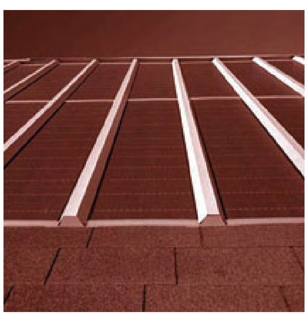
UTILITY SOLAR ASSESSMENT (USA) STUDY

REACHING TEN PERCENT SOLAR BY 2025



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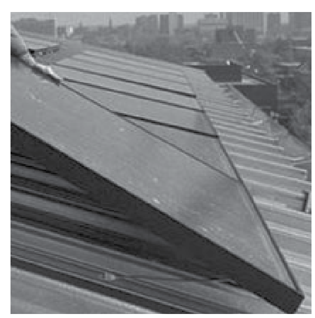

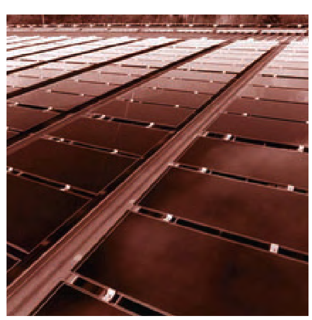

CLEAN EDGE
THE CLEAN-TECH MARKET AUTHORITY

Co-op America

UTILITY SOLAR ASSESSMENT (USA) STUDY
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JUNE 2008

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EXECUTIVE SUMMARY

Solar power has been expanding rapidly, growing an average of 40 percent per year since the beginning of this decade. In the past five years, global solar installations have expanded more than fourfold from approximately 600 megawatts (MW) in 2003 to nearly 3000 MW (the equivalent of three conventional power plants) in 2008.

Many industry analysts and experts believe that solar offers the promise of contributing a significant percentage of America's and the world's energy needs moving forward. How much could it reasonably contribute? Today, solar still represents a minuscule amount of U.S. energy supply—less than one tenth of one percent of total electricity generation. What would it take to dramatically increase this number to make solar a significant portion of electricity use, transforming the way U.S. utilities think about solar in the process?

Our research indicates that the solar contribution could be quite considerable, realistically reaching 10 percent of total U.S. electricity generation by 2025 by deploying a combination of solar photovoltaics (PV) and concentrating solar power (CSP).

Historically, utilities have played a marginal role in the direct growth of solar power. This is due to a number of reasons, from a utility mindset not originally aligned with distributed resources to the very real issue of solar as an expensive and intermittent energy source. But things are beginning to change. Public resistance remains high against nuclear power and increasingly high against coal. Since 2006, some 60 new coal plants in the U.S. have been cancelled, blocked, or delayed, and dozens more are being challenged in 20 states. Some states such as Kansas are considering moratoriums against new coal-fired generation—and this is even before nationwide mandatory carbon caps. California utilities are prohibited from buying new coal-fired power from out of state. In this new world, solar can help deliver the reliability that utilities need.

As conventional electricity sources such as coal, natural gas, and nuclear become increasingly expensive and solar technologies continue their inexorable price decline,

U.S. Solar Installed Capacity (CSP and PV)—Getting to 10 Percent

Year	Cumulative Capacity CSP + PV (MW)	Total Annual Generation Combined PV and CSP (MWh)	Total Projected Annual U.S. Electricity Generation / Demand, All Sources (MWh)	CSP and PV Share of Total U.S. Electricity Generation
2007	1,284	2,513,665	4,119,235,230	0.06%
2010	3,027	5,849,916	4,219,402,150	0.14%
2015	15,184	29,385,504	4,397,329,160	0.67%
2020	69,260	133,345,983	4,608,068,490	2.89%
2025	255,646	485,723,159	4,858,105,640	10.00%

Source: Clean Edge, 2008

the promise of a solar future beckons. Already, solar power can compete in regions with high electricity rates and with favorable incentives. It can compete effectively today for peak power production, in grid-constrained territories, and for applications that are off the grid.

Indeed, solar offers a number of significant benefits to utilities struggling with the complex issues of today's energy landscape. These benefits include:

Projected U.S. Solar Installations as a Percent of Total Electricity Generation—Recent Studies

Program / Report	Target Date	Cumulative MW Installed	Total Electricity Generation	% of Total Electricity Generation
SHINE (with ASAP)	2025	282 GW	520,646 GWh	10.7%
2004 SEIA PV Roadmap	2030	200 GW	360,000 GWh	7% of total generation and "50% of new U.S. generation" by 2030
A Solar Grand Plan: Scientific American	2020 & 2050	84 GW by 2020 (PV & CSP) 3,000 GW by 2050 (PV & CSP)	NA	69% of U.S. electricity and 35% of total energy by 2050

- Solar can offer a price hedge against volatile and increasing costs for fossil-fuel resources like coal and natural gas. Once installed, solar provides stable fixed prices to utilities and users.
- Solar is becoming a cost-effective peak generation resource.
- Within a decade, solar power will be cost-competitive in most regions of the U.S. on a kilowatt-hour (Kwh) basis.
- Compared to coal, nuclear, and gas-fired power plants, solar has no fuel costs, low maintenance costs, and will provide credits, rather than costs, in a carbon-regulated world.
- Solar PV is a widely available resource, suited to most locales around the nation.
- Solar PV can ease congestion in regions where energy demands have stressed the grid.

Comparative Power Costs for Utility Deployment

Energy Type	Coal	Natural Gas Combined Cycle	Geothermal	Wind	Concentrating Solar Power (CSP)	Nuclear	Solar PV
Capital Costs per 1000 MW (U.S. 2007 Average)	$1 billion - $3 billion	$1 billion - $2 billion	$1.2 billion - $2 billion	$1.5 billion - $2 billion	$3 billion - $4 billion	$3 billion - $7 billion	$5 billion - $7 billion
Fuel Costs	Yes	Yes	No	No	No	Yes	No
Subject to C02 Regulations	Yes	Yes	No	No	No	No	No

Source: Clean Edge, 2008

Comparing Crystalline Silicon with Thin-Film / Low-Price, Bulk-Purchase Crystalline - PV Price Reduction 2007-2025

Year	Crystalline Silicon PV - Average Price per Peak Watt Installed	Crystalline Silicon PV - Range kWh Cost	Thin-Film and Low-Price, Bulk-Purchase Crystalline PV - Average Price per Peak Watt Installed	Thin-Film and Low-Price, Bulk-Purchase Crystalline - Range kWh Cost
2007	$7.00	19¢—32¢	$5.50	15¢—25¢
2008	$6.50	17¢—30¢	$5.10	14¢—23¢
2009	$6.03	16¢—28¢	$4.74	13¢—22¢
2010	$5.59	15¢—26¢	$4.39	12¢—20¢
2011	$5.19	14¢—24¢	$4.08	11¢—19¢
2012	$4.82	14¢—24¢	$3.78	10¢—17¢
2013	$4.47	12¢—20¢	$3.51	9¢—16¢
2014	$4.15	11¢—19¢	$3.26	9¢—15¢
2015	$3.85	10¢—18¢	$3.02	8¢—14¢
2016	$3.57	10¢—16¢	$2.81	8¢—13¢
2017	$3.31	9¢—15¢	$2.60	7¢—12¢
2018	$3.08	8¢—14¢	$2.42	6¢—11¢
2019	$2.85	8¢—13¢	$2.24	6¢—10¢
2020	$2.65	7¢—12¢	$2.08	6¢—10¢
2021	$2.46	7¢—11¢	$1.93	5¢—9¢
2022	$2.28	6¢—10¢	$1.79	5¢—8¢
2023	$2.12	6¢—10¢	$1.66	4¢—8¢
2024	$1.96	5¢—9¢	$1.54	4¢—7¢
2025	$1.82	5¢—8¢	$1.43	4¢—7¢

- Utilities can use solar to meet state, and potentially national, Renewable Portfolio Standard (RPS) requirements.

- Solar is a domestically available, carbon-free energy source.

This report, the Utility Solar Assessment (U.S.A) Study, provides a robust roadmap for electric utilities to accelerate the growth of solar energy. Our research incorporates the latest technology, market, and policy breakthroughs, and interviews with more than 30 key industry players and experts, to show how a coordinated effort among regulators, the solar industry, and utilities can enable solar to reach 10 percent of U.S. electricity generation by 2025.

We aren't alone in this assessment. The Solar Electric Industries Association (SEIA) trade group, in its Solar PV Roadmap issued in 2004, stated that solar could provide 50% of new U.S. generation by 2030, a projected 7 percent of total electricity at that time. In our 2005 report, SHINE, we highlighted a plan that would enable the U.S. to get ten percent of its electricity from PV sources alone by 2025 via a concerted effort by the federal government to encourage increased investment in and deployment of solar power. Some people have gone even further. In their widely cited *Scientific American* article, "A Solar Grand Plan" published in January 2008, authors Ken Zweibel, James Mason, and Vasilis Fthenakis outline how the U.S. could get 69% of its electricity from solar by 2050.

Getting to Cost Parity

Capital costs for conventional energy sources are, in many cases, not dissimilar to the capital costs for solar PV. As solar prices decline and the capital costs for coal, natural gas, and nuclear plants increase, we are reaching a crossover point. Solar also has a number of additional advantages when comparing it with a comprehensive view of the expense of conventional resources, including no "fuel" costs, low operating and maintenance costs, zero on-site emissions, and broad public approval.

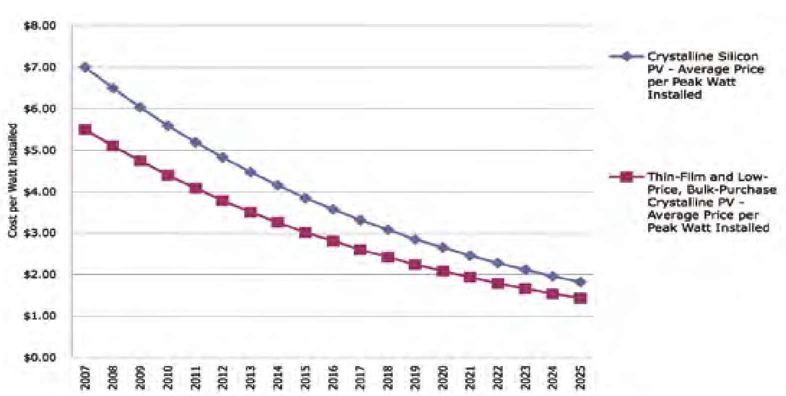
Equally important, we project that solar PV will reach cost parity with conventional retail electricity pricing, on a straight kWh rate basis, throughout much of the U.S. by around 2015.

We project that the cost for crystalline silicon PV systems will drop from an average of $7 peak watt (19-32 cents kWh) today to approximately $3.00 (8-14 cents kWh) a decade from now. Thin-film PV systems and low-price, bulk-purchased crystalline PV systems are projected to drop from around $5.50 per peak watt today (15-25 cents kWh) to $3.00 peak watt in 2015 (8-14 cents kWh) and less than $1.50 peak watt (4-7 cents kWh) in 2025. In our utility-scale concentrating solar power (CSP) calculations we show an average price of $3.50 per watt (around 18 cents per kWh) in 2007 declining to around $1 peak watt (approximately 5 cents per kWh) in 2025.

Recent industry developments, particularly large-scale solar deployment plans announced by major utilities, support the price projections outlined in this report. As utilities and others scale up their solar efforts, they are reaching economies of scale unlike anything we've seen in the past. Southern California Edison's recently announced 250 MW rooftop installation program is the perfect case in point. SCE could reach the $3.50 peak watt installed price as early as 2010. This supports the case that such price points are achievable and that some players may even get there sooner.

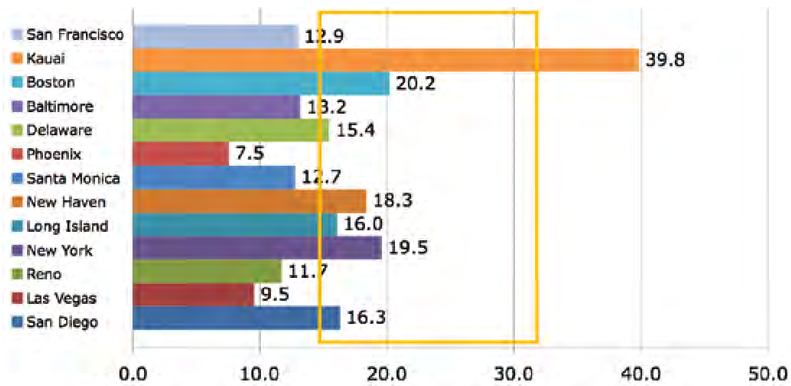
It is also possible that one or more disruptive players could enter the market at a scale and price points as early as 2010 that could achieve solar cost parity even sooner. While this report doesn't specifically map this more accelerated scenario, utilities and policy makers should keep a watch out for even more favorable solar cost comparisons

Comparing Crystalline Silicon with Thin-Film / Low-Price, Bulk-Purchase Crystaline PV Price Reduction 2007-2025



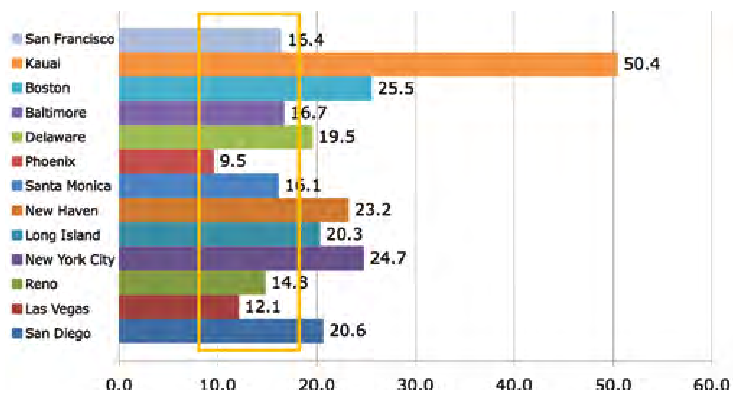
Source: Clean Edge, 2008

Comparing U.S. Average U.S. Retail Electricity Rates with PV, 2007 (Cents/kWh)



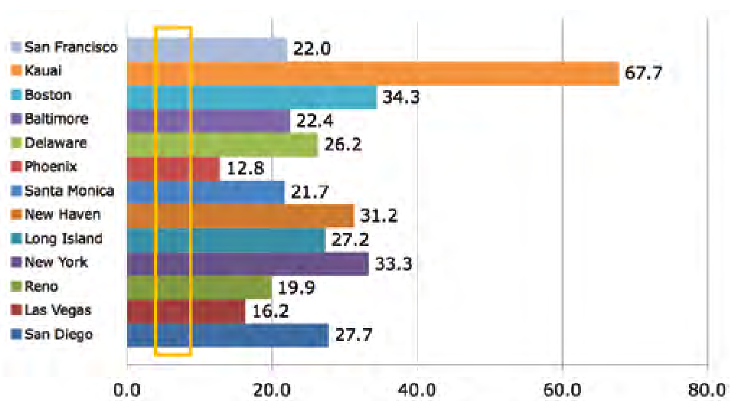
Source: Clean Edge, 2008

Comparing U.S. Average U.S. Retail Electricity Rates with PV, 2015 (Cents/kWh)



Source: Clean Edge, 2008

Comparing U.S. Average U.S. Retail Electricity Rates with PV, 2025 (Cents/kWh)



Source: Clean Edge, 2008

than discussed by this report.

In short, whether the market follows the trajectory mapped in this report, or a disruptive player forces an even more aggressive scenario, solar cost parity is within the planning horizon of most every utility in the U.S.

Based on projected trends in declining costs of solar and increasing retail electricity rates, the following tables show how solar PV—beginning to reach cost competitiveness in just a few U.S. regional markets today—will be cheaper than standard grid power in most U.S. markets by 2025.

What Investment is Required to Reach 10 Percent Solar?

The investment required to reach 10 percent solar in the U.S. by 2025 won't be inexpensive. But the investement is definitely within the range of what utilities and other energy consumers would have to pay for more traditional and polluting sources such as coal- and natural-gas-fired plants, and we believe, considerably less than the price tag for a similar amount of nuclear power or coal power (in a carbon-regulated environment).

Our figures show that the investment will be between $400 billion and $500 billion to install the required PV and an additional $50 billion to $60 billion to install the required CSP to reach the 10 percent target. That's a total projected price tag of between $450 billion and $560 billion between now and 2025, an average of $26 billion to $33 billion per year.

It's important to note that these are not investments in R&D, but in actual deployment of these technologies. In other words, they represent procurement and installation capital costs paid for by utilities, businesses, residences, governments, and others installing solar systems. In this scenario, solar would represent more than half of all new generating capacity installed in the nation by 2025.

To put the projected investment in perspective, the Edison Electric Institute estimates that the U.S. electric utility industry spent more than $70 billion on new power plants and new transmission and distribution investments in 2007 alone. Conservatively assuming similar expenditures between now and 2025 (and most experts believe those annual costs will increase), we're talking about a total investment of more than $1.2 trillion—roughly double to triple our projected investment for solar in the U.S.

Given the appropriate tools and incentives, we believe utilities and their ratepayers could cover a significant portion of the solar investments required to reach the 10 percent target, with the balance picked up by governments (through installations of systems on their own facilities), direct purchasers/installers of solar power, and others.

Nexus Point: Solar and Utilities

In our research, we set out to answer a range of questions, including:

Glossary of Terms

Balance of System: Refers to components of a PV system beyond the cells themselves, including inverters, interconnection devices to the grid, two-way meters, and racking systems.

Baseload: The minimum level of demand on an electrical supply system over 24 hours.

CSP: Utility-scale concentrating solar power—large solar facilities which use mirrors or lenses to concentrate solar energy to heat fluids to power turbines to make electricity. Also called high-temperature solar thermal, CSP requires long days of direct sunlight without clouds and is best suited for desert locations.

Feed-In Laws: Allow solar customers to sell excess power that they have generated back into the grid.

Net Metering: Allows for measuring the difference between the electricity supplied by a utility and the electricity generated by a customer-generator, which is fed back to the utility over the applicable billing period. The meter is allowed to register the flow of electricity in both directions, and only the net amount is billed (or credited) each month.

Peaker Plant: A power plant that can be more easily turned on and off in order to accommodate periods of high demand, such as hot summer afternoon days when there is widespread use of air conditioners.

Peak Watt: The number of watts output when a solar panel is illuminated under standard test conditions.

PV: Solar photovoltaics—direct generation of electricity from sunlight by using solar cells packaged in photovoltaic modules. PV modules can be placed on rooftops or adjacent to buildings for distributed power, or organized into arrays for large-scale deployment in solar "farms" or solar "parks."

Renewable Portfolio Standards: Requires that all energy marketers have to have a certain percentage of renewables in their electricity mix.

System Benefit Charges (Public Benefit Funds): Like telephone and airline fees that support building and upgrading the entire network, SBC are fees placed on electricity companies or customers to fund renewable energy projects with public money.

Time-of-Use Rates: Real-time pricing reflects demand. When demand is greatest (usually between noon and 6 p.m.), pricing is the highest.

- What factors have led to utilities' decisions to implement—or not implement—supportive solar policies and programs?
- What are the major barriers deterring utilities from deploying solar power today?
- What are leading examples of utilities implementing solar into their service areas, both inside and outside the U.S?
- What business models are working most effectively for a range of utilities?
- How is solar being used to offset peak-load issues and what is the role of distributed solar in the utility peak-load management toolkit?
- What's needed in the areas of technology, policy, and finance to accelerate solar growth by utilities?
- What significant new business opportunities exist for solar manufacturers, developers, and system integrators that can serve the utility markets?
- How much solar is likely to be deployed by utilities in the U.S. under a business-as-usual scenario versus a system that aggressively embraces and incentivizes solar opportunities?
- What would an aggressive and effective solar strategy look like with significantly different price signals—e.g., low solar prices and higher natural gas and coal prices?

Unquestionably, utilities have a critical and central role to play in the adoption of solar power. While some industry experts we interviewed felt that solar could continue on its current path without active utility involvement, most concluded that the utility sector's active participation will be required to bring solar "to scale." To do this, the solar industry, utilities, policymakers, and others will need to work together to make the wide-scale deployment of solar power a reality. As one industry insider explained: "To really scale [solar] it's all about utilities."

Increased Momentum for Utility Deployment of Solar Options

In earlier Solar Catalyst Group reports, we discussed the need for utility involvement and started to look at the regulatory frameworks that might make this possible. It was, admittedly, premature. Five years ago, very few solar industry professionals, utilities, or regulators, were talking openly about significant use of solar by utilities. Today, different strategies of how utilities could deploy a range of solar options, from distributed photovoltaics to large-scale concentrating solar power, are gaining significant interest.

In the past year alone, we've seen a sea change in the ways utilities and others are viewing the solar opportunity. Among these developments are:

- Dozens of major utilities—including FPL (Florida), PG&E (California), Austin Energy (Texas), and Duke Energy (North Carolina, Ohio, Indiana, and Kentucky)—have embraced solar. Although their plans are still evolving, the mere fact that they are taking action represents a significant departure from business as usual.

- In 2007, the use of silicon by the world's solar companies exceeded silicon use by the semiconductor industry for the first time. This historic shift, from solar companies surviving off the scraps of the chip industry at the beginning of the decade to now being the principal user of raw silicon material, initially led to significant silicon supply disruptions for solar PV manufacturing. The price of processed silicon feedstock increased dramatically as manufacturers struggled to keep up with demand. Now, supply and demand are coming back into balance and prices are beginning to decrease.

- Thin-film players such as First Solar are delivering non-silicon solar cells at promised lower prices, with some installed systems now at $5 per peak watt (including modules, balance of system, and installation costs). Other thin-film players such as Miasolé and Nanosolar are vying to similarly deliver low-cost, non-silicon alternatives and raising hundreds of millions of dollars from investors toward that end.

- After more than two decades of relative inactivity, utility-scale concentrating solar power (CSP) is back stronger than ever, with a range of investors, technology companies, and utilities looking at how to harness the solar irradiance in deserts around the world. In 2007, more than 70 MW of new CSP was installed worldwide, and hundreds of additional megawatts are under development.

- Google has set an ambitious goal of making renewables less expensive than coal-fired power generation. One of its key initiatives in achieving this goal: the development of cost-effective, next-generation CSP.

Given this momentum at the local, regional, national, and global levels, and the inevitability of a price on carbon in the U.S. in coming years, utilities have reached a unique moment to figure out how to cross the chasm toward rapid scale-up of solar technologies as a key grid-tied energy source.

The Road from Here

Meaningful contributions from solar will require decisive and aggressive action on the part of all parties:

- Regulators will need to remove the regulatory and technical roadblocks and create a stable and consistent environment.

Key Solar Stakeholders and Actions

Solar Companies	Utilities	Regulators
Bring installed solar systems costs to $3 per peak watt by 2018	Take advantage of the unique value of solar for peak generation	Decouple revenue from power consumption
Improve silicon cell efficiency and performance	Better serve customers in grid-constrained areas and “at the edge”	Give utilities the ability to ‘rate-base’ solar
Develop new low-silicon and non-silicon alternatives such as thin film and nanotechnologies	Implement solar as part of demand response systems and build-out of the smart grid	Establish open standards for production, time of use, interconnection, net metering, and smart grid technologies
Streamline installations and make solar a truly plug-and-play technology	Use solar as a price hedge against fuel cost increases and potential carbon costs	Institute a national RPS with a solar carve-out
Ramp up concentrating solutions—including CSP and potentially CPV—for central generation and to drive down costs	Adapt to the new power market with new business models	Create a federal carbon cap-and-trade system
Work with utilities and regulators to develop open standards for net interconnect, two-way flow of electrons, etc.	Harness the power of the desert	Pass a long-term extension of investment and production tax credits for solar and other renewables—and extend them to utilities
	Help train the next wave of workers	

- Utilities will need to fully integrate solar into their long-term business plans and encourage consumers to participate.
- Solar manufacturers will need to make the technology more cost-effective and substantially increase production.

The preceeding table briefly summarizes the actions, detailed throughout the report, required from the three most critical stakeholder groups.

This report outlines the major actions required by each of the key stakeholders to realize the goal of 10 percent solar by 2025. We discuss what it will take to put these strategies into practice, and we demonstrate how utilities have much to gain by being pro-active players in accelerating the growth and deployment of the solar energy market.

For the first time in history, a confluence of forces is coming together—solar technology developments, conventional energy price increases, aging transmission and distribution infrastructure, climate concerns, security issues, and others—that bring the dramatic worldwide growth of solar increasingly to center stage. In this rapidly changing energy landscape, the 10 percent goal is truly within reach.

About the U.S.A Study

Clean Edge, Inc., a research and publishing firm focused on clean technologies, was engaged by Co-op America on behalf of its Solar Catalyst Program to prepare the U.S.A study. As background, this report builds on earlier work done by Clean Edge and Co-op America. Earlier reports in the series include the Solar High-Impact National Energy (SHINE) Project (2005); the Solar Opportunity Assessment Report (2003) and Bringing Solar To Scale: A Proposal to Enhance California's Energy, Environmental, and Economic Security (2002).

Report Methodology:

For the U.S.A Study, Clean Edge employed a comprehensive research methodology which included external interviews and primary and secondary research. We applied:

- Proprietary Clean Edge data—Solar PV market size, cost and pricing data, growth projections, and other key market data
- Expert interviews—Interviewees represented a range of interests including utilities, government agencies, financial institutions, and the solar industry
- Online research of companies and utilities, third-party data, etc.

Interview participants included:

- Jill Cliburn, Electric SUN (Analyst)
- Dan Kammen, UC Berkeley (Analyst)
- Paul Maycock, Editor, PV News (Analyst)
- Chris Robertson, Electric SUN (Analyst)
- Virinder Singh, Energy Consultant (Analyst)
- Travis Bradford, Co-founder of Prometheus Institute (Association)
- Mike Eckhart, American Council on Renewable Energy (ACORE) (Association)
- Julia Hamm, Solar Electric Power Association (Association)
- JP Ross, Vote Solar (Association)
- John White, CEERT (Association)
- David Hawkins, CAISO (Government)
- Sarah Kurtz , NREL (Government)
- Art Rosenfeld, California Energy Commissioner (Government)
- Peter West, Energy Trust of Oregon (Government)
- Julie Blunden, SunPower (Industry & Finance)
- Peter Corsell, GridPoint (Industry & Finance)
- Ron Kenedi, Sharp Solar Energy Solutions Group (Industry & Finance)
- Vinod Khosla, Khosla Ventures (Industry & Finance)
- Erika Morgan, CitizenRE (Industry & Finance)
- Jigar Shah, SunEdison (Industry & Finance)
- Scott Sklar, Stella Group (Industry & Finance)
- Tom Starrs, PPM Energy (Industry & Finance)
- Stuart Valentine, Progressive Asset Management (Industry & Finance)
- Andrew Wilson, Intel Corp. (Industry & Finance)
- Herb Hayden, Pinnacle West (Utility)
- Karl Knapp, City of Palo Alto (Utility)
- Hal LaFlash, Pacific Gas & Electric (Utility)
- Pamela Lesh, Portland General Electric (Utility)
- John McCawley, Excelon-PECO (Utility)
- Ron Miller, Xcel Energy (Utility)
- David Mohler, VP and Chief Technology Officer, Duke Energy (Utility)
- Greg Nelson, PNM (Utility)

KEY INTERVIEW FINDINGS

In just the past year, a number of utilities and solar companies have announced aggressive programs to deploy large-scale solar power projects, including Southern California Edison's plan to install 250 MW of distributed solar PV, Duke Energy's stated goal of investing $100 million in rooftop solar, and Pacific Gas & Electric's announcements to invest in thousands of MW of concentrating solar power in California's deserts. While these players are still in the vanguard, a number of other utilities are looking to join them in building up and deploying solar resources. Our research indicates that while it will take a concerted effort among a range of stakeholders to reach 10 percent solar electrification in the U.S. by 2025, it's not outside the realm of possibility.

To better understand both the opportunities and challenges facing the solar industry, regulators, and utilities in reaching the 10 percent target, below are 12 brief summaries (and supporting quotes) of key findings from our research process. These represent the view of some of the brightest minds tracking and evaluating the solar opportunity as it relates to utilities and broader markets. More extensive discussions of each of these findings are found throughout this report and provide the building blocks for our analysis.

1. Solar resources are ubiquitous. One of the key findings of the interview process is a rather simple conclusion: the sun shines everywhere. Solar PV, unlike many other renewable (and non-renewable) technologies, can be deployed just about anywhere. It's not bound to specific regions. The best evidence of this: among nations, the world's largest producer of solar power is cool, often-cloudy Germany.

"Almost everyone (anywhere in the country) can use solar PV as part of their options—which is not true of hydro, or wind, or geothermal, or wave. Think of it this way: if Washington State can have a robust solar program, then anyone can."

2. Solar can provide utilities with a peak-power hedge. Solar can help utilities mitigate against high-cost peak power. In many regions of the U.S., the peak demand times for electricity, particularly hot summer afternoons, coincides closely, although not identically, with the output from solar PV and CSP.

"Solar is great way to offset peak load issues—a way for utilities to hedge against needing to buy peak power."

"We need to think about solar more creatively with regard to peak—paired with wind, around power plants, etc. Look at where the grid is constrained and put solar PV there."

Solar in the News

Solar increasingly is the domain of multi-billion-dollar financial and corporate institutions. Below is a sampling of early-2008 headlines that demonstrate how big solar has become, and hints at where it is heading.

- *eSolar Raises $130 Million for Pre-Fabricated Utility-Scale Solar Thermal Power Plants*
- *PGE Announces Landmark Deal for up to 900 MW of Solar Thermal Energy*
- *Sharp Announces Plan to build 1000 MW Thin-Film Plant in Japan*
- *Duke Energy to Invest $100M in Roof-Top Solar*
- *Solar Cell Production Jumps 50 Percent in 2007*
- *Morgan Stanley Launches $200 Million Solar Development Fund*
- *Southern California Edison Launches Nation's Largest Solar Panel Installation Program—Up to 250 MW*
- *OptiSolar Sets Sights on World's Largest Solar Farm*
- *Abengoa to Build 280MW Concentrating Solar Power Plant in Arizona*
- *SunPower Signs 3GW Polysilicon Supply Contract with Chinese Company*

3. Environment and carbon are becoming central drivers. The utility landscape is changing. To compete in the future, utilities are realizing that they need to adapt to emerging environmental and carbon regulations—and reinvent their businesses in the process. A pending price on carbon, which many experts see coming at the regional level in the next year or two, and nationally with five years, will have a significant impact on the bottom lines of utilities.

"If you go back 100 years and look at the social compact with the utilities—the original idea was that utilities got a monopoly in exchange for providing cheap, reliable, and ubiquitous electricity. But, these things were achieved at a cost: pollution and inefficiency. We are now asking them to add clean and efficient to the list of requirements."

"In a carbon-constrained environment the relative cost will come down dramatically for PV. CSP will drop below Nat Gas levelized pricing within ten years."

4. Solar power will soon reach price parity with conventional sources. Solar needs to scale up and come down in price to be of interest to more utility players. Utilities themselves can play a role in this process, but the solar industry needs to better deliver on its low-cost promise. A number of solar manufacturers and system integrators are working on this, and recent announcements point to solar reaching price parity with a range of conventional energy sources sometime in the next 3-7 years.

"The price point that's going to make a real difference is getting solar installed on the order of $3 per peak watt. We need to get to that level to see the pricing work. At $3 per peak watt you're definitely competitive with a natural-gas peaker plant."

"The cost of solar is coming down and pretty rapidly right now. And while the cost of PV is coming down, the cost of [fossil fueled] central stations is increasing. So pretty soon we'll be at a place where the costs intersect, where solar will be competitive with new coal and nuclear."

5. Utility participation is critical to solar success. A majority of survey respondents believe that utilities are in the best position to accelerate the growth of solar—and that without their participation the industry is doomed to the margins. In their view, a robust solar future is impossible without active utility involvement. This conclusion underlies the foundation for this report: that utility involvement is integral, not ancillary, to growing a mainstream and thriving solar industry in the United States.

"I think anyone that doesn't understand the centrality of utilities to solar generation is out to lunch. They are regulated monopolies. You don't

want to disintermediate the customer and the utility. Sure, you can get Costco and Whole Foods to put solar on their rooftops—but you'll only get to 1-2 percent penetration. To really scale it's all about utilities. (The solar industry) needs to work with the utilities to make this work."

"Going around the utilities isn't going to scale—it won't make a dent."

6. Smart grid deployment is imperative. The deployment of the smart grid—the integration of information technology into the electric grid in a way that allows more control by both utilities and customers over how and when energy is generated, stored, and used—is essential to the rapid scale-up of solar. But utilities need to understand how the smart grid and solar fit into their development plans and have the regulatory support and tools to deliver new products and services. The smart grid will also be essential to the mass deployment of other renewable sources, such as wind, and for broad-based efficiency and conservation efforts.

"Electric utilities in general don't have a clear pathway to understanding how they make money in the next generation grid—in the same way that AT&T fought the telephone deregulation of 90's, utilities don't have appreciation for next-generation grid value for customers—and more importantly, for themselves—smart meters, demand side, storage. They can't see how it's good for the company, so they fight."

7. Distributed solar PV offers utilities unique advantages. Distributed assets can provide a range of advantages to utilities, including cost reductions and savings around centralized generation and transmission and distribution. Utilities are just now awakening to these opportunities.

"The cost of distributed solar PV is actually less than the cost of marginal generation, transmission and distribution. Most utilities just haven't figured that out yet."

"Everything about solar [distributed] has to do with transmission and distribution—we should NOT be looking at cost of generation—and yet that's what everybody looks at."

"Capital costs for large fossil fuel facilities are very expensive. But solar can be done in small chunks. This can help manage capital investments."

8. The solar industry needs to cooperate with utilities. Solar companies and other stakeholders need to work with utilities, not oppose or blame them for past missteps or mistakes. Solar advocates need to move beyond confrontational approaches of the past, and toward building solutions for all stakeholders.

“This is a time when we [industry] need to be collaborative with utilities.”

9. Standards must be implemented. Standards (around net metering, distributed generation assets, feed-in tariffs, and other elements) are critical to the future growth of solar. These standards, like those that have enabled the growth of the Internet, need to be “open” rather than proprietary, and supported by utilities, industry, and regulators. Without standards, distributed energy sources and the smart grid will not succeed.

”The smart grid [with open standards] is like the Internet—it opens up a world of new business plans and opportunities for the utility.”

10. It’s not just PV, but also CSP. Much of the attention has been on solar PV (because it’s distributed and deployable just about anywhere), but concentrating solar power offers significant opportunity in desert and outlying regions.

“Two years ago, everybody thought CSP was a joke—now it’s getting really serious attention.”

“Long-term, CSP offers a promising solution for centralized solar.”

11. Utilities need to be able to integrate solar expenditures into their rate base—and to be able to take a full life-cycle cost approach. Utilities are used to spending a lot on infrastructure–so the cost of solar doesn’t necessarily scare them off. They just need regulatory approval to recover their expenditures. They also need to be able to compare the full life cycle of a solar installation to building new capacity for coal, natural gas, or nuclear generation. Solar power’s zero fuel cost and very low maintenance expense helps its full life cycle costs compare favorably.

“To a utility $2 billion is not a lot of money—it’s just one plant. Money isn’t the issue, capturing the benefit of the investment is!”

“From a distributed perspective, we want to give the utility the ability to put solar on the roof, own it, and rate-base it.”

“It all comes down to capacity and economic use of that capacity... instead of building a $2 billion coal plant I want to put $2 billion into smart grid, clean distributed generation, and storage—and then make the ‘negawatts’ and clean distributed generation count by ratepayers.”

12. Utilities have a unique relationship with customers. Utilities are in a unique position to serve customers with solar solutions. For example, they already have customers' trust and they touch them on a daily basis.

"People have a relationship with their utility—and recognize that they are reliable and safe. The lights are almost always on. They're out in the rain repairing stuff. So those are the people who can sell solar to the next market. They are so well known. It takes a long time and a lot of money to build a reputation like that."

As conventional electricity sources such as coal, natural gas, and nuclear become increasingly expensive and solar technologies continue their inexorable price decline, the promise of a solar future beckons. For the first time in modern history, the price of solar-generated electricity is within striking distance of conventional energy sources for a wide range of applications. Already, solar power can compete in regions with high electricity rates and with favorable incentives. It can compete effectively for peak power production, in grid-constrained territories, and for applications that are off the grid.

As the below demonstrates, capital costs for conventional energy sources are, in many cases, not dissimilar to the capital costs for solar PV. As solar prices decline, and the capital costs for coal, natural gas, and nuclear plants increase, we are reaching a crossover point. And it's not just about capital costs. As we point out in the Getting To Cost Parity section, solar has a number of additional advantages when comparing it with conventional resources, including no "fuel" costs, low operating and maintenance costs, and zero on-site emissions. Equally important, we project that solar will reach cost parity with conventional electricity pricing, throughout much of the U.S., sometime by around 2015.

Our research also shows that a transition from increasingly expensive, carbon-intensive electricity generation sources toward carbon-free energy sources is well under way in the U.S. Coal, which represented 67 percent of electricity generation in 1949, declined to less than 49 percent in 2007. Petroleum, which represented 14.2 percent of U.S. electricity generation in 1949, declined to around 1 percent in 2007. Natural gas, the cleanest of the fossil-fuel technologies, has remained relatively constant at around 20 percent of U.S. electricity generation between 1949 and 2007.

Carbon-free sources have, to date, been primarily the domain of nuclear power and hydroelectric, representing approximately 20 percent and 6 percent of total electricity generation respectively in 2007. But now, wind power and solar power are projected

Costs for New Plants

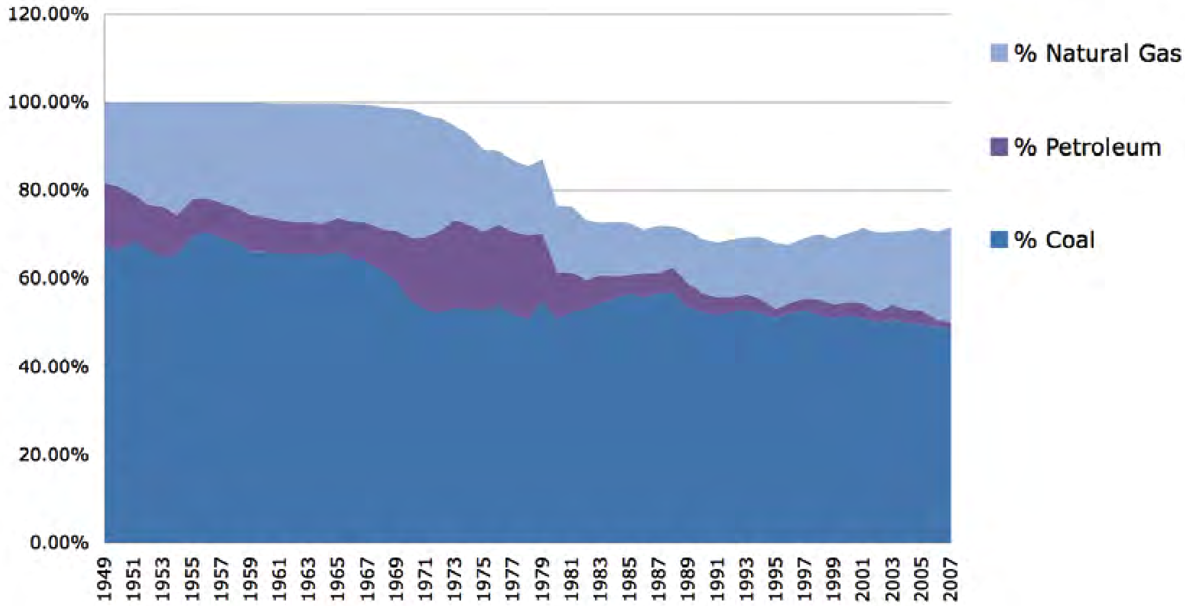
The table below shows the average estimated costs to build power plants fueled by different energy sources. Whereas coal, nuclear, and geothermal plants are able to provide baseload power, solar and wind are variable resources. Solar can compete with higher peak-power rates or as a distributed resource where it competes not only with generation but also transmission and distribution costs. Solar, with storage, can also contribute to baseload power needs. It is also important to note that solar, wind, and geothermal do not have "fuel" costs, since they get their power from the sun, wind, and the Earth's heat—free of charge.

Comparative Power Costs for Utility Deployment

Energy Type	Coal	Natural Gas Combined Cycle	Geothermal	Wind	Concentrating Solar Power (CSP)	Nuclear	Solar PV
Capital Costs per 1000 MW (U.S. 2007 Average)	$1 billion - $3 billion	$1 billion - $2 billion	$1.2 billion - $2 billion	$1.5 billion - $2 billion	$3 billion - $4 billion	$3 billion -$7 billion	$5 billion - $7 billion
Fuel Costs	Yes	Yes	No	No	No	Yes	No
Subject to C02 Regulations	Yes	Yes	No	No	No	No	No

Source: Clean Edge, 2008

Fossil Fuels as a % of Total U.S. Electricity Generation 1949-2007



Annual Energy Outlook 2008, EIA, December 2007

to have an increasing impact on total U.S. electricity generation. Over the next two to three decades, we see these safe, non-polluting, carbon-free energy sources, along with conservation, efficiency, and smart-grid technologies, taking center stage in the U.S.

According to a DOE report issued in May 2008, wind power, which currently provides approximately 1 percent of total U.S. electricity generation, could provide up to 20 percent of U.S. electricity needs by 2030. The report, entitled 20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply, examined ways that the four biggest barriers to such a massive scale-up of wind power—transmission, siting, manufacturing, and technology—can be overcome. Wind is currently providing significant levels of electricity generation already in Denmark (approx. 20 percent), Spain (10 percent), and Germany (7 percent). (The report is available at www.20percentwind.org).

We believe a similar trend will take place in the conversion of sunlight into electricity. While the U.S. currently gets less than one tenth of one percent of its electricity from solar power, our research shows that solar offers the opportunity to provide a significant portion of the nation's electricity supply for both distributed and centralized generation by 2025—up to ten percent from a combination of solar PV and CSP. As storage and smart grid technologies evolve, we see the potential for solar to provide an even larger percentage of U.S electricity needs.

We aren't alone in this assessment. SEIA, in its Solar PV Roadmap issued in 2004,

Projected U.S. Solar Installations as a Percent of Total Electricity Generation—Recent Studies

Program / Report	Target Date	Cumulative MW Installed	Total Electricity Generation	% Of total Electricity Generation
SHINE (with ASAP)	2025	282 GW	520,646 GWh	10.7%
2004 SEIA PV Roadmap	2030	200 GW	360,000 GWh	7% of total generation and "50% of new U.S. generation" by 2030
A Solar Grand Plan: Scientific American	2020 & 2050	84 GW by 2020 (PV & CSP) 3,000 GW by 2050 (PV & CSP)	NA	69% of U.S.'s electricity and 35% of total energy by 2050

Source: Clean Edge, 2008

stated that solar could provide "50% of new U.S. generation" by 2030, a projected 7 percent of total electricity at that time. In our earlier report, SHINE, we highlighted a plan that would enable the U.S. to get ten percent of its electricity from PV sources alone by 2025 via a concerted effort by the Federal government to encourage increased investment in and deployment of solar power. Some people have gone even further. In their widely cited Scientific American article, "A Solar Grand Plan" published in January 2008, authors Ken Zweibel, James Mason, and Vasilis Fthenakis outline how the U.S. could get 69% of its electricity from solar by 2050.

What is the pathway for solar to reach 10 percent of total U.S. electricity generation by 2025? To reach reliable figures we've looked at a number of variables. For example, we:

- Assessed the total projected electricity generation needs for the U.S., on an annual basis, between now and 2025 using 2008 EIA projections.
- Calculated likely reductions in projected generation requirements by applying energy efficiency measures outlined in the Energy Independence and Security Act of 2007.
- Examined historic growth rates for solar PV and applied aggressive, though achievable, growth rates for PV installations in the U.S. through 2025. In this calculation, we applied a compounded annual growth rate (CAGR) of 33 percent for solar PV between 2007 and 2025. At the end of this nearly two-decade period we find solar PV contributing 8 percent of total U.S. electricity generation.
- Analyzed current and planned CSP projects in the U.S. and calculated an accelerated, but within reason, projection for growth through 2025. By applying a 28 percent compound annual growth rate (CAGR) from 2007 through 2025, we find CSP accounting for 2 percent of total U.S. electricity.

While both solar PV and CSP, as noted above, would require aggressive growth rates to reach the goal of ten percent by 2025, such growth isn't without precedent.

U.S. Solar Installed Capacity (CSP and PV)—Getting to 10 Percent

Year	Cumulative Capacity CSP + PV (MW)	Total Annual Generation Combined PV and CSP (MWh)	Total Projected Annual U.S. Electricity Generation / Demand, All Sources (MWh)	CSP and PV Share of Total U.S. Electricity Generation
2007	1,284	2,513,665	4,119,235,230	0.06%
2010	3,027	5,849,916	4,219,402,150	0.14%
2015	15,184	29,385,504	4,397,329,160	0.67%
2020	69,260	133,345,983	4,608,068,490	2.89%
2025	255,646	485,723,159	4,858,105,640	10.00%

Source: Clean Edge, 2008

Solar Photovoltaics (PV)

The solar PV industry has been expanding by more than 40 percent annually since the beginning of the decade, and many analysts believe that it can continue to expand forward at similar rates.

While such growth rates are not sustainable indefinitely, previous technologies have demonstrated that such growth can be achieved over a 20-year period. The personal computer industry, for example, experienced a CAGR of 38 percent from 1980 through 2000, according to the Computer Industry Almanac. In the clean-energy sector, the U.S. wind power industry has demonstrated a CAGR of 22 percent between 1990 and 2007. The cell phone industry, Internet, and other high-tech industries have sustained similar growth rates for sustained periods.

We believe that the solar PV industry (which is built on many of the same semiconductor platforms and breakthroughs as the computer and chip industry), could support double-digit growth rates for the timeframes we're outlining in this report.

In 2007, there were more than 230 MW of solar PV installed in the U.S. As noted above, we applied double-digit growth rates between 2007 and 2025 (on average a 33 percent CAGR). In this scenario, we get to 613 MW installed in 2010; 3066 MW in 2015; 13,746 MW installed in 2020; and nearly 50,000 MW in 2025.

While these are aggressive growth rates, we believe they are achievable. For example, the 2015 projection of 3,066 MW of solar installed in the U.S. is roughly equivalent to the total amount of solar PV installed globally through 2007.

The 13,746 MW installation projection for 2020 would represent approximately a third of total projected global installations in that year. By 2025, solar PV would have to reach 49,467 MW to provide 8 percent of projected electricity needs. While this goal is the most aggressive and would require a significant scale-up in global manufacturing to meet such demand, it is not outside the realm of possibility. Indeed, considering

U.S. Photovoltaic Installations, Generation (Current and Projected)

Year	Annual PV Installation (MW)	U.S. Cumulative Solar PV Installed (MW)	Annual PV Electricity Production at Capacity (MWh)	PV Share of Total U.S. Electricity Generation
2007	233	865	1,591,865	0.04%
2010	613	2,244	4,127,316	0.10%
2015	3,066	11,154	20,518,510	0.47%
2020	13,746	52,789	97,110,018	2.11%
2025	49,467	212,814	391,492,253	8.06%

historic growth rates and the potential impact of the U.S. policy and utility programs outlined in this report, such a figure is within reach.

Utility-Scale Concentrating Solar Power (CSP)

Through 2025, we project CSP expanding by approximately 28 percent per year on average in the U.S. At this growth rate, we would see growth going from 64 MW installed in 2007 to more than 6,000 MW in 2025. Our projections show a total cumulative installed CSP base of 4,000 MW in 2015, the same amount that the Western Governors' Association has targeted for development in the American Southwest by that year. To put this number in perspective, the U.S. installed more than 5,000 MW of wind in 2007. In total, the Western Governors' Association projects that there are more than 200,000 MW (200 GW) of potential CSP generation capacity in the U.S. West. Our report shows that we'd need to develop around 40 GW of this capacity to reach 2 percent of U.S. total generation in 2025.

The Current Scale-Up

The numbers outlined in this report are aggressive, but a closer look at planned solar PV manufacturing plants and CSP projects shows just how quickly the industry is working to meet the global (and U.S.) demand for solar power.

Company	Location; Size of Proposed Project; Technology	Target Completion Date
BrightSource	Various Locations, California; Up to five projects for PG&E totaling 900 MW; Solar Thermal Power Plants	First plant to be brought online in 2011
FPL Energy	Kern Country, California; 250 MW; Solar Thermal Power Plant	2011
REC	Singapore; 1,500 MW; Silicon PV Manufacturing Facility	2012
Sharp	Sakai, Japan;1,000 MW;Thin-Film Silicon Manufacturing Facility	Initial Capacity of 480 MW by March, 2010
SolarWorld	Hillsboro, Oregon;500 MW; Silicon PV Manufacturing Facility	Initial start up in 2009/2010

What Investment is Required to Reach 10 Percent Solar?

The investment to reach 10 percent solar in the U.S. by 2025 won't be inexpensive. But it's also within the range of what utilities and other energy consumers would have to pay for more traditional and polluting sources such as coal- and natural-gas-fired plants, and we believe, considerably less than the price tag for a similar amount of

U.S. Concentrated Solar Power Installations, Generation (Current and Projected)

Year	Annual CSP Installation (MW)	U.S. Cumulative CSP Installed (MW)	Annual CSP Electricity Production at Capacity (MWh)	CSP Share of Total U.S. Electricity Generation
2007	64	419	921,800	0.02%
2010	168	783	1,722,600	0.04%
2015	1,194	4,030	8,866,994	0.20%
2020	3,467	16,471	36,235,965	0.79%
2025	6,613	42,832	94,230,906	1.94%

nuclear power or coal power (in a carbon-regulated environment).

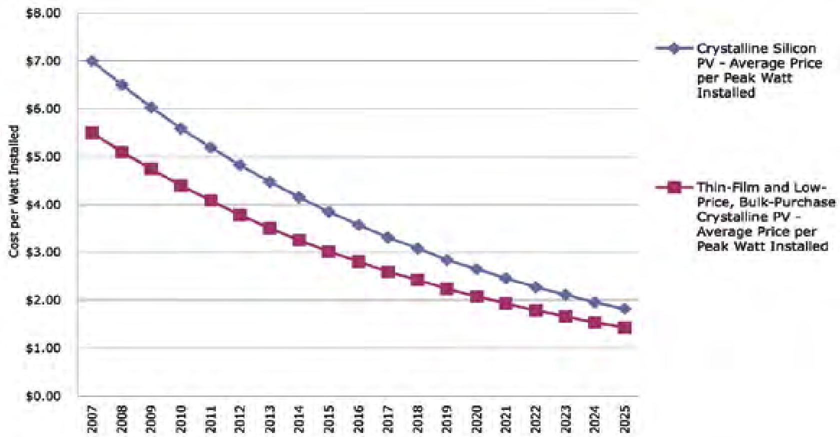
Our figures show that the investment will be between $400 billion and $500 billion to install the required PV and between $50 billion and $60 billion to install the required CSP to reach the 10 percent target. That's a total projected investment of between $450 billion and $560 billion between now and 2025, an average of $26 billion to $33 billion per year. It's important to note that these are not investments in R&D, but in actual deployment of these technologies. In other words, they represent procurement and installation capital costs paid for by utilities, businesses, residences, governments, and others installing solar systems. In this scenario, solar would represent more than half of all new generating capacity installed in the nation by 2025.

To put the projected $450 billion–$560 billion investment in perspective, the Edison Electric Institute estimates that the U.S. electric utility industry spent more than $70 billion on new power plants and new transmission and distribution investments in 2007 alone. Assuming similar expenditures between now and 2025, we're talking about a total investment of more than $1.2 trillion—roughly double to triple our projected investment for solar in the U.S. Globally, some analysts estimate that investments by power companies, for generation and transmission and distribution (T&D), will total approximately $11 trillion between now and 2030.

The tables below show some of the projections for our calculations. For the high-range solar PV cost estimate we used a conservative starting price of $7 per peak watt installed and for the more aggressive, low-range solar PV cost estimate we started at $5.50 per peak watt. The $7 peak watt price in 2007 represents systems based on traditional crystalline silicon PV technologies, whereas the $5.50 peak watt system pricing represents thin-film and bulk-purchased crystalline solutions.

As we highlight in the "Technology Pathways: Getting to Cost Parity" section of this report, many of today's large-scale solar PV installations are already being installed at the lower-end price of around $5.50 per peak watt and these thin-film and low-cost silicon solutions are projected to decline to an average $3.50 peak watt by 2013 and

Comparing Crystalline Silicon with Thin-Film / Low-Price, Bulk-Purchase Crystaline PV Price Reduction 2007-2025



Source: Clean Edge, 2008

approximately a $1.50 peak watt by 2025. In our CSP calculations we show an average price of $3.50 per watt (around 18 cents per kWh) in 2007 declining to around $1 peak watt (approximately 5 cents per kWh) in 2025. The first table is based on cost reduction projections from third parties such as NREL, whereas the second table is based on an 18 percent reduction for every doubling of U.S. CSP installations.

The price projections outlined in this report are supported by recent developments. The reason: As utilities and others scale up their solar efforts they can reach economies of scale unlike anything we've seen in the past—not only around bulk module purchase agreements, but balance of system components and installation costs.

Southern California Edison's recently announced 250 MW rooftop installation program is the perfect case in point. They could reach the $3.50 peak watt installed price a few years earlier than our average predictions (see side bar below). This supports the case that such price points are achievable and that some players may even get there sooner.

Southern California Edison Targeting $3.50 Solar Systems

Southern California Edison, which was responsible for enabling the first wave of CSP in the nation more than two decades ago, is now looking to initiate the nation's largest utility-based rooftop solar PV program. Below are program details and highlights:

Total Planned Capacity: 250 MW

Cost: $875 Million

Estimated Cost / Peak Watt Installed: Average $3.50 peak watt

Timeline: 5 years (an average 1 MW a week) starting August 2008 on commercial roofs in San Bernardino and Riverside counties, the nation's fastest growing urban region

Size: 65 Million Square Feet of Commercial Rooftop (1128 football fields)

Transmission: Installations will be connected directly to the nearest neighborhood circuit, eliminating the need to build new transmission lines

Peak Demand: Solar units produce the most power when customer usage is at its highest

Source: Southern California Edison and Clean Edge, 2008

In addition, the following tables show how much PV and how much CSP would have to be installed annually to meet the 10 percent solar target by 2025. In the table below, we show the cost with a starting price of $7 peak watt. In the second table, we show a starting price of $5.50, the average price to install low-cost thin-film solutions and competitively prices crystalline silicon systems in 2007.

In both cases, we apply a price reduction curve of approximately 18 percent for every doubling of projected global PV manufacturing output.

As noted above, the investment required to install solar PV and CSP is not dissimilar to what it would cost to install conventional gas, coal, and nuclear sources, with the added benefit of zero energy costs (the sun is provided free of charge), zero emissions at the point of power generation, and a resource that can be deployed in just about any

U.S. PV Growth Through 2025—Total Install Cost ($7 / watt starting point)

Year	U.S. Solar PV Annual Market Size (MW)	Average Price per Peak Watt (U.S.)	Cost to install (U.S.)
2007	233	$7.00	$1.63 billion
2008	322	$6.50	$2.09 billion
2009	444	$6.03	$2.68 billion
2010	613	$5.59	$3.43 billion
2011	845	$5.19	$4.39 billion
2012	1,167	$4.82	$5.62 billion
2013	1,610	$4.47	$7.20 billion
2014	2,222	$4.15	$9.21 billion
2015	3,066	$3.85	$11.80 billion
2016	4,170	$3.57	$14.89 billion
2017	5,671	$3.31	$18.79 billion
2018	7,713	$3.08	$23.72 billion
2019	10,335	$2.85	$29.49 billion
2020	13,746	$2.65	$36.40 billion
2021	17,869	$2.46	$43.91 billion
2022	23,230	$2.28	$52.97 billion
2023	30,199	$2.12	$63.90 billion
2024	39,259	$1.96	$77.09 billion
2025	49,467	$1.82	$90.13 billion
		Total	**$499.34 billion**

Assumes an average starting price of $7 peak watt in 2007 (for average-priced crystalline silicon based modules), the total cost to install enough solar PV between 2007 and 2025 to reach 8 percent of total U.S. electricity generation would total $499 billion. Assumes 18% price reduction per doubling of global annual market size.

U.S. PV Growth Through 2025—Total Install Cost ($5.50 / watt starting point)

Year	U.S. Solar PV Annual Market Size (MW)	Average Price per Peak Watt (U.S.)	Cost to install (U.S.)
2007	233	$5.50	$1.28 billion
2008	322	$5.10	$1.64 billion
2009	444	$4.74	$2.10 billion
2010	613	$4.39	$2.69 billion
2011	845	$4.08	$3.45 billion
2012	1,167	$3.78	$4.41 billion
2013	1,610	$3.51	$5.65 billion
2014	2,222	$3.26	$7.24 billion
2015	3,066	$3.02	$9.27 billion
2016	4,170	$2.81	$11.7 billion
2017	5,671	$2.60	$14.77 billion
2018	7,713	$2.42	$18.64 billion
2019	10,335	$2.24	$23.17 billion
2020	13,746	$2.08	$28.60 billion
2021	17,869	$1.93	$34.50 billion
2022	23,230	$1.79	$41.62 billion
2023	30,199	$1.66	$50.21 billion
2024	39,259	$1.54	$60.57 billion
2025	49,467	$1.43	$70.82 billion
		Total	**$392.34 billion**

Assumes an average starting price of $5.50 peak watt in 2007 (for thin-film and low-cost, bulk-purchased crystalline silicon based systems), the total cost to install enough solar PV between 2007 and 2025 to reach 8 percent of total U.S. electricity generation would total $392 billion. Assumes 18% price reduction per doubling of global annual market size.

location in the U.S.

While solar prices decline, conventional sources are likely to rise considerably, making solar a more attractive option as utilities look to expand their energy generation assets and make the grid more reliable. According to Cambridge Energy Research Associates (CERA), conventional U.S. power plant costs have risen more than 130 percent between 2000 and the end of 2007, and were up 27 percent between October 2006 and October 2007. CERA, owned by IHS Inc, established the Power Capital Costs Index (PCCI), which uses 2000 costs to set a base for the index of 100 points. According to the firm, the index was at 231 at the end of the third quarter of 2007, meaning a $1 billion plant built in 2000 cost $2.31 billion to build in late 2007 with the same materials and specifications. And this is before cap-and-trade or other regulations put a price on

U.S. CSP Growth Through 2025—Total Install Cost (Based on Third-Party Projected Cost Reductions)

Year	U.S. Solar PV Annual Market Size (MW)	Average Price per Peak Watt (U.S.)	Cost to install (U.S.)
2007	64	3.50	$ .22 billion
2008	83	3.24	$ .27 billion
2009	112	3.00	$ .34 billion
2010	168	2.78	$ .47 billion
2011	253	2.57	$ .65 billion
2012	379	2.38	$ .90 billion
2013	569	2.21	$ 1.25 billion
2014	853	2.04	$ 1.74 billion
2015	1,194	1.89	$ 2.26 billion
2016	1,672	1.75	$ 2.93 billion
2017	2,006	1.62	$ 3.25 billion
2018	2,407	1.50	$ 3.62 billion
2019	2,889	1.39	$ 4.02 billion
2020	3,467	1.29	$ 4.47 billion
2021	3,987	1.19	$ 4.76 billion
2022	4,584	1.10	$ 5.06 billion
2023	5,272	1.02	$ 5.39 billion
2024	5,905	0.95	$ 5.59 billion
2025	6,613	0.88	$ 5.80 billion
		Total	**$53.00 billion**

fossil fuels that could potentially increase their price.

To supply the amount of electricity generation (ten percent of total electricity consumption in 2025) outlined in our projections would require hundreds of billions of dollars in new coal, nuclear, and natural gas power-plant investments. As we point out in the "Technology Pathways: Getting to Cost Parity" section, solar is becoming increasingly competitive against these technologies, and in some cases is already price competitive. And as we seek to deploy cleaner, less volatile sources of energy—solar remains a very attractive option.

U.S. CSP - Using 18% Reduction Rate Per Doubling of Annual Installation

Year	U.S. Solar PV Annual Market Size (MW)	Average Price per Peak Watt (U.S.)	Cost to install (U.S.)
2007	64	$3.50	$.22 Billion
2008	83	$3.28	$.27 Billion
2009	112	$3.08	$.34 Billion
2010	168	$2.88	$.48 Billion
2011	253	$2.70	$.68 Billion
2012	379	$2.53	$.96 Billion
2013	569	$2.37	$1.34 Billion
2014	853	$2.23	$1.89 Billion
2015	1,194	$2.09	$2.49 Billion
2016	1,672	$1.96	$3.26 Billion
2017	2,006	$1.83	$3.67 Billion
2018	2,407	$1.72	$4.13 Billion
2019	2,889	$1.61	$4.65 Billion
2020	3,467	$1.51	$5.23 Billion
2021	3,987	$1.41	$5.63 Billion
2022	4,584	$1.33	$6.07 Billion
2023	5,272	$1.24	$6.55 Billion
2024	5,905	$1.17	$6.87 Billion
2025	6,613	$1.09	$7.22 billion
		Total	**$62.04 billion**

CHALLENGES AND ROADBLOCKS

Making solar more widely accessible and affordable requires no more and no less than the participation, cooperation, and coordination of the usual players involved in electricity generation—from legislators to regulators to contractors to financial institutions. But the key players, we believe, are the nation's energy utilities, ranging from huge investor-owned companies to small rural cooperatives, all of which are potentially large buyers, developers, and sellers of solar power.

On balance, despite some significant gains in the past 12 to 18 months, U.S. electric utilities have been reticent to deploy solar technologies, despite the many potential advantages it offers them. Even worse than inaction, many utilities have historically set up roadblocks—in the form of uncooperative positions toward net metering and interconnect standards—making it difficult for both business and residential customers to cost-effectively deploy solar. A number of utilities have also lobbied against pro-solar policies and initiatives. In short, some view solar as a problem rather than an opportunity.

But those attitudes are changing, and we believe those changes can be accelerated. For many utilities, solar PV represents a distributed energy resource that can reduce the need to build large, costly, polluting and publicly opposed fossil-fuel power plants and can ease congestion in regions where energy demands have stressed the grid. One thing is clear, however. For solar technology producers and developers to achieve the economies of scale (from mass production and implementation) necessary to make solar prices competitive on a wide scale, and to do it quickly, will required the sustained support, investment, and cooperation of utilities.

The challenges and roadblocks that the solar industry has faced from utilities and their regulators are many are varied. Understanding these technological, political, regulatory, cultural, and even psychological. Below are the top six challenges based on our interviews with industry players.

1. Utilities see themselves first and foremost as 'protectors of reliability.'

Risk aversion has been a cultural trait of the utility industry for decades, and it's not unwarranted—utilities are legally charged with the responsibility of keeping the lights on, at the lowest possible cost. That tends to reinforce decisions and strategies that favor tried-and-true, 'we've done it this way for decades' models of electric generation. And those models have traditionally been biased toward large, centralized fossil fuel or nuclear-powered generating plants.

But change is in the air. Going forward, it is going to be increasingly difficult—and costly—to build new coal and nuclear plants. Public resistance remains high against nuclear power and increasingly high against coal. Since 2006, some 60 new coal plants in the U.S. have been cancelled, blocked, or delayed, and dozens more are being challenged in 20 states. Some states such as Kansas are considering moratoriums against new coal-fired generation—and this is even before nationwide mandatory carbon caps, which we believe will be mandated next year and take effect early in the next decade. California utilities are prohibited from buying new coal-fired power from out of state. In this new world, solar can help deliver the reliability that utilities need.

We map out detailed strategies for solar's cost-effectiveness in the section titled "Technology Pathways: Getting to Cost Parity." Perceptions about the reliability of distributed solar PV technology are changing as the industry grows, its players mature, and major solar installations prove reliable for major utilities and their customers around the world. And CSP, where feasible, gives utilities a path to solar that fits with their traditional centralized generation model, as evidenced by the recent adoption of CSP among major California utilities.

2. The power grid is outdated and in disrepair—making solar integration difficult today.

Today's grid, antiquated and fragile in most parts of the country, presents a significant barrier to the incorporation of solar and other distributed energy sources. Originally designed to accommodate large centralized power stations generating the traditional "one-way flow" of electrons to substations and customers, the grid is often ill-prepared to accommodate electricity produced by local sources such as on rooftops. Solar's intermittent nature, with less electricity generated on cloudy days and none after sunset, is another attribute that's incompatible with a grid designed primarily for baseload power. This equation, of course, changes when deploying batteries or other storage options.

Since utilities will have to update the grid anyway, doing so with an eye toward integration of solar (plus energy efficiency, wind power and other renewables) makes a lot of sense. "Utilities will begin to embrace distributed solar as they invest in the smart grid—in things like informatics, telemetrics, and analytics," said one interviewee. "The great thing about the smart grid is that it's modular. You can add it in pieces, district by district. If you don't have a smart grid—you can't really leverage distributed solar."

3. Most utilities aren't organizationally structured to exploit or understand the value of solar.

The traditional management chart inside utilities can stack the cards against solar. At many utilities, for example there is no one responsible for evaluating the business case for solar. As one former utility executive put it, "Utilities are organized around centralized plants and distribution lines, so is this [distributed solar] something that the central plant guys deal with, or the poles and wires guys, or customer service?" For utilities with well-worn processes and with a preference for the status quo, it typically takes an internal champion to enact change, and many utilities lack that person.

Another part of the issue: utility management is usually heavily weighted toward mechanical engineers, who pride themselves on reliability and whose vision of solar is stuck in the 1970s, when solar was far less reliable and was championed by back-to-the-earth types. Even today, we heard that some utility traditionalists flat out don't like the "new solar people."

Of course, many in the solar industry, and in organizations advocating and lobbying for it, don't trust the utilities, either. "Many people in solar are suspicious of the motives of utilities, and often with good reason," said one industry advocate. "Utilities' actions have often been more about keeping control over solar and marginalizing it than about bringing the technology to its maximum potential." In one situation, a residential solar system in New York state was kept offline by a major Northeast utility, which had sent "letters of denial" on 11 occasions rebuking the solar system owner's request for interconnection.

4. Cost is still an issue

There is still a widespread perception that solar is not cost competitive with conventional fossil fuel or nuclear generation, or with other clean-energy sources, primarily wind power. While solar PV makes sense in remote locations without access to grid transmission lines, it's still challenged by cost in many other applications. One utility executive summed it up tersely: "Expense is the number-one reason not to implement solar."

There is validity to this perception. But as we detail in the "Technology Pathways: Getting to Cost Parity" section, things are changing rapidly. Solar will be cost competitive in nearly every area of the country within the planning time horizon of most utilities.

As a general rule, solar costs are declining while the costs of traditional centralized generation are going up. And when you add in the cost to not only build new fossil-fuel generation facilities, but also to build out transmission and distribution systems, distributed solar PV in particular can make sense even today. The challenge, in many cases, is to get utilities' perceptions—and their budgetary models—to catch up with new realities.

5. Absence of technical standards for integrating solar

Standards drive every industry, and a lack of standards can severely impede innovation and growth. At present, solar interconnection, reliability, and other critical standards either don't exist at all or exist as a hodgepodge of different standards, hindering utility solar planning for and implementation. To reach the target of 10 percent of U.S. generation by 2025, the industry needs to look and act more like the telephone industry, with much more consistent "plug and play" standards across the country. Imagine the Internet without standards and protocols: It wouldn't have flourished. The same is true for solar.

“There are no national standards with enforcement for power reliability and quality” for solar, lamented one industry insider. “The utility industry is one of the few where the customer absorbs all the risk of power quality, surges and the like. The system we have [dates back to] a time when quality and reliability weren’t the main issues—you were just lucky to have electricity. It’s only in the last 20 years that we’ve become a digital country.”

In sum, the barriers to the large-scale development and deployment of solar by utilities are not trivial. However, some are quickly becoming concerns of the past as costs of solar fall, costs for everything else rises, and, with the coming carbon regulation, more and more people inside and outside of utilities realize that better analytical tools for evaluating the true benefits of solar are needed. And as we discuss throughout this report, such challenges can be transformed into major opportunities with the right combinations of shifts in technology, policy, and business models.

TECHNOLOGY PATHWAYS: GETTING TO COST PARITY

Solar PV and CSP are becoming increasingly attractive resources in today's electricity environment, where coal and natural gas prices are skyrocketing, grid infrastructure is crumbling, and carbon policies are beginning to dramatically alter the energy landscape. For example, although solar PV is currently two to three times the cost of retail electricity rates in most of the U.S., it is beginning to compete in high-cost regions like Hawaii, New York, and Southern California.

As a semiconductor-based technology, solar PV is ripe for continued downward pricing and efficiency improvements—much like the computer chip, its semiconductor brethren. We foresee PV prices falling from today's 15-32 cents per kWh to a projected 7-15 cents per kWh within a decade and around 4-8 cents per kWh by 2025. By 2015,

Comparing Crystalline Silicon with Thin-Film / Low-Price, Bulk-Purchase Crystalline - PV Price Reduction 2007-2025

Year	Crystalline Silicon PV - Average Price per Peak Watt Installed	Crystalline Silicon PV - Range kWh Cost	Thin-Film and Low-Price, Bulk-Purchase Crystalline PV - Average Price per Peak Watt Installed	Thin-Film and Low-Price, Bulk-Purchase Crystalline - Range kWh Cost
2007	$7.00	19¢-32¢	$5.50	15¢-25¢
2008	$6.50	17¢-30¢	$5.10	14¢-23¢
2009	$6.03	16¢-28¢	$4.74	13¢-22¢
2010	$5.59	15¢-26¢	$4.39	12¢-20¢
2011	$5.19	14¢-24¢	$4.08	11¢-19¢
2012	$4.82	14¢-24¢	$3.78	10¢-17¢
2013	$4.47	12¢-20¢	$3.51	9¢-16¢
2014	$4.15	11¢-19¢	$3.26	9¢-15¢
2015	$3.85	10¢-18¢	$3.02	8¢-14¢
2016	$3.57	10¢-16¢	$2.81	8¢-13¢
2017	$3.31	9¢-15¢	$2.60	7¢-12¢
2018	$3.08	8¢-14¢	$2.42	6¢-11¢
2019	$2.85	8¢-13¢	$2.24	6¢-10¢
2020	$2.65	7¢-12¢	$2.08	6¢-10¢
2021	$2.46	7¢-11¢	$1.93	5¢-9¢
2022	$2.28	6¢-10¢	$1.79	5¢-8¢
2023	$2.12	6¢-10¢	$1.66	4¢-8¢
2024	$1.96	5¢-9¢	$1.54	4¢-7¢
2025	$1.82	5¢-8¢	$1.43	4¢-7¢

Source: Clean Edge, 2008

we see solar reaching cost parity with conventional energy sources in many markets in the U.S., given expected cost increases in fossil-fuel-based electricity. CSP, ideal principally for desert locations, has the ability to decrease from around 18 cents per kWh today to as little as 5 cents per kWh by 2025.

The solar industry hasn't been standing still in working to achieve cost and price reductions. In 2003, solar PV represented just 620 MW of total installations worldwide. By 2007, that number had quadrupled to nearly 3,000 MW. Clean Edge and other analyst projections put the global market for solar PV at around 8,000 MW–12,000 MW in terms of annual installations, and 15,000 MW–25,000 MW in terms of overall annual manufacturing capacity sometime between 2010 and 2012.

At these rates, solar PV is expanding globally by approximatley 40 percent annually. CSP has been a comparatively late starter, with very little new development throughout the 1990s and the first half of this decade. But CSP is now on the rise, with thousands of megawatts on the drawing boards and under development in the U.S., Spain, and elsewhere.

And pushing solar to cost parity at a potentially even faster pace, there are continuous technology and efficiency improvements going on across the solar spectrum. These include advances in thin-film solar PV technologies, CSP advances, more efficient, less costly crystalline silicon-based semiconductor materials for PV, along with advances in balance of system components and installation cost reductions.

Investors seem to agree that the solar value chain is ripe for advancements, with venture capitalists pouring hundreds of millions of dollars into advancing these technologies, and the public markets rewarding a range of solar companies. In 2005, solar companies represented three of the top performing technology IPOs of the year (Q-Cells of Germany, SunPower of the U.S., and Suntech Power of China). The following chart shows the annual investments of U.S. venture capitalists in solar companies. Solar now represents the largest clean-energy sector in terms of venture activity in the U.S., exceeding $1 billion in 2007.

U.S. Venture Capital Investments in Solar Power Companies

Year	Total Venture Investments (U.S.$ Millions)
2001	16
2002	46
2003	58
2004	78
2005	155
2006	305
2007	1,068

Source: New Energy Finance with supporting data from Nth Power and Clean Edge
NOTE: VC figures are for development and initial commercialization of technologies, products and services, and do not include private investments in public equity (PIPE) or expansion capital deals.

These investments serve a critical role in helping solar to reach the Holy Grail: price parity with fossil fuel power.

The Scale-up of Solar PV

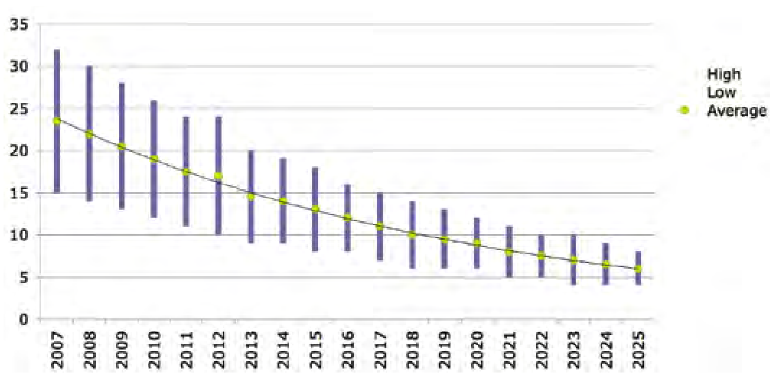
The granddaddy of solar is crystalline-based photovoltaic technology, which has experienced incremental improvements in efficiency (the percent of sunlight falling onto a solar cell that is converted into electricity), while costs have dropped dramatically from approximately $30 per peak watt in 1980 to around $7 peak watt today. Polysilicon, the same feedstock used in the global chip and semiconductor industry, remains the dominant source material for PV cells, used in more than 90 percent of solar modules currently manufactured, according to the Solar Energy Industries Association.

Although solar PV has grown considerably in recent years, silicon supply constraints have been a problem. In an historic tipping point in 2006, solar surpassed semiconductors as the largest user of silicon. This caught silicon manufacturers by surprise and resulted in a temporary increase in solar PV pricing worldwide as demand outstripped supply. However, investments in silicon manufacturing plants designed for PV are expected to ease the supply pressure and reduce prices over the next year or so.

Another major trend impacting costs is the growth of thin-film PV. First Solar, a thin-film leader, is currently shipping PV modules that are being installed for around $5.50 peak watt, considerably less than the cost of conventional PV. The company already is sold out for the next five years, amounting to $6 billion and 3,000 MW worth of PV at an average price of $2 per peak watt, when the PV leaves the factory. At that price, total installation costs could drop to $4 a peak watt.

The following chart shows Clean Edge projections, on a kWh basis, for both crystalline and thin-film PV solutions. As global manufacturing increases, and utilities and others increase installations in the U.S., we see prices dropping from 15-32 cents kWh today to around 4-8 cents kWh in 2025, making solar cost-competitive with conventional generation in virtually every part of the United States.

U.S. Crystaline and Thin-Film PV Price Range 2007-2025 (Cents/kWh)



Source: Clean Edge, 2008

Sharp Solar, one of the world's top PV manufacturers, is also aiming its guns at thin film. Once an unabashed crystalline silicon leader, Sharp ceded the top manufacturing spot in 2007 to Germany's Q-Cells because of Sharp's inability to line up enough silicon feedstock. The company is aiming to bring online a 1,000 MW thin-film production line before the end of the decade. According to industry insiders, we could see up to six such thin-film plants from the company in coming years.

Other alternatives to polysilicon include nanotechnology-enabled solar cells. Because of their ability to replace or reduce the need for expensive silicon, thin-film

The Next Wave: Thin-Film, Nano, and Concentrating PV Technologies

Amorphous Silicon is the most developed of the thin film technologies. However, it is less energy efficient (11 percent versus around 15 to 22 percent for polysilicon), so therefore requires more area to generate the same amount of energy. Efficiency is a concern when space is constrained (on residential rooftops, for example). However, in a solar farm or solar park where space is not at a premium, lower overall expense can be more important.

CIGS (Copper indium gallium selenide) solar cells do not require silicon, but are similarly less efficient than polysilicon. CIGS cells' manufacturing costs promise to be lower than PV as they can be printed directly onto glass sheets and other substrates. Nanosolar, Miasolé, Heliovolt are among the leading CIGS companies working on expanding production.

Cadmium Telluride (CdTe) cells are less expensive than silicon but not as energy efficient. Several companies including First Solar and Q-Cells are developing the technology. NREL currently holds the world-record conversion efficiency for CdTe of 16.5%. CdTe and CIGS, compared to silicon, have some additional concerns in terms of the availability and toxicity of some of these rare earth metals.

Nanotechnologies include inorganic semiconductor nanocrystals, self-assembling nanostructures, and dye-sensitized nanometer-scale crystals. Not yet in production today, nanotechnologies that can be printed through a roll-to-roll manufacturing processes have the potential to substantially reduce the cost of PV.

Concentrating PV basically concentrates the light of the sun onto silicon and other cell materials, at ratios of 2X all the way up to around 1000X. In effect, these companies can reduce the amount of silicon or other materials required for solar power, by the amount of concentration achieved. Companies such as SolFocus, Solaria, Soliant Energy, Energy Innovations and others are working to bring the technology to commercialization.

and nanotechnologies promise to be easier and cheaper to mass- produce over time. Manufacturing techniques include printing, sputtering, or stamping solar cells on substrates and integrating them into a wide variety of materials including roofing material and flexible panels. Large players, including Applied Materials, Sharp, and BP, are manufacturing thin-film cells, and several startups in the U.S. and China are building thin-film manufacturing plants.

In addition to these many technology advances, we're also seeing the general scale-up of manufacturing. For example, Renewable Energy Corp. of Norway recently announced it will build a solar manufacturing plant capable of producing 1,500 MW of solar panels in Singapore, which will equal three quarters of the entire world production in 2006. A 2004 report from the U.S. Energy Department's National Renewable Energy Lab theorized that large-scale manufacturing plants like this could cut the cost of PV modules down to $1 per peak watt. Another industry expert expects that by 2010, the cost of crystalline PV modules will shrink to $1.50 per watt, and $1 per watt for thin-film. These projections refer to estimated industry costs, not wholesale or retail module pricing.

Mass production in China is expected to further lower the cost of producing PV. "On

Module vs. Installed Prices

Solar prices typically are quoted in either wholesale module prices or installed prices, usually in terms of price per peak watt. Wholesale prices refer to the price per watt of a PV module purchased from the manufacturer. Installed prices refer to the full price of an entire solar PV system, once it is installed in a business or residence.

Unfortunately, many solar energy discussions refer to wholesale and installed prices interchangeably, thereby confusing analysis.

In this report, we typically refer to installed system prices (unless otherwise noted).

PV Efficiency—How High Can It Go?

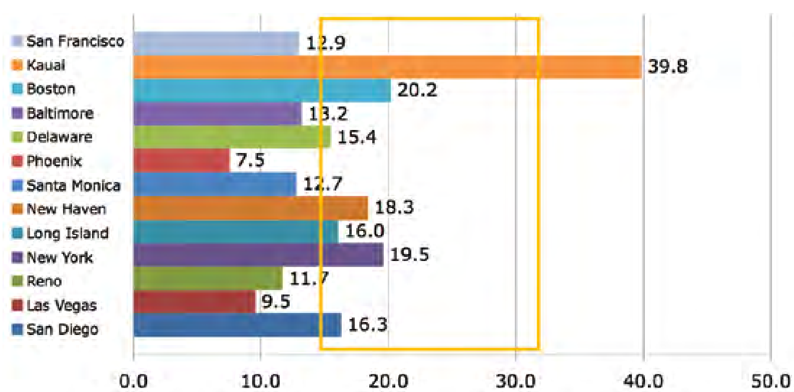
Looming on the horizon is a research and development project with substantial public and private backing that could throw current cost and performance measurements into disarray. The very-high-efficiency solar cells (VHESC) consortium, funded by the U.S. military with participants including the University of Delaware, MIT, DuPont, and BP Solar, has a stated goal to increase the efficiency of converting sunlight into energy from approximately 17 percent today to near 50 percent. The research is still in its infancy, but prototype cells have surpassed 40 percent efficiency. Doubling or tripling the efficiency of PV cells would have significant implications, especially for powering electronic devices such as computers and for applications where space is at a premium (such as rooftops). Such breakthroughs on a commercial scale, however, may be many years away.

the crystalline side lots of investment and scaling of manufacturing will bring down costs—[there will be] a staggering amount in China, and their ability to drive down costs [is well known]…" said one of our industry respondents.

Solar PV: Gaining a Competitive Price Advantage

Solar PV today is still approximately two to three times the cost of most retail electricity rates (before subsidies) in the U.S. With average retail electricity rates of 8-12 cents per kWh in the U.S.—solar PV must still drop by as much as 70 percent from today's average prices of 15-32 cents per kWh.

Comparing U.S. Average U.S. Retail Electricity Rates with PV, 2007 (Cents/kWh)



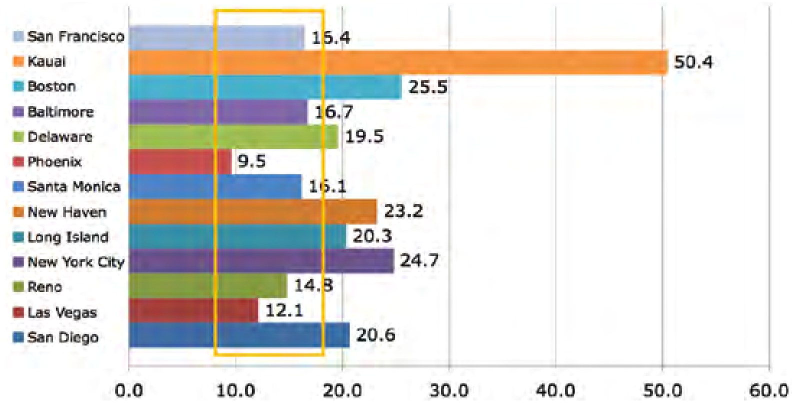
The above table shows the current cost for retail electricity in select U.S. cities compared with the high and low cost range for installing solar PV. In 2007 solar was competitive in just a few markets without subsidies, such as the Hawaiian island of Kauai.
Source: Clean Edge, 2008

But a closer look at the numbers shows that in some cases distributed solar PV—solar placed on rooftops or adjacent to buildings/users—can compete even at today's prices. In high-priced energy markets like Hawaii and Southern California, where retail rates can easily exceed 20 cents per kWh, solar PV may already be competitive with minimal or no subsidies.

In markets with strong subsidies and incentives, like California, New Jersey, and New York, solar PV can also be competitive through creative financing structures. A number of companies, such as SunEdison and MMA Renewable Ventures, have taken advantage of this and are offering customers competitive power purchase agreements (PPAs). In these cases, the systems integrator/financier takes care of system procurement, installation, and financing. Instead of selling the system itself to the customer, they sell the system's energy output. In many cases, these companies are able to offer electricity for the same price or less than prevailing utility rates. As an added bonus, since they know the future costs of sunlight (i.e. zero), customers may be able to lock in pricing, over a specific contract period, usually ten years. That allows customers certainty over energy prices, immune from the vagaries of fuel price fluctuations.

Major utilities are now getting into the act of low-priced solar. As noted earlier, Southern California Edison launched its own program in early 2008 which aims to install 250 MW of solar in its territory over the coming years. The projected price to install these systems on commercial, industrial, and residential rooftops: around $3.50 a peak watt. SCE can hit such a competitive price because of economies of scale in procurement, installations, and integration, and the ability to eliminate costly middlemen. Other utilities are likely to follow suit.

Comparing U.S. Average U.S. Retail Electricity Rates with PV, 2015 (Cents/kWh)

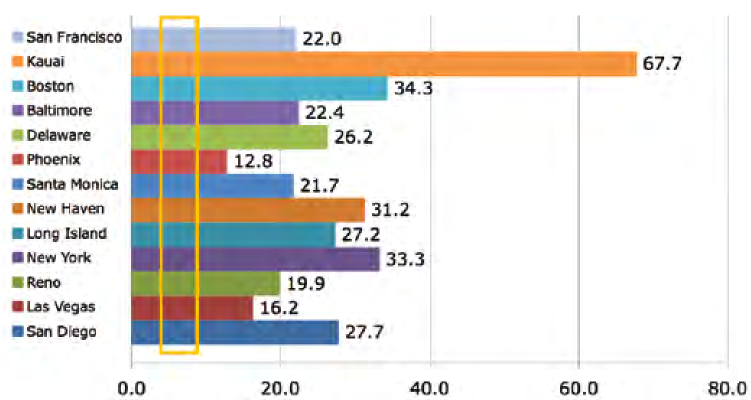


The above table shows projected cost for retail electricity in select U.S. cities in 2015 compared with the high and low cost range for installing solar PV. By 2015 Clean Edge projects that solar will be increasingly price competitive with retail electricity rates. Source: Clean Edge, 2008

But even with such innovative installation and pricing schemes gaining popularity, solar PV is still too high to compete on a price-only basis without subsidies in nearly all U.S. markets today. Our research shows that PV must reach approximately $3 per peak watt or less (equivalent to around 8-14 cents per kWh) to be competitive in most U.S. retail markets. Based on current growth rates and average pricing, however, we see the industry reaching that price in a decade or less—by around 2015. And it's important to note that the industry may reach this crossover point even sooner, should conventional electricity rates in the U.S. rise and PV prices decline faster than expected.

By 2025, we believe that solar PV will be competitive against retail electricity rates in most regions of the U.S. And that's with applying a very conservative increase in retail electricity rates—just 3 percent per year. That's considerably less than the average rate

Comparing U.S. Average U.S. Retail Electricity Rates with PV, 2025 (Cents/kWh)

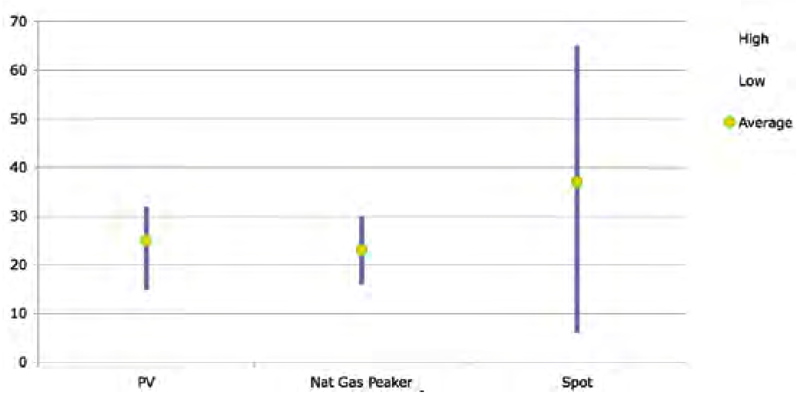


The above table shows projected cost for retail electricity in select U.S. cities in 2025 compared with the high and low cost range for installing solar PV. By 2025 Clean Edge projects that solar will be price competitive with retail electricity rates in every market in the U.S. Source: Clean Edge, 2008 increases most consumers have been seeing over the past few years. With continued spikes in energy costs, the advent of carbon pricing schemes in the U.S., and other drivers, prices may change even more dramatically (as noted in the Within Reach: 10 Percent Solar section).

Peak Generation Opportunity

Another area where solar PV can be cost competitive today is for peak power generation—the times of day when utilities need the highest level of power output to meet demand, usually requiring them to fire up their least-efficient, most-costly generators. Solar PV at 18-32 cents per kWh, and CSP between 14-23 cents per kWh today, already compete favorably with a number of other peak-power solutions. As the table below shows, natural gas "peaker" plants cost between 8 and 30 cents per kWh, and spot energy can cost between 6 and 65 cents per kWh. At these prices, solar is already competitive.

Current Cost of Electricity - Electricity Source (Cents / kWh)



Source: Clean Edge, 2008

CSP: Desert Power

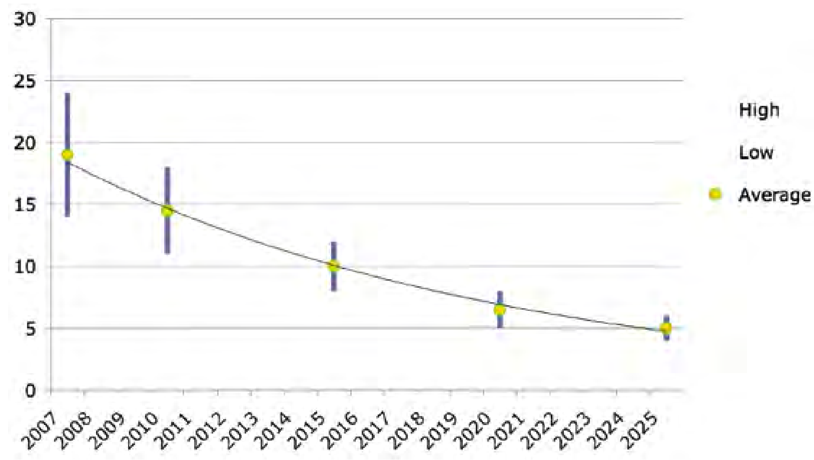
Whereas PV will be used primarily for distributed resources (and increasingly for centralized, as utility-scale solar farms are built), CSP is optimized for centralized plants located in desert regions. CSP systems use reflective materials such as mirrors to focus the sun's rays to heat a fluid (usually oil or water) to high temperatures that creates steam to drive a turbine to produce electricity. CSP technologies include several variations, such as parabolic troughs, dish systems combined with Stirling engines, central towers, and other hybrid technologies. Some of the key players in this sector include Ausra, BrightSource, and Solel. These firms have contracted with major California utilities to supply hundreds of megawatts of CSP at grid-competitive rates, from plants in the Mojave and other Southwestern deserts, in the coming decade.

CSP requires consistent, direct sunlight, but is extremely efficient and theoretically cheaper than PV. Up until 2006, the U.S. actually had more megawatts of CSP installed than PV. As noted elsewhere in this report, we believe that CSP prices could drop considerably in the next two decades as the technologies are scaled up and deployed more widely. Price ranges for electricity produced from CSP plants today (as shown in the chart on left) show that it is already approaching grid-parity in some regions.

Moving Forward

The cost for solar power is becoming increasingly competitive with conventional energy sources. As solar prices drop due to economies of scale and the absence of fuel costs (there's no charge to tap the sun), and conventional prices rise because of increases in capital, fuel, and operational costs, the divide between solar and other energy sources will shrink and ultimately be erased. We predict a point in the not-too-distant future in which solar can be deployed more cheaply, more reliably, and more cleanly than fossil-fuel-based energy. Achieving this will require some technology and systems breakthroughs, but many of the technologies are already here. The solar technology landscape is changing rapidly, offering utilities opportunities for innovation and dramatic cost improvements.

CSP Price Ranges 2007-2025 (Cents/kWh)



Source: Clean Edge, 2008

UTILITY PATHWAYS: SOLAR AS A SOLUTION

In the Challenges and Roadblocks section, we discussed the top technical, regulatory, and cultural barriers against widespread adoption of solar by utilities. But out of these many challenges come a range of opportunities. We've developed seven key pathways for utilities. They are:

1. Take advantage of the unique value of solar for peak generation
2. Better serve customers in grid-constrained areas and "at the edge"
3. Implement solar as part of demand response systems and build-out of the smart grid
4. Use solar as a price hedge against fuel cost increases and potential carbon costs
5. Adapt to the new power market with new business models
6. Harness the power of the desert
7. Help train the next wave of workers

1. Take Advantage of the Unique Value of Solar for Peak Generation

Solar is discounted by some utilities because its cost is mistakenly compared to base-load energy costs. Instead, solar, in most cases, should be directly compared with the cost of power during daylight hours that encompasses much of the peak demand.

Solar has value beyond its basic kilowatt-hour cost because solar power is generated during daylight hours and is most productive at times of day that coincide with utilities' peak demand period, particularly in the energy-intensive summer months. Solar plants that utilize tracking systems and storage can maximize power generation to address late afternoon peaks.

Solar can replace the least energy-efficient (and most expensive) "peaker" plants that are brought online to meet peak demand. Power from natural gas peaker plants can cost up to 15-30 cents per kWh. And energy bought on the "spot" market by utilities desperate for power can cost even more). Since distributed solar PV and CSP typically cost between 15-25 cents per kWh, they can be cost-effective replacements.

The advantages go beyond cost. Old fossil fuel-powered peaker facilities are more costly to maintain and emit more greenhouse gases, which are likely to become even more expensive in the future as expected U.S. carbon-cap legislation takes effect. The cost of solar relative to these peak demand costs is competitive in many markets today.

As one analyst said, "If [utilities] would see all the [full] value of solar, it could be done without subsidies."

Solar's contribution to meeting peak-load demands also can be critical in helping utilities defer capital investments in central fossil-fueled generation capacity. Instead of adding multibillion-dollar generating plants that typically are underutilized during off-peak hours (generating costs but not revenue), solar energy delivers only when it is most needed. "The economic value of solar is really in the timing (relative to peak loads) and the resulting capital issue (that it can helps prevent or defer peak investments)," said one expert, echoing the comments of many. The value is in the peak power, not just the kilowatt-hours."

As outlined in the "Getting to Cost Parity" section, coal and natural gas power plants require upfront investments of $1 billion to $2 billion or more (nuclear plants require at approximately two to three times that, assuming they can be licensed in the first place), as well as operational fuel costs. Such plants typically are not cost-effective unless they are able to produce several hundred megawatts. And these costs are projected to continue to rise. Solar plants, on the other hand, can be built to the exact scale needed to meet demand, with additional modules added as needed.

2. Better Serve Customers in Grid-Constrained Areas and "At the Edge"

Distributed solar PV can be a cost-effective complement to existing generation in areas of the grid where power generation capacity has difficulty meeting peak demand and where consumption is expected to increase. Solar is able to fill demand with lower capital and per-kWh costs than many competing energy options. Meeting increased demand at great distances from existing generation plants with fossil fuel-based resources requires costly investment in additional downstream power plants, or significantly upgrading the transmission infrastructure to accommodate expanding centralized resources.

Utilities looking to reduce their transmission and distribution (T&D) costs and increase grid stability can benefit by increasing the percentage of distributed solar PV in their energy mix. Some utilities have not included the cost of T&D in their planning for expansion, particularly to power new housing developments and office parks at the fast-growing outer edges of "exurbia." "T&D to a suburb has been very reactive," said one industry observer.

The strain on the existing transmission lines and need for power increasingly further from central plants is forcing them to reconsider. Greater power demands at points far from centralized resources over increasingly overtaxed transmission lines are putting pressure on the grid. Distributed solar plants can be installed closer to the demand location, and to the scale needed, at a lower cost than increasing centralized production and/or upgrading transmission lines, which are multimillion dollar investments.

"This is what a disruptive technology does—it exploits the inefficiencies of the old system," said one expert. "Usually it's not a choice between the two; it's a marginal decision about what we do next. The grid is getting more and more expensive to maintain, and what solar lets us do is reduce that maintenance investment, by offsetting investments in line extensions. Everything about [distributed] solar has to do with transmission and distribution; we should not be looking only at the cost of generation, and yet that's what everybody looks at."

Regarding T&D planning, one utility official said, "We're really in the infant stages on that. We had traditionally thought we couldn't even plan our service territory T&D more than five years out. Now we're looking further out, like 20 years, and seeing that solar might help us defer, or not do, some T&D, or do smaller substations."

For regions where costly transmission lines are near maximum utilization, distributed solar can be economically preferable to major grid overhaul, explained one expert. "In cases where the utility is grid- or transmission-constrained, and the next choice is to upgrade the grid, if they could compare and contrast distributed solar in their budget, it would make sense."

Distributed solar generation capacity can also increase the flexibility and redundancy of the grid, thus improving reliability. It can alleviate bottlenecks on the grid that drive up costs for customers and facilitate competitive electricity markets that will ultimately lower prices.

However, utility ownership of distributed solar requires a seismic shift in the way utilities think about the ownership, management, and distribution of power. The "comfort zone" has been to manage centralized power plants or purchase large amounts of energy from a centralized third-party source. Utilities can introduce technology for managing distributed resources to meet this challenge; we discuss this pathway further in the Adapt to the New Power Market section below.

3. Implement Solar as Part of Demand Response Systems and Build-Out of the Smart Grid

Part of utilities' reluctance to embrace distributed solar is the inability of the aging power grid to respond to variable or intermittent power. But rather than continue to use this as an excuse for eschewing solar, utilities should join in a national effort to add intelligence to the grid and metering systems.

Smart meters, which provide two-way communications between customers and the grid, are a requisite for assessing hourly changes in power consumption and production. With smart meters in place at grid-tied solar locations, utilities can better manage the aggregated power, which can enable them to defer adding capacity and reduce supply shortfalls. Customers who are billed by time of use pricing will better track their energy consumption and will decrease their consumption of peak power.

According to one solar industry executive, "Electric utilities in general don't have a clear pathway to understanding how they make money in the next generation grid—in the same way that AT&T fought the telephone deregulation of the '80s, utilities don't have appreciation for next-generation grid value for customers—and more importantly, for themselves—smart meters, demand-side management and storage. They can't see how it's good for the company, so they fight."

Advances in information technology and the Internet have spawned a new generation of intelligent devices that have revolutionized communications and created a multitude of operating efficiencies. Utilities need to apply these same principles to power generation and transmission. Smart grid technology, which connects meters and transformers with central management facilities, can harnesses distributed solar to cut transmission costs and dynamically respond to changes in demand. The deployment of these technologies will give utilities unparalleled control over their resource so that they can access the least costly power when it is needed.

Several interviewees envisioned an intelligent grid system that would create an "open market" enabling solar customers to monetize the value of their system by selling excess power at optimal prices. Pricing for power could be based on time of use and the location-specific value of that power on the grid—and include any green and carbon-reducing attributes. "The real opportunity is allowing my meter to interact with the utility so I can make money," said one industry expert. "Right now, I can zero out my bill, but I cannot make money. This now makes it an under-incentive to invest."

While relying on distributed resources including solar and energy efficiency adds to the complexity of resource management, having more power sources in more locations can reinforce the integrity of the grid. Distributed power increases the flexibility and redundancy of the grid, and improves reliability because the failure of one generation facility will have less overall impact. This should be factored into the cost of acquiring power generation.

Using solar and intelligent grid technologies to eliminate failure points can also prevent costly blackouts. The blackout of August 2003 that decimated the Eastern U.S. cost between $7 to $10 billion, according to ICF Consulting and the Electricity Consumers Research Council. Solar power that can be controlled independently can minimize the losses of failed centralized generation. Locating solar plants adjacent to substations—where utilities often have right-of-ways and additional industrial land—can make the substation more cost effective.

Utilities are caught between increasing demand for peak power and an unfriendly environment against building new coal and nuclear power plants—which aren't best suited for meeting peak power in the first place, since they can't be dialed up or down very far. One option for avoiding new centralized plants and increasing the performance of the grid is to focus on demand response. The North American Energy Standards Board and regional groups are creating guidelines for integrating distributed resources into demand response systems, which will simplify the addition of solar into the mix.

By curtailing the use of non-essential power during a demand surge or increasing rates and tapping into distributed customer-owned power, utilities can more quickly react to prevent outages and reduce their costs. Solar can contribute to utilities' demand curtailment services because peak solar energy production coincides with peak demand as noted above, and customers who have installed solar often have the smart metering equipment that is needed to control the power resources.

Distributed solar can also be aggregated and made available to utilities on demand. Project Opportunity Notice in New York State has created several projects that demonstrate how solar power can provide peaking capacity to specific areas of the grid. Utilities can work with commercial and residential customers to acquire distributed solar power as part of their demand response planning.

4. Use solar as a price hedge against fuel cost increases and potential carbon costs

As we detail throughout this report, fuel costs for coal and natural gas-fired generation are on the rise, in some cases dramatically, and most energy experts expect those trends to continue. They are also increasingly volatile, posing significant planning challenges to both utilities and regulators. Solar power, with its fuel cost of zero, can provide a key stability hedge in this volatile environment.

That advantage will take on increased significance when carbon caps, as expected, take effect in the U.S. in the next five years if not sooner. We won't speculate here about the potential price of carbon credits, but a power generation portfolio with solar power will pay increasing financial dividends in an economy with mandated carbon constraints.

5. Adapt to the New Power Market with New Business Models

Solar PV's rapid annual growth rates have been fueled in part by power customers—from homeowners to small and large businesses to government agencies—who appreciate the flexibility of owning (or leasing) part of their power generation and the security of protecting against future price increases. Customers and third-party developers own the overwhelming majority of the solar PV installed in the U.S. today—utilities own only a fraction of the 500 MW of solar PV systems currently installed nationwide.

That situation underlies much of the utility industry's traditionally less-than-enthusiastic, and sometimes contentious, relationship to distributed solar energy. Ownership of power generation beyond utilities reduces utilities' total revenue potential from traditional customers. Each kWh of power created at a residence or commercial rooftop is one less kWh needed from a utility, which could make it more difficult to request rate increases and maintain profit levels. Utilities must adapt to this new competition and customer relationship by creating new business models and forming new collaborations.

Across the country, commercially-owned PV installations are rising in popularity and growing in size. SunPower's PowerLight unit, for example, now has a contract with Wal-Mart to build solar electric power systems totaling 4.6 MW on seven facilities in California. Google has installed what was the nation's largest commercially-owned solar array when it went live in 2007—1.6 MW at its Mountain View, Calif., headquarters. Google plans on building 50 MW of solar by 2012. Utilities need to track these and similar developments as part of their overall demand projections, and to form partnerships to acquire the excess power of such installations.

Utilities also face increasing competition from third-party companies that own solar plants located on the premises of commercial and residential customers and sell the power or rent the panels to the customer at a fixed rate. Customers pay a deposit that is smaller than the usual upfront cost and commit to a long-term PPA that provides additional savings as electricity prices rise. Companies such as SunEdison, MMA Renewable Ventures, EI Solutions, and SunRun Generation guarantee the amount of power generated from the system and pay the difference if the solar power is less than expected. They also handle all aspects of installation, operation financing, and maintenance and get the benefit of receiving state and federal rebates.

Such third-party arrangements often include creative, innovative business and financing models—something that regulated utilities have rarely embraced. SunPower signed a contract with Hewlett-Packard to install a 1 MW PV system and perform system maintenance for 15 years at an HP facility in San Diego. HP will buy back the solar power at a reduced, locked-in rate. The system will be financed and owned by General Electric, which allows HP to take advantage of the environmental and financial benefits of solar with no upfront capital costs.

While these third parties originally targeted larger projects with commercial or industrial or university customers, some entrepreneurs are targeting residential systems. SolarCity in Foster City, Calif., is going the lease route, providing solar as a service as one option for its residential customers. With its SolarLease, the company obtains the necessary permits and installs and maintains (and owns) the system, all for one monthly fee, over a 15-year contract. In April 2008, SolarCity began offering a no-downpayment option to homeowners in California, and planned to make that option available in Oregon and Arizona later in the year.

Utilities can similarly capture some of the potential revenue from rooftop solar by owning the equipment, selling the power to the property owners, and sending the excess energy to the grid. While this scenario represents a significant change in the way utilities operate, this model provides an opportunity for utilities to maintain revenue levels and keep their existing relationship with customers, leveraging their existing billing, customer service, and other operations. Furthermore, as utilities gain experience in installing and maintaining PV, they could develop new services that compete with the solar maintenance organizations that are growing in popularity.

That is starting to happen. Partnerships with third parties or other utilities that share the cost of solar plants enable utilities to participate in solar with minimal investment. Nevada Power, for example, is partnering with the Las Vegas Valley Water District and SunPower to build six facilities that will generate a total of 3.1 MW. The Distributed Solar Array project, as the effort is called, will cost $22.6 million to complete and will generate 5.3 million kWh during its first year of operation.

Utilities also are banding together to jointly own solar resources and share development costs. A trio of utilities in Arizona has joined with a California power producer and private companies to build a 250 MW CSP plant. Group members sign a long-term PPA for the installation that is more cost-efficient because of the economy of scale of pooling demand.

This model could be broadened to groups of homes and businesses that are able to pool their resources and reduce utilities' per-kWh cost of monitoring and maintaining distributed resources. However, some jurisdictions place limits on the size of systems that qualify for rebates, and rules that prevent utilities from being eligible for federal tax credits available to third parties or customers would have to be modified. Aggregating power from many smaller installations also brings substantial technical challenges, including maintenance and grid management.

Several experts also envision utilities becoming directly involved in their customers' solar installations as another way to broaden customer relationships and better understand the distributed power opportunity. Utilities can generate additional revenue by developing service plans and financing options for solar.

Utilities can complement solar with wind power to get a more continual energy source, since wind resources tend to be stronger at night and solar's during the day. Puget Sound Energy in Washington State installed 450 KW of solar PV adjacent to the utility's Wild Horse wind power facility near Seattle.

In short, utilities should look to these new solar market players as both potential collaborators and examples of new business models that can be emulated.

Utilities' ownership of the relationship with power customers could be substantially diminished if they do not actively participate in customer adoption of PV. If utilities get involved in promoting solar, installation, and maintenance, they could grow their revenue opportunities instead of ceding them to new players.

6. Harness the Power of the Desert

The greatest opportunity for cost effectively implementing solar power on a grand scale in the U.S. is in the Mojave, Sonora, and other great deserts of the Southwest. Along with conventional PV, concentrating photovoltaic (CPV) and CSP have potential to make significant contributions to utilities' energy contributions, if current technical challenges of distribution and storage can be overcome. Once proven, these technologies could become attractive options for diversifying energy and meeting renewable portfolio standards.

The potential output from concentrating solar electricity in the Southwest U.S. is more than triple the current installation of all forms of solar worldwide, according to a 2007 study from the American Solar Energy Society. With appropriate federal and state policy support, 4 gigawatts (4,000 MW) of additional CSP plants could be deployed in the Southwest by 2015, and a much greater amount by 2025. The CSP Global Marketing Initiative, for example, anticipates a 5 GW increase in CSP by 2014, while the Western Governors Association's Clean and Diversified Energy Initiative, comprising 19 states, has plans to install up to 8 GW of solar by 2015, roughly half from PV and half from solar thermal. This would represent 13.3 percent of the estimated new electricity generation for those participating states.

Others believe that the potential for CSP and CPV could be much greater. In their Solar Grand Plan report in *Scientific American,* authors Zweibel, Mason and Fthenakis projected that up to 69 percent of U.S. electricity, and 35 percent of U.S. total energy, could come from desert regions by 2050. This ambitious scheme calls for 30,000 square miles of CPV and 16,000 square miles of CSP. Although ambitious, the plan clearly highlights the massive potential of southwestern deserts' solar resources.

While PV is effective in many areas and climates of the world, concentrating solar technologies have considerable limitations in less-than-optimal sunlight conditions. Both CSP and CPV perform at productive levels only in areas that have direct sunlight and few clouds for most of the year.

Other limitations to CSP include:

- CSP plants can require a large supply of water—obviously not ideal given desert locations.
- Ideal CSP sites are often located in remote regions, far from the utility grid.
- Natural gas systems can be required to provide back-up power to CSP facilities.
- The process for obtaining the necessary licenses and permits to develop CSP plants can be slow and expensive.

These challenges could slow CSP's adoption in the short term.

City Loans for Solar—A New Concept

The upfront capital cost for residential solar systems, typically over $15,000, can be prohibitive for most homeowners. But a growing number of federal, state, and municipal tax credits and rebates are making solar more accessible.

In a unique program, the city of Berkeley, Calif., is trying to make solar more accessible with a plan that would pay the upfront cost of the system, with homeowners repaying the cost over 20 years through additional tax payments. The Berkeley City Council preliminarily approved the plan in November 2007, and shortly thereafter the mayor of San Francisco offered a similar loan program for building owners across the Bay. Will other cities follow suit?

Lost in Transmission

Transmission lines near desirable CSP locations are often inadequate to handle the capacity—or are non-existent. The current financing model for new transmission lines discourages the participation of all but the largest utilities, as new facilities are required to pay for most of the costs of new transmission lines up front.

Creating new transmission lines and generation facilities simultaneously falls into the classic chicken-and-egg conundrum. Currently power plant developers are responsible for most of the upfront cost of building the transmission trunk lines to the grid, a capital-intensive proposition that can prohibit the participation of smaller renewable power developers. It can be difficult for utilities to receive financing for transmission projects to support generation that's yet to be built, and likewise new generating facilities won't receive funding without accompanying transmission lines. Of course, this issue also applies to traditional centralized power plants such as coal and nuclear; one proposed nuclear station in Florida includes an estimated $2 billion price tag for new transmission lines.

The California Independent System Operator Corporation in October 2007 approved changes to transmission financing requirements that could pave the way for improved federal regulations. Under the new system, as individual generation projects are built and connected to the grid, each generator would pay its pro-rated share of the annual Transmission Revenue Requirement (TRR) payments required by the Federal Energy Regulatory Commission. Instead of paying upfront, the costs increase as power generation capacity goes online.

This financing arrangement would continue until the entire capacity of the project is filled, at which time the remaining TRR for the transmission facility would be supported by the project developers. This will make it easier for solar power developers to participate alongside utilities in the expansion of the transmission lines necessary to reach remote areas of power generation.

Until the wave of current CSP projects (currently exceeding 3,000 MW in the U.S.) provides quantifiable benefits and reliable performance, utilities will likely be slow to adopt concentrating solar. But there are encouraging developments. The designers of the recently installed Nevada Solar One CSP plant are addressing some of CSP's limitations with a design that is more efficient in holding temperatures than the original SEGS plants, and requires a natural gas backup equal to just 2 percent of the power output, far less than previous systems.

Several experts interviewed for this report believe older, more proven trough technology will be a more widely accepted CSP technology because it is viewed by risk-averse utilities as a stable, simple technology. As one interviewee said, "Mirrors are easy, tubes are easy, and steam turbines are easy." Said another 30-year utility veteran, "Trough (technology) is proven; it works." The biggest maintenance challenge for the technology that reflects the rays of the sun is how to economically keep the mirrors clean.

7. Help Train the Next Wave of Workers

Utilities need to work with solar companies, community colleges, NGOs, and other key stakeholders to help provide job training for the coming demand for solar and energy efficiency jobs. Having enough people for these jobs is one of the key success factors for the growth of solar. In addition to the investment in the utilities' own business future, this pathway will also pay off in positive community relations, from providing both job training and actual jobs. Some utilities such as PG&E and Southern California Edison offer both online and in-person workshops for training in solar technology.

As part of this pathway, utilities should reach out to and work with grass-roots groups advocating “green jobs” for members of low-income communities, such as Sustainable South Bronx in New York City and the Ella Baker Center for Human Rights in Oakland, California. Such efforts are awaiting significant federal support via the Green Jobs provision of the 2007 energy bill, which Congress passed but has not yet allocated funding.

There are many potential routes for utilities to take to dramatically increase their development and use of both PV and CSP solar resources. But we believe that these seven pathways are the most realistic and carry the greatest potential for solar to reach our threshold of 10 percent of U.S. generation by 2025. With the right mix of innovation, changes of mindset, and technology improvements, we believe it is possible.

Utilities, however, do not exist in a vacuum—virtually every move they make requires approval, or at least oversight, from government regulators and in some cases, legislators. The pathways for regulators are the focus of our next section.

REGULATORY PATHWAYS: CHANGING THE RULES

Utilities operate in a highly regulated industry, which means that government—federal, state, and local—has a critical role to play if solar is to reach 10 percent by 2025. Indeed, this goal cannot be reached without policy makers removing roadblocks and increasing incentives. In the current regulatory framework, the natural evolution of solar energy's steady growth and gradually reducing prices is insufficient to transform it from a niche resource into a mainstream technology that becomes a pillar of the electricity mix.

Public policy provides both the carrots and sticks that prompt utilities to add solar to their portfolios. Through legislation, they develop the financial incentives that can justify investing in solar power plants, or through renewable portfolio standards, they can require (either indirectly or through carve-outs) the inclusion of solar as a percentage of their power generation. Regulations control the technical standards that so far have hindered integrating solar, as well as the rules and licensing requirements for the power industry.

Congress has established corporate tax credits for utilities and third-party power producers of solar energy; expansion of these incentives would likely result in increased investment from utilities. Similarly, federal tax credits for residential and commercial solar purchases made through the end of 2007 have spurred installations, but such tax credits are currently unavailable to utilities for distributed solar projects.

The Federal Energy Regulatory Commission sets the rules for transmission requirements and permitting of power generation for utilities. States have their own rules for transmission and interconnecting solar resources with the grid, forcing utilities that do business across state lines to grapple with multiple regulations.

State utility commissions control the electricity rates that can be used to finance expanded solar investments as well as the grid interconnection standards, while environmental agencies oversee siting and permitting. These rules and regulations vary by state and even within utility service territory, which can impede solar development because of the higher cost of compliance with multiple rules. The agencies' ability to create consistent statewide and interstate regulations can simplify and reduce the cost of developing and deploying solar power.

Municipal rules for interconnections or permitting can also vary from city to city, hindering investments in solar for utilities who want to serve multiple regions. The glut of local-government paperwork and technical hurdles as well as the economic uncertainty from temporary incentives has dampened utility enthusiasm for solar. Local regulators and policy makers could play a significant role merely by showing interest in solar, as evidenced by the Berkeley, California, City Council's municipal loan program for residential solar installations as discussed in the Utility Pathways section. As one utility executive said, "If (local) commissioners got fired up about solar, that is more powerful than anything else."

These and other issues need to be addressed to enable utilities to implement solar power effectively and efficiently. Below we highlight the six major steps that regulators and policy makers can take to help enable the growth of the U.S. solar industry, and to give power producers and utilities the tools necessary to greatly expand their use of solar resources. They are:

1. Decouple revenue from power consumption
2. Give utilities the ability to 'rate-base' solar
3. Establish open standards for production, time of use, interconnection, and smart grid technologies
4. Institute a national RPS with a solar carve out
5. Create a federal carbon cap-and-trade system
6. Pass a long-term extension of investment and production tax credits for solar and other renewables—and extend them to utilities

1. Decouple Revenue from Power Consumption

State regulators can make solar much more attractive to utilities by changing the system by which they earn profits and set rates. In most states utilities earn more when their customers consume more energy, so it is in their best interest not to encourage customers to "go solar" because it reduces their revenue. Tying profits to total power sold also discourages utilities from promoting energy efficiency.

Decoupling earnings from revenues enables utilities to increase their profitability while encouraging customers to become energy efficient or install solar power. Decoupling is among the most important policy matters that legislators and regulators need to adopt; it should become the standard for all states as a mechanism of promoting energy efficiency and solar adoption.

As one utility interviewee said, in working through the difficult discussions with regulators on investments, capacity, and rates, why deal with the hassle and loss of margin on something small and unknown like distributed solar—when "on the contrary, if I just go and make this single-cycle turbine investment, it's a known result and a known return on investment."

2. Give Utilities the Ability to 'Rate-Base' Solar

Decoupling, as big a change as it would be for many utilities, will not be enough. Utilities need to be able to "rate-base" solar—that is, be able to recoup their investments in distributed solar PV by including those costs in customer rate calculations. That's currently not the case in most areas. Utilities currently make money by generating power, but only for large-scale central facilities. Regulators need to give utilities the tools to make money from distributed generation sources like solar PV—as well as from investments in efficiency and the smart grid. That will require a major paradigm shift for many public utility commissions. But it's a necessary step, and one that will help many utilities get over solar's price hurdles.

"To a utility $2 billion is not a lot of money—it's one plant," said one utility director. "Money isn't the issue, capturing the benefit of the investment is. We're not seeing much yet [from regulators] in the way of decoupling. Utilities need to be able to make money by investing in efficiency. If you want us to have a clean, efficient grid, let us make money doing it."

One solar industry executive uses the mnemonic DRR to express what's needed—Decoupling, Rate-Basing, and Rate Design. Solar and efficiency investments must be spread across the rate base to avoid inequities in rate design. Otherwise, utilities run the risk of having non-solar customers effectively subsidize those with solar, by charging higher rates to make up for what they perceive as revenue shortfalls from customers with solar installations paying zero to the utility. "If you don't do [decoupling and rate-basing], rate design will piss off customers," said the executive. "When collecting less [from solar users] due to net metering, they have to collect more for everybody else. But if fixed costs are collected on a per-bill basis, they don't have this issue."

In the design of all aspects of DRR, regulators must make provisions to ensure that low-income customers are helped, not hurt, by the regulatory changes. There are a number of ways to accomplish this goal, such as offering lower rates for low-income customers, providing direct subsidy programs, and offering low-income customers free energy-efficiency audits and upgrades to keep their bills low. Protecting low-income customers is essential from both a social and economic justice perspective, and will help utilities create alliances with consumer and community groups so that they support rather than protest changes.

3. Establish Open Standards for Production, Time of Use, Interconnection, and Smart Grid Technologies

National net-metering and time-of-use pricing rules would promote conservation and bring solar's value to the fore. Net metering enables solar power users to deduct excess energy sent to the grid at premium rates from their utility bills. Time-of-use pricing shows consumers how much they are paying for the use of electricity at different times throughout the day and night, which would encourage energy efficiency and distribute demand more evenly.

Lack of consistent and open interconnection standards between states has resulted in a patchwork of regulations that has discouraged the adoption of solar because of the technical challenges in connecting solar to the grid. National standards for interconnections would reduce the cost and time involved in integrating solar and would help guarantee a more level playing field for distributed generation of solar power. A unified and open standard would benefit installers and utilities by removing uncertainty and enabling consistent services and products to be offered across state lines. Utility executives considering major investments in smart grid technology say they don't want to get locked in to a proprietary standard that could hinder, or add to the expense of, further improvements down the line.

Municipalities should enact solar-friendly building codes to eliminate barriers to installing solar PV in residential or commercially zoned areas. These codes would fast-track the permitting process for buildings that integrate solar. Cities such as San Francisco have begun requiring solar power to be part of new commercial construction.

4. Institute a National Renewable Portfolio Standard with a Solar Carve-Out

At the federal level, a national RPS can be a significant spur to solar deployment from utilities. We recommend a national RPS that would mandate solar development, via a solar carve-out, by utilities in states with good solar resources. Some of those states currently lack a state RPS, such as "Sunshine State" Florida.

The state RPS experience has been telling. State RPS's and tax incentives for solar have been the prime motivators for utilities to become involved in solar projects. The states with the largest adoption of solar—California, New Jersey, New York, Colorado, and Arizona—have all seen greatly accelerated demand after an RPS or incentives were put into place. Not surprisingly, these states ranked as the top five in PV installations in 2006. (For a list of state by state RPS's, see the Database of State Incentives for Renewables and Efficiency at www.dsireusa.org.) "Where an RPS is in place, an operator (independent from the utility) makes it possible for the utility to benefit without having to get directly involved" in solar construction, said one utility executive.

Most utilities that have embraced solar thus far have done so out of necessity: renewable portfolio standards (RPS) in the states where they operate require them to purchase a percentage of solar and wind energy. Since many large utilities sell power in more than one state, a national RPS would spark demand and provide utilities with a consistent target across all of their regions of operation. In December 2007, the Senate rejected a bill that include a national RPS that would have required investor-owned utilities to purchase a mere 2.75 percent of power from renewable sources by 2010 and 15 percent by 2020. Many climate advocates feel that the RPS needs to be at least 20 percent by 2020. It is imperative that the next Congress pass a national RPS with aggressive targets.

5. Create a Federal Carbon Cap-and-Trade System

A nationally mandated carbon cap-and-trade system (or carbon tax, which seems less likely politically) would help solar and other renewables move faster toward cost parity with fossil-fuel and nuclear power generation. But it needs to happen soon—and preferably with 100% allocation. The prospect of establishing a federal carbon legislation has prompted some utilities to hold off on solar and other investments, including efficiency. Utilities are "realizing that something is coming, and that solar has to be considered in their area," but they are delaying solar investments because of the uncertainty and lack of a clear business model, said one industry observer.

Assessing the comparative impacts on solar of the many current and potential cap-and-trade schemes before the U.S. Congress is beyond the scope of this report. But the basic concept of establishing a price for carbon emissions in the U.S. will be a critical financial motivator for large-scale solar development. It will especially spur utilities to reconsider investments in the most carbon-intensive of all energy sources, coal, and look to alternatives like solar (both PV and CSP) to supply future power needs.

6. Pass a Long-Term Extension of Investment and Production Tax Credits for Solar and other Renewables—and Extend Them to Utilities

Consumers and utilities alike will invest in solar with greater frequency when the tax benefits are consistent and reliable over several years. While countries such as Germany and Japan have seen an explosion in solar because of government initiatives and long-term, stable tax benefits, the U.S. federal government has been an unfortunate example of unpredictable, on-again off-again policy incentives. As this report went to press, Congress had still not passed extensions of investment and production tax credits for clean energy that will expire at the end of 2008. And even if they are passed, there's a likely possibility that they will be stopgap extensions for just one year. A long term (10-year) federal tax credit would not only motivate manufacturers to build more solar panels (making it cheaper for consumers), but it would also further legitimize the technology.

Congress missed an opportunity to significantly boost investments solar when it did not renew solar investment tax credits as part of the energy legislation that was signed into law in December 2007. The commercial and residential solar tax credits should be renewed and extended for a minimum of five years to give purchasers security to invest in solar. These credits should be extended to utilities as well, since they would be able to invest in solar on a much larger scale than individual consumers of energy. If Congress deemed it necessary to continue the generous tax incentives for the oil and gas industries to find new sources of energy, then surely investing in renewable energy is worthy of similar incentives. The on-again, off-again history of production tax credits in the U.S. has been particularly devastating to the wind power industry, resulting in a roller-coaster of boom and bust cycles that plague industry players, investors, and clean energy advocates.

Production tax credits have proven to be the most effective policy instruments to encourage investments in solar. Production-based incentives such as feed-in tariffs have driven the world-leading adoption of solar in Germany, Spain and Japan. Feed-in laws, which enable business and homeowners to sell excess energy back to the grid at beneficial rates and have been crucial abroad, yielding the following results:

- Spain reached 76MW of grid connected by 2006, and sales of PV more than doubled in 2007.

- Germany, with the most generous feed-in program in the world, is already generating more than 11 percent of its electricity from renewables, and 3 percent of the total energy mix is from solar. Somewhat amazingly, given its northern location with fewer hours of sunlight than most U.S. areas, Germany generates roughly half of the world's PV power via more than 300,000 solar installations. Approximately 250,000 Germans are now employed by the renewable energy industry.

- Japan has set and met specific goals for residential solar through a generous feed-in program and by reimbursing homeowners for a percentage of the cost of the system.

Production credits also reflect the value of solar in meeting energy needs more than cost of system-based credits. A bill currently under consideration in the Michigan legislature would mandate feed-in rates equivalent to that of Germany and could be used as a model for a national initiative. Washington State has already passed feed-in tariffs, and so has Ontario, Canada. Similar feed-in tariff bills are under consideration in Minnesota, Illinois, and Rhode Island. Most industry insiders feel that a national feed-in tariff is unlikely in the U.S., given recent congressional difficulties in passing extensions to the much less aggressive investment tax credits for solar and other renewables.

In February 2008, the California PUC approved a significant, though limited, feed-in tariff for solar in the Golden State. Small-scale solar systems of 1.5 MW or less, operated by customers of PG&E and SCE under long-term contracts of 5 to 15 years, are eligible to receive payments of 8 to 31 cents per kWh; most will average about 15 cents. The program carries a total cap of about 105 MW for PG&E and about 125 MW for SCE. Those two utilities and five others are also eligible for a separate feed-in tariff only for solar arrays located at public water and wastewater facilities. That program has a statewide cap of 250 MW. California's program is a positive step, but its intricate rules and limitations point up the challenge of getting beyond incremental improvements. Regulators and legislators need to think much bigger and adopt even more aggressive policies in order to achieve a nationwide goal of 10 percent solar.

State and local governments can also spur solar sales through property tax incentives including exemptions, exclusions and credits that exclude the added value of a solar

States in the Lead

Following is a summary of select incentives and other policies promoting solar in states producing the most solar power, listed in order of the states with the greatest solar output.

California

- The "Million Solar Roofs" program (2006) requires that solar be an option for buyers of all new construction, expands the ceiling on net metering, and directs municipalities to create solar rebate programs.
- The California Solar Initiative (CSI) dedicates $3.2 billion over ten years to create 3,000 MW of solar power by 2017. CSI is focuses on distributed installations and awards incentives based on the projected output of the system.
- A feed-in tariff approved in early 2008 allows payment of 8 to 31 cents per kilowatt-hour to customers of utilities PG&E and SCE with PV systems of 1.5 MW or less.

New Jersey

- Has been proactively encouraging solar investment through an RPS and strong support from the state's Board of Public Utilities.
- RPS requires that 2.12 percent of energy come from solar power by 2021. Customer rebates are available for the capital costs of their system and a renewable energy credit program.
- Net metering and interconnection policies are among the strongest of any state.

  A law passed in August 2007 prevents homeowners associations from blocking solar panel installations on certain types of properties.

New York

- Second state to adopt uniform interconnection standards for distributed generation systems up to 2 MW.
- New York offers a state sales tax exemption (passed in 2005) for residential solar heating and energy equipment, and a property tax exemption for the additional value of a property due to installing solar or other renewable power resources.

Arizona

- Solar-friendly RPS requires 15 percent of the state's energy needs from renewable energy, of which 30 percent must come from distributed generation.

Colorado

- Colorado was first to bring an RPS to the voting public, which passed it in 2004.
- Solar set-aside requires that 0.4 percent of the state's power comes from solar energy by 2015.

system from tax assessment. Another method is through personal income tax credits for the cost of solar purchases, which are now available in 32 states.

In sum, more than in most industries, the strategies and decisions of electric utilities are inextricably entwined with public policies established by legislators and implemented by regulators. Whether carrots or sticks, the policies and regulatory changes recommended above are critical to achieving the ambitious goals for U.S. solar expansion that we map out in this report. Regulators and policymakers share with the utilities a large share of responsibility to make it happen.

THE ROAD FROM HERE

In this report we've highlighted the biggest opportunities and challenges facing the widespread adoption of solar by utilities; reviewed the history of utilities' growing involvement in solar; and highlighted the key pathways that major stakeholders need to take for the U.S. to achieve 10 percent of its electricity mix from solar by 2025. These pathways include:

- The solar industry bringing down costs and scaling up manufacturing
- Utilities putting a value on solar assets and embedding them into their strategic planning
- Regulators giving utilities the tools to rate-base and recover their investments in solar

Below is a table that highlights the key activities that we've outlined in this report, and which, based on our research, we believe will go a long way in enabling the growth of a robust solar industry in the U.S.—thereby creating jobs, reducing our nation's dependence on polluting and volatile supplies of fossil fuels, and ensuring economic competitiveness.

Key Solar Stakeholders and Actions

Solar Companies	Utilities	Regulators
Bring installed solar systems costs to $3 per peak watt by 2018	Take advantage of the unique value of solar for peak generation	Decouple revenue from power consumption
Improve silicon cell efficiency and performance	Better serve customers in grid-constrained areas and "at the edge"	Give utilities the ability to 'rate-base' solar
Develop new low-silicon and non-silicon alternatives such as thin film and nanotechnologies	Implement solar as part of demand response systems and build-out of the smart grid	Establish open standards for production, time of use, interconnection, net metering, and smart grid technologies
Streamline installations and make solar a truly plug-and-play technology	Use solar as a price hedge against fuel cost increases and potential carbon costs	Institute a national RPS with a solar carve-out
Ramp up concentrating solutions—including CSP and potentially CPV—for central generation and to drive down costs	Adapt to the new power market with new business models	Create a federal carbon cap-and-trade system
Work with utilities and regulators to develop open standards for net interconnect, two-way flow of electrons, etc.	Harness the power of the desert	Pass a long-term extension of investment and production tax credits for solar and other renewables—and extend them to utilities
	Help train the next wave of workers	

Game Changers

In addition to actions outlined in this report, in which solar PV and CSP "scale" through a range of stakeholder actions, we believe there are a number of potential game changers that could disrupt the system and accelerate the growth of solar, potentially even more dramatically. There are three that we think are particularly worth noting:

- ### PHEVs and All-Electric Vehicles Take Charge

  A large number of respondents to our survey spoke about the advent of a distributed smart grid in which plug-in hybrid electric vehicles (PHEVs) and all-electric vehicles could be used to store and feed energy into the grid on demand—freeing up bottlenecks and reducing the need to build new, expensive, and polluting centralized conventional power plants. In this scenario, there would be hundreds of thousands of storage and back-up systems around the country. Since vehicles typically aren't in use more than 90 percent of the time, they could provide the perfect "vehicle" for storing electricity (in their battery packs), then sell this energy back to the grid at times when it most needed, such as evening hours after commuters return home. Vehicles' power might come from rooftop solar carports at work, from residential solar PV systems, or from centralized PV or CSP power plants.

  In other words, PHEVs could charge during the day (if the vehicle is parked at home or at work), with that power used to reduce the household's demand during the peak (most expensive) hours. Taking it further, an arrangement with the utility could allow that power to be dispatchable by the utility through communications and electrical protocols within a vehicle-to-grid (V2G) system. Such systems already are being considered. In January 2008, General Motors convened executives from 50 U.S. utilities for a two-day "vehicle electrification workshop," at which participants shared the challenges and opportunities for creating a V2G system that would be, among other things, compatible from region to region.

  Pioneering Texas utility Austin Energy is playing a leading role in Plug-In Partners, a national campaign to help drive this vision. Another leader, Central Vermont Public Service, is driving this vision through their "plug 'n go" campaign, installing charging stations in town that will eventually allow the utility to also tap the stored energy in cars to address peak power needs.

  Imagine a hot summer day in California. As people drive home to turn on their air conditioners and TVs and ovens to cook their dinners—thereby taxing the grid—they add one simple thing to their nightly ritual. As they park their PHEV in the garage—they plug it into the grid to help ease the power demands and constraints on a sweltering California day.

This vision would require the advent of a truly smart "two-way" grid (outlined earlier in the report) as well as a dramatic increase in PHEVs and all-electric vehicles, few of which are on the road today. But it's not outside the realm of possibility. In fact, with quite a few organizations and innovators working on this solution—we think it's more a matter of when then if. The big question is: Are we looking at five, 10, 15 or more years?

■ A Manhattan Project / Apollo Mission / New Deal for Clean Energy Becomes a Reality

Influential New York Times columnist Thomas Friedman likes to say that "green is the new red, white and blue." In the book *The Clean Tech Revolution* [written by this report's principal authors, Ron Pernick and Clint Wilder] we make the case that U.S. economic competitiveness and relevance lies in tapping the growth potential for clean energy, efficiency, and other clean technologies. Who else better to enable the growth of the clean-tech revolution than the country that brought the world the airplane, the automobile, the computer chip, and the Internet?

But America can't rest on its laurels. The U.S. federal government, in many respects, has been missing in action for the past quarter century, ceding clean-technology control and leadership to states and to other nations.

But what if there were a Manhattan Project, Apollo Mission, or New Deal for clean energy? If national leaders were to make the research, development, and deployment of clean energy and the build-out of clean-tech infrastructure the centerpiece U.S. economic competitiveness, energy independence, and job creation, renewable energy, including solar, could shift into hyper-drive. Such a program would likely include a mix of tax credits, a federal RPS, R&D support, carbon cap-and-trade, and other features—backed up with hundreds of billions in research and capital investment.

Clean Edge and Co-op America previously envisioned a Manhattan Project for solar in our 2005 SHINE report.

Such a concerted federal effort, which would inspire a generation of entrepreneurs, scientists, educators, financiers, and others, would change the national and global energy landscape.

Germany, which has been promoting the growth of its renewable energy industry at the national level, has seen significant results in its efforts—and provides a strong example. Renewable energy jobs in Germany equaled 250,000 in 2007, nearly double the number of clean-energy jobs just three years earlier. According to government figures, as many as 400,000 people could be employed in the renewable energy industry in Germany by 2020. Germany, not a particularly sunny country, is the world's largest market for solar PV and now has the largest solar PV manufacturing company (Q-Cells) in the world.

Imagine what might happen if the U.S. pursued a plan of its own.

■ Large-Scale Energy Storage Breakthroughs Reshape the Grid

To get beyond the ten percent number for solar will require significant breakthroughs in both central and distributed storage options. As noted above, distributed energy storage systems (such as those in electric vehicles) could be tapped for a next-generation grid that exploits the solar resource. And residential and commercial customers could install batteries for short-term evening use on peak summer days, or longer term storage for use through shorter, sometimes cloudier winter days.

But what about energy storage for large-scale solar plants? Research continues on a host of advances that could make centralized solar more economical for utilities. Possible utility-scale storage options include pumped hydro (water pumped above a hydro electric plant, or water left available above the dam because the solar energy was available); compressed air storage (in underground caverns); heat storage (underground steam storage, molten salt or hot water; high-speed flywheels; and large-scale batteries to store electrons from both solar and wind generation sources. Later this year, Xcel Energy and partners including NREL will begin testing an 80-ton, one-megawatt battery pack (20 batteries of 50 KW each) that stores power from a wind farm. When fully charged, the battery could power 500 homes for more than seven hours. If successful, that type of storage could also be used for solar, another energy source in which Xcel has significant investments.

Breakthroughs in any of these technologies, either in feasibility or cost or both, would dramatically change the game. They would help transform the current perception of solar, held by many key principals at utilities, as primarily a provider of peak power on hot summer days. And peak demand doesn't always coincide exactly with solar's top output. One utility executive says peak demand in his region occurs one to two hours after peak PV production. While solar can still be helpful in this scenario, storage would erase any of the disadvantages caused by differences between peak solar production and peak utility demand. So large-scale- or distributed-storage could help significantly. As one expert put it, "Storage is the holy grail. Anyone who solves this will earn enormous returns. Utilities should look into R&D here."

These game changers would certainly assist in the rapid growth of the solar industry, but as we mention above, they are not a requirement for getting to the 10 percent vision.

A Goal Within Reach

Dramatic change is never easy. But we strongly believe, based on our assessment of industry dynamics and the many interviews conducted for this report, that today's grand vision—10 percent of U.S. electricity from solar by 2025—is not a pipe dream. Challenges exist, but the pathways we have mapped out for utilities, regulators, policymakers, and technologists are sensible and realistic. Most importantly, cost parity for solar is within the planning horizon of most every utility in the U.S.

Grand visions for solar power are not new. Since the 1970s, solar industry advocates have waxed enthusiastic about the technology's potential to supply a significant portion of the nation's electricity needs. But for myriad reasons, the reality of solar power in the U.S. has fallen far short of that vision.

We believe, based on the research in this report and the industry trends we see unfolding every day, that the context of solar power in the United States is changing rapidly. Technology and efficiency are improving, costs are falling, costs of traditional power sources including natural gas, coal and nuclear are skyrocketing, and utilities that have long ignored or even opposed solar on a large scale are changing their tune.

From now to 2025 and beyond, solar (both PV and CSP) presents dramatic new, cost-effective opportunities for utilities struggling with the challenges of increased fuel and construction costs for fossil fuel and nuclear plants, RPS mandates, public and political opposition to coal, demands for grid modernization, and the strong likelihood of nationwide carbon caps in the next 12 to 18 months.

Admittedly, the price tag to get to 10 percent solar—$450 billion to $560 billion—isn't small. But utilities are used to spending billions of dollars in capital investments for generation assets and transmission and distribution—as long as they have the incentives and tools to get there. Indeed, the financial requirements outlined in this report aren't for R&D, they would go toward the direct installation of solar PV systems on rooftops, carports, and adjacent to buildings and to large-scale PV and CSP systems. They would equate to actual energy production, a combined cumulative installation of 250 GW of solar power.

To put the $450 billion to $560 billion price tag in perspective: the Edison Electric Institute estimates that the U.S. electric utility industry spent more than $70 billion on new power plants and new transmission and distribution investments in 2007 alone. As we point out earlier in the report, the estimated solar price tag would represent approximately a half to a third of utility investments between now and 2025, if similar spending patterns occur.

Venture capitalists, government labs, corporations, and others have been building out the next-gen solar opportunity—with big players like Sharp, Applied Materials, and GE competing against relative newcomers like Suntech Power, SunPower, and Q-Cells, who themselves are working to stay ahead of smaller startups like Miasolé, Nanosolar, and SolFocus. These companies are delivering advanced, scaleable technologies that will enable the next wave of energy innovation.

Our research indicates that the goal of 10 percent solar by 2025 is absolutely within reach. We recommend that all the players covered in this report—utilities, industry players, regulators, and policymakers—start on these courses of action with a strong sense of urgency. In the context of U.S. energy independence, economic innovation, job creation, and climate change—there is no time to lose.

APPENDIX A: SOLAR AND UTILITIES: A BRIEF HISTORY

The solar industry has a rich and deep history. Most people point to Bell Labs' work and the first conversion of sunlight to electricity via a PV cell in 1954 as the birth of the modern solar era. But modern solar roots date back even further to two of the great scientific minds of the 20th century: Nikola Tesla issued a patent for a "radiant energy" apparatus in 1901 and Albert Einstein published a paper on the "photoelectric effect" in 1905. (See Appendix B for comprehensive solar history timeline.)

To a large extent, the early history of solar PV (outside of non-terrestrial applications for satellites and the space program) has been written by residential and commercial energy customers purchasing and maintaining their own systems (or more recently acquiring solar energy through "green power" providers). Utilities, to date, have played a limited role in the maturation of solar PV, at least in the United States.

In the early 1970s, a few residential properties were the first to rely on solar power. The federal government largely stayed on the sidelines until later in the decade, when President Jimmy Carter created a research center for solar energy and instituted the first federal tax credits (and placed solar cells on the roof of the White House).

Throughout the 1980s the federal government showed almost no interest in solar, as symbolized by President Ronald Reagan removing the solar panels from the White House. According to the Renewable Energy Policy Project, solar received the equivalent of 3 percent ($4.4 billion) of the subsidies given to the nuclear industry ($145.4 billion) from 1947-99.

The first large-scale purchase of solar power by a utility was by Southern California Edison, which started receiving power from the Solar Electric Generating Stations (SEGS) concentrating solar thermal plants in the mid 1980s. (These plants are still online and providing some 350 MW of generating capacity). In the early 1990s, the Energy Policy Act of 1992 restored the 10 percent federal investment tax credit for using solar in power production, and utilities such as California-based Pacific Gas & Electric began to dabble in purchasing PV systems.

Until the early 21st century, most utilities continued to rely almost exclusively on fossil fuels and nuclear energy for power. This is understandable given the lack of state and local legislation promoting renewables and the cost disparity between abundant and inexpensive fossil fuels and newfangled but costly solar.

However, since the beginning of the decade, a number of utilities have begun deploying solar more aggressively. In recent years more than two dozen states have established renewable portfolio standards that require utilities to purchase clean energy, several of which include solar carve-outs. Utilities have begun buying equipment and purchasing solar energy through power purchase agreements from concentrating solar plants

Table: Solar Grows Up—The Increasing Size of PV Installations

Back as early as 2000, a 200 kW solar PV system was considered large. But that's changing, as Google's 1.6 MW system at its "Googleplex" corporate headquarters has gone online and as Wal-Mart proceeds with plans for large PV arrays on the roofs of 22 stores and distribution centers in California and Hawaii. Below is a table showing some of the larger solar PV rooftop and ground-mounted systems sprouting up around the globe.

Installation	Capacity	Installation Type	Location
Shenzhen International Floral Exhibition Buildings	1 MW	Built-in PV	Shenzhen, China
Alvarado Water Treatment Plant	1.1 MW	Rooftop	San Diego, California
Sierra Nevada Brewing	1.4 MW	Rooftop	Chico, California
Google	1.6 MW	Rooftop	Mountain View, California
Fort Carson	2 MW	Ground Mounted	Fort Carson, Colorado
Hall's Warehouse Corporation (SunEdison)	2 MW	Rooftop	South Plainfield, New Jersey
Springerville Generating Station	4.6 MW	Ground Mounted	Tucson, Arizona
Sharp Plant, Kaneyama	5.2 MW	Built-in PV	Kameyama, Japan
Alamosa Photvoltaic Solar Plant (SunEdison)	8.2 MW	Ground Mounted	San Luis Valley Alamosa, Colorado
Serpa PV Power Plant	11 MW	Ground Mounted	Serpa, Portugal
Nellis Airforce Base	14 MW	Ground Mounted	N. Las Vegas, Nevada
Solarpark "Waldpolenz"	14.7 MW	Ground Mounted	Brandis, Germany
Solarpark Beneixama	20 MW	Ground Mounted	Alicante, Spain
Hoya de Los Vincentes	23 MW	Ground Mounted	Murcia, Spain

Source: Clean Edge research including review of company press releases and public web sites.

as well as large PV farms and distributed PV installations. Utilities are also getting involved because of improvements in the technology—spurred by an unprecedented investment in venture funding and other private and public financing—as well as in their efforts to address grid congestion and other utility constraints.

But despite the recent surge in interest, solar remains a negligible portion of utilities' energy mix. Net solar power generation in the U.S. from utility-scale facilities is currently around 500 MW of capacity—half the size of an average nuclear, natural gas, or coal-fired power plant. Even more humbling, the U.S. has less than 20% of the installed PV capacity of global solar leader Germany, a country one quarter its size and with considerably less sunshine than many parts of the U.S.

The granddaddy of CSP, the SEGS plants near Barstow, Calif., helped prove to utilities that CSP can be a reliable and durable energy source. SEGS' parabolic trough performance—operating nearly 100 percent of the time during peak hours—has encouraged development of next-generation concentrating technologies. Operating since the mid 1980s and completing its ninth and final station in 1989, the SEGS units provide more than 350 MW of solar power generation. Originally developed by the now defunct Luz International, the plants are now owned and operated by FPL Energy and Carlyle Riverstone.

For nearly two decades there was no new solar CSP development in the U.S. But over the past two years, CSP has been the major catalyst of a new chapter in utilities' embrace of solar power. Emerging CSP technology developers like Ausra, BrightSource, and Solel have applied for CSP projects totaling more than 24,000 megawatts in the Southern California desert, and California's big utilities have shown major interest. For example, PG&E has agreed to purchase 900 MW from a series of BrightSource plants.

FPL Energy, the Florida utility's development arm, is aiming to augment its leadership in wind power with major solar efforts. FPL said in 2007 it will spend $1.5 billion over seven years to built solar plants in California and Florida, mainly CSP. And CSP is also one of the three technologies targeted by Google's RE<C initiative to make renewable energy cheaper than coal. It's too early to say what Google's impact might be, but any push to significantly reduce solar costs could greatly expand utilities' participation beyond the wave of early leaders currently embracing the energy source.

Leading the Charge

Thanks to aggressive measures by the state's public utilities commission, as well as supportive political leadership, utilities in California have been setting the pace in solar adoption by building centralized installations and by offering rebates to customers who install distributed solar power. A brief look at California's top utilities and their solar activities to date:

Sacramento Municipal Utility District (SMUD)

SMUD has been a leader in solar energy for more than 20 years. SMUD has installed about 10 megawatts of solar power in its service territory on residential, commercial, and government buildings and in larger, utility-scale arrays. Ten megawatts of electricity is enough to power about 9,000 average-size single-family homes in the Sacramento region.

SMUD commissioned its first solar project, a 1-MW photovoltaic electricity generating facility, in 1984. SMUD encourages residential consumers through the SolarSmart Homes program that matches approved PV installers with interested consumers, resulting in more than 2,500 solar homes to date. SMUD also provides financing for certain energy efficiency measures for commercial, industrial, agricultural, and multifamily customers.

PG&E

California's largest electric utility built the first utility-owned distributed power system in 1993, with its grid supported PV system in Kerman, California. In 2007, PG&E began offering rebates to residential and commercial customers who purchase solar systems. The utility is aggressively adding renewable electric power resources to its supply and is on target to exceed 20 percent under contract or delivered by 2010. PG&E now has contracts to provide 18 percent of its future energy supply from renewable sources.

In 2007, PG&E announced plans to double its existing commitments to buy renewable solar thermal electric power, adding 1,000 MW of new supply to its portfolio over the next five years. This commitment builds on the company's previously announced plans with Solel and BrightSource to purchase more than 1,000 MW of solar thermal power. The additional commitment will be enough to power more than 750,000 homes.

Southern California Edison (SCE)

SCE has used solar energy as part of its generation portfolio since the 1980s as a buyer of electricity generated by the SEGS units in the Mojave Desert. But perhaps its biggest step came in March 2008, when SCE said it will invest $875 million to deploy up to 250 MW of PV modules on 65 million square feet of roofs of Southern California commercial buildings over the next five years.

SCE's renewable portfolio currently has the ability to deliver more than 2,700 megawatts of electricity, 354 MW of it from solar via the SEGS project. The utility has signed new power purchase agreements (PPAs) with Stirling Energy Systems to establish large CSP plant complexes in Southern California. SCE and San Diego Gas & Electric have pledged to buy a combined minimum of 800 MW annually from Stirling. SCE also has a one-megawatt PPA with California Sunrise for a PV plant.

San Diego Gas & Electric

SDG&E is considering spending $1.5 billion to encourage distributed solar power as an alternative to building a controversial 150-mile power line, some of it through environmentally sensitive areas. Beyond that, SDG&E hasn't made as many commitments in solar as its fellow Golden State utilities, but that could change soon. In March 2008, the utility said it was soliciting bids from clean energy suppliers including solar to help it meet California's 20 percent RPS mandate by 2010.

Some leading utilities in solar elsewhere in the U.S.:

FPL Group

FPL Group, Inc., one of the country's leading generators of renewable electric power, announced a $2.4 billion investment program in 2007 aimed at increasing U.S. solar thermal energy output, increasing efficiency, and reducing carbon dioxide emissions that contribute to global warming.

FPL Group, and its subsidiaries Florida Power & Light and FPL Energy, will invest up to $1.5 billion in new solar thermal generating facilities in Florida and California over the next seven years, starting with a project at Florida Power & Light; up to $500 million by FPL to create a smart network that will provide its 4.5 million customers with enhanced energy management capabilities; and at least $400 million over five years in a new FPL Energy consumer education program and new consumer generation and energy-efficiency products.

Xcel Energy

Xcel is one of the best examples of how RPS mandates can spur a utility toward clean-energy leadership. Xcel, though already a leading developer of wind power at the time, lobbied heavily against Colorado's 2004 ballot initiative for an RPS of 20 percent by 2020. But in the three years since voters passed the measure, Xcel has become aggressive in solar. In January 2008, Xcel issued RFPs for a total of 25 MW of solar in its service area, which would bring it one-fourth of the way to Colorado's RPS solar carve-out mandate of 100 MW.

Xcel is also working with third-party solar developer SunEdison in a partnership that exemplifies the new types of business models utilities could, and may need to, embrace to achieve our 10 percent by 2025 vision. SunEdison financed, constructed and will maintain an 8.22 MW PV array in Alamosa, Colo., one of the largest in the U.S. Xcel purchases the solar-generated electricity and the renewable energy credits from the facility.

Xcel is also embarking on installing the first city-wide smart-grid system in the nation, in Boulder, Colo. In May 2008, it engaged smart grid technology leader GridPoint to provide a variety of control and monitoring systems, including one that allows plug-and-play integration of residential and small commercial PV systems.

Public Service Electric and Gas Company (PSE&G)

New Jersey's largest utility recently received approval from state regulators to offer $105 million in loans to help finance the installation of solar systems on homes, businesses, and municipal buildings throughout its service area. (Initially the program will be available only to non-residential customers, as PSE&G needs approval from the N.J. Department of Banking and Insurance to provide direct loans to residential customers.) The program will support the development of 30 MW of solar power, designed to fulfill about 50 percent of the RPS requirements in PSE&G's service area in 2009-2010.

Under the program, PSE&G will provide loans to developers or customers to cover approximately 40-60 percent of the cost of a solar installation project, depending on the projected output of the solar energy system and the cost of the system. Remaining costs will be funded by the owner of the solar installation. The program addresses one of the biggest hurdles facing homeowners and businesses who want to cut their electric bills by installing solar panels: the huge upfront costs.

Tucson Electric Power (TEP)

A subsidiary of UniSource Energy, TEP currently has 4.6MW of solar PV at the Springerville Generating Station Solar System in northeastern Arizona, installed by Global Solar Energy. This site generates approximately 7,800 MWh annually.

An additional 742 MWh are produced by local systems and community installations sponsored by TEP's SunShare program.

Both TEP and Xcel are part of a multi-state consortium of Southwestern energy service providers issuing a request for proposal (RFP) for a utility-scale CSP plant. The plant would be owned by a third party, with consortium members each signing long-term PPAs. It is expected to produce 250 MW and be located in either Arizona or Nevada. When completed, it would be the largest solar power plant in either state. Other participants are Arizona Electric Power Cooperative, Arizona Public Service, Southern California Public Power Authority, and Salt River Project.

In short, utilities can look to pioneers like these to find examples how utilities are adopting solar power. One could make the case that the U.S. solar industry would not be where it is today without these utilities' participation. But overall, the historical growth of utilities' embrace of solar has been incremental, not transformative. That will have to change for the U.S. to reach the goal of 10 percent solar generation by 2025.

APPENDIX B: SOLAR ELECTRICITY HISTORICAL TIMELINE

(Utility-Related Items in Gray)

!901 Nikola Tesla receives the patent U.S.685957, “Apparatus for the Utilization of Radiant Energy”, and U.S.685958, “Method of Utilizing of Radiant Energy”.

1905 Albert Einstein publishes his paper on the photoelectric effect (along with a paper on his theory of relativity).

1918 Jan Czochralski, a Polish scientist, produces a method to grow single-crystal silicon.

1950s Bell Labs produces solar cells for use in the space program. The work of Bell Labs represents the birth of the modern era of the solar PV industry.

1955 Western Electric licenses commercial solar cell technologies. Hoffman Electronics-Semiconductor Division creates a 2% efficient commercial solar cell for $1,785/Watt.

1956 William Cherry, U.S. Signal Corps Laboratories, approaches RCA Labs’ Paul Rappaport and Joseph Loferski about developing photovoltaic cells for proposed orbiting Earth satellites.

1958 Hoffman Electronics achieves 9% efficient photovoltaic cells.

1959 The National Aeronautics and Space Administration (NASA) uses solar modules to power the Vanguard 1 satellite. This was a perfect solution to the power needs of space exploration, as solar modules are lightweight, durable, and require little-to-no maintenance. Sunlight is also in constant abundance in space.

1960 Hoffman Electronics achieves 14% efficient photovoltaic cells.

1963 Japan installs the largest array of the time, a 242-watt, photovoltaic array on a lighthouse.

1970s Dr. Elliot Berman, with help from Exxon Corporation, designs a significantly less costly solar cell, bringing price down from $100 a watt to $20 a watt. Solar cells begin to power navigation warning lights and horns on many offshore gas and oil rigs, lighthouses, railroad crossings and for off-grid residential applications.

1977 Total global PV manufacturing production exceeds 500 kilowatts.

The U.S. Department of Energy launches the Solar Energy Research Institute “National Renewable Energy Laboratory”, a federal facility dedicated to harnessing power from the sun.

1978 The Public Utility Regulatory Policies Act (PURPA) mandates the purchase of electricity from solar producers determined to be qualifying facilities (QFs) that meet specified technical standards for energy source and efficiency.

A 15-percent federal energy tax credit is added to an existing 10-percent investment tax credit, providing incentive for capital investment in solar thermal generation facilities for independent power producers.

1982 The first, photovoltaic megawatt-scale power station goes on-line in Hisperia, California. It has a 1-megawatt capacity system, developed by ARCO Solar, with modules on 108 dual-axis trackers.

Worldwide photovoltaic production exceeds 9.3 megawatts.

1983 Worldwide photovoltaic production exceeds 21.3 megawatts, with sales of more than $250 million.

ARCO Solar dedicates a 6-megawatt photovoltaic substation in central California. The 120-acre, unmanned facility supplies the Pacific Gas & Electric Company's utility grid with enough power for 2,000-2,500 homes.

The first in a series of Solar Electric Generating Stations (SEGS) plants, generating 13.8 megawatts, is installed, with output sold to Southern California Edison Company. SEGS I uses solar trough technology to produce steam in a conventional steam turbine generator. Natural gas is used as a supplementary fuel for up to 25 percent of the heat input.

1984 The Sacramento Municipal Utility District commissions its first 1-megawatt photovoltaic electricity generating facility.

1985 20% energy conversion efficient silicon cells are created by the Centre for Photovoltaic Engineering at the University of New South Wales.

1986 ARCO Solar releases the G-4000—the world's first commercial thin-film solar module.

The world's largest solar thermal facility is commissioned in Kramer Junction, California. This is the first of 9 SEGS solar thermal installations produced by Luz International.

1989 Federal regulations that govern the size of solar power plants are modified to increase maximum plant size to 80 megawatts from 30 megawatts. The larger size allows SEGS VIII and IX to improve the economics of the power block, controls and auxiliary equipment, and to lower operating and maintenance costs.

1991 Luz International goes bankrupt while building its tenth SEGS plant. SEGS I through IX remain in operation totaling 354 MW.

1992 University of South Florida develops a 15.9% efficient thin-film photovoltaic cell made of cadmium telluride, breaking the 15% barrier for the first time for this technology.

A 7.5-kilowatt dish prototype system using an advanced stretched-membrane concentrator, through a joint venture of Sandia National Laboratories and Cummins Power Generation is installed in Abilene, Texas.

The Energy Policy Act restores the 10-percent federal investment tax credit for independent power producers using solar technologies.

1993 Pacific Gas & Electric installs a 500-kilowatt "distributed power" PV system in Kerman, California.

The National Renewable Energy Laboratory (NREL) completes construction of its Solar Energy Research Facility; it will be recognized as the most energy-efficient of all U.S. government buildings in the world.

1994 Solar global cumulative installed capacity reaches 500MW.

NREL develops a solar cell—made from gallium indium phosphide and gallium arsenide—that becomes the first one to exceed 30% conversion efficiency.

The first solar dish generator to use a free-piston Stirling engine is hooked up to a utility grid.

NREL develops a solar cell made of gallium indium phosphide and gallium arsenide; it's the first one of its kind to exceed 30% conversion efficiency.

1996 Solar Two, a test 10MW solar concentrator is installed in Barstow, California.

1998 Solar global cumulative installed capacity reaches 1 GW.

1999 Spectrolab, Inc. and the National Renewable Energy Laboratory develop a photovoltaic solar cell that converts 32.3 percent of the sunlight that hits it into electricity.

Researchers at NREL develop a record-breaking prototype thin film solar cell that measures 18.8% efficient, topping the previous record for its type by more than 1%.

Cumulative installed photovoltaic capacity reaches 1000 MW worldwide.

2000 In Perrysburg, Ohio First Solar establishes the largest photovoltaic manufacturing plant with capacity to produce 1000 MW of panels annually.

2001 Solar global cumulative installed Capacity reaches 2 GW.

PowerLight Corporation (now SunPower) installs the largest rooftop solar power system in the United States—a 1.18 megawatt system—at the Santa Rita Jail in Dublin, California.

2002 President George W. Bush installs 'building-integrated photovoltaics' or BI-PV solar electric generators at the White House .

2003 Solar global cumulative installed Capacity reaches 3 GW.

2004 Solar global cumulative installed capacity reaches 4 GW.

California Governor Arnold Schwarzenegger proposes the Solar Roofs Initiative for one million solar roofs in California by 2017.

Colorado voters pass Amendment 37, the first state renewable energy portfolio standard approved by voters through a ballot initiative. The initiative requires the state's largest utilities to obtain 3 percent of their electricity from renewable energy resources by 2007 (with 4 percent of that coming from a solar carve-out) and 10 percent by 2015. It also establishes a standard net metering system for homeowners and ranchers.

2005 Polysilicon use in photovoltaics exceeds all other polysilicon use for the first time.

New solar cell breaks the "40 Percent Efficient" sunlight-to-electricity barrier

2006 Solar global cumulative installed capacity reaches 8 GW.

California Public Utilities Commission approved the California Solar Initiative (CSI), a $2.8 billion program that provides incentives toward solar development for the next 11 years.

Solar market reaches more than 2 GW of solar cell manufacturing output; $15 billion in revenues and $264 million in venture capital investment.

Colorado utility Xcel Energy begins its solar rebate program. Originally opponents of the state's solar initiative, the utility now offers funding for solar energy systems to be rebated at $2 per watt for residential systems up to 10 kilowatts (kW).

2007 Solar global cumulative installed capacity reaches 10 GW.

SolarWorld AG Announces it will build 500 MW solar manufacturing plant in Hillsboro, Oregon—largest in U.S.

Acciona completes 64 MW solar thermal plant in Nevada. It is the largest solar plant to be built in the world in the last 16 years. This project is representative of the rebirth of CSP in Spain and the U.S.

Google's 1.6 MW solar panel project begins operation—largest corporate solar installation to date.

More than 24,000 MW in solar thermal projects applied for under BLM land in Southeast California desert.

California Public Utilities Commission approves the California Solar Initiative (CSI), a comprehensive $2.8 billion program that provides incentives toward solar development over 11 years. Originally limited to customers of the state's investor-owned utilities, the CSI is expanded in August 2006, as a result of Senate Bill 1, to encompass municipal utility territories as well. Municipal utilities are required to offer incentives beginning in 2008 (nearly $800 million); many already offer PV rebates.

California utility PG&E announces it will buy an additional 1,000 megawatts of solar thermal power over the next five years.

Florida utility FPL announces it will spend $1.5 billion over the next seven years to build solar power plants in California and Florida. That includes a 300-megawatt solar power station using technology developed by Ausra, a Silicon Valley start-up.

2008 PG&E signs the largest solar PPA in history for 900 MW (enough to power half a million homes) from five CSP plants to be built and operated by BrightSource in the Mojave Desert. The deal follows previous agreements by PG&E to buy more than 700 MW of solar CSP from providers Ausra and Solel.

The Sacramento Municipal Utility District announces its largest solar homes deal—$8.9 million in incentives and rebates for 1,487 residences built by Woodside Homes near Rancho Cordova, Calif. It will bring the number of homes powered by solar under SMUD's SolarSmart program to 4,000.

New Jersey's largest utility, PSE&G, receives approval from state regulators to offer $105 million in loans to help finance the installation of solar systems on homes, businesses and municipal buildings.

Duke Energy announces $100 million investment in rooftop solar on commercial buildings and signs a PPA with SunEdison to purchase the electricity from a 16 MW solar PV system in North Carolina.

Southern California Edison announces a planned $875 million program to install 250 MW of solar PV on commercial rooftops over the next five years.

Sources: Clean Edge Research, Solarbuzz, EERE, Wikipedia, Renewable Energy World, and the books From Space to Earth: The Story of Solar Electricity by John Perlin and Solar Revolution by Travis Bradford.

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