SunShot $1 per Watt Solar Cost Goal: Mission Accomplished, Years Ahead of Schedule

U.S. utility fixed-tilt system pricing is below $1.00 per watt. How crucial was the DOE in reaching this milestone?

by Eric Wesoff

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With the advent of $1.00-per-watt (DC) pricing for utility fixed-tilt PV systems, the solar industry has crushed the SunShot Program's $1.00-per-watt goal for 2020 three years early.

In early 2011, Steven Chu, Secretary of the U.S. Department of Energy (and a scientist), along with Dick Swanson, founder of SunPower, christened the DOE's SunShot initiative. Swanson cited DOE's early support of SunPower as a factor in SunPower's success.

At the time, $1.00 per watt seemed more aspirational than real -- but one needs a North Star. The intrepid analysts at GTM Research were tracking utility solar at close to $4.00 per watt in early 2011.

The SunShot initiative hoped to reduce the total costs of PV solar energy systems by about 75 percent so that they were cost-competitive with other forms of energy without subsidies before 2020. Chu said that SunShot would work to bring down the cost of solar -- by focusing on four main pillars:

- Technologies for solar cells and arrays
- Power electronics to optimize the performance of the installation
- Improvements in solar manufacturing processes
- Installation, design and permitting for solar energy systems

In fact, steep reductions in system pricing have stemmed not just from modules, but also from price reductions in inverters, trackers and even labor costs. It's only stubborn soft costs such as customer acquisition that have actually risen.

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And so here we are -- SunShot mission accomplished. However, MJ Shiao, director of research at GTM, recently pointed out on The Interchange that these are EPC prices, and "in many cases, there is still an asset developer's margin on top of this."

Shiao notes that the drop in module pricing from 60 cents per watt last year to 30 cents per watt this year represents "a huge reduction for the utility sector, supported by other reductions in the cost stack," adding that foreign inverter companies and new tracker companies continue to bring "aggressive" pricing to the market. Shiao also observed that that developers and EPCs are "thinking more about overall system costs, rather than just buying the cheapest component." (Tracker systems at 1,500 volts will average $1.08 per watt by the second half of 2017, according to GTM Research.)

Shayle Kann, GTM's SVP of research, said that what "astounded" him is that there is still 30 cents per watt in the cost stack devoted to non-labor soft costs. Shiao noted that the biggest chunk is overhead and margin, along with permitting, engineering and design. Shiao said that there is "a case to be made that some of these additional costs will be hard to squeeze out."

A question to ask in 2017, with renewable energy and efficiency personnel departing from the DOE, is this: How crucial was the SunShot program in reaching this seemingly unachievable goal? Could this have happened without a DOE effort?

GTM Research solar analyst Ben Gallagher acknowledges that it was "pure market forces" such as "scaling in China" and, more recently, "global macro supply-demand imbalances" that have forced a drastic drop in the solar system cost stack.

But Gallagher emphasized that the signals, monetary and otherwise, that SunShot sent to investors and entrepreneurs "made the market more efficient." He said that SunShot helped accelerate this industry and allowed vendors and customers to be able to tolerate a bit more risk.

Gallagher said, in a previous interview, that given the "dramatic" downward price trend, "even renewable energy skeptics" would have to acknowledge solar's increasing cost-competitiveness.

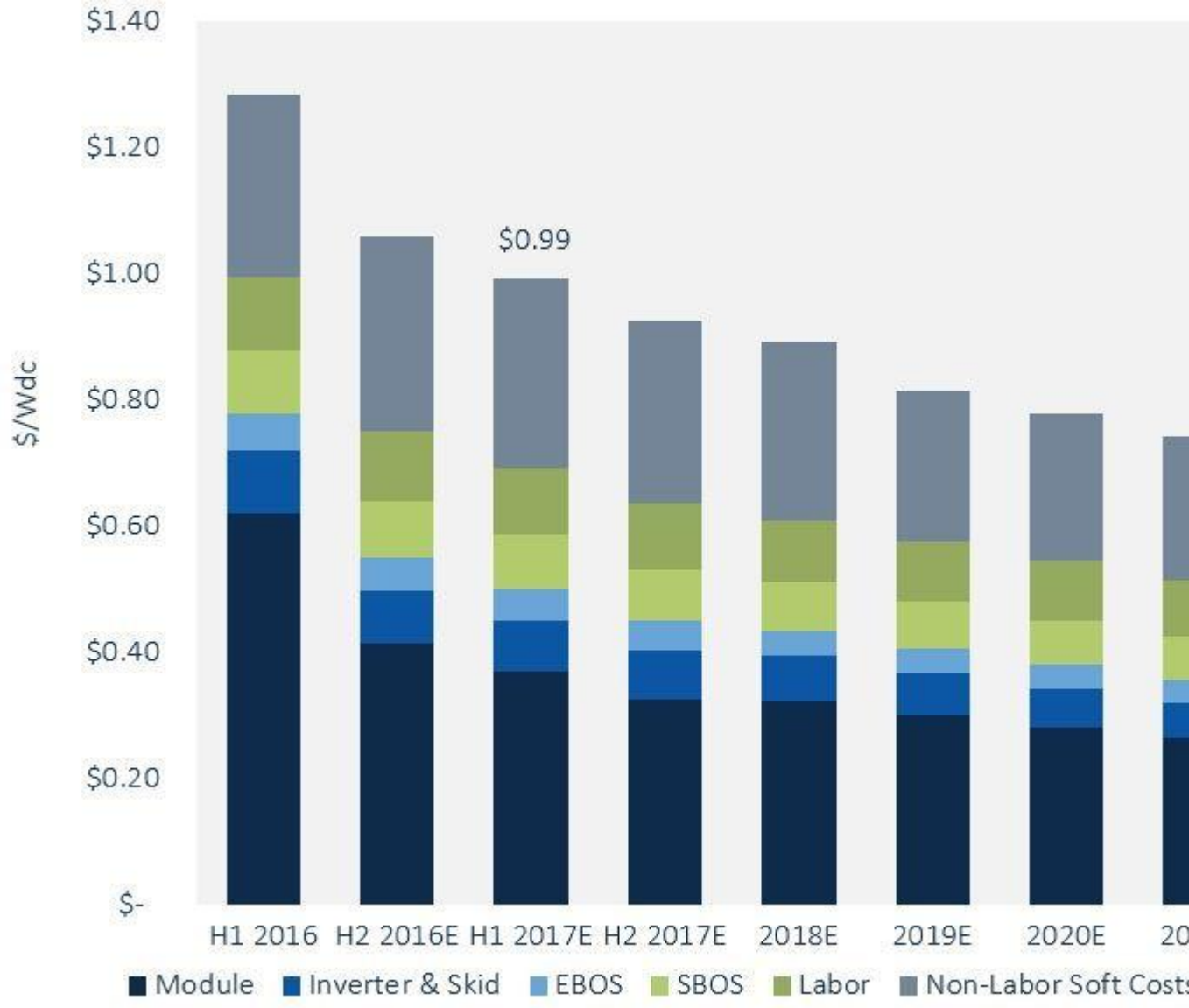
The U.S. Department of Energy loans program, it could be argued, was more responsible for solar's cost drop than SunShot. The loan program let SunPower and First Solar build the first enormous solar plants with lower costs of capital.

Cylindrical CIGS aside, the program was, by any objective measure, a booming success. The loan program has a loss ratio of 2.33 percent on $32 billion in commitments -- a fail rate better than most banks, according to former program head Peter Davidson, as reported by GTM's Julia Pyper.

According to Bloomberg, not only has the program’s loan portfolio generated about $1.65 billion in interest payments to date, but its mission to support major energy projects fits into Trump’s goal of stimulating investment in the U.S., said Jonathan Silver, a former head of the loan programs office. “The President-elect was talking directly about significant investments in infrastructure,” Silver said in a Bloomberg interview. The program is intended to support not just clean-energy projects, but also industries Trump championed during the campaign, including coal, among other advanced fossil fuels. “This is infrastructure. It doesn’t get any more infrastructure-ish than this.”

The loan program cannot be voided by Trump alone -- only Congress can end the program by passing new legislation. But Bloomberg notes that the new Energy Secretary nominee Rick Perry could effectively kill the program by refusing to sign off on any new loans.

FIGURE: U.S. Utility PV Fixed-Tilt Turnkey EPC System Pricing, H1 2016-2021E ($/Wdc)



Source: U.S. PV System Pricing H2 2016

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Addendum: List of 2011 SunShot Awards

ADVANCED SOLAR TECHNOLOGY AWARD SELECTIONS FOR THE SUNSHOT INITIATIVE - By Project Category

Sept. 1, 2011

Category 1: Extreme Balance of System Hardware Cost Reductions

Awardee Name	City	State	Award Amount	Brief Project Description
Amonix	Seal Beach	CA	$4,474,000	Project will develop new dual-axis tracking systems specifically for concentrating PV systems.
Carlisle Construction Materials Incorporated	Carlisle	PA	$4,558,960	Project will develop low-cost, high-efficiency, flexible, building-integrated PV solar cells on roofing membranes.
Cascade Engineering	Grand Rapids	MI	$602,623	Project will develop an innovative racking system for commercial rooftops, using polymers.
The Dow Chemical Company	Midland	MI	$12,800,000	Project will develop a building-integrated PV application that includes high power density with an efficiency target as high as 30%, integrated schemes for heat management and recovery, and integrated power electronics.
GE Global Research	Niskayuna	NY	$1,575,985	Project will develop innovative components that simplify and reduce the cost of both the mechanical and electrical portions of the installation. Innovations include prewired, mechanically interconnected, foldable strings of PV modules.
Georgia Tech	Atlanta	GA	$2,871,214	Project will develop reengineered, whole system designs to include module mounting, integration, materials, and wire management.
Raymond Tinnerman Manufacturing	Rochester Hills	MI	$1,670,000	Project will develop an innovative bracket system for commercial rooftop installations.
Solexel and Owens Corning	Milpitas Granville	CA OH	$12,967,200	Project will develop a building-integrated PV roofing shingle and installation accessories for residential sloped-roof applications.
Zep Solar	San Rafael	CA	$919,626	Project will develop innovative structural components for ground-mount applications as an extension of their work in mounting hardware for commercial PV systems.

Category 2: Foundational Program to Advance Cell Efficiency

Awardee Name	City	State	Award Amount	Brief Project Description
Astro Watt	Austin	TX	$1,500,000	Project will research high-efficiency, thin silicon-based PV cells.
Colorado State University	Fort Collins	CO	$1,500,000	Project will develop barrier layers in cadmium-telluride PV devices. The research provides a path to increase PV cell efficiency while also being applicable to manufacturing processes.
Georgia Institute of Technology	Atlanta	GA	$1,500,000	Project will research high-efficiency PV cells based on thin wafer silicon.
Oak Ridge National Laboratory	Oak Ridge	TN	$1,500,000	Project will develop technologies that will overcome the open-circuit-voltage limitation in cadmium-telluride solar cells by understanding and controlling the grain boundaries (i.e., the bounding surface between crystals).
Ohio State University	Columbus	OH	$1,500,000	Project will advance the integration of high-efficiency semiconductor materials with silicon in a PV cell. The proposed approach provides a path to reduce the cost and increase the efficiency of concentrating PV cells.
National Renewable Energy Laboratory	Golden	CO	$6,240,942	Project will research high-efficiency PV cells based on CIGS (copper indium gallium diselenide) in order to reduce related cost barriers. Areas of focus are to benchmark the project partners' PV devices, address the buffer and transparent conducting oxide layers, and broaden the approach to processing CIGS cells.
National Renewable Energy Laboratory	Golden	CO	$3,500,000	Project will research high-efficiency concentrating PV cells based on high-efficiency materials; the goal is to approach the cells' photovoltage limit
National Renewable Energy Laboratory	Golden	CO	$1,500,000	Project will research high-efficiency cadmium-telluride PV cells on flexible glass with roll-to-roll processing.
North Carolina State University	Raleigh	NC	$1,000,000	Project will develop a multiple-junction PV cell capable of very high solar concentration (as high as 2,000 times the energy of sunlight falling on the cell). This research will advance concentrating PV technologies and lead to higher-efficiency solar panels.
Old Dominion University	Norfolk	VA	$1,117,402	Project will research high-efficiency, ultra-thin, CIGS PV cells.
Solar World Industries America	Hillsboro	OR	$4,636,633	Project will research the use of laser processing techniques to develop advanced device architectures leading to thin-silicon PV cells with higher efficiency.

Category 3: Solar Energy Grid Integration Systems: Advanced Concepts				
Awardee Name	**City**	**State**	**Award Amount**	**Brief Project Description**
Advanced Energy	Bend	OR	$3,100,000	Project will develop, demonstrate, and commercialize technologies designed to reduce the impacts of distributed PV systems and enable a high penetration of PV installations.
Alencon	Plymouth Meeting	PA	$3,000,000	Project will develop, demonstrate, and commercialize a drastically cost-reduced, large-scale PV system. The planned system features a centralized, 100-megawatt inverter and a network that harvests high-voltage energy.
Delphi	Kokomo	IN	$1,900,000	Project will develop and demonstrate a PV inverter with a modular architecture designed to lower manufacturing costs and increase inverter reliability and serviceability.
Electric Power Research Institute	Knoxville	TN	$4,400,000	Project will develop, implement, and demonstrate smart grid-ready PV inverters that include grid-support functionality and the utility communication and control link needed to capture the full value of distributed PV assets.
General Electric	Niskayuna	NY	$2,100,000	Project will demonstrate a cost-reduction approach for an alternating-current (AC) PV module that is driven by innovations in the microinverter design, module integration and packaging, and integration with a new intelligent circuit breaker.
SatCon	Boston	MA	$3,000,000	Project will develop and demonstrate a control architecture for PV inverters that virtually eliminates the impacts of voltage variation caused by PV generation variability.
SolarBridge	Austin	TX	$2,300,000	Project will develop an innovative AC-PV module that consists of an integrated "universal dock" and a high-reliability, low-cost, high-efficiency microinverter to substantially reduce balance of system costs in residential and commercial PV systems.
University of Hawaii	Honolulu	HI	$6,100,000	Project will develop and demonstrate utility-controlled, smart grid-enabled PV inverters at two utilities—one on the Island of Maui and the other, Oklahoma Gas and Electric, on the mainland. This technology has the potential to significantly reduce the system- and distribution-level impacts of distributed PV systems and facilitate their broader adoption at lower cost.

Category 4: Transformational PV Science and Technology: Next Generation Photovoltaics II				
Awardee Name	**City**	**State**	**Award Amount**	**Brief Project Description**
Bandgap Engineering	Woburn	MA	$750,000	Project will develop silicon-nanowire arrays that will be used to create a new type of solar cell. The goal is to achieve a 36%-efficient solar cell using silicon only.
California Institute of Technology	Pasadena	CA	$750,000	Project will develop a flexible, low-cost, wire-array solar cell. Layers of high-efficiency semiconductor materials will be used to form dual- and triple-junction PV devices.
Colorado School of Mines	Golden	CO	$1,484,364	Project will develop new approaches to create nanocrystalline-silicon materials to explore and exploit hot carrier collection (which creates high-energy electrons) as a way of significantly boosting the efficiency of nanoscale PV films.
Massachusetts Institute of Technology	Cambridge	MA	$1,500,000	Project will research next-generation, tin-sulfide materials via systematic defect engineering.
Massachusetts Institute of Technology	Cambridge	MA	$750,000	Project will develop thin-film, crystalline-silicon solar cells with a thickness of less than 10 microns and efficiencies greater than 20%.
National Renewable Energy Laboratory	Golden	CO	$750,000	Project will develop a system for thin-film PV applications using Earth-abundant materials. Properties of the new PV cell will be tunable over a wide range to enable high-volume, low-cost manufacturing of PV modules.
National Renewable Energy Laboratory	Golden	CO	$750,000	Project will develop technology that will allow amorphous silicon and organic materials-based PV technologies to break the Shockley-Queisser limit (i.e., a fundamental limiting factor to increasing solar cell efficiency), thereby dramatically improving solar conversion efficiency.
National Renewable Energy Laboratory	Golden	CO	$750,000	Project will develop new copper-nitride PV cell layers based solely on Earth-abundant elements. Such elements are widely available and low in cost, providing excellent potential to reduce the cost of PV systems.
National Renewable Energy Laboratory	Golden	CO	$750,000	Project will modify a copper-oxide base material through alloying with materials such as sulfur, zinc, and magnesium, thereby tailoring the band structure properties to match the solar spectrum and leading to the development of a new PV cell layer material.
PLANT PV	Berkeley	CA	$750,000	Project will study the feasibility of using cadmium selenide as the top cell and silicon as the bottom cell in a tandem architecture.

Princeton University	Princeton	NJ	$1,476,609	Project will develop organic molecules and polymers with appropriate parameters, deposit them onto silicon, characterize the fundamental properties of the interface, and then incorporate these silicon/organic interfaces into solar cells to create high efficiencies.
Purdue University	West Lafayette	IN	$750,000	Project will to develop inks based on copper, zinc, tin, and sulfur for deployment of low-cost PV cells.
Sandia National Laboratories	Livermore	CA	$749,853	Project will develop a new class of PV material, crystalline nanoporous frameworks, which will allow detailed control of key interactions at the nanoscale.
Stanford University	Stanford	CA	$1,380,470	Project will develop an efficient upconverting material (one that can increase the energy of a stream of light) for incorporation into commercial solar cells using computational and experimental techniques.
University of California, Berkeley	Berkeley	CA	$1,500,000	Project will grow high-quality microstructures of high-efficiency semiconductors on low-cost substrates.
University of California, Los Angeles	Los Angeles	CA	$1,500,000	Project will identify and develop a new high-efficiency material system for solar cells via experimental analysis supported by modeling.
University of California, Irvine	Irvine	CA	$1,422,130	Project will develop a 10%-efficient prototype solar cell made from nontoxic, inexpensive, and Earth-abundant iron pyrite (also known as fool's gold), which offers a clear pathway to 20% PV module efficiency.
University of Chicago	Chicago	IL	$1,500,000	Project will develop new nanocrystal-based materials for next-generation solar cells. The nanocrystals will be fabricated by very inexpensive and scalable wet chemistry, which will allow combining the advantages of conventional inorganic semiconductors with inexpensive fabrication.
University of Delaware	Newark	DE	$1,278,110	Project will develop new low-symmetry gratings for next-generation, thin crystalline silicon and CIGS (copper indium gallium diselenide) PV cells.
University of Michigan	Ann Arbor	MI	$1,500,000	Project will develop the next generation of organic PV technology using small-molecule systems incorporated into a tandem architecture.
University of Minnesota	Minneapolis	MN	$1,500,000	Project will develop tandem cells based on CIGS technology. The project addresses all three of the major barriers to tandem CIGS through the use of new materials and processes.
University of Wisconsin-Madison	Madison	WI	$462,508	Project will develop nanostructures of a pyrite semiconductor to overcome the material's bottlenecks and enable its application in high-performance solar PV devices. Pyrite is the most abundant sulfide mineral the Earth's crust.

Category 5: Reducing Market Barriers and Non-Hardware Balance of System Costs				
Awardee Name	**City**	**State**	**Award Amount**	**Brief Project Description**
Boise State University	Boise	ID	$2,820,154	Project will develop an open-source, project planning tool based on geographic information systems that optimizes siting for utility-scale solar developments. The tool will enable users to assess sites based on quantifiable physical characteristics and constraints of the natural resource as well as military, land use, solar resource, water resource, and public acceptance factors.
Clean Power Finance	San Francisco	CA	$3,000,000	Project will develop an open-source, online information technology (IT) platform that will consist of a database of PV permitting requirements by the authorities that have jurisdiction, in addition to complementary turnkey IT solutions for installers and electric utility companies.
Illinois State University	Normal	IL	$850,000	Project will design, populate, and maintain a comprehensive national database of utility rates and rate design.
Hawaii Department of Business, Economic Development and Tourism	Honolulu	HI	$750,000	Project will provide technical assistance to the state Public Utilities Commission as it sets statewide technical reliability standards through the form of a technical and policy-solution roadmap to resolve grid-reliability issues and to reduce commercial business concerns around the integration of renewables, specifically solar, onto the transmission and distribution systems.
Interstate Renewable Energy Council	Albany	NY	$3,000,000	Project will focus on removing technical and administrative barriers to cost-effective interconnection and transmission, expanding market opportunities for solar PV by enabling the availability of net metering, community solar, and solar in wholesale power markets, and incorporating high-penetration PV scenarios into utility planning and operations management.
Rocky Mountain Institute	Boulder	CO	$683,692	Project will accelerate large-scale adoption of solar PV through the creation and adoption of innovative approaches to utility regulation, rate design, and business models that enable high penetration of solar PV onto the utility grid.
SolarTech	San Jose	CA	$2,500,000	Project will develop a scalable national platform to develop model codes, standards, rules, and processes that will enable reduced time frames for PV installations and deployment at lower cost.

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