Advancing Green Energy Technology

Biography in Brief

Prof. Rick Stevens is associate laboratory director for Computing, Environment, and Life Sciences at Argonne National Laboratory and a professor of computer science at the University of Chicago. His research interests are in high-performance computer architectures and computational science, especially problems in the life sciences. He heads Argonne's efforts in advanced computing targeting the development of exascale computing technology and applications in systems and computational biology and environmental modeling and simulation. He is a fellow of the American Association for the Advancement of Science and a co-founder and senior fellow of the Argonne/University of Chicago Computation Institute, a multidisciplinary institute aimed at connecting computing to all areas of inquiry at the university and the laboratory.

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Our nation urgently needs to accelerate the research and development of new energy technologies and to dramatically lower the environmental impact of the products and services that support our standard of living. By making a focused effort now to develop new green energy technologies and establish U.S.-based manufacturing of these technologies, we can simultaneously reinvigorate the U.S. economy and address the challenges of reducing U.S. CO_2 emissions.

Advanced computing is key to the development of any new energy technology. In particular, advanced modeling and simulation can optimize performance, reduce costs, improve time-to-market, and explore designs beyond the reach of traditional approaches.

The opportunities are significant: novel processes for manufacturing lower-cost, higher-performance photovoltaics; new mechanisms for directly converting sunlight to chemical fuels; new materials for higher-energy density and lower-cost batteries; and the re-architecting of the power grid to integrate distributed generation and large-scale storage that make solar and wind feasible at large scale.

Advanced materials science underlies nearly all energy technologies. For computational materials science to play a major role in energy research, it must evolve from a tool used for characterization and explanation to a tool useful for design optimization. Progress toward computationally driven materials design will accelerate the development of novel materials for solar power, selective catalysis, and energy storage.

Environmentally friendly manufacturing is also a major challenge. Computational modeling has been used to reduce waste and improve time to market. But if the manufacture of that technology is not equally green, the environmental advantages of green energy technology can be reduced. It is critical that modeling and simulation be employed to make green energy technology production as green as possible.

Building complex integrated devices (such as next-generation intelligent batteries and smart grid controllers) is difficult. Predicting the performance of these devices in real-world operation is even harder. Both are necessary to reduce the time-to-market for practical systems, and both can be tackled with simulation and modeling at scale. Using scalable systems enables broad ranges of parameters to be investigated before committing limited resources to specific design points.

We have an amazingly complex energy supply, transmission, and consumption network that has developed and evolved for over a hundred years, in response to market forces and injection of new technologies. During the next twenty years we will need to accelerate the deployment of new technologies at a much faster pace than in the past. Modeling and simulation of the global energy system can be a critical tool to avoid destabilization while guiding the accelerated deployment of new technologies.

As increasingly diverse energy sources are integrated into the global energy system and as consumers become more cost aware and energy conscious, it will be critical to have more flexibility in control systems for the grid that can balance production and demand. Modeling and simulation can be used to better understand the operating characteristics of grids and to help formulate the degree of intelligence that must be embedded to keep them stable and responsive.

Recent studies have shown promise in using weather prediction to optimize wind farm productivity (for example, by timing availability of base load) and the efficiency of heating and cooling systems in buildings (for example, by anticipating changes in load). Advanced simulation programs integrating these predictive methods can enable designers to capitalize on opportunities for savings.

It is generally believed that we will need multiple breakthroughs in many different energy technologies to enable us to sufficiently reduce our dependence on fossil fuels and meet our goals for reducing greenhouse gas emissions. A common thread through the various development paths is the opportunity to apply advanced computing.

Simulation and modeling can make a crucial difference in how we get there, how fast we get there, and perhaps whether we get there at all.

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