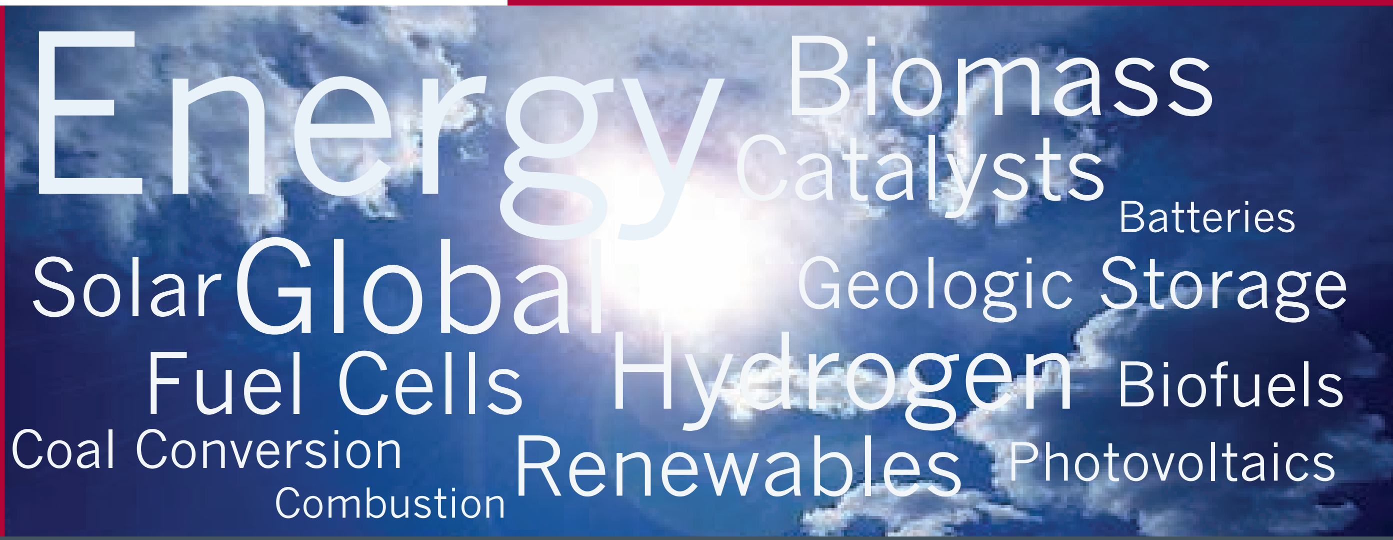
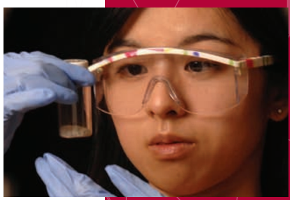
GCEP

Global Climate & Energy Project

STANFORD UNIVERSITY



Global Challenges **Global Solutions** **Global Opportunities**



GLOBAL CHALLENGES


Director's Message

Energy production and use are intricately woven into the fabric of modern life. Access to secure and affordable energy resources is essential to the prosperity and productivity of our information-intensive, technology-rich civilization. But we have come to understand that the way we use energy today is affecting the life-support systems of our planet, including our atmosphere, water resources, food supply, and the rich biodiversity of terrestrial and ocean ecosystems. We face a *global challenge* to find new ways to meet our growing need for energy while protecting these life-support systems. To meet this challenge, we need *global solutions*—a portfolio of new energy technologies that efficiently and cleanly transform the earth's abundant energy resources into useful energy services, when and where we need them.

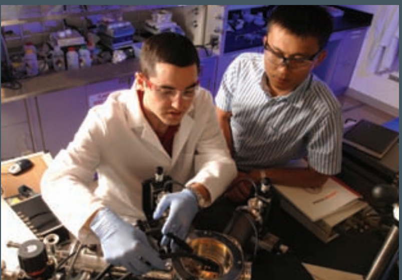
At this moment in time, we are poised on the brink of an energy technology renaissance. Building on recent advances in nanoscience and nanotechnology, biotechnology, computational sciences, material sciences, geosciences, and information technology, we have the *global opportunity* to strengthen the fabric of our civilization with new energy technologies for the 21st century and beyond.

The Global Climate and Energy Project is embracing this opportunity. We are grateful for the generous support of our sponsors, including ExxonMobil, GE, Schlumberger, and Toyota, who have provided the resources needed to transform opportunity into reality.

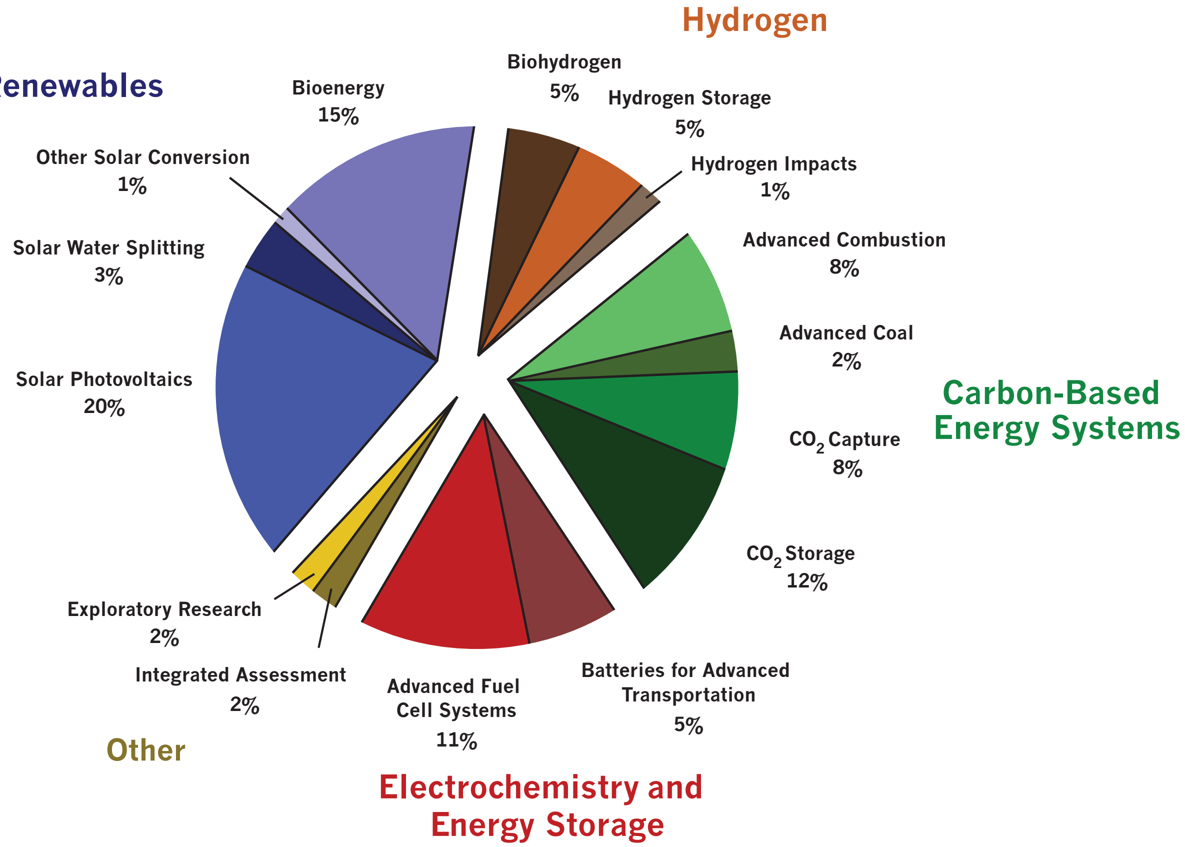
– Sally M. Benson
GCEP Director

"The worldwide demand for energy represents one of the greatest challenges in this century. It also represents a global opportunity. Through the breakthrough research being done at GCEP, Stanford is meeting the challenge and working to find global solutions through technologies that are sustainable and affordable."

– John L. Hennessy
President
Stanford University




Research Portfolio



Researchers Around the World

China
Peking University
China University of Geosciences

Japan
RITE

Australia
UNSW
University of Sydney

USA

Stanford University
Boise State University
Brigham Young University
California Institute of Technology
Carnegie Institution for Science
Harvard University
Purdue University
SRI International
University of Illinois
University of Montana
University of Wisconsin
University of Southern California

Europe

ECN
ETH Zürich
IRDEP/CNRS
TU Delft
University of Dundee
Ghent University
Universite de Picardie Jules Verne
Universidad Politécnica de Madrid
Uppsala University
Utrecht University/FOM

GCEP Research Highlights

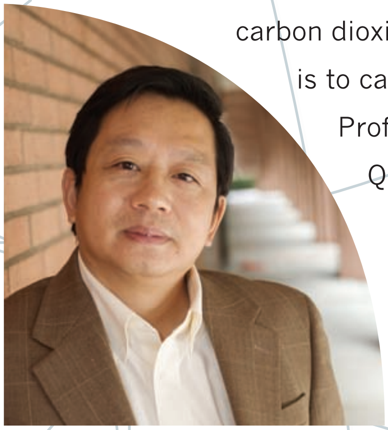
At Stanford and many other institutions around the world, GCEP currently supports over 40 innovative research efforts that have the potential to be global solutions—to significantly reduce future greenhouse gas emissions that result from energy use. The highlights that follow represent just a few of the exciting new concepts now being pursued through GCEP.

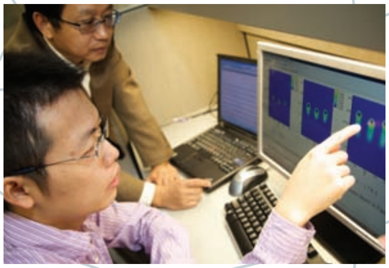
Optimizing Designer Plants for Biofuel Production

Nature has designed lignin to defend plants against biological and chemical attack by reducing permeability and porosity in plant cell walls. Lignin's protective function is a major obstacle in developing designer plants for biofuels, since it inhibits access to the sugar feedstock. Professors Claire Halpin and Gordon Simpson are plant biologists at the University of Dundee, U.K. Their goal is to develop technology for using crops, such as Miscanthus and poplar, that are close to CO_2 neutral for biofuel production. By interfering with lignin's biosynthesis at the genetic level, Halpin and Simpson have achieved improved cell wall hydrolysis to sugars while maintaining plant vigor, bringing us a step closer to sustainable, environmentally friendly crops for second-generation biofuels.

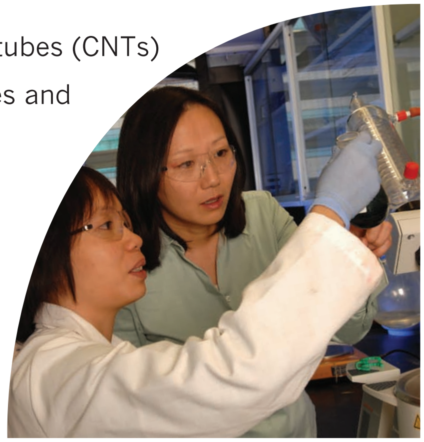
Collaborating on Carbon Sequestration in China's Saline Aquifers

More than 70 percent of China's energy comes from coal, an abundant, domestic resource that will continue to support the nation's rapidly growing economy. However, burning coal releases large amounts of carbon dioxide to the atmosphere. One way to avoid these harmful greenhouse gas emissions is to capture the carbon dioxide and sequester it in deep geological formations. Professors Dongxiao Zhang of the University of Southern California (USC), Qingdong Cai of Peking University (PKU), and Yilian Li of China University of Geosciences in Wuhan (CUG) are leading an effort to develop safe and effective methods for sequestering carbon dioxide in China's saline aquifers. This international, multi-institution collaboration comprises 39 researchers, scientists, and students at PKU, CUG, and USC, with expertise in geochemistry, geophysics, numerical modeling, and hydrogeology.



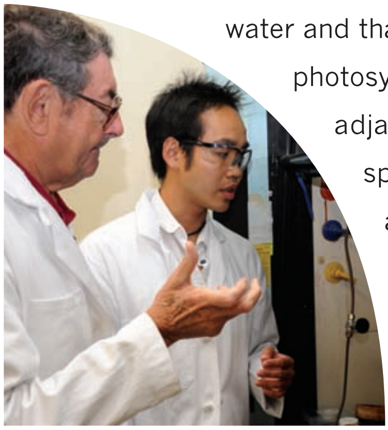


Improving Solar Cell Efficiency with Carbon Nanotubes



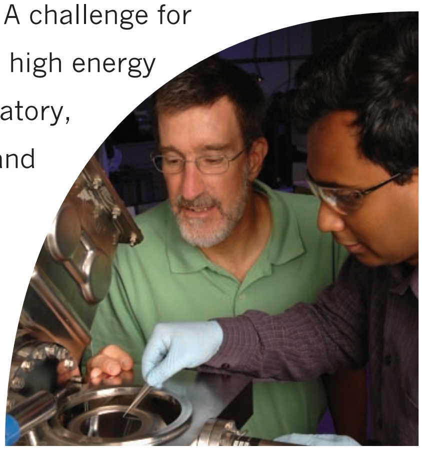
The extraordinary mechanical, thermal, and electrical properties of carbon nanotubes (CNTs) have found a variety of applications, from structural materials to electric batteries and hydrogen storage devices. Professor Zhenan Bao, of the Stanford Chemistry Department, is investigating the use of CNTs in a new generation of transparent electrodes that could lead to less costly, more efficient photovoltaic cells. Her innovative synthesis process simultaneously selects optimal CNT types and directs structural organization of the CNT mesh during deposition, optimizing both the optical and electrical properties of the electrode. Conventional opaque metal contacts cast shadows on the solar cell. By contrast, transparent CNT electrodes allow sunlight to pass through to the absorbing materials and still provide both efficient collection of the charges produced by photon absorption and charge transmission to the external electric circuit.

Artificial Photosynthesis: Using Sunlight to Produce Liquid Fuels



Imagine one day fueling your car with sunlight and water. This is the vision of Caltech professors Nathan Lewis, Harry Gray, and Harry Atwater. They are developing a system that uses sunlight to produce hydrogen from water and that eventually could be adapted to yield hydrocarbons from CO_2. Inspired by biological photosynthesis, this revolutionary system consists of a photo-sensitive membrane with two adjacent semiconductor layers. The two layers absorb different fractions of the solar spectrum, generating electrical charges that split water molecules, producing hydrogen and oxygen on opposite sides of the membrane. Key issues that the team is working on include optimizing the material composition, system architecture, and surface catalysis.

Harnessing Carbon Nanotubes as an Energy Carrier



Hydrogen has been proposed as an alternative to carbon-based energy carriers. A challenge for researchers has been to produce and store hydrogen in dense volumes without a high energy penalty. Professors Anders Nilsson of the Stanford Synchrotron Radiation Laboratory, Bruce Clemens of the Stanford Materials Science and Engineering Department, and Hongjie Dai of the Stanford Chemistry Department are finding new ways to store hydrogen on carbon nanotubes (CNTs). The research team has discovered that hydrogen can form carbon-hydrogen bonds with CNTs rather than just absorb hydrogen molecules as was previously thought. Based on this result, the team is moving forward to develop catalysts, nanotube structures, and electrolyte systems that will greatly improve the potential for hydrogen storage.

Global Climate and Energy Project

Project Status

- $119M funding allocated to GCEP
- 66 full-term research programs
- 21 exploratory research activities
- 27 institutions
- 18 Stanford departments
- 107 investigators (59 at Stanford, 48 at GCEP-funded external institutions)
- Over 300 graduate students and post-doctoral scholars
- 17 patent applications, two patents issued
- 227 peer-reviewed publications, 316 presentations at meetings

GCEP

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Global Climate and Energy Project

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