First Person—Reinventing the Nation's Energy Systems: An "Unparalleled" Economic Opportunity

The Story in Brief

Lynn Orr is Under Secretary for Science and Energy at the U.S. Department of Energy. In this interview with *EPRI Journal*, Orr discusses his agency's recently released *Quadrennial Technology Review*, which examines the status of energy-related science and technology and R&D opportunities to advance them.

EJ: What is the significance of the recently released *Quadrennial Technology Review*?

Orr: As Under Secretary for Science and Energy, I look over the full range of fundamental science and applied energy research. My office led the effort to produce this Quadrennial Technology Review, though it involved a couple hundred people across the Department of Energy and about 500 outside experts helping with reviews and workshops. It was requested by the President's Council of Advisors on Science and Technology. They asked for the first one in 2010, and that was published in 2011, and this 2015 report is the next in the sequence.


Lynn Orr

We believe that the future of the United States depends on having a set of energy systems that are low-cost, secure, robust, and resilient, and that help us avoid climate change and other environmental impacts. The overall conclusion is that while we have made significant progress on all those fronts, there's a lot more to do. And there's a lot more we can do. There is a huge opportunity to invent the energy technologies and systems of the future, and our job now is to build and execute a portfolio of research that makes that possible. We need both the applied side and fundamental research. This is a time where we can put science and energy research to work in the interests of the nation.

The report's chapters look at six major energy sectors: the electricity grid, electric power generation, buildings, advanced manufacturing, fuels, and transportation. It also looks at these sectors from a systems standpoint, recognizing that individual energy technologies are important—and so are the systems in which they function. This perspective gives us some additional opportunities.

EJ: What are the next steps?

Orr: Translate this wide-ranging assessment of energy technologies and systems into the particular programs that we undertake. To decide where the best research opportunities are for us—and where there's an appropriate government role. Some of the work will be done by industry and other parts by us. The document is meant to be broader than just Department of Energy programs. We hope it will also be useful to others who are thinking about the energy system today and where it might go in the future—industry, research organizations, universities, and students around the world.

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EJ: How does the report address the big changes and related challenges in the electric power sector?

Orr: This was the fun part of the assessment. There have been big changes in the electric power system since the last Quadrennial Technology Review, on both the supply and demand sides. There's a lot more wind and solar on the grid. There's been a shift in the mix of primary fuels that go into generating electric power. There are a lot of new phasor measurement units distributed around the nation, and there are a lot more smart meters. We have an opportunity to move the grid into an entirely new space. For example, having many more advanced sensors can tell us about the state of the grid, and advanced modeling can help us use that information to figure out where power should go. Advanced technologies and materials for power electronics and energy storage can help us manage deeper penetration of distributed generation and intermittent renewables, as well as microgrids. There is a big opportunity to provide better services, and to be more robust and resilient with new software and visualization tools to operate the transmission and distribution systems of the future.

EJ: What are the top three takeaways from the report?

Orr: I have four. The first is that the nation's energy systems—such as the electric power grid, pipeline systems, and transportation systems—are becoming much more connected with each other through communications and the Internet. These linkages give us opportunities previously not available by just working on individual systems. We can think about operating the linked systems in ways that balance loads and generation, and we can begin to optimize across these systems.

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The second is the diversification on both the supply side and the demand side. We have a richer set of energy resources being deployed for electric power generation, and we have diversified end uses. We're starting to think about electrifying transportation in a significant way. We've electrified a lot of our lives already, and that will continue in smart buildings and smart cities, so there's opportunity to provide better services there.

The third is energy efficiency. We have realized that we need to do energy efficiency everywhere in the system. It has immediate economic benefits, and it allows us to address climate change as well.

Fourth, we need to remember how important it is to have vigorous, fundamental scientific research underlying all these efforts—that takes advantage of our national laboratories and their user facilities. For example, it will be important to have ways to do advanced materials science, and high-performance computing can enable better control of very complex systems like the grid.

EJ: What might the convergence of all these energy systems look like? What do you see emerging to help them work in tandem?

Orr: There's both an opportunity and a challenge. The challenge is that all these systems have to communicate with each other to work effectively. That means that the communications need to be absolutely secure. Additional research is needed to achieve better cyber security, communications, and control systems.

In the 'how-cool-could-this-be' part of my answer, think about a city in the future. A unit for a city is a building. New energy-efficient buildings are complicated systems that require communications and sensors to figure out who's doing what and where, and what they need for heating, cooling, and other uses. In a neighborhood, there's a collection of buildings, and they might be connected by a microgrid that serves their needs. That microgrid links with the bigger grid, providing opportunities to manage heating, cooling, lighting, and power at the local and regional levels.

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Then there's the business of transporting yourself around the city. You'll use your Internet access to order your car with automatic, autonomous navigation, and that will get you where you need to go by avoiding the bad traffic spots and synchronizing with the traffic lights in the right way. You can imagine this as a set of linked, complex systems—systems of systems. There are plenty of challenges and opportunities to make this work in a way that will provide better services.

EJ: What is the role of research on breakthrough or "outside-the-box" technologies?

Orr: Sometimes breakthroughs will come because you backed up and tried to solve a problem in another way, and sometimes there is a new idea. Those are hard to schedule, but we can make sure that we take advantage of them when they happen. For example, particle accelerators were invented to allow us to understand the fundamentals of high energy and nuclear physics, and now we have 30,000 of them in use for applications in medicine, semiconductor manufacturing, security, and science.

Materials science offers opportunities for breakthroughs in almost all the areas in which we work, because many of the problems we need to solve require advanced materials. For example, wide bandgap semiconductor materials offer many opportunities for better transformers, active controls on power flow, and new design configurations that will enable better services.

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Another example: We can make many kinds of nanostructured materials now, and when you combine that with improved catalysts and the ability to make high-surface-area materials in the battery/fuel cell/energy conversion arena, that's a rich sandbox to play in, and we're trying to capitalize on that. That's a place where the fundamental science has an important role to play.

EJ: In light of the report's conclusions, how can EPRI help address DOE's R&D priorities over the next five years?

Orr: We've already taken advantage of EPRI and many of its member companies because there was such wide participation in preparing the report. But that was just the first step. We are trying to reinvent the nation's energy systems, and we need all the tools we have now, plus more that we need to create. EPRI supports that work. EPRI can also help us communicate to the world why this is an important and necessary undertaking that is in all our interests. If we do this right, we have an economic opportunity for the United States that is quite unparalleled. Just as electricity is woven through the fabric of modern society, a cost-efficient, robust, and resilient transmission and distribution system will underpin a globally competitive economy.

The assets of the energy system are, for the most part, privately owned, and there are myriad regulators at state and local levels. DOE helps to convene conversations among these groups to figure out ways to work together effectively. But to have a conversation, you have to have participants. We can count on EPRI to help us carry the conversation as we invent the electricity system of the future. That's a worthy endeavor.

EJ: The energy sector is transforming so rapidly that R&D needs may change in just a year. How does DOE plan R&D in such an environment?

Orr: We cheer. The fact that we can deploy the science and energy R&D resources that we have available, particularly in our 13 national labs that work on this area—that we can work in an agile way on the energy systems of the future—that's the most exciting thing that we can think of. We welcome the speed of change.

It is true that surprising changes have happened over the last four years, but they're the result of a lot of hard work to bring down the cost of things such as wind and solar. You're seeing utility-scale solar, and you're seeing individuals and businesses installing many solar panels. Wind is creeping up on 5 percent of electric power generation. Those are big changes, and they're an indication that the kind of research we've done in the past has paid off.