How do we provide humanity with the affordable energy it needs and stabilize the climate?

Developing global solutions for the future of energy

This paper was published in June 2015. The ideas and recommendations within it are among dozens of suggestions that arose from the Stanford Engineering Future process. Share your thoughts with us at SoEFutureFeedback@stanford.edu.
One of the greatest challenges humanity will face this century is providing the world’s growing population and economy with the clean and affordable energy it needs.

In a business-as-usual scenario, there are no solutions to provide this energy while reducing greenhouse emissions so that the global climate can be stabilized. Developing solutions to this global problem is paramount.

Since launching the Global Climate and Energy Project (GCEP) in 2002, Stanford has been one of the world’s leading institutions for tackling the energy and climate challenges. SoE Future urges the university to continue leveraging its great strengths in engineering, science, humanities, business and law to develop energy technology and public policies.

We anticipate that the global energy landscape will go through a significant transition in the next 20 to 30 years, requiring industries and countries to adapt to the changing landscape. Such transitions should provide strategic opportunities for Stanford to offer value.
Continue investment in energy technology research.

Since the launch of GCEP 13 years ago, some noteworthy facts and a few unmistakable trends and drivers have started to affect the energy sector:

**Renewable energy** such as solar and wind is becoming cheaper and will soon be, if not already, the most affordable way to produce electricity.

**The United States has found** an abundance of affordable natural gas, which is transforming the electricity and chemical industries. Furthermore, North America will soon become energy independent, reducing its dependence on imports from other regions. While others nations have large shale reserves, they lack the infrastructure to utilize this natural resource.

**Electricity storage** is becoming more affordable, with costs expected to be reduced by a factor of two by 2020. Consequently, their use in transportation and stationary power is growing rapidly, although it is still at an early stage.

**Cyberthreats to our energy system** are growing every year and are unlikely to decrease.

**The U.S. energy infrastructure** is aging and needs to be modernized, whereas emerging economies may not have any infrastructure, offering opportunities to start fresh.

**Global carbon dioxide emission rates** continue to increase linearly over time, and consequently the atmospheric concentrations are increasing exponentially.

**Nuclear energy faced a setback** with the Fukushima incident, but the focus on small modular reactors could reduce the cost of electricity and make financing less risky.

How do we provide humanity with the affordable energy it needs?
Stanford should continue to grow its game-changing research on solar cells, batteries, fuel cells, power electronics and efficient engines, among others.

We strongly encourage expanding research on using carbon-free energy to chemically transform CO2 to create the foundations for scalable technologies for synthesizing fuels and chemicals that are cost-competitive at scale with technologies based on fossil fuels. This is one of the grand challenges of the 21st century.

Our electricity grid was not designed for intermittent and decentralized generation and storage resources. Research on redesigning the electricity grid so that it can utilize energy from intermittent and decentralized sources and offer affordable, reliable electric power to people is still in its infancy and should be expanded.

Particular attention should be paid to cybersecurity and the fault tolerance of our electricity infrastructure.

Nuclear energy should be seriously considered as a primary source of baseload carbon-free energy. Although Stanford has no program in nuclear engineering, it is exceptionally strong across other important disciplines with experts in nuclear physics, security, policy, safety, etc. We urge the School of Engineering to start a focused effort to:

• Leverage strengths in engineering, security and policy to offer a unique research and educational experience for its students.
• Provide value to enable the nuclear industry and government to move rapidly toward new, safe and more efficient reactor designs.
• Reduce costs of existing design and construction.
• Speed up the safety-focused regulatory process.
• Enable adoption in the market.

While energy efficiency has been reasonably successful in California, significant untapped potential remains. We recommend an approach that combines technology, financing, market structure, business models, policies and studies of consumer behavior to dramatically reduce consumption of electricity and transportation fuels. We need to leverage our existing efforts, but also to bring in fresh ideas, new people and new engagement in public policy.
DOE Energy Frontiers Research Center.

While we have research centers such as SUNCAT, GCEP, the TomKat Center for Sustainable Energy, the Precourt Institute for Energy and others on campus, it is noteworthy that Stanford Engineering does not have an Energy Frontiers Research Center (EFRC) through the U.S. Department of Energy.

One of SoE’s goals should be to establish at least one EFRC on campus. Furthermore, we recommend that Stanford play a leading role in ensuring that federal and state lawmakers understand the value of energy research for our long-term economic growth and security, and work to protect and increase the budget for energy research and to preserve open competition.

Engage venture community in long-term investment in energy.

During the past few years, venture capitalists have substantially reduced their investments in the energy sector because introducing energy technology into the marketplace generally requires investments that are large and long-term.

SoE faculty and students have worked closely with the local venture-capital community in the past decade to transfer new energy technologies. While VC investment in the area has waned, we recommend that the university stay committed to research that ensures affordable clean energy to everyone in the world.
Scaling new energy technologies.

We predict university researchers will have to go beyond the proof-of-concept stage of research (a typical outcome of federally funded research) to the proof-of-system stage (typically where industry gets interested) and beyond, and thereby reduce risk by demonstrating that the technologies can be scaled up economically and made durable. We propose to raise funding for such an effort, and we recommend that SoE offer space for proof-of-system demonstrations that can engage the entire ecosystem to define what is possible.

Strategic industrial and governmental partnerships.

We propose increased effort to help existing industries adapt to changes through innovations and to educate new industries about the technological, regulatory and business landscapes they would encounter. We recommend a new campaign within SoE, in coordination with the relevant Stanford centers and institutes as well as SLAC, to create strategic partnerships with small and large businesses worldwide, and directly with national governments. The MIT Energy Initiative has done a good job in this area, and given our location in Silicon Valley, we ought to raise the bar even higher.

Bottom line: Stanford should become the go-to place for global industry, federal and state governments in the United States, and other nations\(^1\) to learn how to best navigate this transition.

\(^1\)For example, Mexico has denationalized its energy sector and recently opened its energy sector for global investments and competition. But it does not have sufficiently educated personnel to manage this transition. This offers an opportunity for Stanford to help in both research and education.