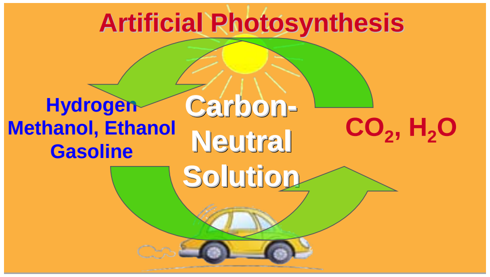
EXPLORE AND COLLABORATE
AMERICAN INDUSTRY AND AMERICA'S NATIONAL LABS
MATERIALS FOR ENERGY APPLICATIONS

ARTIFICIAL PHOTOSYNTHESIS RESEARCH IN THE DOE NATIONAL LABS

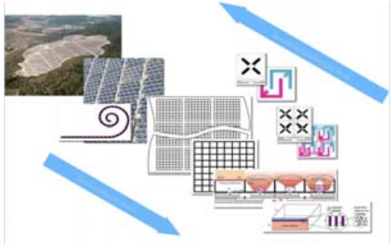
Turning sunlight directly into fuel for energy storage and transportation

Artificial Photosynthesis, providing the carbon-neutral fuel of the future:

The Department of Energy has made a substantial investment in artificial photosynthesis through an Energy Innovation Hub and a number of Energy Frontier Research Centers. The basic research focus is to remove the barriers which prevent economical conversion of abundant sunlight into usable fuels.



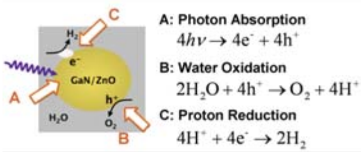
Joint Center for Artificial Photosynthesis (JCAP)



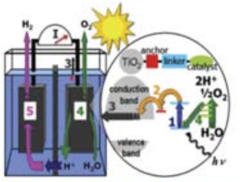
JCAP is an Energy Innovation Hub centered at Cal Tech and Lawrence Berkeley National Lab. JCAP's goal is to demonstrate a manufacturably scalable solar fuel generator, using earth-abundant elements, that, with no wires, robustly produces fuel from the sun, 10 times more efficiently than (current) crops. JCAP is employing a start-up company approach with a highly focused research strategy with parallel R&D efforts ranging from basic science to prototype development, at scales from the nano to the macro, with scalable and sustainable manufacturing considered throughout.

Computational Materials and Chemical Sciences Network program: "Solar Water Splitting Simulation Team (SWaSSiT)"

The SWaSSiT collaboration led by Brookhaven National Laboratory and involving Stony Brook University, Yale University, and the University of Rochester, is studying the fundamental steps of fuel-generating photocatalysis.



Argonne-Northwestern Solar Energy Research Center (ANSER) and Solar Fuels program at Brookhaven National Laboratory

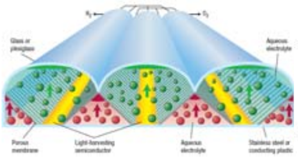


Photocatalytic cell with schematic of elementary processes

ANSER, an Energy Frontier Research Center, is studying the fundamentals of the individual steps of artificial photosynthesis from the generation of electrical charge by light absorption to the transfer of electrons to and from chemical bond in the synthesis steps. Similar objectives as well as CO_2 reduction using semiconductors for the light absorption and both homogeneous and heterogeneous catalysts is being pursued in the Solar Fuels program at Brookhaven National Laboratory.

NREL expertise in theory and synthesis of semiconducting materials, technoeconomic analysis and device structures

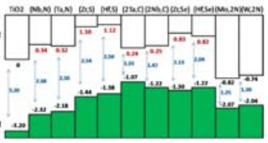
Panel Design for Technoeconomic Analysis



Conceptual design for solar water splitting panel using the index of refraction of water as the light concentrator

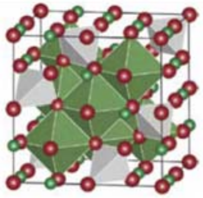
- Reduces semiconductor material requirement
- Higher efficiency and lower hydrogen costs

Theory-based Engineering of Semiconductor Band Structure



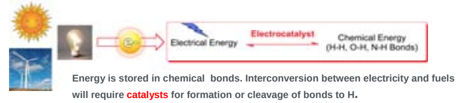
Using TiO_2 as a starting point, alloy compositions are calculated that would have lower gaps and better band edge energetics for water splitting.

Center for Inverse Design (CID)



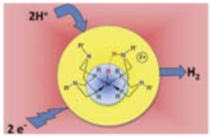
CID, an ERFC at the National Renewable Energy Laboratory (NREL), is discovering new material which can be components of AP systems using large scale, first principles, calculations. CID's approach replaces trial-and-error methods used in the development of materials for solar energy conversion with an inverse design approach powered by theory and computation.

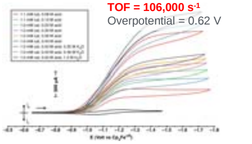
Center for Molecular Electrocatalysis (CME)



Energy is stored in chemical bonds. Interconversion between electricity and fuels will require catalysts for formation or cleavage of bonds to H.

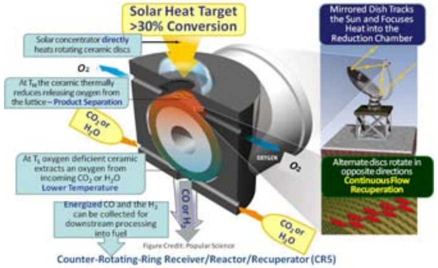
CME, an EFRC located at Pacific Northwest National Laboratory (PNNL) is working to understand, design and develop molecular electrocatalysts for solar fuel production and use. New molecular catalysts based on inexpensive, earth-abundant nickel, developed in the CME, are the fastest molecular electrocatalysts for both production and use (oxidation) of hydrogen.





Extremely fast catalyst for H_2 production

1st Generation Thermochemical Reactor



In thermochemical fuel production, heat from the sun is concentrated to drive fuel-producing reactions such as CO_2 reduction. An optimal reactor design will have flexibility to the working material, (2) direct solar absorption, (3) internal heat recovery (recuperation), (4) spatial separation of reaction products, and (5) continuous flow. Prototype testing at the National Solar Thermal Test Facility have shown promising results. Developed by Sandia National Labs, ongoing R&D in cooperation with BP.

U.S. DEPARTMENT OF ENERGY Office of Science · NREL National Renewable Energy Laboratory · Sandia National Laboratories · Brookhaven National Laboratory · Argonne National Laboratory · Pacific Northwest National Laboratory · Berkeley Lab Lawrence Berkeley National Laboratory