

Energy Surety Microgrid: E&IF Group Project

Sandia National Laboratories



Help our nation secure a peaceful and free world through technology.

Our nation depends on secure, reliable, sustainable, and cost effective supplies of energy to support economic development and to maintain a high standard of living. The present energy infrastructure was designed to meet these needs with fossil fuels because their inherent high energy and power densities enable the creation of flexible, adaptive mobile and fixed power supplies with intrinsic storage and dispatchability. These benefits have come at a cost of high carbon emissions, dependence on foreign petroleum, and low energy source diversification investment. In order to move beyond the present state of an insatiable appetite for fossil fuels and the resulting infrastructure, new concepts, ideas, and technologies will be needed to support the DOE's National Energy Policy goals to:

- Diversify our energy mix and reduce dependence on foreign petroleum,
- Reduce greenhouse gas emissions and other environmental impacts,
- Create a more flexible, more reliable and higher capacity U.S. energy infrastructure, and
- Improve energy efficiency and productivity.

Energy Surety

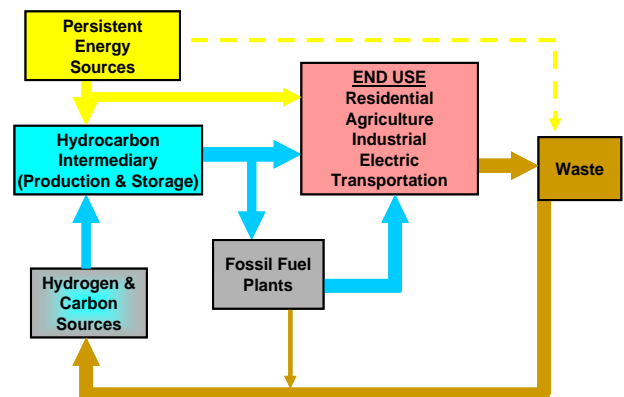
Sandia's approach to addressing these goals under the present constraints of our existing infrastructure and short-term, market-based mentality is an iterative top-down, bottom-up optimization process called Energy Surety. *Energy surety* is a collection of features of an "ideal" energy system, which, when satisfied, enable the system to function properly while at the same time allow it to resist stresses that could result in unacceptable losses. The attributes (metrics) of the energy surety model include safety, security, reliability, sustainability, and cost effectiveness. The chart provides the definitions of each of the metrics. More details on energy surety can be found in SAND2005-6281: Toward an Energy Surety Future.

Energy System is:

	If it:
Safe	Safely supplies energy to end user
Secure	Maintains power in a malevolent environment
Reliable	Maintains power when and where needed
Sustainable	It can be maintained indefinitely
Cost Effective	Produces energy at lowest predictable cost

Synergy within the Energy Infrastructure

Today's energy infrastructure reflects an inherent mismatch between the rate of energy use (primarily fossil fuels) and the production by the biosphere of new, effective (compatible with our current energy infrastructure) sources of energy. This mismatch is evident in our farming practices which utilize petroleum fuel to accelerate food production in order to expand the carrying-capacity of the infrastructure (biosphere) to support an ever increasing population. The "closed-on-mass energy system" diagram illustrates a concept to meet requirements of safety, security, reliability, sustainability, and cost effectiveness. This concept attempts to couple persistent energy sources (> 200 years supply with present consumption) that close the mass waste cycle to the existing infrastructure through multiple paths including novel processed fuels (hydrocarbon intermediary) as energy carriers such as hydrogen. These "closed-on-mass" energy cycles can be achieved through technologies such as nuclear with reprocessing, solar, geothermal, wind, and clean coal with sequestration. This system also takes advantage of "stored or available" energy within the waste stream as an energy recycling element. We are presently evaluating this concept within the energy surety framework.

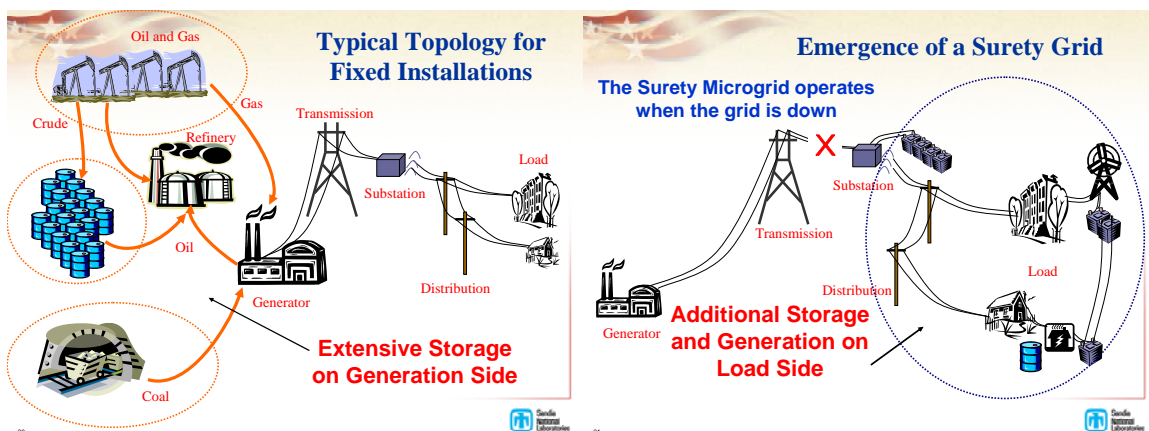


Power Grid Surety

The North American electric power grid is critical to the US economy and our way of life. Although it has historically been one of the most reliable power grids in the world, relatively little investment has been made in R&D to assure continued surety in light of increasing energy demands, dependence on fossil energy sources, transmission congestion, and terrorist threats. The “closed-on-mass” energy surety approach facilitates a more safe, secure, reliable, sustainable, and cost effective power grid. This new power grid concept that couples to the novel processed fuels grid enables penetration of intermittent persistent (e.g., wind, solar) and distributed energy sources, helps alleviate transmission congestion, provides an understanding of security issues and interdependencies, and enables more resistance to catastrophic outages and natural disasters including faster and more efficient reconstitution after such events.

Energy Surety Microgrid

Today electric energy production is largely fueled by coal, nuclear, and natural gas, which we will call the “primary fuels.” A very small amount originates from hydro and other sources. The simplified diagram presents the US electric generation and grid system with its constituent primary fuels. There are three important features of this system. First, there is a huge stockpile of stored energy at or near the large-scale generators. All of the primary fuels are forms of stored energy, most being created millions of years ago and sequestered in the earth until recently mined. The majority of the large-scale generators that burn these fuels are located either near its fuel source (mine mouth, coal fired generation) or have a large amount of fuel storage on site (oil fired, train fed coal fired, nuclear). Others, such as natural gas generators, depend on a reliably steady supply of gas to operate. While the cost of the primary fuels is rising, they are still relatively abundant. Second, large-scale generation is highly reliable. The approximately 2700 generating plants in the US are well maintained, sited with all the machinery centrally located and have an on site maintenance staff performing periodic, preventive maintenance. Rarely is a power outage caused by generator failure. Third, the transmission and distribution systems are widely dispersed with over 650,000 miles of transmission lines, 5,600,000 miles of distribution lines and over 60,000 substations spread throughout the United States connecting the generation stations to the consumer. In comparison to the generation stations, the T&D system receives little preventive maintenance, especially on the lines themselves, and is much more subject to the whims of nature. Congestion in the transmission system exacerbates these problems. The T&D system is the source of nearly all electricity disruptions and outages. There is virtually no storage on the load side of the system to buffer the consumer from the effects of these problems. Sandia is developing a new concept for energy generation and delivery systems called the Energy Surety Microgrid. This concept is designed to put into play the energy surety concepts outlined above on an electric power system. The Energy Surety Microgrid will supplement the existing grid structure by adding high reliability generation near critical loads, by adding storage at critical locations and by introducing sustainable generation on a local scale as well as taking a step toward the power grid of the future.



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