

### Message from the Director



In 2010, a small team at the U.S. Department of Energy (DOE) posed a basic question: What would it take for solar to become a significant fraction of the nation's electricity generation capacity? The team started from the premise that solar energy must become an economically attractive option in order to grow beyond early adopters and early markets. We anchored our effort in the notion that consumers and businesses would choose solar energy not only because it is the environmentally sustainable choice, but because it will be the economic choice.

After extensive analysis to evaluate what it would take for solar energy to reach cost parity without subsidies, DOE developed a plan and launched the SunShot Initiative in early 2011. The initial analysis in the SunShot Vision Study set aggressive cost and performance targets, which at the time seemed distant and unrealistic. But such goals served a very important purpose; they created a framework to assess and address the grand challenges to achieve the ambitious SunShot goal by the end of the decade.

The greater danger for most of us lies not in setting our aim too high and falling short; but in setting our aim too low, and achieving our mark.

- Michelangelo

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Fast forward only a few years, and solar deployment is up. Way up. The amount of solar power installed in the United States reached an estimated 13 gigawatts at the end of 2013—an 11 fold increase since 2008. This dramatic growth in deployment has led to impressive job growth in the sector. By nearly all measures, the solar energy industry has been one of the fastest growing industries in the U.S. over the last five years. There are now more than 143,000 jobs in the solar sector, and these jobs are growing at almost 10 times the rate of the United States economy. Every four minutes, another American home or business goes solar, supporting workers whose jobs can't be outsourced.

This growth in deployment is supported by rapidly declining costs. The targets set for 2020 are now within reach. Just three years into a decade-long initiative, the industry has progressed 60% of the way toward the 2020 SunShot goal.

## Message from the Director

Yet, solar still only accounts for approximately 1% of the nation's electricity generation capacity. There is plenty of room to grow, but many challenges and opportunities remain. Concentrating solar power holds the promise of integrated and dispatchable storage, but must overcome high capital costs for large-scale deployment. Low-cost photovoltaic modules can enable significant solar deployment, but face the challenge of a weakened U.S. manufacturing industry. Non-hardware soft costs, which now account for 64% of the total cost of small residential systems, create opportunities for innovative solutions to streamline processes and drive down the costs of permitting, interconnection, finance, and customer acquisition. And, as deployment reaches even higher levels of grid penetration, grid integration will become a more significant challenge—creating opportunities for storage-based solutions and building energy management integration.

As daunting as all those hurdles and roadblocks appear, I am continually reminded of the tremendous amount of innovation and ingenuity flowing from our national laboratories, businesses, and communities across the country. There are several large-scale concentrating solar power plants now online using technologies originally developed by DOE. SunShot awardees have broken more than a dozen world record solar cell efficiencies in the past few years. We now have photovoltaic inverters with advanced functionality that can help support the electrical grid. Communities are using innovative group purchase programs to reduce the cost of residential solar by more than 20%, and some cities now conduct permitting entirely online, cutting down the time to go solar from weeks to minutes. We have achieved much, but there is more to do.

We are at the dawn of the age of solar energy, and the future is bright.

Thank you,



**Minh Le**

*Director*

Solar Energy Technologies Office, SunShot Initiative  
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## Tackling Challenges in Solar Energy

The U.S. Department of Energy (DOE) Solar Energy Technologies Office works to accelerate the market competitiveness of solar energy by targeting cost reductions and supporting increased solar deployment. In 2011, DOE announced the department-wide SunShot Initiative—a collaborative national effort that aggressively drives innovation to make solar energy fully cost competitive (subsidy-free) with traditional energy sources before the end of the decade. In support of this crucial goal, the Solar Energy Technologies Office pivoted its focus to fulfilling the SunShot vision and continuously evaluates areas of opportunity to further support cost reductions. Through SunShot, DOE supports efforts by private companies, universities, and national laboratories to drive down the cost of utility-scale solar electricity to about \$0.06 per kilowatt-hour (kWh), and distributed solar electricity to at or below retail rates.

### ENERGY INNOVATION: THE STATE OF SOLAR TODAY

Widespread solar energy deployment can strengthen U.S. economic competitiveness in the global clean energy race, help cut carbon pollution to combat climate change, and secure America's energy future. The United States has enormous potential to get its energy from the sun: photovoltaic (PV) panels on just 0.6% of the nation's total land area could supply enough electricity to power the entire United States.<sup>1</sup> PV can also be installed on rooftops with essentially no land use impacts. Seven southwestern states have the technical potential and identified land area to site enough concentrating solar power (CSP) to supply more than four times the current U.S. annual demand.<sup>1</sup> And as a domestic energy source, solar supports broader national priorities, including national security, economic growth, and job creation.

Energy captured from the sun is more affordable, accessible, and prevalent in the United States than ever before. In 2012, rooftop solar PV panels cost about 1% of what they did 35 years ago. Since the beginning of 2010, the average cost of solar PV panels has dropped more than 60% and the cost of a solar electric system has dropped by about 50%.

U.S. installations have grown eleven-fold from 1.2 gigawatts (GW) in 2008 to an estimated 13 GW. This is enough capacity to power the equivalent of 2.2 million average American homes<sup>2</sup> or supply the combined electricity needs of Austin, Texas, and Seattle, Washington, for one year.<sup>3</sup>

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Markets for solar energy are maturing rapidly around the country, and solar electricity is now economically competitive with traditional energy sources in several states, including California, Hawaii, and Minnesota. Moreover, the solar industry is a proven incubator for job growth throughout the nation. Solar jobs have increased by nearly 20% since the fall of 2012, which is 10 times the national average job growth rate. There are more than 142,000 solar workers in the United States, and each day the solar industry creates 56 new jobs across America.<sup>4</sup>

1. National Renewable Energy Lab and U.S. Department of Energy. SunShot Vision Study. Feb. 2012. pp.4-5. See: <http://energy.gov/eere/sunshot/sunshot-vision-study>.

2. See: <http://www.seia.org/blog/seia-turns-40-shout-out-solar>

3. Based on electricity consumption data for 2012.

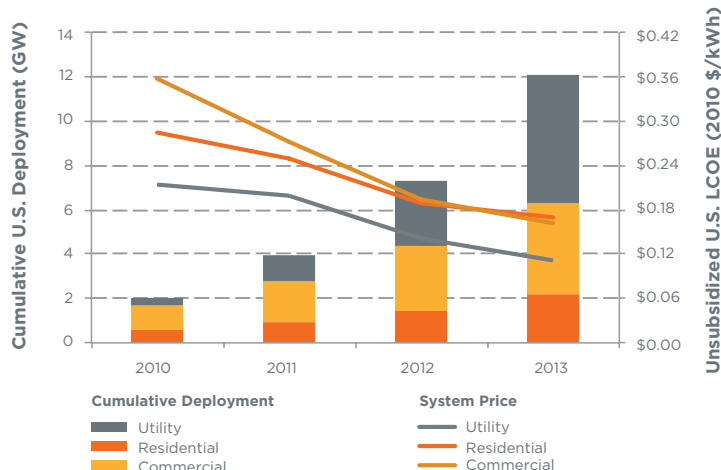


Figure 1. Average U.S. system price and cumulative deployment, by sector 2010-2013.

In 2013, solar energy reached a significant milestone: more than 1% (13 gigawatts) of the nation's electricity generating capacity is now powered from the sun. This is a vast increase from 2008, when solar generation was less than 0.1% of the nation's electricity capacity.<sup>2</sup> Yet significant work remains before solar achieves grid parity and realizes its full potential throughout the country. Solar hardware costs have fallen dramatically, but market barriers and grid integration challenges continue to hinder greater deployment. Non-hardware solar "soft costs"—such as permitting, financing, and customer acquisition—are becoming an increasingly larger fraction of the total cost of solar and now constitute up to 64% of the cost of a residential system.<sup>5</sup> Technological advances and innovative solutions are needed to increase module and process efficiencies, drive down costs, and enable utilities to rely on solar for baseload power.

The SunShot Initiative is designed to establish American technological and market leadership in solar energy, diversify the nation's electricity supply, reduce the environmental impacts of electricity generation, strengthen manufacturing competitiveness in the United States, train the next generation of the solar workforce, and catalyze domestic economic growth. The *SunShot Vision Study*, a guiding document

for the Initiative's work, estimates that meeting SunShot cost reduction goals would allow solar to scale rapidly and potentially generate up to 14% of the nation's total electricity demand by 2030 and 27% by 2050.<sup>6</sup>

## THE SUNSHOT APPROACH

Modeled after President John F. Kennedy's Moonshot goal to place a man on the moon in the space of a decade, SunShot is an aggressive, goal-driven national initiative. SunShot targets call for solar cost reductions of 75% relative to 2010 baseline levels. As such, the SunShot approach targets significant technological and market advancements that are needed to achieve grid parity by 2020. SunShot promotes market competitiveness with cost-based metrics, aiding the spread of technology and process innovations and enabling rapid growth in solar energy deployment.

Within SunShot, dedicated teams work on each of the Initiative's five focus areas: PV, CSP, systems integration, technology to market, and soft costs.

- **PV and CSP:** SunShot funding supports transformative PV and CSP technology research and development (R&D) with the potential to yield significant cost reductions, efficiency improvements, and improved reliability standards. SunShot also supports the development of next generation PV technologies to carry innovation in solar energy beyond 2020 as well as CSP thermal energy storage technologies that can provide dispatchable power generation and enable greater deployment of other renewable energy sources.
- **Systems Integration:** Systems integration funding supports strategies to dramatically increase solar penetration in the nation's electrical grid and enable safe, reliable, cost-effective, and widespread solar deployment.
- **Technology to market:** Technology to market funding supports commercialization, market readiness, and

4. The Solar Foundation. National Solar Jobs Census 2013. Feb. 2014. See: <http://thesolarfoundation.org/research/national-solar-jobs-census-2013>.

5. National Renewable Energy Laboratory. Dec. 2013. See: <http://www.nrel.gov/news/press/2013/5306.html>.

6. National Renewable Energy Laboratory and U.S. Department of Energy. SunShot Vision Study. Feb. 2012. p.7. See: <http://energy.gov/eere/sunshot/sunshot-vision-study>.

# Tackling Challenges in Solar Energy

domestic manufacturing supply chains. Small solar businesses selected to participate in SunShot's competitive Incubator program have earned more than \$18 in follow-on funding for every \$1 in government investment. The success of this program has spurred similar efforts throughout the DOE Office of Energy Efficiency and Renewable Energy (EERE).

- **Soft Costs:** And while recent technological advances have drastically reduced the cost of solar hardware, making soft costs a greater share of the overall cost of solar, SunShot soft costs funding supports market transparency, workforce training, local solutions, and process improvements to make solar deployment faster, easier, and cheaper.

Since 1978, the Energy Department has supported the research, development, and deployment of a diverse array of energy technologies. These efforts have reduced the cost of these technologies and helped to improve the safety and reliability of the electrical grid. Within the Department, SunShot's work supports applied projects that target cost effective solutions to technological and market barriers, filling an important niche. SunShot coordinates its activities with the DOE Office of Science and the Advanced Research Projects Agency-Energy (ARPA-E) to prevent duplication of efforts while maximizing department-wide impact on solar energy. SunShot supports the Department's broader Clean Energy Manufacturing Initiative to increase the efficiency of the U.S. manufacturing sector and ensure that clean energy technologies continue to be made in America. SunShot also supports foundational research that is crucial to the advancement of solar energy technologies at the national laboratories and at user facilities that provide critical capabilities to the American solar industry.

## FY13 funding distribution

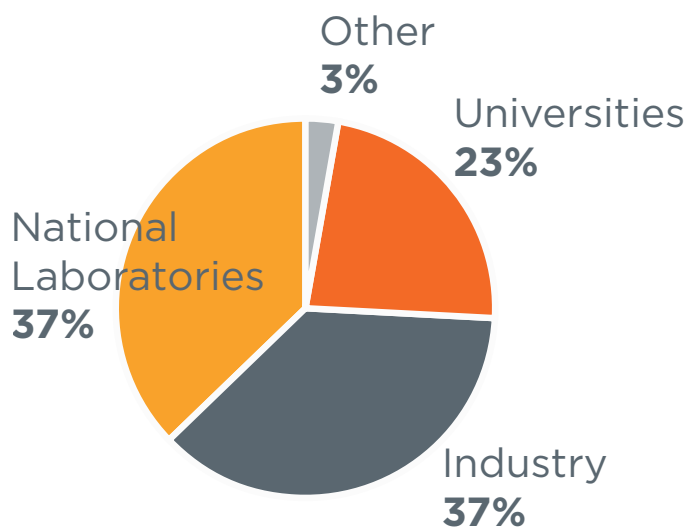


Figure 2. SunShot Initiative FY13 funding distribution.

## A SUNSHOT FUNDING OPPORTUNITY: FROM CONCEPT DEVELOPMENT TO MANAGEMENT

SunShot funding programs target technical and market barriers for solar energy. To develop new funding programs, SunShot holds idea development sessions across teams to ensure cross-pollination between program focus areas and support the development of holistic approaches to tackling major challenges. The most promising topics are identified through internal debate and rigorous review by all SunShot program managers. SunShot also gathers industry experts at technical workshops to provide feedback on targeted barriers and potential solution pathways, and solicits broad input from stakeholders. Some of the ideas discussed at stakeholder workshops may eventually be incorporated



## Core considerations for Office of Energy Efficiency and Renewable Energy programs

### The proposed funding is...

<b>Impactful</b>	Targets a high-impact problem.
<b>Additive</b>	Will make a significant difference relative to private sector and other funding entity efforts.
<b>Inclusive</b>	Focuses on the broad problem.
	Is open to new ideas, new approaches, and new performers.
<b>A Return on Investment</b>	Will result in enduring economic benefit to the United States.
<b>Within DOE's Role</b>	Fulfills a proper, high-impact role for government versus an issue that is best left to the private sector to address on its own.

into funding programs, while others may not, based on stakeholder feedback. As part of the rigorous review for new funding programs, SunShot staff debate and refine potential topics and justify new programs with a set of criteria issued by EERE (see table).

Once a funding program is created, a solicitation or Funding Opportunity Announcement (FOA) is publicly issued to the stakeholder community to solicit applications (See the Appendix for a list of all SunShot FOAs). Each application is subjected to a rigorous review process, including evaluation by an external peer review panel consisting of distinguished scientists, engineers, and practitioners from academia, industry and national laboratories across the nation. Based on the rigorous technical review process, the alignment of the

application to SunShot goals, and the availability of funding, awards are made to the top few applications in any given funding program.

Once funding awards are made, SunShot team members actively manage projects through the length of the award agreement to ensure awardees meet agreed-upon project objectives, deliver on milestones, and yield valuable results. Post-award workshops and other SunShot events, including the biennial SunShot Grand Challenge Summit and Peer Review, connect awardees and other leaders doing innovative work in solar energy, furthering the spread of ideas and best practices within the SunShot community.

# Tackling Challenges in Solar Energy

## SUNSHOT: A STRIKING RECORD OF SUCCESS

Through game-changing innovations, SunShot's nearly \$900 million in investments over the last three years are transforming how solar systems are conceived, designed, manufactured, and installed in order to make it faster, easier, and cheaper to deploy solar. SunShot has funded hundreds of projects that are making solar more affordable and accessible—from streamlining panel manufacturing processes to reducing the red tape involved with permitting a residential solar energy system.

Only three years into the Energy Department's decade-long SunShot Initiative, the solar industry is already more than 60% of the way to achieving SunShot's cost target of \$0.06 per kWh for utility-scale PV (based on 2010 baseline figures),<sup>7</sup> and more than halfway to CSP cost targets.<sup>8</sup> Since SunShot's inception, the average price per kWh of a utility-scale PV project has dropped from about \$0.21 to \$0.11, the levelized cost of electricity for CSP has decreased from about \$0.21 to \$0.13,<sup>7</sup> and solar jobs have grown by 53%.<sup>3</sup>

SunShot's success is a shining example of how government and industry can partner to move markets and grow our economy. SunShot's investments are paying dividends for domestic clean energy, while helping to prevent carbon emissions. Today, as a result of DOE's SunShot Initiative investments and the industry's accelerated pace to meet SunShot goals, the cost of going solar continues to drop and more solar is being added to our nation's energy mix.

While the solar industry has made significant progress only three years into the SunShot Initiative, grand challenges remain. The final 40% cost reduction to achieve the SunShot goal will require the most game-changing ideas and cutting-edge technological developments, from harnessing the power of big data to developing innovative financing mechanisms and more streamlined and efficient manufacturing processes. As SunShot continues to support innovative technical and market solutions to reduce the costs of solar, the Initiative will help to enable a world where homes, workplaces, and communities are powered by clean, renewable energy; utilities can count on solar to provide baseload power; and ubiquitous and cost-effective solar energy helps cut carbon pollution and fight climate change.

7. U.S. Department of Energy. Feb. 2014. See: <http://www.energy.gov/articles/us-utility-scale-solar-60-percent-towards-cost-competition-goal>

8. National Renewable Energy Laboratory. Internal Cost Model. Nov. 2013.