Sandia National Laboratories
Refueling The Nation
An Energy Surety Approach

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

Our highest goal: become the laboratory that the U.S. turns to first for technology solutions to the most challenging problems that threaten peace and freedom for our nation and the globe.

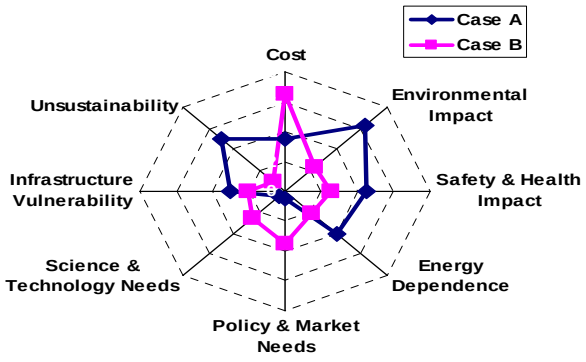
Energy and Infrastructure Assurance Goal: Enhance the surety (safety, security, and reliability) of energy and other critical infrastructures.

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.

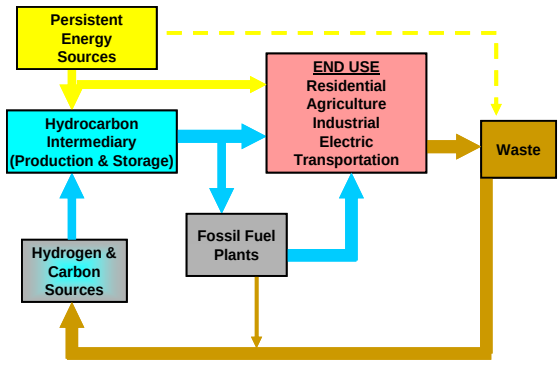
Energy Surety

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, recoverability and sustainability. The "bulls-eye diagram" presents one way to visualize this trade-off (optimization) process. More details on energy surety can be found in SAND2005-6281: Toward an Energy Surety Future.



Synergy within the Energy Infrastructure

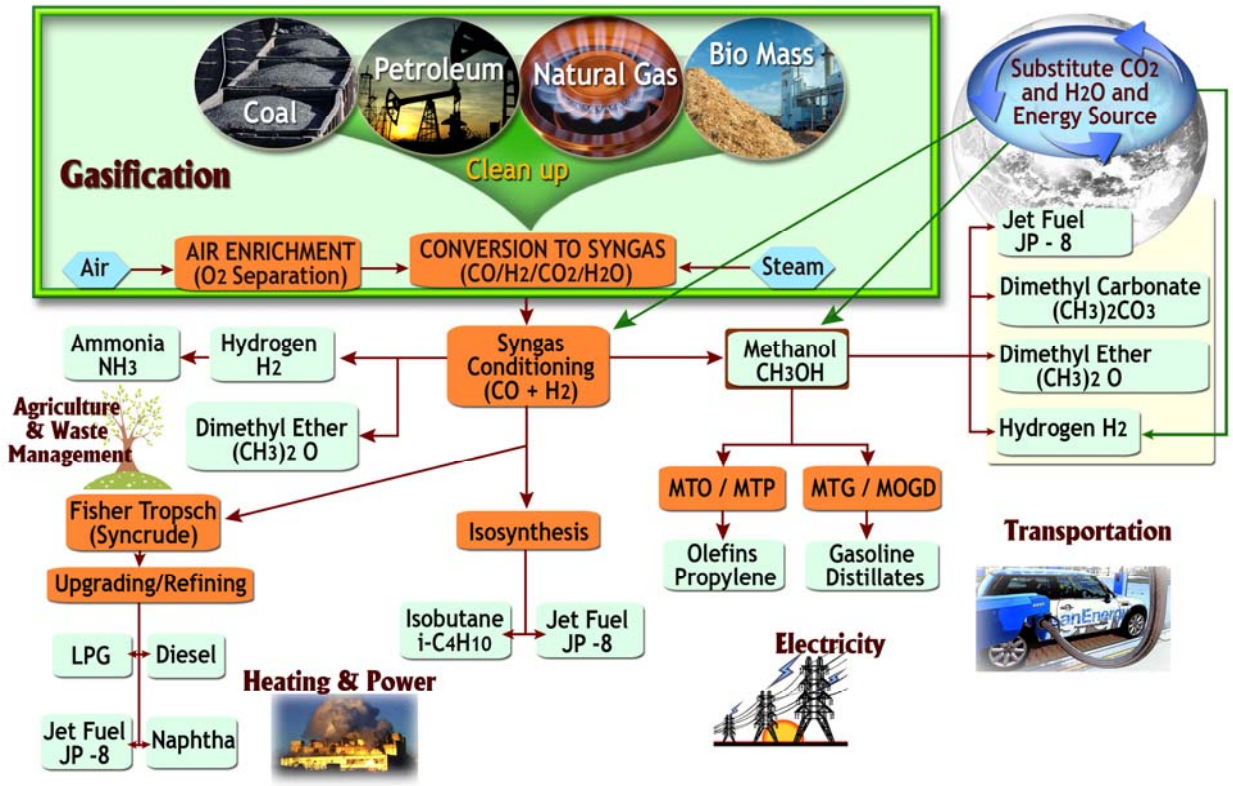
Today's energy infrastructure reflects an inherent mismatch between the rate of energy use (primarily fossil fuels) and the production by the biosphere of new, effective (compatible with our current energy infrastructure) sources of energy. This mismatch is evident in our farming practices which utilize 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, reliability, security, sustainability and affordability. 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.

Novel Processed Fuels

The novel processed fuels provide a unique opportunity to couple directly into the entire infrastructure, cross-couple many unconventional energy sources throughout the infrastructure, provide a more diverse energy mix particularly in transportation fuels, and provide a transition path to the hydrogen economy. One of the most effective ways to store, transport, and utilize hydrogen within the existing infrastructure is to attach a carbon molecule to the hydrogen to produce a novel processed fuel. The synfuels diagram provides several possible paths between hydrocarbon energy sources and synfuels that can be used as a baseline to develop and transition to novel processed fuels derived from water, carbon dioxide, and energy sources such as heat, light, electricity, and nuclear. The carbon dioxide would initially come from sequestered stack gases such as coal burning plants and transition to coming out of the air. The heat source would come from nuclear/solar, in particular hydrogen production, with the possibility of optimizing the paths between water, carbon dioxide, and heat and the novel processed fuel without explicitly creating hydrogen and carbon monoxide.



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 secure, reliable, and sustainable 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.

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