



*Light-Inspired Solutions*

# Solar to Fuels



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“So we have a choice to make.

*We can remain one of the world’s leading importers of foreign oil, or we can make the investments that would allow us to become the world’s leading exporter of renewable energy.*

*We can let climate change continue to go unchecked, or we can help stop it.*

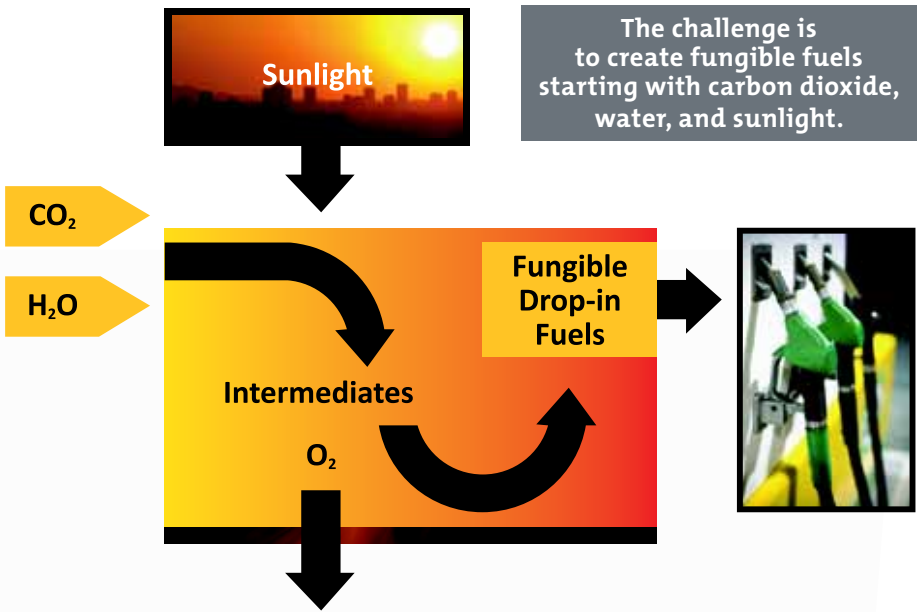
*We can let the jobs of tomorrow be created abroad, or we can create those jobs right here in America and lay the foundation for lasting prosperity.”*

—President Barack Obama  
March 19, 2009

### The Challenges

Numerous studies and accounts in the scientific and popular press point to the serious economic, security, and environmental risks faced by the United State and the world from a business as usual approach to supplying energy. The risks from climate change, disruption to energy supplies, and the economic consequences of failure to lead in new green technologies are upon us. It is important to act with resolve and determination. We pose the call to act in four questions:

- **How do we move away from dependence on fossil fuels, toward environmental, economic, and energy security?**
- **How can we develop a source of fuel that is sustainable, carbon-neutral, and scalable?**
- **What would it take to be market-deployed within 15 years?**
- **Can the United States mobilize and align a team of scientists and engineers from National Laboratories, academia, and industry to address such a formidable goal?**



### The Vision

There is much we can do now based on good science, engineering and commercial sense.

First, we must recognize that there is no panacea, no magic bullet, no nascent disruptive technology coming to save the day.

Radical new technologies are a good and welcome addition to the option set for new energy solutions, but we should not depend on them.

Against this backdrop, our vision of a solar-to-fuels solution will target a specific part of the energy system – transportation.

Building on the existing consumption and supply paradigm and infrastructure, we will create deployable technologies that can take advantage of the bulk of the existing supply and distribution system for petrol, jet fuel and diesel to supply the same fuels but from local sources and sustainable technologies.

Our approach builds on new but established science and requires no “miracles”. It also limits new infrastructure requirements to the fuel production system. The transportation, distribution, and consumption of these fuels will make use of the trillions of dollars of worldwide investment that already exists.

Programs based on a breakthrough technology that requires creation of entirely new energy systems and infrastructure will take many decades to deploy.



### The Goal

Our foundational goal is to create the technology to enable deployment of fungible fuels from sunlight, CO<sub>2</sub> and water, in two phases:

- Our 10-year goal is to create functioning devices as components to integrated systems.
- Our 15-year goal is to create deployable systems ready for industry to produce and install.

To achieve these milestones we will approach the challenge comprehensively, engaging physical and social sciences and engineering through a “convergence” model that funnels research and development towards practical devices and systems following best practice project management.

We combine forefront capabilities with facilitative leadership and management skills all with a sharp focus on commercial viability.

Our research collaboration comprises leading physical and social scientists, engineers and business people from top universities, national laboratories, and business formed to create energy systems that use sunlight, carbon dioxide, and water to produce sustainable, scalable, and infrastructure-compatible liquid hydrocarbon fuels.





## Gary Dirks

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## Multiple Pathways, Multiple Potential Solutions

**We have identified promising pathways capable of this transformation, resulting in more than one potential solution.**

Current technologies for the production of fungible transportation fuels from carbon dioxide and water using sunlight as the energy source are not commercially viable.

To meet the challenges, we will advance the science, engineering, technology, and economics of converting sunlight, carbon dioxide, and water into hydrocarbon fuel plus oxygen by:

- **Generating useful intermediates and products:**
  - hydrogen ( $H_2$ ),
  - carbon monoxide (CO), formic acid ( $HCOOH$ ), formaldehyde ( $CH_2O$ ), methanol ( $CH_3OH$ ), methane ( $CH_4$ )
- **Processing the intermediates into infrastructure-compatible transportation fuels:**
  - mixtures of longer-chain hydrocarbons such as gasoline, diesel, and aviation fuels.

The development of energy systems that take sunlight, carbon dioxide, and water and produce sustainable, scalable, and infrastructure-compatible liquid hydrocarbon fuels is an ambitious but achievable goal.

***We believe that it can – and must – be done.***

We are committed to performing disciplined, focused R&D that is relentlessly outcome-oriented.

***But those efforts require financial support to conduct the research, create the materials, reactors and systems, and deploy the technology.***

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