

# quantum energy and sustainable solar technologies



**NSF/DOE ENGINEERING RESEARCH CENTER**

Generating sustainable power by using photovoltaic technologies to harness today's unlimited sunshine

# the qesst

QESST is an Engineering Research Center sponsored by the National Science Foundation (NSF) and U.S. Department of Energy (DOE) that is focused on advancing photovoltaic science, technology and education in order to address one of society's greatest challenges: transforming electricity generation to sustainably meet the growing demand for energy. Photovoltaics (PV) leverages one of the 20th century's greatest scientific advances—quantum mechanics—to realize electricity generation that is fundamentally different than other electricity generation, with no moving parts, high reliability and high efficiency.

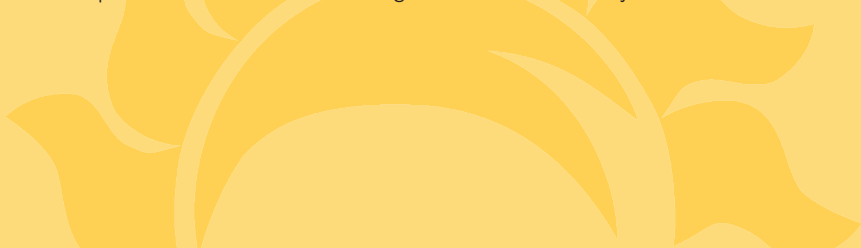
Solar energy has the unique capacity to meet the entire world energy demand, and at current growth rates, photovoltaics will have sufficient capacity to meet the entire new U.S. electricity demand within five to 10 years.

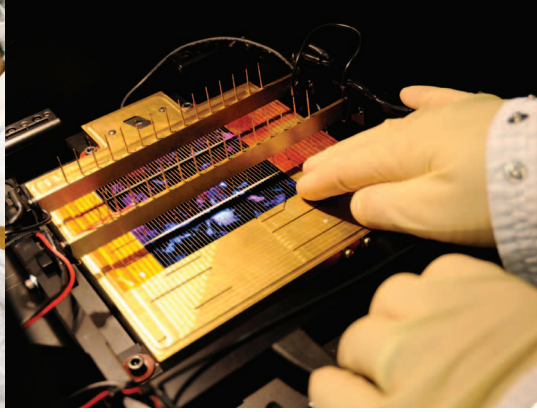
QESST is developing new photovoltaic technologies that address the critical barriers to realizing transformation of electricity generation. An interdisciplinary team—consisting of faculty and researchers from multiple universities, scientists and leaders from world-renowned companies and leading PV entrepreneurs—is building a strategic partnership to generate innovative solutions to sustainable electricity generation that will:

- realize continuous improvements in performance (efficiency), cost and manufacturability of PV technologies through focused research on the underlying material science, energy conversion processes and advanced manufacturing approaches
- reinvigorate interest in science and engineering education by using renewable energy as an inspirational example that challenges students' intellectual growth and technical skill, and allows students to develop creative solutions and solve important societal problems
- position the American PV industry to lead through innovation and stimulate economic development in the expected trillion dollar PV market

## The impact of QESST

For the past decade, the PV industry has grown at an average compound annual growth rate of nearly 40 percent. At this growth rate, the PV industry will enable all new global demand for electricity in the next 10 years. Sustaining such growth rates is an enormous challenge—but one that has been met by other semiconductor industries. The goal of the QESST ERC is to develop a technology path for photovoltaics that has significant impact and supports continued rapid growth by allowing existing commercial photovoltaic technologies to circumvent trade-offs in performance and cost and enable commercial photovoltaics to exceed the goals envisioned today.





# an evolutionary path to revolutionary devices

There is no one “silver bullet” material or revolutionary device that will transform the existing electricity generation system, making it sustainable and cost-effective. The QESST approach integrates technology and participants and creates a bridge between disconnected PV technologies and research and development efforts. We have mapped a path of interwoven technology and process advancements that will result in a continuously expanding implementation of revolutionary new approaches to enhance performance, reduce cost, and enable new functionality that will:

- lead to disruptive breakthroughs in the performance and cost of sustainable energy through advances in material sciences particularly relating to surfaces, interfaces and defects, photonics, energy conversion processes, advanced nanofabrication and characterization technologies and new multifunctional energy conversion devices
- enable the PV industry to continue to expand production by developing technologies that support the scale-up of new devices into large-scale manufacturing
- introduce readily scalable, highly efficient, transformative PV technologies that circumvent cost/performance trade-offs and maintain compatibility with PV manufacturing techniques



Caltech



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## industry and innovation

QESST has attracted more than 40 solar energy companies that span the spectrum from basic materials, semiconductor manufacturing and PV production to energy system installation firms and utilities; from start-up and high-growth PV firms to established large companies moving into the PV industry. The QESST Industrial Affiliate program seeks to maximize the impact of university research and education through entrepreneurship and innovation that speeds the translation of research results into commercialization.

Our unique structure and composition including a large base of industrial members, an academic team that values and appreciates technology transfer, a wide-ranging education and outreach program, and excellent facilities and infrastructure support provides an ideal platform to stimulate economic development. All QESST university campuses partner to drive intellectual property (IP) licensing, technology transition and startup/spinoff company formation and student ventures into the innovation cycle. Multiple venture capitalists, industry analysts and economic and small business development organizations work with QESST as innovation partners.

## sustainability

QESST is motivated to answer how the PV industry can simultaneously optimize environmental quality, economic development and social advancement. This sustainability awareness provides strategic guidance to our research and educational activities. The cross-cutting theme of sustainability in QESST includes:

- mass-flow and industrial ecology analyses to address the environmental implications of new technology and approaches we develop
- development of economic models to understand the lifecycle cost of photovoltaic energy systems
- real-time technology assessment and anticipatory governance to investigate the role of policy and governance on future growth of the PV industry



christiana honsberg, QESST director



QESST main labs and office space

## education and outreach

Through a wide range of programs—university education, public engagement and outreach, pre-college curriculum development, teacher training, participation with policymakers and external stakeholders—QESST aims to use sustainable energy as a vehicle to revitalize the popular perception of science and engineering. QESST broadens participation in science and engineering through its support of community-based projects that are well connected to our students' social contexts.

QESST leverages education at all levels to engage students and develop a trained workforce capable of advancing the fast-paced solar industry. QESST conducts educational research to determine the best practices for training this workforce, and develops programs and curriculum which utilize those best practices. QESST students, in-service teachers and youth have the opportunity to make meaningful connections with national and international experts in PV. QESST has built an international collaboration with leading universities in Asia, Europe and Australia. These partnerships enable valuable interactions for our students and allow wide dissemination of our findings on the best practices for training students in renewable energy, PV and semiconductor research.

## facilities

QESST is headquartered in state-of-the-art laboratory, clean room and office space in the MacroTechnology Works building at the ASU Research Park—a venue ideally suited for leading a collaborative network of industry-relevant research. To support QESST, ASU and partners have invested in a full suite of equipment for fabrication and characterization of silicon, III-V, nano-structured and thin-film devices as well as cell and module pilot manufacturing lines. QESST leverages cyber-infrastructure to empower effective information sharing between all participants—universities, industrial partners and external stakeholders.

**For more information visit our website at [www.qesst.org](http://www.qesst.org)**



# QESST is revolutionizing energy for the world.

Electricity is the lifeblood of modern society—powering everything from cities to pacemakers—and the demand for electricity continues to grow. The electricity generation system faces challenges: harmful environmental impacts; the lack of access to electricity for over one-quarter of the world's population; threats to national security; resource-supply problems; and difficulty in powering autonomous applications. A new system for supplying electricity is needed. QESST is transforming the existing electricity generation system, making it sustainable, ubiquitous and multifunctional by developing photovoltaic and quantum energy converters that fundamentally alter how energy is used.



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