades,” Lester says, “bigger than most people recognize. And the system as a whole isn’t close to being up to the task.” While the focus of this analysis was U.S. institutions for energy research and development, financing, regulations, standards, and markets, he says, “U.S. leadership in energy innovation will be essential to world success” in affordable mitigation of climate change.

But the urgency isn’t solely related to climate change, Lester says: The world’s recent energy shocks have included last year’s massive oil spill in the Gulf of Mexico, this year’s Fukushima nuclear accident in Japan, and oil-price volatility and supply uncertainty resulting from revolutions in the Arab world. Still, he says, “achieving large-scale reductions in carbon emissions is the biggest and most difficult” problem to solve, and “if we solve that, we will probably make a number of other problems better.”

Lester and Hart identify four stages through which an innovative technology becomes an established part of the energy infrastructure. Of those, the first stage — the discovery of new technological options — and the final stage — fine-tuning of technologies already in commercial use — are relatively well-managed, he says, though both will require more investment.

But the two middle stages, Lester says, are less well-managed. These stages, spanning what is often referred to as “the valley of death,” include the development of prototypes to demonstrate viability in the marketplace and the initial implementation of the first full-scale systems by early adopters in the marketplace. These intermediate stages are costly and pose high investment risks, and a modest carbon price will do little to accelerate them.

Lester and Hart's analysis of past advances reveals several steps that tend to foster energy innovation: encouraging competition (and always leaving space for new market entrants), making rigorous and timely selections of promising concepts, and matching the scale of the system to the scale of the need. "The current system satisfies none of these," Lester says.

He adds that it's essential to pursue parallel innovation strategies aimed at different timescales: changes over the next decade focused on efficiency improvements such as building insulation and gas mileage; midrange efforts to reduce the costs and risks of known low-carbon energy-supply and electricity-storage technologies; and, from about 2050 on, a third wave of technological deployments drawing on fundamentally new developments in fields such as materials and catalysis. "All three waves of innovation must be pursued in parallel, immediately," Lester says.

Since coal and natural gas represent about 70 percent of all electricity generation nationally, finding cost-effective ways of replacing those fuels and mitigating their emissions will be critical, the book says. One specific idea the team advocates is a regional approach to managing and financing the intermediate stages of innovation. Lester suggests that such a regionally based system, with decisions made by innovation users, would be more effective than the present system where decision making often rests with the federal government, a system that so far "has proved only partly successful."

"The federal government is structurally unable to play this role effectively," Lester says. This proposed approach "would expand the scale of the energy-innovation system considerably, but reduce the federal role."

Bringing about such radical changes will not be easy, he concedes, especially given the current gridlock in Congress. But in fact the current

difficulties in Washington only add to the case for regionalization. Implementation "will probably have to happen from the bottom up," he says. "It will have to be an organic process."

William Madia, vice president of the Stanford Linear Accelerator Center at Stanford University, says Lester and Hart "advance bold ideas for both public and private sector approaches that will undoubtedly spark controversy but represent the kind of new thinking that is needed to change the fundamental dynamics of the energy sector … [they] offer us a blueprint for transformation of the energy sector."

And Ralph Izzo, chairman, president and CEO of the Public Service Enterprise Group of New Jersey, a major gas and electric utility, says the book "provides powerful and innovative approaches to fostering greater innovation in how energy is produced, delivered and used." He adds, "The emphasis on energy efficiency recognizes that this area is not only 'low-hanging fruit,' but apples on the ground ready to be collected."

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