Harnessing the POWER of the SUN:

Investing in Utility-Scale Solar Technologies

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EXECUTIVE SUMMARY

The three canonical reasons to support development of alternative energy sources have been increasing energy demand, rising energy costs and climate change. To these now must be added political instability in oil producing regions and technological risks associated with traditional energy production approaches, notably deep ocean drilling and nuclear power. As the risks to U.S. energy security, writ large, grow, so too does the need to exploit every available means of reducing that risk.

No single source, be it fossil fuels, natural gas or nuclear power can address all these needs. Renewables too must play a part. But, of all sources of energy they play the least role, amounting to only 8 percent of total U.S. energy production. Yet renewables, notably wind and solar, have the potential to make the greatest contribution to feeding U.S. demand for reliable energy at stable prices.

The opportunities provided by solar energy are almost incalculable. Solar photovoltaic (PV) technology can be applied almost everywhere, and at almost any scale from individual homes and businesses, to factories and utility-level installations. Moreover, the cost of solar installations has been dropping sharply in recent years. There are credible estimates that with some supporting investments by government and utilities, PV can achieve price parity with standard forms of energy by 2020. Some experts believe that even current generation solar, particularly PV, is approaching cost or grid parity particularly in high cost areas such as Hawaii and California.

While the potential is there for solar technology to transform energy production in the United States, many challenges remain to the achievement of cost-effective solar power. These include continuing to reduce the cost of individual solar modules, development of a supporting infrastructure for utility-level solar power and development of an appropriate regulatory and licensing regime conducive to the expanded use of solar energy. Concentrated solar power plants in areas of the Southwest United States could readily be competitive with current oil and gas-fired plants. With the proper incentives and regulations in place, solar can address both the demand and cost sensitivities of the current U.S. energy production system while simultaneously reducing greenhouse gas emissions and, in some cases, even reducing customer energy costs.

There are a number of steps that must be taken in order to address the challenges confronting viable solar photovoltaic power. A number of these have been identified in the Obama Administration's SunShot Initiative. The SunShot Initiative seeks to bring down the full cost of solar power by 75 percent before 2020 by investing in critical enablers: technologies for solar cells and arrays; electronics that optimize the performance of solar installation; solar module manufacturing processes; and the efficient designing, installing and permitting of solar energy systems.

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INTRODUCTION

Recent events have underscored the fragility of the current international energy environment and the need for diversification of energy sources. At the same time, there is a general consensus on the desirability of reducing greenhouse gases without hamstringing the U.S. economy. There is a limit to what can be done with fossil fuels, including natural gas and clean coal. There is a clear need to increase the overall U.S. supply of energy while simultaneously reducing reliance on fossil fuels. In his recent speech on energy security, President Barack Obama called on the nation to "get serious about a long-term policy for a secure, affordable energy future."[1]

When examining the options for expanding the supply of non-polluting fuel energy sources, the need to increase the role of renewable energy sources (hydroelectric, biofuel, ocean-based, wind and solar) is clear. Renewable sources provide a defense against price fluctuations or shortages in other energy supplies. They possess obvious attractiveness with respect to the goal of reducing greenhouse gas emissions.

Today, renewables play a remarkably small role in supplying the nation's energy requirements, about 8 percent total, and of this only about half comes from the most readily available sources, wind and solar. There is a clear need to include more renewable energy in the overall portfolio. This means, in particular, solar energy. The United States is advantaged with respect to the availability of sunlight, most notably in the Southwest.

Solar power offers the potential to become a major part of the U.S. energy portfolio. Moreover, solar power at both utility scale and in non-distributed or local applications may be on the edge of a breakthrough that will make it cost competitive with traditional energy sources. This is the result of the continuing reduction in the cost of solar equipment as well as improvements in designing and developing concentrated solar power for utility-scale installations. Realizing its potential requires investment in technology, infrastructure and new regulatory approaches.

A number of obstacles currently stand in the way of solar power becoming a major contributor to the U.S. energy market in the next few decades. Chief among these obstacles is the relatively high cost of energy produced from utility-scale solar facilities. The Obama Administration has recognized that in order for solar power to be viable at scale, it will be necessary to reduce the costs associated with solar energy by as much as 75 percent. Recent administration policy has focused on reducing these costs and streamlining the processes by which solar facilities are designed, constructed and permitted.

[1] President Barack Obama, "Remarks by the President on America's Energy Security," Georgetown University, Washington, DC, March 30, 2011.

Worker examines solar mirrors at the Blythe Solar Power Project, on public land in Blythe, California. (Photo: First Solar)

There are many reasons for governments, utilities and individuals to seek increased use of renewable energy sources. One reason is as a defense against price fluctuations or interruptions of energy supplies created by changes in demand, political circumstances or technical difficulties. With adequate storage capacity, solar and wind provide essentially free and uninterruptable sources of energy. Another reason is to balance demand; solar, in particular, can be very useful as a means of meeting peak daytime demand for energy. A third reason is to reduce greenhouse gas emissions.

The United States is extremely well positioned to exploit solar power. While exposure to the sun's rays is highest in the Southwest, even Northeastern states have levels of access to solar energy equal to or greater than in Central Europe. Unlike Europe, the United States has large expanses of open land, much of it owned by the federal government, on which utility-scale solar facilities could be sited. Finally, the U.S. has a history of large and steadily increasing demand for energy.[2]

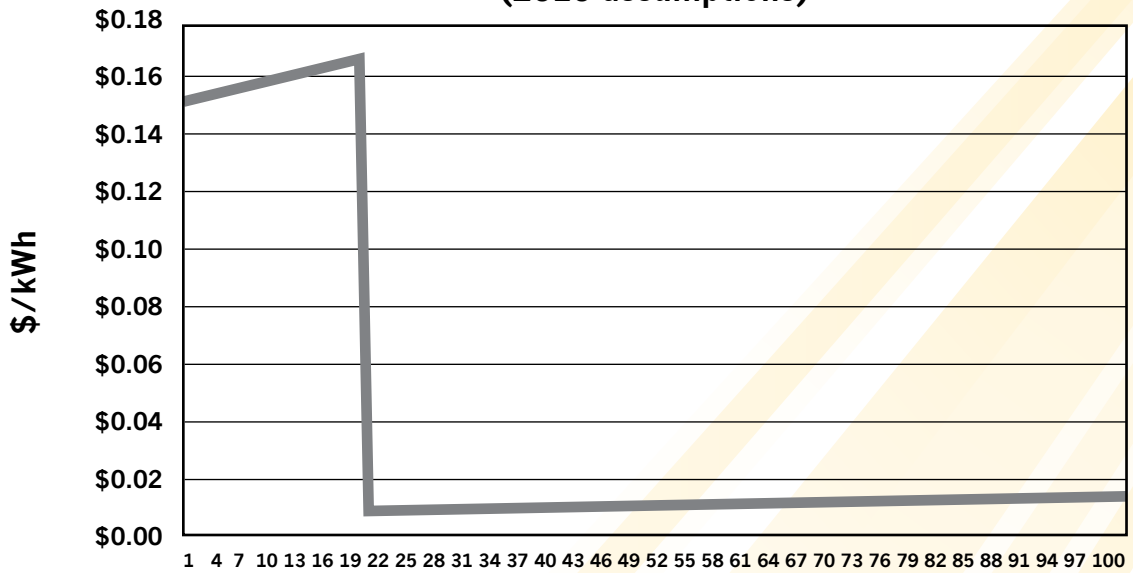
There are some who argue that renewables could transform the U.S. energy landscape at costs no higher than those associated with traditional energy sources. Proponents of solar power have put forward a "Solar Grand Plan" which envisions the possibility of supplying almost 70 percent of U.S. electricity needs by 2050 by means of solar power. The keys to this outcome are efficient solar installations, large-scale energy storage and high-power transmission.[3] Even without such a focused national effort and the expenditure of the large sums required, efficient solar power at both the utility and non-distributed or local scale can make a major contribution to U.S. energy independence.

The marketplace for renewable energy is highly dynamic. There are millions of jobs and tens of billions of dollars at stake. At present, China has capitalized on the demand for solar-powered facilities created by regulatory decisions in Europe and North America to become the largest producer of silicon-based solar collector modules. Chinese manufacturers of solar technologies currently enjoy significant cost advantages that include access to cheap labor as well as government-sponsored loans and subsidies: they produced half of total shipments in 2009 and comprise five of the world's ten largest solar-panel manufacturers.[4]

However, the marketplace is extremely sensitive to the introduction of new solar-related technologies. The development of new solar materials, particularly thin films, methods for generating concentrated solar power without high capital investments and innovative techniques for mass energy storage will transform the solar energy markets. The path is still open for the United States to become a leader in the field of solar energy production.

[2]Enfinity and GTM Research, *The U.S. PV Market in 2011*, White Paper, 2010, p. 2.
[3]Ken Zweibel, James Mason and Vasilis Fthenakis, "A Solar Grand Plan," *Scientific American*, December 16, 2007.
[4]Kevin Bullis, "Solar's Great Leap Forward," *Technology Review*, July/August 2010.

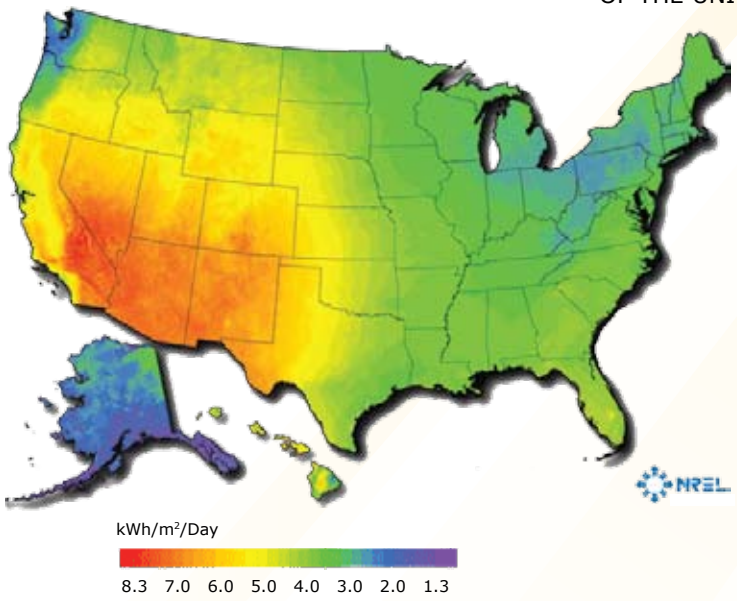
Annualized Cost of PV Electricity by Operational Year (2010 assumptions)



Source: K Zweibel Energy Policy 38 (2010) 7519-7530

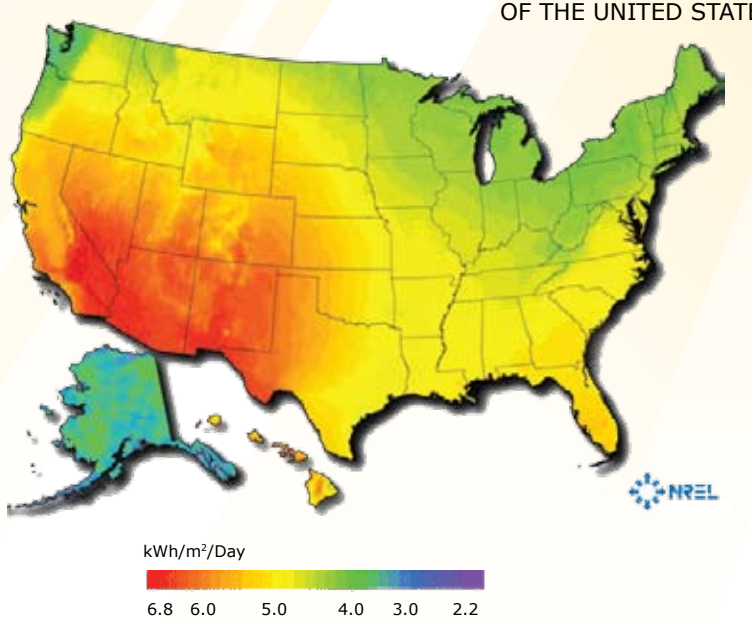
Concentrated Solar Power Potential

OF THE UNITED STATES



Photovoltaic Solar Potential

OF THE UNITED STATES



Source: National Renewable Energy Laboratory, October 20, 2008

WHAT MAKES SOLAR ATTRACTIVE?

A number of factors make solar energy generation attractive. First, it uses no fuel and is immune to fuel price uncertainty. Second, photovoltaic (PV) technology can be applied almost everywhere and at a variety of scales, although it is most economical in sunnier parts of the country, particularly for utility-scale applications using methods to create concentrated solar power (CSP). Third, PV has a number of off-grid and emergency power uses. Fourth, PV facilities have long economical operational lifetimes without additional tangible costs.[5]

In some regions of the country with high energy prices, discrete solar units can substantially impact domestic and small business energy costs. When net metering is available, it is possible for these individual units to actually return power to the grid. With proper financing arrangements, such as lease purchase of solar units, solar systems can be attractive at both the consumer and utility levels without requiring costly upfront investments.

While solar is often criticized for its intermittency, this criticism ignores the fact that solar works during daytime, which is the period of peak demand for electricity. In essence, in this role solar facilities supplement the base production of electricity. However with the construction of CSP facilities and advanced storage systems, the duration of energy production can be increased.

In recent years PV has experienced a 20 percent reduction in cost for every doubling of volume.[6] If this continues, PV will be viable everywhere, not just in sunny climates. There are some experts who believe that even current generation solar, particularly PV, is approaching cost or grid parity particularly in high cost areas such as Hawaii and California.[7] As the technology matures, utility-scale solar can be rendered cost competitive with traditional production means at between five and ten cents per kilowatt hour. When increased costs of conventional fuels are considered over the decades-long life of solar facilities, it is possible that PV solar will be cheaper than conventional or nuclear power.[8]

[5]REN21 Secretariat, *Renewable Energy Potentials*, Summary Report, Renewable Energy Policy Network for the 21st Century, Paris, August, 2008, p. 4.
[6]Kevin Bullis, "Solar's Great Leap Forward," *Technology Review*, July/August 2010.
[7]Ken Zweibel, "Should solar photovoltaics be deployed sooner because of long operating life at low, predictable cost?," *Energy Policy*, No. 38, August 2010.
[8]Ken Zweibel, "Cost Comparison of PV with other Electricity Options," Briefing, GW Solar Institute, Washington, DC, October 15-16, 2009.

At a 25,000 square foot site in New Bedford, Massachusetts, Konarka Technologies operates the world's largest roll-to-roll flexible thin film solar manufacturing facility. (Photo: Manufacturing Konarka Power Plastic)

CONCENTRATED SOLAR POWER

The conventional picture most Americans have of a solar power installation is a single panel powering an emergency call box or a set of panels on the roof of a single-family home, office building or apartment house. There is no question that this form of solar power can make a substantial input to the nation's overall energy needs as well as insulating American families and even small businesses from price fluctuations or supply interruptions. If privately-owned systems are connected to the grid and metered then they can in many cases also return power.

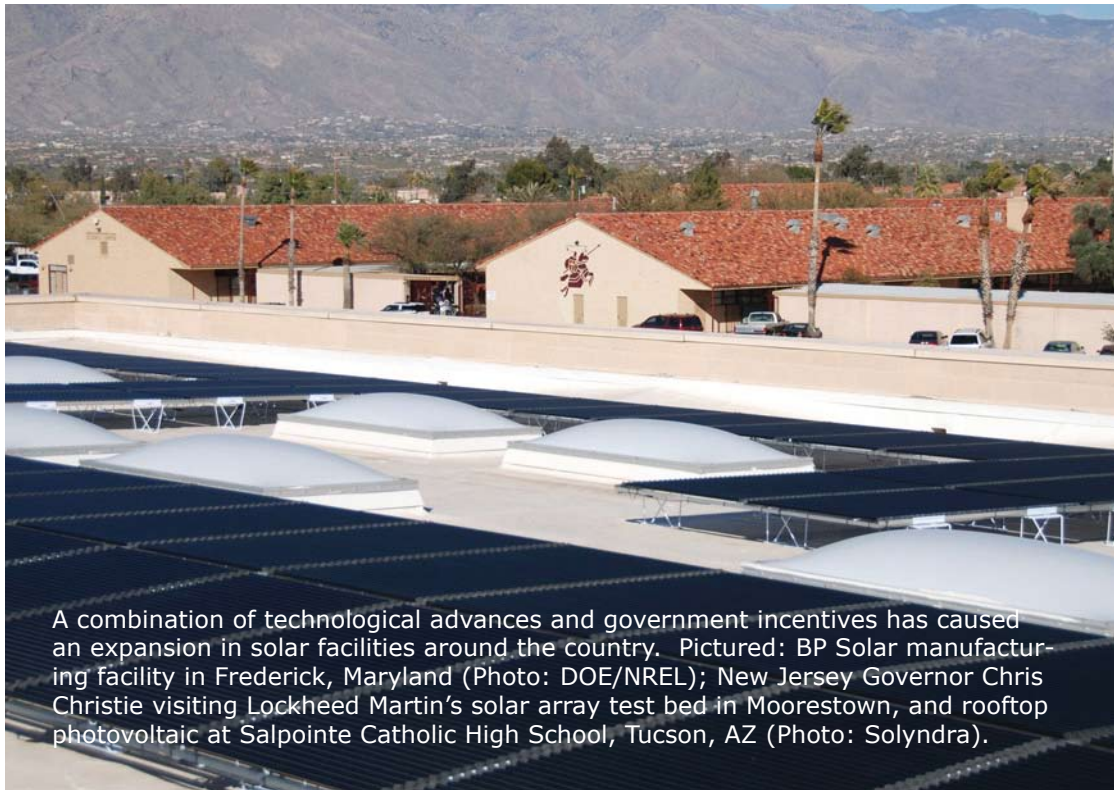
Less well recognized, but of greater significance to the nation is the potential for utility-scale solar installations. It is widely held that the most viable models for utility-scale solar are based on techniques that concentrate the natural power of the sun. Systems designed to provide concentrated solar power rely on mirrors combined with tracking systems to focus sunlight. An area of the Southwest desert about 250 by 250 kilometers covered with Concentrated Solar Power (CSP) generation could supply the world's current electricity demand.

The three principal mechanisms concentrating sunlight are the parabolic trough, the solar power tower and the linear fresnel.[9] CSP combined with advanced storage systems can provide continuously dispatchable power. Such storage systems could include thermal mechanisms that convert solar power to heat energy and then back again, battery storage and even compressed air systems. The better the ability of the storage medium to retain and transmit heat, the more efficient the solar utility can be. Currently, experiments are proceeding on the development of CSP facilities using direct steam generation, molten salt thermal storage and compressed air.

A number of CSP facilities have been built or are in the process of being constructed in the United States. They are mostly located in the American Southwest where they can take advantage of the abundant sunlight while being relatively close to large and growing population centers.

A number of factors pose difficulties for the large-scale deployment of CSP. One is the high cost associated with current generation technologies for both concentrating solar energy and thermal storage. Secondly, the large size of CSP facilities raises land use issues. Water cooled plants require access to fairly large sources of the liquid in regions of the country that tend to lack that resource. Finally, even if CSP facilities themselves can be made cost effective, the need to transmit their energy over long distances poses both cost and regulatory hurdles.[10]

[9]Craig S. Turchi, "Concentrated Solar Power (CSP): Technology, Markets and Development," Briefing, National Renewable Energy Laboratory, October 2009.
[10]Paul Komor, *Wind and Solar Electricity: Challenges and Opportunities*, Pew Center on Global Climate Change, June 2009, p. 11.



A combination of technological advances and government incentives has caused an expansion in solar facilities around the country. Pictured: BP Solar manufacturing facility in Frederick, Maryland (Photo: DOE/NREL); New Jersey Governor Chris Christie visiting Lockheed Martin's solar array test bed in Moorestown, and rooftop photovoltaic at Salpointe Catholic High School, Tucson, AZ (Photo: Solyndra).

THREE CHALLENGES TO AN EXPANDED ROLE FOR SOLAR POWER

There are three basic classes of challenges to the expanded use of solar power. The first set reflects the nature of solar energy. Unlike fossil fuels, solar energy as a source of power is best generated in daytime. Some, but not all, types of solar installations can continue to generate power under overcast conditions. While large swathes of American territory receive sufficient sunlight to make small-scale solar power installations viable, utility-scale solar facilities require relatively intense sunlight that generally restricts viable locations to southern latitudes.

The second set is associated with the current state of solar technologies and the need to invest in new capabilities to store and transmit the energy that is collected. All experts agree that in order to make solar truly competitive with fossil fuels the efficiency of solar modules must be increased. Because solar power is generated in daytime, utility-scale solar facilities require the development of new large-scale storage methods that would allow the power generated while the sun shines to be distributed over an entire 24-hour period. There are also advances required in the techniques and technologies associated with concentrating solar power. Finally, because large-scale solar facilities are likely to be geographically concentrated in the Southwest and away from urban centers, connecting the new energy sources to the national grid will require construction of a network of transmission lines.

The third set of challenges are those in the domain of regulatory policies and incentive structures for solar investments. Regulatory issues related to land and transmission access stand in the way of large-scale CSP deployment in the United States. CSP plants require relatively large land areas, on the order of a square mile or more. There are issues associated with the environmental and ecological effects of CSP facilities and the construction of transmission lines.

Two common ways of creating demand for solar power are through government mandates and the use of price incentives for electricity generated by solar systems. Both of these amount to an additional tax or rate increase on citizens and businesses. At the very least, all levels of government need to address ways of reducing the impact of regulatory and licensing practices on the costs of solar energy.

More broadly, there are reasons to look at government incentives such as loan guarantees and accelerated depreciation schedules that can make solar energy grid competitive without the need for subsidies or tariffs. However, the vast array of federal, state and local incentives are difficult for utilities and consumers to access and coordinate; even then, current studies suggest that the full weight of such incentives do not ensure that solar power is cost competitive with traditional sources of electricity.[11]

[11]Jeffrey Perlman and Andrew McNamara, "Is Real-Time Pricing Right for Solar PV?," *Natural Gas and Electricity*, April 2010, p. 16.

The first challenge posed to solar substantially increasing its contribution to the nation's energy supplies is the current state of solar technologies, particularly the efficiency and producibility of solar panels. Overall, there is a need to improve efficiencies for both silicon solar cells and thin film systems. The near-term goal is better than 20 percent efficiency. This is key to attaining a competitive position for PV in the absence of subsidies.[12]

The previously cited Solar Grand Plan focused in particular on investment in thin film photovoltaic technologies that are expected to be significantly cheaper than current generation crystalline silicon-based solar cells. Thin films use less PV materials, permit the application of cheaper, continuous manufacturing techniques and can be applied on a variety of surfaces.[13]

There are a range of approaches being pursued to develop efficient thin film photovoltaics including advanced forms of silicon, metals such as cadmium telluride and copper indium selenide, organic dyes and polymers and nanomaterials.[14] Thin film and microscale PV cells may be cheaper than larger, heavier bulk silicon solar panels and be moldable into a variety of shapes that would allow for much expanded deployment. For example, microscale PV cells could be woven into clothing and military uniforms to power everything from cell phones to thermal sites, combat radios and laser range finders.

A key goal of investments in technology must be to reduce costs. Solar cells based on thin-film silicon would be cheaper than bulk or wafer silicon modules. Similarly, organic materials yet hold the promise of a substantial price reduction in comparison to thin-film silicon and a faster return on investment. These cells create the possibility of a simple roll-to-roll printing process, leading to inexpensive, large-scale production. The demonstration of floating PV systems that could be deployed on water sources such as reservoirs could reduce the requirement to build utilities on potentially fragile land areas.

[12]Jef Poortmans, "Photovoltaics and How to Avoid the Fall of Icarus," *Photovoltaics World*, February 10, 2011.
[13]Komor, op cit., p. 18.
[14]Chris O'Brien, "Why Less is More: How Thin-Film Manufacturing is Finding Momentum," *Photovoltaics World*, February 7, 2011.

Energy experts and the Obama Administration alike recognize that the key to making solar power a significant contributor to the nation's energy supply is to make it price competitive. In order to do this, the costs associated with constructing and managing large-scale facilities must be reduced. A drop in cost of non-module expenses produces overall cost reduction. At utility-scale solar this involves improved mirror designs, software enhancements to permit better mirror focusing and tracking and, in the case of solar thermal facilities, use of exotic materials to increase and prolong heat transfer for steam generation.[15] Improvements in production performance modeling, solar assembly design, facility design, construction and management can also help to reduce costs.

An equally large challenge is posed by the need to store and transmit energy. Where solar facilities are co-located with energy users this is not a problem. But for large-scale exploitation of solar energy there is a requirement to store the power generated during periods of sunlight and transmit that power over potentially, long distances. Large-scale battery storage is possible. However, the technology today is not adequate to support large-scale production. Compressed air systems are another possibility but have yet to be tested at scale. Flywheel technologies, like the next-generation flying-ring flywheel system developed by Massachusetts-based Beacon Power, also hold potential.

Finally, there is the need to create a new network of high-powered transmission lines to move large amounts of energy produced by solar power from areas such as the Southwest to the rest of the country. This is primarily an issue of regulatory policy and not of technology. It is difficult to envision high levels of PV penetration of the energy market without a transformation of the grid.

However, if the existing energy grid is to accommodate the production of significant quantities of renewable energy -- wind as well as solar -- then attention must be focused not only on expansion of the transmission network but on improving the reliability and functionality of the nation's power grid. Expansion of consumer investments in renewable energy production requires a system to meter the energy produced and consumed. In turn, this requires that the management of the energy grid be able to make use of the power generated by a large number of small producers or, at a minimum, account for the energy displaced by the consumer's alternative source.

[15]David Rotman, "Praying for an Energy Miracle," *Technology Review*, March/April, 2011.

The Challenges of Designing Appropriate Regulatory Policies and Incentive Structures

Recent experience with increased demand for solar power has been a consequence, in principle, of a combination of regulatory requirements on utilities to produce specified levels of power through the use of renewables, and on government incentives that reduce the capital investment costs for deploying solar systems or impose tariffs for the production of energy from renewable sources. These approaches are justified on a mix of grounds including societal benefits from the reduction of greenhouse gases and the need to support investment in solar manufacturing capacity until such time economically viable scale of production can be achieved.

Solar energy systems can be cost effective on the basis of approaches that favor the natural advantages of daytime solar through tiered or time-of-use rates. Alternative financing arrangements that allow investors to recoup the high initial capital costs of systems that are either longer term or capture non-energy benefits from grid connected solar systems could make the cost competitive in the near term. However, more near-term and widespread adoption of solar systems will likely rely on public incentives.

A key challenge to expanded production of solar energy then is the structure of incentives governments create. High subsidy levels or steep feed-in tariffs, both intended to encourage expanded investment in solar energy, can have the unintended consequence of limiting its competitiveness by reducing overall energy demand or decreasing incentives to invest in technologies that further lower the cost of producing solar power.[16] In periods of reduced revenues, governments have been forced to reduce subsidies for energy production which, in return, has resulted in sharp price increases and reduced demand.

A wiser strategy is to incentivize utilities to develop cost competitive solar power options. The current 30 percent investment tax credit is a critical incentive. Another means of encouraging investment in PV is regulatory policies amenable to the construction of smaller-scale utility projects (approximately 50 megawatts) in proximity to urban centers thereby obviating the need for large-scale storage and high cost transmission lines.

Another key issue of governmental policy is achieving a public consensus on the deployment of utility-scale solar facilities. Opposition to new large-scale energy production facilities and to the transmission lines required to move electricity is an increasingly important disincentive to such investments.[17] In light of growing resistance, development of national standards for land use determination, project review and permitting and environmental assessments that avoid lengthy litigation may be a sine-qua-non for successful development of utility-scale solar projects.

[16]"In 2011: Diversification in PV Tech, Equipment Sophistication, CPV Gains," *Photovoltaics World*, February 4, 2011.
[17]See for example Todd Woody, "Solar Energy Faces Tests on Greenness," *The New York Times*, February 23, 2011; Julie Cart, "Court rejects U.S. bid to establish corridors for new electric transmission lines," *Los Angeles Times*, February 2, 2011.

SUNSHOT INITIATIVE

The Obama Administration is committed to making cost competitive PV a central element of its strategy for reduced energy dependence and cleaner energy production. Secretary of Energy Steven Chu clearly articulated this view: "America is in a world race to produce cost-effective, quality photovoltaics. The SunShot Initiative will spur American innovations to reduce the costs of solar energy and re-establish U.S. global leadership in this growing industry. These efforts will boost our economic competitiveness, rebuild our manufacturing industry and help reach the President's goal of doubling our clean energy in the next 25 years."[18]

As described in Department of Energy press statements, the SunShot Initiative is focused on investments in research and development that will make PV cost competitive with traditional forms of energy. "The DOE SunShot Initiative is a collaborative national initiative to make solar energy technologies cost-competitive with other forms of energy by reducing the cost of solar energy systems by about 75 percent before 2020. Reducing the total installed cost for utility-scale solar electricity to roughly 6 cents per kilowatt hour without subsidies will result in rapid, large-scale adoption of solar electricity across the United States. Reaching this goal will re-establish American technological leadership, improve the nation's energy security, and strengthen U.S. economic competitiveness in the global clean energy race."[19]

SunShot will work to bring down the full cost of solar -- including the costs of the solar cells and installation -- by focusing on four main pillars:

- Technologies for solar cells and arrays that convert sunlight to energy;
- Electronics that optimize the performance of the installation;
- Improvements in the efficiency of solar manufacturing processes; and
- Installation, design and permitting for solar energy systems.

Among the projects being supported under the SunShot Initiative are several focused on dramatically improving the manufacturability of photovoltaic modules including not only silicon technology but also advanced flexible film systems. Other projects focus on improvements to the operation of CSP facilities.

[18]"DOE Pursues SunShot Initiative to Achieve Cost Competitive Solar Energy by 2020," Department of Energy, February 4, 2011.
[19]Department of Energy, *at SunShot Initiative*, at www1.eere.energy.gov/solar/SunShot/

CSP Solar Trough Collector utilized to generate solar power in Seville, Spain.

RECOMMENDATIONS

When price incentives that reflect externalities are included (climate change, fuel price uncertainty, national security concerns), there are some sources that assert that solar power has achieved price parity at least when it comes to areas of the Southwest.[20] But as the Obama Administration itself acknowledges, the only way that solar will ever make a significant contribution to U.S. energy demand is if it can achieve true price parity without incentives. Clearly there is a need for a transition period during which economies of scale in the production of the elements of solar installations can be achieved. However, even here it is best to pursue incentives that cause the fewest market distortions.

It would make sense to maintain the current federal investment tax credit. A major determinant of the cost competitiveness of PV is the cost of capital based on high initial infrastructure investment. Lowering real costs has a very significant impact on the willingness of utilities to make the large upfront investments in solar facilities.

The laws supporting long-term power purchasing agreements (PPAs) should be reformed and expanded. At the federal level, the length of time for PPAs should be extended from 10 to at least 25 years. States that do not have standardized PPAs should be encouraged to create them. A second important step is pursuit of the SunShot Initiative. Ensuring adequate funding for the SunShot Initiatives is critical. The range of potential participants needs to be expanded to include the private sector.

Even if the technology innovation can lead to a reduction in the price of solar power, there will be a need to resolve regulatory and permitting issues that have already had a

significant impact on the viability of major solar projects. Easing access to federal lands, including simplification of permitting and clarity on environmental assessments would go a long way to supporting solar developments.

[20]James Mason, Vasilis Fthenakis and Ken Zweibel, "Solar Grand Plan: Solar as a Solution," *Sun and Wind Energy*, April 2008.

GLOSSARY OF TERMS

Concentrated Solar Power (CSP): System that uses lenses or mirrors to concentrate a large area of sunlight onto a small area. Electrical power is produced when the concentrated light is converted to heat, which drives a heat engine (usually a steam turbine) connected to an electrical power generator.

Distributed Solar: The generation of solar power from many small energy sources, like rooftop solar panels on a residence, available for distribution.

Feed-In Tariff (FiT): A public policy mechanism designed to encourage the adoption of renewable energy sources and to help accelerate the move toward grid parity for renewable power. FiTs typically include three key provisions: guaranteed grid access; long-term contracts for the electricity produced; and purchase prices that are methodologically based on the cost of renewable energy generation and tend towards grid parity.

Generating Capacity: Amount of available energy to meet demands for power and to generate power during scheduled or unscheduled outages.

Kilowatt (kW): One thousand watts. The average annual electrical power consumption of a household in the United States is about 8,900 kilowatt-hours.

Megawatt (MW): One million watts. U.S. nuclear power plants have net summer capacities between approximately 500 and 1,300 megawatts.

Net metering: A renewable energy incentive for consumers who own renewable energy facilities or electric vehicles. Under net metering, a system owner receives retail credit for at least a portion of the electricity they generate. "Smart" electricity meters accurately record in both directions, allowing a no-cost method of effectively banking excess electricity production for future credit.

Photovoltaic Solar Cell (PV): Device that converts sunlight directly into electricity. Photovoltaic power generation employs solar panels composed of a number of cells containing a photovoltaic material.

Power-Purchasing Agreement (PPA): Contracts between two parties, one who generates electricity for the purpose of sale and one who is looking to purchase electricity. All sales of electricity are metered to provide both seller and buyer with the most accurate information about the amount of electricity generated and bought.

Smart Grid: A smart grid electricity network delivers electricity from suppliers to consumers using two-way digital communications to control appliances at consumers' homes which can save energy, reduce costs and increase reliability. A smart grid includes an intelligent monitoring system that keeps track of all electricity flowing in the system, but in more detail and also has the capability of integrating renewable electricity such as solar and wind, but has the potential to do so more effectively.

Utility Scale: Utility-scale solar energy facilities are systems that can generate large amounts of electricity to be put directly onto the electricity transmission grid.

RELATED STUDIES

Moving Forward on Smart Grid, August 2009

Smart Grid Implementation: Strategies for Success, May 2010

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