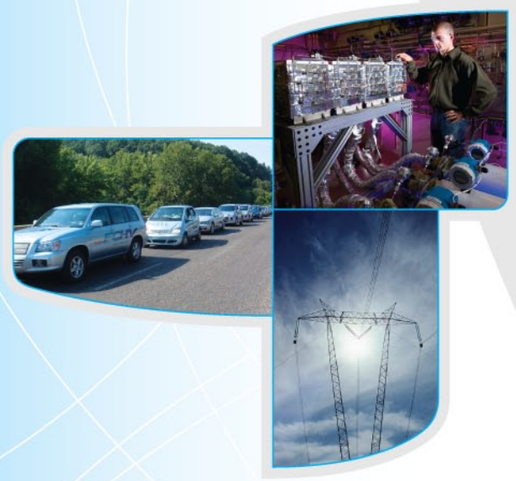
We are actively seeking private industry and government partners to join us in innovative collaboration toward a secure and sustainable transportation energy future.

To learn more, please visit any of the following Sandia Web sites:

- ***Sandia's Hydrogen Program*** *(http://www.ca.sandia.gov/hydrogen/)*
- *The* ***Hub for Innovation in the Transportation Energy Community*** *(http://www.HITECtransportation.org/)*
- ***Sandia National Laboratories*** *(http://www.sandia.gov/)*
- ***Sandia National Laboratories, California*** *(http://www.ca.sandia.gov/)*
- *The* ***Metal Hydride Center of Excellence*** *(http://www.ca.sandia.gov/MHCoE/)*



Building the Path to a Diverse Energy Future

SANDIA'S HYDROGEN PROGRAM

Sandia National Laboratories
A Department of Energy National Laboratory

Building the Path to a Diverse Energy Future
SANDIA'S HYDROGEN PROGRAM

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NNSA National Nuclear Security Administration

Sandia National Laboratories
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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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SANDIA NATIONAL LABORATORIES

Building the Path to a Diverse Energy Future

The energy we use to drive our economy and power our lives comes at a steep price—air pollution, dependence on foreign sources of petroleum, and emissions of greenhouse gases that contribute to global warming.

A long-term solution to this problem requires a diverse portfolio of alternative and advanced fuels. However, public acceptance and widespread use of fuel cells and hydrogen—key elements of such a portfolio—are currently impeded by significant technical, institutional, and market barriers.

With a long history of exploring basic science for energy and transportation, Sandia National Laboratories is at the forefront of discovery that could help fuel cells and hydrogen take their place in a sustainable energy future.

Advancing Fuel Cells

Fuel cells provide a clean, reliable, and highly efficient way of producing electricity. They can use a number of fuels, including biogas, natural gas, propane, diesel, and hydrogen.

To advance **fuel cell technology**, a Sandia team is working with an industrial partner to resolve the technical challenges that face proton-exchange-membrane (PEM) fuel cells. PEM fuel cells are used in a wide range of applications, including distributed power, backup power, auxiliary power, portable power, and transportation.

Hydrogen—A Clean Fuel for Fuel Cells

Hydrogen is particularly useful for fuel cells because it provides a clean fuel that can be renewably produced using diverse resources, such as renewable energy, fossil energy, and nuclear energy. Since hydrogen is typically found in combination with other elements, these diverse energy sources must be separated to produce useable, pure hydrogen. Sandia is exploring ways to use the sun—the ultimate renewable resource—to produce hydrogen directly.

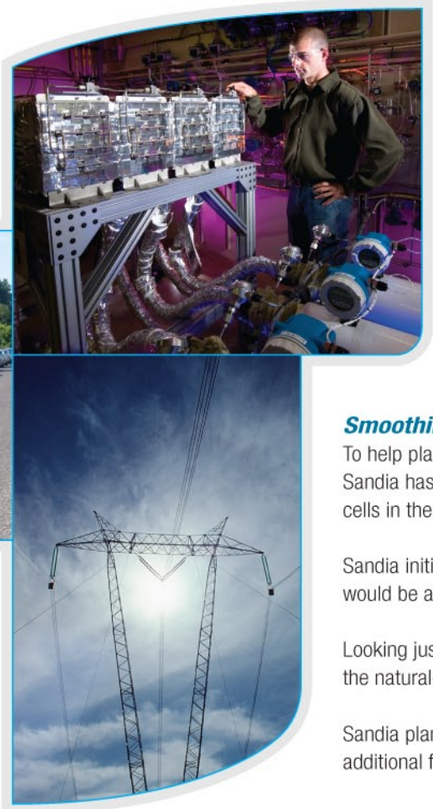
Specifically, Sandia researchers have been investigating solar-driven thermochemical processes since 2003. These processes split water into hydrogen and oxygen by applying **concentrated solar energy** to drive a series of chemical reactions.

Solving the Hydrogen Storage Problem

Finding ways to store hydrogen in lighter and more compact storage systems is key to enabling its widespread use. Improved storage technologies will help reduce the footprint of stationary fuel cell installations and hydrogen fueling stations. These technologies will especially impact passenger cars and small trucks, which require substantial improvements to enable a 300-mile driving range. The U.S. Department of Energy is funding three major research initiatives, called the Centers of Excellence, to develop the materials involved in hydrogen storage systems.

Sandia has led one such effort, the Metal Hydride Center of Excellence, since its inception in 2004. The aim of the center is to create a new material that can soak up and concentrate hydrogen into a small volume, release the hydrogen when needed, and then repeat this cycle over and over. In addition, the material must possess the following characteristics: it must be inexpensive and readily available, it must be able to store and release hydrogen within a practical temperature range, and it should enable vehicle refueling in about three minutes.

As the lead organization for this venture, Sandia coordinates the work of some 18 organizations engaged in several promising areas of research. Sandia is also contributing to **materials development** work and helping direct research by refining materials theory.



Storage for Vehicles

With more than five decades of experience in design engineering for energy storage systems, Sandia was a natural choice when General Motors sought a partner to design and demonstrate a metal-hydride **hydrogen storage system**.

The path to demonstrating an optimized storage system involved numerous tasks, such as materials characterization, the development of models for component design, and the assembly of a large-scale hydride production lab.

This multiyear project, which was completed in 2009, resulted in a suite of engineering tools to facilitate the design of follow-on systems.

Smoothing the Introduction of Fuel Cells and Hydrogen

To help planners smooth the introduction of fuel cells and hydrogen into an already complex energy system, Sandia has created a dynamic model. The model simulates the potential impacts of using hydrogen and fuel cells in the overall **energy infrastructure**—from the fuel production site to the end user.

Sandia initially applied the model to examine how natural-gas prices, supplies, and delivery infrastructure would be affected in the likely early-stage scenario where hydrogen is largely derived from natural gas.

Looking just at California, the model demonstrated that a rapid expansion of hydrogen use could overwhelm the natural-gas infrastructure in about 20 years—pointing to the need for mitigation strategies.

Sandia plans to expand the model to examine other regions and additional fuel scenarios.

Ensuring Safety

Drilling down into the basic science of hydrogen, Sandia is helping to create a sound technical basis for the codes and standards needed for safe hydrogen use.

For example, Sandia has been examining hydrogen jet flames to learn more about their shape and heat radiation—information that will lead to specifications about the safe storage and use of hydrogen. Our scientists are also developing cost-effective, solid-state hydrogen sensors that can withstand harsh industrial environments.