

SOLAR ENERGY TECHNOLOGIES PROGRAM NEWSLETTER

Building On Momentum: Solar Program Strategy & Priorities for 2007

During the first 18 months of the U.S. Department of Energy (DOE) Solar America Initiative (SAI) we have implemented a broad-reaching change in program strategy for one clear purpose: to accelerate the date at which solar photovoltaics (PV) technologies can become cost-competitive in all major domestic grid-tied markets to 2015. We emphasize that this change was not implemented simply for the sake of change, but rather to take advantage of progress in module efficiency and fabrication principally achieved by industry, universities, and the national laboratories in recent years. These successes form the foundation for the PV systems that the DOE program will be supporting in the future.

To build on this success, priorities in 2007 for the Solar America Initiative include: 1) Filling out the industry R&D pipeline for next-generation low-cost, scaleable products; 2) Establishing a framework for university involvement in SAI; 3) Calibrating the National Renewable Energy Laboratory (NREL) research portfolio and role for the future; 4) Ramping up testing and evaluation for development and qualification; 5) Catalyzing the collaboration on industry-wide issues such as standards; and 6) Expanding U.S. policy and regulatory measures.

Other areas the program will focus on include market transformation activities that work with cities, states, and the federal government to explore innovating financing mechanisms, grid integration, and policy measures to aid PV development. DOE is also engaged with NREL and Sandia to create industry roadmaps for each major PV material system and processing approach. Roadmaps will be used to coordinate R&D among industry, universities, and national laboratories. Roadmapping activities are also ongoing for PV market penetration and grid integration. Starting in late summer 2007, DOE will engage Solar Energy Industries Association (SEIA) and industry players to create a new PV industry roadmap. This encompassing roadmap will cover 3-, 10-, and 25-year projections for supply/demand and cost/pricing, product standards, areas for collaboration amongst industry players and market penetration/grid integration.

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U.S. Department of Energy

**Energy Efficiency
and Renewable Energy**

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

During the remainder of 2007, we will continue to work on these projects and build on the momentum established over the first year of our Solar America Initiative. We deeply appreciate the support we have received from the U.S. PV community in recent years, and hope to continue to play an important role for the community in the years to come.

PV Priorities for 2007

Photovoltaics R&D Programs

- **Systems Development.** Awarded first set of \$340 million in cost-shared industry-led Technology Pathway Partnership projects for PV systems development and manufacturing demonstrations.
- **New Module Development.** Awarded next set of cost-shared projects to incubate PV module prototype development and pilot manufacturing demonstrations in June 2007.
- **New PV Device Concepts and University Process and Product Development.** Completing solicitations for new PV device concepts and university support to industry process/product development, with awards to be made in 2007.
- **Upstream Supply-Chain Development.** Formulating a program to fund development and optimization of the upstream PV supply chain, including new feedstock materials, module-packaging solutions, and PV manufacturing tools standardization and accelerated delivery times.
- **PV-Grid Integration.** Developing concepts for a set of activities to address grid reliability and economic issues associated with PV market penetration above 5%–10% of served load on grid distribution systems.

Market Transformation and Deployment

- **Federal Government.** Developing a concept for a program to establish the federal government as a major purchaser of solar electricity.
- **States.** Engaging with key target states to create favorable regulatory frameworks (net metering, interconnection) and rebate programs.
- **Cities.** Awarded 13 Solar America Cities, which DOE will help to develop local markets and downstream sales channels, and create rebate programs and municipal bonds for acquiring PV installations.

Industry Roadmapping

- **Technology Roadmapping.** Released technology roadmaps for each major PV material system and processing approach. Roadmaps will be used to coordinate R&D among industry, universities, and national laboratories. The current plan is to perform a biannual review of these roadmaps to better coordinate the domestic/international development of the PV industry (see www.eere.energy.gov/solar/solar_america/planning.html).
- **PV Market Penetration and Grid Integration Roadmapping.** In May 2007, initiated a study that will map out scenarios for wide-scale market penetration of PV in U.S. electricity markets.
- **General PV Industry Roadmap.** Starting in late summer 2007, we will work with SEIA and industry players to create a new PV industry roadmap that will cover projections for supply/demand and cost/pricing, product standards, areas for collaboration between companies, and policy needs.

NATIONAL LABORATORY TECHNOLOGY DEVELOPMENTS: *PHOTOVOLTAICS*

Fabrication of 33.8% One-Sun Efficiency GaInP/GaAs/InGaAs Solar Cell

NREL has fabricated a 2-terminal multijunction GaInP/GaAs/InGaAs solar cell with an efficiency of 33.8% measured under AM1.5 global conditions. The device area, open-circuit voltage, short-circuit current density, and fill factor were 0.25 cm², 2.96 V, 13.1 mA/cm², and 86.9%, respectively. This device was grown inverted (i.e., top junction first) on a single-crystal GaAs substrate. The bottom 1.0-eV InGaAs layer was lattice-mismatched and grown last. The 10-micrometer structure was mounted on a silicon “handle” and the GaAs substrate removed. This efficiency surpasses the previous one-sun record of 32.0% for Spectrolab’s GaInP/GaAs/Ge solar cell. *Publication:* The result will be published in the next Progress in PV, “Solar Cell Efficiency Tables.”

NATIONAL LABORATORY TECHNOLOGY DEVELOPMENTS: *PHOTOVOLTAICS*

Manufacturing, Reliability, and Diagnostic Activities

Sandia National Laboratories have done work on bench-scale demonstration of a non-immersion ultrasonic solder-bond diagnostic, which promises to substantially increase yield and reliability of modules while reducing diagnostic costs and speeding implementation. It also has worked on the characterization of microcracks in silicon wafers and cells, using acoustic methods. Other advances were made in collaboration with industry partners, including: identification and resolution of diode faults in pre-commercial modules, isolation of faulty soldering operations, and development of improvements that reduced field failures of a manufacturer’s product. For more information see: www.sandia.gov/SAI/Modulesystems.htm

Technology Development: Seeing New Solar Products Through Collaborative R&D

The Solar America Initiative (SAI)—as part of President Bush's Advanced Energy Initiative—was announced during the 2006 State of the Union Address. The time since that announcement has been filled with activity in both R&D and market transformation to ensure its implementation.

The Big Shift: Pre- and Post-January 2006

Before January 2006, DOE research focused on technical progress to increase the conversion efficiencies of solar cells and reduce the manufacturing costs of photovoltaic modules. The national laboratories—NREL and Sandia—implemented this R&D drive, which included providing relatively stable funding to companies and universities to achieve steady, incremental progress. Hundreds of individual projects were funded at the national laboratories, universities, and companies and these projects generated continued interest in photovoltaics (PV) throughout the country.

This picture changed, however, after January 2006 when a DOE change in program strategy coincided with the investment community taking a fresh look at the solar energy industry as well as states and cities developing supportive policies for solar energy deployment. These conditions proved ideal for DOE to launch a new venture, which shifts the focus of research from technical progress on components to integrated PV systems. Under this new strategy—called the Solar America Initiative (SAI)—funded companies are expected to develop products for priority markets, and industry is expected to influence the research agenda for the national laboratories and universities.

Under the SAI, dramatic progress is anticipated from multiple competitive solicitations coupled with an aggressive process to evaluate results and eliminate awardees that do not meet predetermined performance targets. Please refer to Figure 1 for a full listing of the Funding Opportunities and Solicitations under the Solar America Initiative. The first set of large awards, called Technology Pathway Partnerships, funds teams that comprise of multiple partners that seek to reduce costs across the entire value-chain. Smaller projects will target earlier-stage technologies and focus on improvements at the module level. The large-scale, high-visibility projects are intended to help lower PV market barriers and will likely attract public attention to developments taking place in solar energy.

NATIONAL LABORATORY TECHNOLOGY
DEVELOPMENTS: PHOTOVOLTAICS

PV Systems Optimization

Sandia's PV Systems Optimization Laboratory has developed an inverter performance model, which has now been integrated into an overall system performance model; completed a systems performance test procedure for lab and field use; and conducted technical studies with industry partners on new technologies such as new materials (e.g., antireflective coatings), bifacial modules, and new inverters. *Publication:* "Recommended Practice for the Rating of Photovoltaic System Energy Production," and "Performance Model for Grid-Connected PV Inverters" (both drafts for publication later in 2007).

NATIONAL LABORATORY TECHNOLOGY
DEVELOPMENTS: PHOTOVOLTAICS

Photovoltaic Inverter and BOS Development & Testing

Phase III of DOE's High Reliability Inverter Initiative is complete, with Xantrex delivering a prototype new inverter and GE completing in-house beta testing. These products have calculated mean-time-between-failures (MTBF) of more than 10 years, representing significant improvements in residential-size inverters. Other accomplishments include a proof of concept for a micro-inverter with no electrolytic capacitors and a calculated MTBF of 250,000 hours of operation; completion of a MATLAB-based inverter development model for single- and three-phase inverters; characterization of four commercial inverters for long-term evaluations; and the development of a 5-year strategy document for PV-related power electronics and systems controllers, which has been folded into the Solar America Initiative. For more information see: www1.eere.energy.gov/solar/

Figure 1. Summary of Solar Program R&D Funding Opportunities






 AWARDED  OPEN  UPCOMING

FUNDING OPPORTUNITY ANNOUNCEMENT (FOA) OR SOLICITATION	AWARD DATE	FUNDING AMOUNT	DESCRIPTION
Systems Development and Manufacturing: Technology Pathway Partnerships (TPP)	March 8, 2007	\$168 M over 3 years	Cost-shared industry-led projects for PV systems development and manufacturing demonstrations. Collective portfolio of projects will reduce direct manufacturing and installation costs by at least 30% by 2010, and will deliver up to 2.4 GW of new manufacturing capacity by year-end 2010. See www1.eere.energy.gov/solar/solar_america/technology_pathway_partnerships.html
Market Transformation: Codes and Standards	March 26, 2007	\$4.2 M over 5 years	The Working Group will address code development and outreach activities in areas of critical importance to solar market penetration such as interconnection procedures, net metering, product safety, and international standards coordination. Will lead to a major improvement in the responsiveness, effectiveness, and accessibility of codes and standards to U.S. solar stakeholders at all levels. See www1.eere.energy.gov/solar/solar_america/market_transformation.html
Market Transformation: State/Utility Solar Technical Outreach	March 26, 2007	\$1.7 M over 3 years	Will conduct tailored solar technical outreach to states and utilities and will provide resources and best practices to address solar issues faced by states and utilities. See www1.eere.energy.gov/solar/solar_america/market_transformation.html
Market Transformation: Utility Capacity Credit Valuation Activity	March 26, 2007	\$0.2 M for 1 year	Will help utilities measure the impact and value of distributed photovoltaics on the grid. See www1.eere.energy.gov/solar/solar_america/market_transformation.html
Market Transformation: Solar America Showcases	May 16, 2007	Technical Assistance	Showcases are designed to help facilitate large-scale installations that involve cutting edge solar technologies, novel applications of solar, high visibility sites, and/or high likelihood of replicability. SAS does not provide financial assistance; instead it provides technical assistance through teams of DOE-funded solar experts from the National Renewable Energy Laboratory, Sandia National Laboratories, the Southeast and Southwest Region Experiment Stations, and private firms. See www1.eere.energy.gov/solar/solar_america/market_transformation.html
Component and Pilot Scale Production: PV Module Incubators	June 20, 2007	\$27 M over 18 months	Projects focused on solving technical challenges that must be overcome to scale-up manufacturing and commercialize new products by 2010 and shortening the timeline for companies to transition pre-commercial PV technologies into full-scale manufacturing. See www1.eere.energy.gov/solar/solar_america/pdfs/pv_incubator_prospectus.pdf
Market Transformation: Solar America Cities	June 20, 2007	\$2.5 M and technical support over 2 years	Cities will integrate solar technologies into city energy planning, zoning and facilities, streamline city-level regulations and practices that affect solar adoption by residents and local businesses (e.g. permitting, inspections, local codes), and promote solar technology among residents and local businesses (e.g., outreach, curriculum development and/or implementation, incentive programs, etc.). See www1.eere.energy.gov/solar/solar_america/solar_america_cities_awards.html

Continued on next page

Summary of Solar Program R&D Funding Opportunities, *Continued*

 AWARDED  OPEN  UPCOMING

FUNDING OPPORTUNITY ANNOUNCEMENT (FOA) OR SOLICITATION	CLOSING DATE	FUNDING AMOUNT	DESCRIPTION
 Device and Process Proof of Concept: Future Generation PV Device and Processes	June 26, 2007	Up to \$4 M per year over 3 years	For companies to perform exploratory R&D for the development of innovative and highly disruptive future-generation solar electric technologies. The device and manufacturing process research that is targeted by this opportunity is expected to produce prototype cells and/or processes by 2015, with full commercialization coming to fruition in the 2020-2030 timeframe. See www1.eere.energy.gov/solar/solar_america/device_process_foa_032607.html
 Concentrating Solar Power Funding Opportunity Announcement	August 9, 2007	\$10 M-\$20 M over 2 years	For companies to develop storage solutions, manufacturing approaches, and new system concepts for large-scale concentrating solar power (CSP) plants. The collaborative public-private partnerships established herein will work to reduce the nominal levelized cost of energy (LCOE) of CSP power plants from 13-17 ¢/kWh in 2007 to a target of 7-10¢/kWh by 2015 and 5-7¢/kWh by 2020. See www1.eere.energy.gov/news/progress_alerts/progress_alert.asp?aid=237
 Round 2- Market Transformation: Solar America Showcases	August 15, 2007	Technical Assistance	Showcases are designed to help facilitate large-scale installations that involve cutting edge solar technologies, novel applications of solar, high visibility sites, and/or high likelihood of replicability. SAS does not provide financial assistance; instead it provides technical assistance through teams of DOE-funded solar experts. See www1.eere.energy.gov/solar/solar_america/market_transformation_funding_opps.html
 Systems Development and Manufacturing: University Product and Process Development Support	September 12, 2007	Up to \$30 M over 3 years	For universities to perform targeted materials science and process engineering research that offers direct, near-term improvements in PV products and development processes for commercialization by 2010. See www1.eere.energy.gov/solar/solar_america/system_development_manufacturing_univ_process_foa_032607.html
FUNDING OPPORTUNITY ANNOUNCEMENT (FOA) OR SOLICITATION	SOLICITATION RELEASE DATE	FUNDING AMOUNT	DESCRIPTION
 Component and Pilot Scale Production: Advanced Integrated Inverters and Energy Management Systems	July 2007	Up to \$24 M over 3 years	To perform exploratory R&D targeting dramatic improvements in inverters and energy management technologies for solar electricity production. See www1.eere.energy.gov/solar/solar_america/funding_opportunities.html

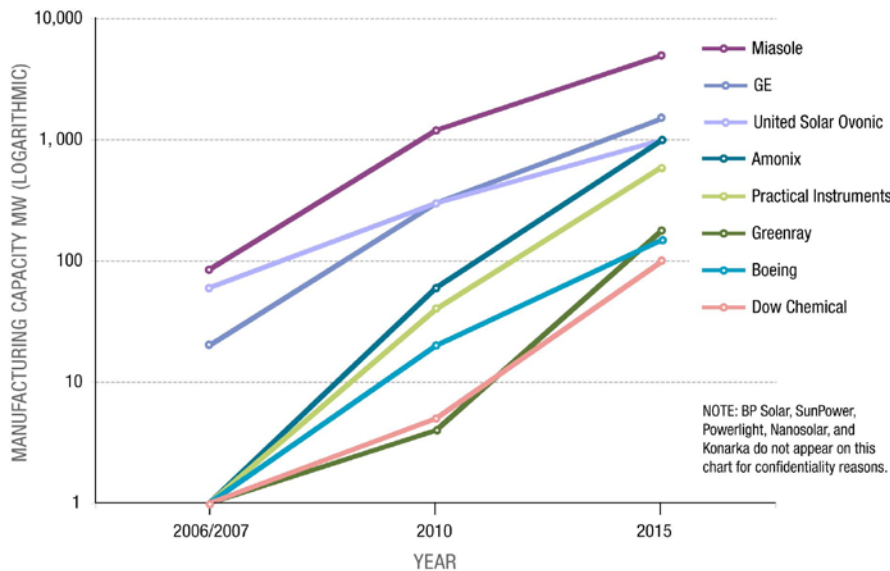
Beginning to Fill the R&D Pipeline: The First Technology Pathway Partnerships

The announcement of the Technology Pathway Partnerships (TPPs), a large Funding Opportunity Announcement (FOA), was the most dramatic evidence of SAI's strategy. Entrance criteria for commercial applicants included prototype components, pilot production demonstration, and an established business case. At the end of three years, awardees are expected to have commercial PV systems and subsystems with annual production of greater than 25 MW. Partnerships with national laboratories, universities, and suppliers focus on the development, testing, demonstration, validation, and interconnection of PV components, systems and manufacturing equipment—while expecting costs to be reduced to \$0.05–\$0.10 per kWh by 2015.

In March 2007, DOE announced \$340 million in cost-shared industry lead projects as part of the Technology Pathway Partners program. These 13 projects included a broad cross-section of U.S. industry involving more than 50 companies, 14 universities, 3 non-profits, and 2 national laboratories in 20 states. The selected projects leaders are Amonix, BP Solar, Boeing, Dow Chemical, General Electric, Miasolé, Nanosolar, SunPower, PowerLight, United Solar Ovonic, Konarka, GreenRay and Practical Instruments. Since the DOE announcement, SunPower and PowerLight have merged and Practical Instruments is now called Soliant.

Total DOE project funding will be about \$64 million for year 1, \$68 million for year 2, and \$48 million for year 3. The teams contribute private cost share well over the DOE funding totals. This new portfolio continues DOE’s historical investment in thin films and increases support significantly for concentrator photovoltaics and crystalline silicon technologies. The portfolio of technologies is intended to deliver on the near-term potential in residential markets (32% of funding targeting) and commercial markets (48% of funding), and on the longer-term with utility markets (20% of funding) (see Figure 2).

Figure 2. Technology Pathway Partnership Objectives: Manufacturing Capacity vs. Time



Keeping the Pipeline Full: Solicitations for PV R&D

In addition to the Technology Pathway Partnerships, five other funding opportunities will keep the PV R&D pipeline full (see Figure 3 for a summary of the current DOE PV portfolio). Most recently, on June 20, 2007 Secretary Bodman announced the selections of 10 PV Incubator awardees. These Incubator projects will receive in total up to \$27 million in DOE funding, with minimum private cost share of 20% of total project costs—with partner cost share, the total research investment is expected to reach \$71 million. The primary objective of these 18-month projects is to address the challenges faced by small businesses in transitioning pre-prototype and pre-commercial PV technologies into pilot and full-scale manufacturing on an accelerated timeline. Projects will work to produce hardware that proves their PV technology is ready for commercialization. This and other SAI solicitations are described in greater detail at: www.eere.energy.gov/solar/solar_america/funding_opportunities.html.



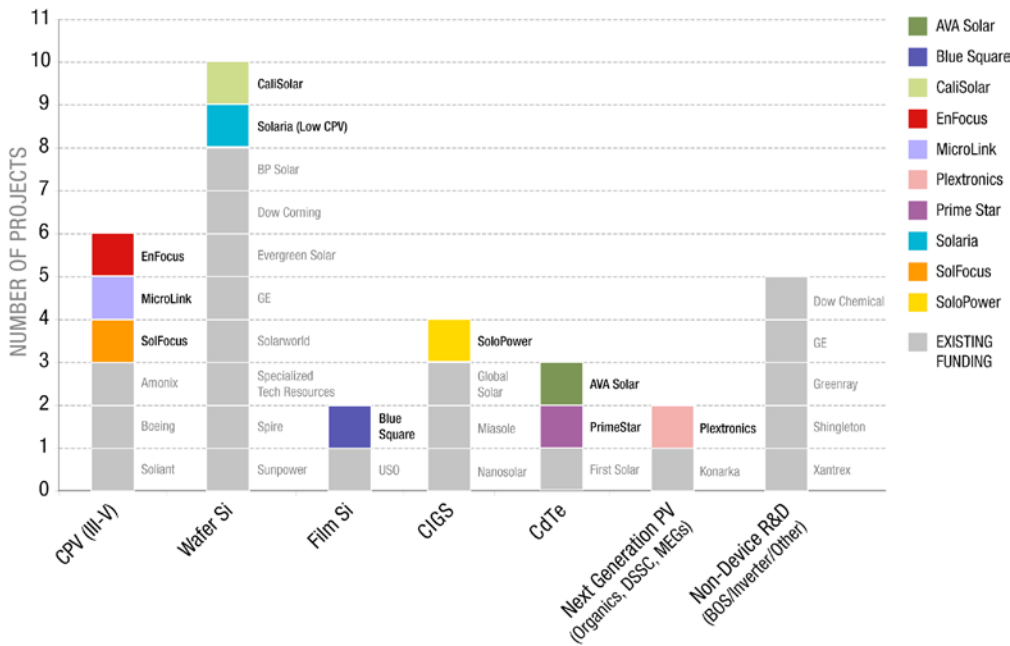
Acciona Energy announced on June 7th that Nevada Solar One, a 64-megawatt solar thermal power plant near Boulder City, Nevada, is now online. The new facility is the largest of its type to be built in the world since 1991, although a 1-megawatt solar thermal plant was built in Arizona last year. The Nevada Solar One plant consists of 350 square acres of parabolic mirrors arranged in a grid and will produce enough power to supply 15,000 average U.S. homes.

NATIONAL LABORATORY TECHNOLOGY DEVELOPMENTS: PHOTOVOLTAICS

Updated Benchmarks of Springerville Utility-Scale PV Generating Plant

Working with Tucson Electric Power Company (TEP), Sandia has characterized the performance and operations of the 26 crystalline-Si systems, rating a total of 3.51 MW, after 5 years of operational experience. Some of the results: average annual AC energy output is 1707 kWhac per kWdc of array; average annual AC system power is 79% of the DC nameplate rating; average annual O&M cost is 0.12% of the initial capital cost of the system, not including inverter rebuilds; and the mean time between unscheduled maintenance services is 7.7 months. Additionally, solar generating intermittencies have been observed to have significant impacts on capacity value to the utility and require hardware/control system modifications. This is an area of high interest and continued investigation. For more information see: www.sandia.gov/SAI/ReliabilityLifecycle.htm

Figure 3. SAI Technology Portfolio with Incubator Additions



Former Solar Program Manager, Steven Chalk, Named Deputy Assistant Secretary for Renewable Energy; Craig Cornelius Appointed New Program Manager

On April 30, 2007 the DOE’s Office of Energy Efficiency and Renewable Energy (EERE) announced the appointment of two Deputy Assistant Secretaries. David E. Rodgers will become the first Deputy Assistant Secretary for Energy Efficiency in the Department’s history and Steven G. Chalk will become the Deputy Assistant Secretary for Renewable Energy. Together, they will oversee the technology development and deployment of the Nation’s applied R&D portfolio for clean, domestic, and affordable energy technologies. Both have extensive background in energy policy, technology, and DOE’s commercialization efforts.

On June 1, 2007, Craig Cornelius, was selected as the Acting Program Manager for the Solar Energy Technologies Program. Craig has led the Solar America Initiative since November 2005, and has also worked within DOE to complete strategic reviews of EERE’s 11 Energy Efficiency and Renewable Energy programs. His work has helped guide improvements in program strategies and objectives, R&D planning, risk assessment and portfolio management, market research, and industry partnering. Cornelius came to DOE from NASA, where he played a leadership role in the formulation of the President’s Vision for Space Exploration—a multi-decade program that will develop the next generation of human and robotic systems for solar system exploration.

NATIONAL LABORATORY TECHNOLOGY DEVELOPMENTS: CONCENTRATING SOLAR POWER

Enhanced System for CSP Mirror Optical Characterization

NREL researchers designed a new optical characterization system to test long focal length and/or flat mirror panels used in concentrating solar power technologies. This new system enhances the Video Scanning Hartmann Optical Test (VSHOT), a system originally designed to test point-focus mirrors used in parabolic dish technology and modified to test profiles of single-axis curvature mirrors used in parabolic trough technology. The VSHOT uses laser ray-tracing to map mirror surfaces. Enhancements include new digital video hardware/software, as well as a large target capable of capturing reflected rays off of flat or nearly flat mirrors. NREL is close to finalizing a CRADA with the Australian company Solar Systems in which NREL will design a similar optical test system for their mirror development needs. Completion and shakedown of the new system is expected in mid to late summer. For more information see: www.nrel.gov/csp/troughnet/testing_standards_reports.html

NATIONAL LABORATORY TECHNOLOGY DEVELOPMENTS: CONCENTRATING SOLAR POWER

Dish/Stirling Development

Continuous efforts in reliability improvement have resulted in over 8,500 hours of operating experience for the six Stirling Energy Systems (SES) dishes at Sandia, with over 30% gross efficiency and over 25 kW net per dish measured. Structural improvements have reduced the design weight of the rotating platform by about 4000 lbs. Further developments in controls and operation have led to these results. Sandia will continue to work closely with SES as they move to complete their 40-unit next-generation build. For more information see: www.energylan.sandia.gov/sunlab/projects.htm

Market Transformation: Scaling the Barriers to Solar Markets

Tom Kimbis of the DOE Solar Technologies Program heads a new \$20 million Solar Energy Market Transformation subprogram. The Solar Energy Market Transformation subprogram currently has 37 distinct activities that are supported by 25 individuals across DOE headquarters, the DOE Golden Field Office, Sandia, NREL, and support service contractors.

A Widget Fable on Market Barriers

To understand market transformation, during a recent solar program review Kimbis used a humorous parable of an imaginary Widget Company in Widgetvale, California to describe some of the issues that face the solar industry. This imaginary Widgetmaker has a “eureka” moment leading to a new SuperWidget, twice the size and speed of any Widget and certain to transform the market. A consumer survey confirms the Widgetmaker’s beliefs and Widget Company retools, starts production, and finally ships its first 100,000 SuperWidgets.

In this story, a catastrophic journey to market begins. The Widgetmaker receives a call from a store in the State of Sol where SuperWidget purchasers are returning the product, stating that they couldn’t be properly installed. Sol had created legislation a few years earlier, putting safety limits on the size and speed of widgets so that the SuperWidgets are illegal. Other states, towns, and even the federal government had modeled new widget laws after the Sol law, and full trucks began turning back for Widgetvale. Then another obstacle: SuperWidgets work so well in southern Soleil that they are judged to be a threat to the WidgetGrid. Some analysts compare possible damage caused by SuperWidget installations to a series of exploding nuclear suitcases.

The catastrophes accelerate further. Banks compare SuperWidget investments with the Titanic. The insurance industry raises concerns and rates due to fire danger. *USA Tomorrow* calculates a 198-year payback for SuperWidgets. A state enacts legislation requiring, for its citizen’s safety, that all SuperWidgets be examined individually—including being unpacked, disassembled, and reassembled by hand—by an under-funded and overloaded group of three Widget Experts. Finally, the Widgetmaker starts hearing that his competitors are shipping new series of MiniWidgets, MicroWidgets, and NanoWidgets. Ironically, the SuperWidget does not transform the market; it is the market that transforms and downsizes the SuperWidget.

Looking at the Solar Markets

Solar may not be as bad as SuperWidgets, but, according to Kimbis, “It’s close.” Continuing, Kimbis said, “Many of the examples used in the SuperWidget story are actually quite similar to the solar barriers we have encountered during our first year or two working on Market Transformation.” The lesson to be learned is that it isn’t good enough just to make great technologies. You must also study the marketplace to identify any conditions that would preclude the successful introduction of those products.

NATIONAL LABORATORY TECHNOLOGY
DEVELOPMENTS: *CONCENTRATING SOLAR POWER*

Heliostat Cost Reduction

A study was completed to identify and quantify means of reducing the costs of heliostats for power tower applications. Two separate workshops enlisted the input of 30 experts to complete the study. The study concludes that R&D efforts can reduce heliostat price by at least \$17/m²—from \$126/m² to \$109/m². Continued reduction to ~\$90/m² is expected through learning during the deployment of the initial 9 GW of power plants over a decade or more. This equates to a power tower system cost of \$0.056/kWh. *Publication:* G.J. Kolb et al., “Heliostat Cost Reduction Study,” Sandia National Laboratories, SAND Report and ASME conference paper, May 2007.

NATIONAL LABORATORY TECHNOLOGY
DEVELOPMENTS: *CONCENTRATING SOLAR POWER*

Molten Salt Heat Transfer Fluid Development

Thermal stabilities and viscosities of different salt formulations have been investigated and reported, with plans to optimize promising nitrates. *Publication:* D.A. Brosseau and R.W. Bradshaw, “Sandia Solar Technologies FY07 Test Plan: Molten Nitrate Salt Investigations for Thermal Energy Storage,” Sandia National Laboratories Report, August, 2006. For more information see: www.nrel.gov/csp/troughnet/pdfs/2007/brosseau_sandia_molten_salt_tes.pdf

The specific goal of the Market Transformation subprogram is to reduce market barriers and promote market expansion of solar energy technologies through non-R&D activities. To identify these activities, Kimbis and his team held meetings open to the public and issued requests for information to those who weren't at these meetings. Representatives from utilities, solar companies, federal agencies, states, cities, academia, the building industry, and the financial community provided guidance as to which activities were appropriate and worthwhile for DOE to fund.

Paving the Way for Market Development

This valuable guidance led to the following key activities:

Solar America Board of Codes and Standards. A consortium led by New Mexico State University will receive \$4.2 million over 5 years to examine codes and standards issues and provide best-practice recommendations. Standards specify minimum sets of test conditions that, if passed, reduce risks for potential market problems such as product failure, inadequate performance, or danger to humans. The consortium includes the Arizona State University's Photovoltaic Testing Laboratory, BEW engineering consultants, Florida Solar Energy Center, Interstate Renewable Energy Council, PowerMark, Sherwood Associates, Inc., and Underwriters Laboratories, Inc.

Solar America Cities. To address barriers and opportunities at the local level, we are partnering with 13 cities ready to make solar mainstream by 2015. We will provide a combined \$2.5 M in financial assistance plus hands-on technical assistance to help cities in their efforts to integrate solar into city energy planning and facilities, streamline city-level regulations and permitting, and promote solar technology locally through outreach and education. The 2007 Solar America Cities—announced June 20 by Secretary Bodman—are: Ann Arbor, MI; Austin, TX; Berkeley, CA; Boston, MA; Madison, WI; New Orleans, LA; New York, NY; Pittsburgh, PA; Portland, OR; Salt Lake City, UT; San Diego, CA; San Francisco, CA; and Tucson, AZ.

State and Utility Solar Technical Outreach. Recognizing the important role of States in the growth of solar markets, we have awarded three groups to provide solar technology information and policy best practices to key decision makers such as state legislators, public utility commissions, and clean energy fund administrators. The Program will provide a combined \$795,000 over three years to the National Conference of State Legislatures, the National Association of Regulatory Utility Commissioners, and the Clean Energy Group. We also wish to support outreach to utilities as they further integrate solar technologies into their programs and business plans. To that end, we have awarded the Solar Electric Power Association with \$990,000 over three years to provide tools, information resources, and hands-on assistance to help utilities advance their solar efforts.

Solar America Showcases. Under this activity, DOE will provide technical assistance to large (greater than 100 kW), high-impact solar installation projects that stand out for their high-visibility, novel application or potential for replication. An initial set of three projects were awarded in May 2007, and we are accepting proposals for the next round until August 15. The initial Showcase projects include a large PV installation on the Orange County Convention Center in Orlando,



Crowds at the 2006 Solar Decathlon. Please see page 12 for details on the 2007 event.

NATIONAL LABORATORY TECHNOLOGY DEVELOPMENTS: *CONCENTRATING SOLAR POWER*

Theoretical Overlay Photographic (TOP) Alignment System for Parabolic Trough Collectors

Alignments have been completed at the newly constructed Arizona Public Service Saguaro 1-W plant, with a cycle time of 70 seconds per trough module. The long-term goal for this method is 30 s per module. An error analysis indicates root-mean-square alignment uncertainties that are less than the slope errors of the mirrors themselves. *Publication:* R.B. Diver and T.A. Moss, 2006, "Practical Field Alignment of Parabolic Trough Solar Concentrators," ISEC2006, Denver, CO.

Florida; integrating PV into a large military housing development in Hawaii led by Forest City Military Communities; and integrating PV into a set of eight city-owned facilities in the City of San Jose, California.

Education. This area targets a possible lack of trained PV installers over the long-term. DOE is working with many groups and individuals across the country to identify best practices in this area that may lead to future action. DOE will not be training or certifying installers, and DOE may decide that this is entirely a market-driven issue with a market solution.

Product Certification. Market Transformation is working with Underwriters Laboratories to respond to industry concerns about the slow pace of module safety certification. It also has increased funding for the Solar Rating and Certification Corporation (SRCC), helping it to eliminate certification bottlenecks for solar water heaters and to develop a business plan to become self sufficient.

Building-Integrated PV (BIPV). NREL's BIPV team is working with DOE's Buildings Program to improve its software and analysis tools to help better integrate solar panels into building structures.

Finance. Whether the buyer is large (such as the federal government) or small (such as a homeowner), there is a need to identify high-priority financial issues and the most appropriate roles for DOE to play within the financial marketplace. This work is just beginning.

Policy Analysis: Exploring the Limits of PV Penetration

Policies become critical as the impacts of solar energy on various segments of society become clearer. For example, utilities around the world have traditionally discouraged solar customers—for obvious reasons: The markets in which utilities work require them to maximize income from every customer for the benefit of their investors. And solar customers do not increase utility profits like traditional customers do.

But before breaking the traditional paradigm, we must first understand it so that new policies can be created that benefit all aspects of society. Paul Denholm and Robert Margolis, two NREL energy and policy analysts, have evaluated the limits of large-scale deployment of solar photovoltaics in traditional electric power systems in an attempt to understand these limits. Their new understanding can lead to more effective operating paradigms and policies.

Can PV Really Provide Enough Energy for a Utility?

Denholm and Margolis recently published two articles on this topic in the journal *Energy Policy*. Their first article evaluated the ability of PV to provide up to 50% of the energy for a Texas utility system by comparing hourly output of a simulated large PV system to the amount of electricity actually usable within the utility's service territory.

DOE SOLAR WEB SITES

SOLAR:

Solar America Initiative:
www.eere.energy.gov/solar/solar_america

EERE Solar Energy Technologies Program:
www.eere.energy.gov/solar

NREL Solar Research: www.nrel.gov/solar

PHOTOVOLTAICS:

NREL PV Research: www.nrel.gov/pv

SNL PV Systems R&D: www.sandia.gov/pv

BNL PV Environmental, Health and Safety Assistance Center: www.pv.bnl.gov

ORNL Solar Technologies Program:
www.ornl.gov/sci/solar

PV Value Clearinghouse:
www.nrel.gov/analysis/pvclearinghouse/

CONCENTRATING SOLAR POWER:

NREL CSP Research: www.nrel.gov/csp

TroughNet: www.nrel.gov/csp/troughnet

BUILDINGS:

EERE Buildings Technologies Program:
www.eere.energy.gov/buildings

NREL Buildings Research:
www.nrel.gov/buildings

Solar Decathlon:
www.solardecathlon.org

OTHER:

Golden Field Office:
www.eere.energy.gov/golden

Industry Interactive Procurement System (IIPS):
<https://e-center.doe.gov/iips/faopor.nsf/ViewMenu?ReadForm>

The two researchers found that under high penetration levels and existing grid-operation procedures and rules, the system had excess PV generation during certain periods of the year that increased PV costs—that is, the PV electricity had to be dumped. The limited flexibility of baseload generators, which cannot respond to rapid changes in load, produces more unusable PV generation when PV provides more than approximately 10%-20% of a system's energy.

Help from Flexibility, Load Shifting, and Storage

Margolis and Denholm's second article evaluated technologies that might enable PV to overcome the limits discovered in the first article. They considered means to increase system flexibility, load shifting via demand-responsive appliances, and energy storage. Increasing *flexibility* from the study's baseline of 65% to 90% almost doubles the amount of energy that variable loads can provide. *Load shifting* through appliances (e.g., water heaters) with controls sensitive to utility load is another option to increase the coincidence of PV output and electricity demand without drastically altering lifestyle. However, not all appliances (e.g., heat pumps) are suited for this type of control.

Finally, the study considered storage benefits, while recognizing there are *storage* losses and additional capital and operating costs for storage systems that need to be included. Their analyses showed that for a 25% increase in average PV cost, a combination of 11 hours of storage, and a utility with 80% flexibility, PV could provide roughly half of the system's energy. They concluded, "This level of PV penetration would truly require a radical transformation of the electricity system—from a centrally controlled to a highly distributed and interactive system."

An intriguing possibility that results from changing a utility's traditional loads is the use of surplus or low-value PV-generated electricity to supply mid-day recharging for plug-in hybrid electric vehicles. Such an application could be an additional benefit from PV generation.

For details on the two studies summarized above, view the following two articles:

- P. Denholm and R.M. Margolis, Evaluating the limits of solar photovoltaics (PV) in traditional electric power systems, *Energy Policy* 35 (2007) 2852–2861.
- P. Denholm and R.M. Margolis, Evaluating the limits of solar photovoltaics (PV) in electric power systems utilizing energy storage and other enabling technologies. *Energy Policy* (2007), in press.

For more information, please visit: www.nrel.gov/analysis/pvclearinghouse/

SOLAR EVENTS CALENDAR

Solar 2007: Sustainable Energy Puts America to Work
July 7–12, 2007: Cleveland, OH
www.ases.org/solar2007

SolWest Renewable Energy Fair
July 27–29, 2007: John Day, OR
www.solwest.org

17th Workshop on Crystalline Silicon Solar Cells and Modules: Materials and Processes
August 5–8, 2007: Vail, CO
www.nrel.gov/silicon_workshop

SPIE Optics & Photonics—
Solar Energy and Its Applications
August 26–30, 2007: San Diego, CA
www.spie.org/

2007 Joint ACS/AICHE
Rocky Mountain Regional Meeting
August 29–September 1, 2007: Denver, CO
www.uwyo.edu/rmr2007acs%2Daiche

22nd European Photovoltaic Solar Energy Conference and Exhibition
September 3–7, 2007: Milano, Italy
<http://p12611.typo3server.info>

ISES Solar World Congress 2007
September 18–21, 2007: Beijing, China
www.swc2007.cn

Solar Power 2007
September 24–27, 2007: Long Beach, CA
www.solarpowerconference.com

2007 Solar Decathlon
October 12–20, 2007: Washington, DC
www.solardecathlon.org

Greenbuild 2007
November 7–9, 2007: Chicago, IL
www.greenbuildexpo.org

Energy Efficiency Global Forum & Exposition
November 11–14, 2007: Washington, DC
www.eeglobalforum.com/

2007 Material Research (MRS) Fall Meeting
November 26–30, 2007: Boston, MA
www.mrs.org/s_mrs/sec.asp?CID=4749&DID=164574

Solar 2008
May 3–10, 2008: San Diego, CA
www.ases.org/programs/conference.htm

SOLAR EVENT NEWS

2007 Solar Decathlon Set to Go in October

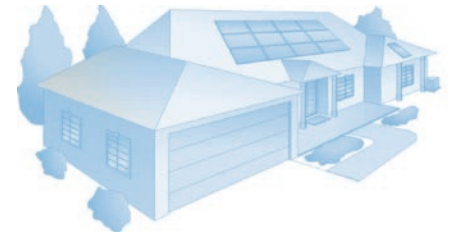
The third Solar Decathlon competition (www.solardecathlon.org) will be held October 12–20, 2007, in Washington, D.C. The event requires university teams to build and operate energy-efficient solar-powered homes on the National Mall, forming a temporary “solar village.” In January 2006, DOE selected the following 20 teams to participate in the competition—sixteen teams from 13 states, as well as four teams representing Puerto Rico, Canada, Spain, and Germany:

- Carnegie Mellon University
- Cornell University
- Georgia Institute of Technology
- Kansas State University
- Lawrence Technological University
- Massachusetts Institute of Technology
- New York Institute of Technology
- Pennsylvania State University
- Santa Clara University
- Team Montréal (école de Technologie Supérieure, Université de Montréal, McGill University)
- Technische Universität Darmstadt
- Texas A&M University
- Universidad Politécnica de Madrid
- Universidad de Puerto Rico
- University of Cincinnati
- University of Colorado
- University of Illinois
- University of Maryland
- University of Missouri–Rolla
- University of Texas at Austin

Beginning on October 12, teams will be judged in 10 areas encompassing architecture, engineering, livability, comfort, power generation for space heating and cooling, water heating, and powering lights and appliances. The Decathlon’s prototype solar homes are zero-energy, yielding zero carbon emissions, and will include the latest high-tech solutions and money-saving benefits to consumers, without sacrificing comfort, convenience, and aesthetics. Each house must also produce enough “extra” energy to power an electric car. Visitors can tour the homes daily, except for Wednesday October 17, when they are closed for competition purposes.

WE WANT TO HEAR FROM YOU

This *DOE Solar Energy Technologies Program Newsletter* is for you—the participants and stakeholders in the DOE Solar Program and the Solar America Initiative. We envision sending this newsletter every quarter. If you have any comments or suggestions about the frequency or content of the newsletter, please e-mail solar@ee.doe.gov.



A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy’s Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

For more information contact:

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 1-877-EERE-INF (1-877-337-3463)
www.eere.energy.gov