Sandia National Laboratories

Energy, Climate & Infrastructure Security

The Infrastructure Security program area works to develop and apply technologies/analytical approaches to secure the nation's critical infrastructure against natural or malicious disruption.

Vision

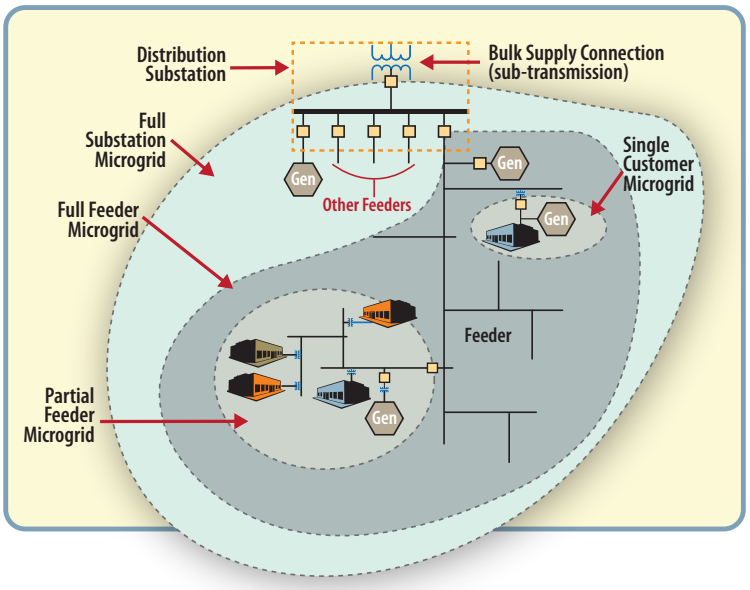
To enhance the nation's security and prosperity through sustainable, transformative approaches to our most challenging energy, climate, and infrastructure problems.

Goal: Design and demonstrate 30% renewable energy penetration into the energy surety microgrid within five years

The present electricity grid is based on a foundation created more than 100 years ago. The infrastructure is geographically fixed, power sources are centralized and dispatchable (completely controllable), the loads are largely predictable, and the control of power flow at the load is essentially an open-loop—making it vulnerable to terrorist attacks, natural disasters, infrastructure failures, and other disruptive events.

This grid model limits renewables and other distributed energy sources from being economically and reliably integrated into the grid because it has been optimized over decades for large, centralized power generation. While a national renewable-energy portfolio standard (RPS) has yet to be established, many states are forging ahead with their own programs and policies and utilities must adapt.

The energy surety microgrid (ESM) is a Sandia-developed grid architecture that moves away from unidirectional power and limited information flow and, rather, adopts closed-loop controls and an agent-based architecture with integrated



Sandia is working toward implementing an energy security microgrid (ESM) in cooperation with Kirtland Air Force Base, the location of Sandia's New Mexico site.

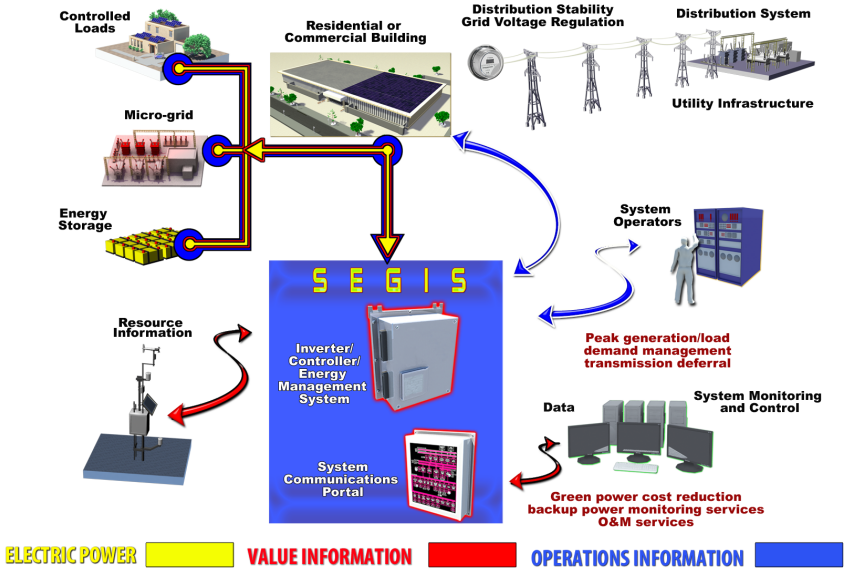
U.S. DEPARTMENT OF ENERGY

Microgrid
A small-scale version of a centralized electrical grid; implemented at a local level and taking advantage of locally generated power sources (photovoltaics, small wind, biomass, small hydro, combined heat and power, and energy-storage). A microgrid can be tied to the larger grid, yet retains the ability to independently supply energy in the event the larger grid experiences power interruptions or price fluctuations.

communication networks. Adding a feedback component to the input signal establishes an intelligent power-flow control and provides a basis for integrating renewables and distributed power sources into the grid. This bold approach will enable a self-healing, self-adapting, self-organizing architecture and allow a trade-off between storage in the grid and information flow to control generation sources, power distribution, and loads. Incorporating agent-based, distributed, nonlinear control to maintain reliable energy distribution while minimizing the need for excessive storage or backup generation will be a revolutionary step toward extreme penetration of renewable energy sources into the U.S. energy infrastructure. The development of dynamic nonlinear source models, scalable agent-based architectures, and multi-time-variant simulations will be key components to this solution. By advancing these sciences and technologies, we are enabling reliable, resilient, secure, and cost-effective microgrids and interconnected microgrids making up the smart grid of the future.

Solar Energy Grid Integration System

Because of renewable energy generation's variability, the future electrical grid will require integrated energy management. The DOE's SEGIS program seeks to seamlessly accommodate the two-way power flows required by wide-scale deployment of distributed resources. Sandia researchers are helping to develop integrated, innovative inverters and balance-of-system elements for residential/commercial applications which incorporate energy-management and communicate with stand-alone energy-management systems as well as with utility smart meters. The SEGIS program works to improve power-generation inverter/controller reliability while developing interfaces for advanced grid integration. The heart of SEGIS, the inverter/controller, will manage generation and dispatch of solar energy to maximize value, reliability, and safety. The inverter/controllers will interact with building energy-management systems and/or smart loads, with energy storage, and with the electric utility.



SEGIS seeks to integrate small-scale distributed energy generation into residential construction and have it interact intelligently with the electricity grid.

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