

A Texas Solar Roadmap

February 2009
by

Public Citizen • Environment Texas • Vote Solar

Table of Contents

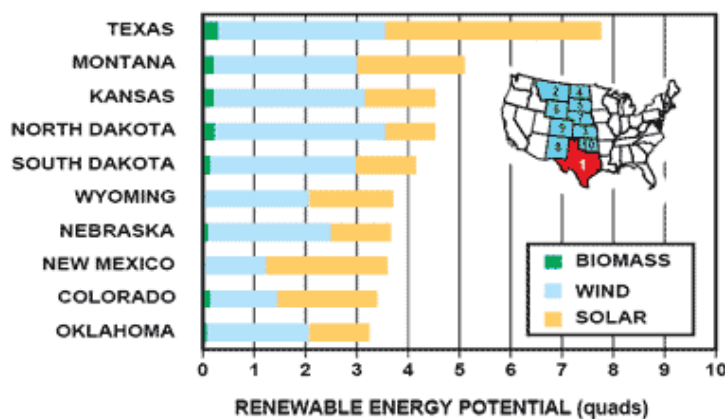
Executive Summary-----	1
Introduction-----	5
Texas' Solar Energy Potential-----	7
Solar Energy Technologies and Their Role in Texas' Energy Future-----	9
Photovoltaics-----	9
Silicon-based PV-----	9
Thin-film PV-----	11
Concentrating Solar Power-----	13
Solar Water Heaters-----	19
Energy Storage-----	23
Central Station Solar vs. Distributed Generation-----	26
Benefits of Solar Energy-----	29
Job Creation-----	29
Other Economic Benefits-----	31
Meeting Energy Needs-----	32
Barriers to Solar Power Development-----	37
Incentives for Solar Power-----	41
Recommendations-----	44

Executive Summary

Texas has the “right stuff” to become a world leader in solar energy development – reaping the benefits of cleaner air, a robust economy and reduced dependence on fossil fuels. Decisions made by policy makers in the next year will determine whether Texas can ride the solar wave, capturing the vast potential of solar power for our state.

Texas has the best solar potential in the nation and we could power the entire state many times over with our abundant sunshine. In fact, according to the State Energy Conservation Office, the energy from sunshine falling on just one acre of land in West Texas is equal to 4000 barrels of oil each year. Solar panels lining an area thirty miles by thirty miles in West Texas could power the entire state¹.

Figure ES-1. Texas’ Renewable Energy Potential²



There are several solar energy technologies that can make a real contribution to meeting Texas’ energy needs:

- Photovoltaic (PV) systems harness sunlight to create electricity. PV panels produce electricity at the times when it is needed most – on sunny days – helping to meet peak demand for electricity. PV systems can be arrayed in utility-scale power plants or distributed across the state on homes, shopping centers, parking lots and other built-up areas, providing electricity close to where it is needed.
- Concentrating solar power (CSP) systems use mirrors to harness the sun’s heat to produce electricity. West Texas has significant potential for CSP power plant development, which, if paired with energy storage technologies, can supply consistent power from the sun, even at night.
- Solar water heaters use simple rooftop solar collectors to provide much of the hot water needs of homes and businesses – reducing the need to use natural gas or electricity for water heating.

¹ Presentation by John O’Donnell, AUSRA

² Texas State Energy Conservation Office, *Texas Solar Energy*, downloaded from www.seco.cpa.state.tx.us/re_solar.htm, 29 December 2008.

Solar energy can provide both economic and environmental benefits for Texas.

- Texas is already home to 11.5% of the world's processing capacity for silicon – the key ingredient in silicon-based PV panels. Texas is also home to pioneering companies producing solar PV technology. These firms show the potential for economic growth in Texas from solar power investment.
- The Renewable Energy Policy Project estimates that, by 2015, a national move to encourage PV could create as many as 5,500 jobs in Texas.
- Analysis using NREL's Jobs and Economic Development Impact model shows that CSP plants bring 5x the long term jobs of a comparable natural gas plant and 10x the jobs during construction.³
- Additional analysis by Vote Solar show's that with the right local economic incentives as many as 21,500 new jobs would be created by 2020 in under a 2000 MW program.⁴
- Solar power can also help reduce Texas' demand for natural gas, thereby lowering prices, provide rural economic development opportunities, and meet Texas' growing demand for electricity while reducing emissions.

Emissions Benefits of 2000 MW in TX⁵		
CO₂ Avoided (tons)	Methane Avoided (tons)	NOx Avoided (tons)
29,072,576	523	29,336

Texas should spur the development of solar power within the state by adopting the following public policies:

- 1.Include solar-specific requirements to an increase of Texas' existing and highly successful Renewable Portfolio Standard.
- 2.Establish goals and create incentives for building-integrated solar at the time of construction as part of the PUC's advanced buildings incentive program. This can be accomplished by creating a rebate program. A declining rebate should be planned over 10-year period to give the industry confidence to invest in production, research and development. At a minimum, new buildings should be "solar ready."
- 3.Allow third party ownership of PV systems
- 4.Make solar systems and installations exempt from state and local sales tax.
- 5.Create fair buyback rates for energy produced by solar. Direct utilities to employ metering programs that provide time-of-use billing and buyback, which rewards owners of PV systems for producing lower cost solar power during the periods of highest demand. Require all of the state's utilities to offer net metering.
- 6.Improve contract and interconnection standards and consumer protections for owners of solar systems while banning Home Owners Associations from denying homeowners the right to install PV panels.

³ Environmental Defense Fund CSP Research, November 2008.

⁴ Navigant Consulting. "Economic Impacts of Extending Federal Solar Tax Credit." September 15, 2008, http://www.seia.org/galleries/pdf/NCI_Nevada_fact_sheet.pdf

⁵ www.votesolar.org and EIA state energy profiles January 2009

7. Provide for the construction of solar ties to new Competitive Renewable Energy Zone (CREZ) transmission lines in West Texas.
8. Promote new ways to store the excess energy produced by the sun for later use, such as thermal storage technologies, flywheels, and compressed air energy storage.
9. Increase funding of research and development. Create an R&D technology center similar to the micro-computer consortium that was so successful in developing the microchip industry in Texas.
10. Create a PUC program to provide incentives for solar installations on new and existing Buildings.

Introduction

Texans have never been afraid to take advantage of an opportunity – particularly when it comes to energy.

Over the decades, Texans have relied on private enterprise – coupled with a supportive hand from state government – to develop the state’s wealth of energy resources: oil and gas, coal, nuclear power and, over the last decade, wind. Texas’ recent experience with wind power – fueled by wise choices by the Texas Legislature – has created over 2,500 jobs and \$28 million in new tax revenue.⁶ Yet, wind power isn’t the only renewable energy source with the potential to transform Texas’ economy and our environment. Indeed, the sun that strikes our buildings and soil each day has the potential to power the state many times over – and the technologies needed to harvest that energy are already here.

The question facing Texas is whether we will lead the solar energy revolution – bringing good jobs and clean power to our state – or whether we will lag behind. Already, states such as California and New Jersey – and nations such as Spain, Germany and Japan – are taking the lead in solar power development and reaping the benefits of their investment.

Here in Texas, we know how to build cutting-edge industries from the bottom-up. Our state’s role in the creation of the Microcomputer Consortium and Sematech led to the creation of a multibillion dollar manufacturing center in Texas that has employed tens of thousands of people. We now stand at similar crossroads in the development of solar power.



Pat Wood addresses the Texas Solar Forum

In April 2008, over 350 Texans – including state officials, entrepreneurs, and environmental advocates – gathered at the Capitol to hear from 40 presenters about how to develop a blueprint (or, in this case, “yellow” print), for the transition to a solar future. This paper reviews many of their findings and suggestions, discusses the many opportunities Texas has to take advantage of solar power, and suggests a series of steps the state can take to become a world leader in solar power.

The best way for Texas to ensure a future expansion in solar power capacity is by committing to a 10 year market development program that includes financial incentives and new building design policies. Experience in

California and in other countries, especially Germany, has shown that such government programs can lead to increased demand and lower prices— the first steps on the road to a robust, self-sufficient solar market in which government incentives are no longer necessary.

⁶ Public Citizen study “Wind Energy Delivers Benefits Throughout Texas” 7-14-2008

Public support for such a program is already here. Texans want more solar power in this state and they're willing to pay for it. A January 2007 poll by Baseline & Associates found that 84% of Texas voters think that the Legislature should encourage investment in solar power and 81% of Texas voters are willing to pay more than a dollar per month to encourage solar developments.

Table ES-1. Texans Support Solar Power⁷

Do you think the Texas Legislature should encourage investment in solar power in Texas?		Would you support having the Texas Legislature encourage solar power investment in Texas if it would cost you less than one dollar per month on your electric bill?	
84%	Yes	81%	Yes
10%	No	17%	No
6%	Unsure / refused	3%	Unsure / refused

In 1999, the Texas Legislature created one of the nation's earliest and most successful renewable energy initiatives: the Renewable Portfolio Standard (RPS). In 2005, the Legislature increased the RPS and set a target of generating 10,000 megawatts of renewable energy by the year 2025. These laws created a boom for wind power that helped make Texas the national leader in wind energy.

We can learn from and build off of this success. By creating incentives for homeowners and businesses to install on-site solar systems and for big commercial enterprises to develop large central station solar projects, the Legislature can help Texas reduce our reliance on fossil fuels, reduce pollution, meet our growing demand for electricity, reduce future fuel cost increases, create tens of thousands of new jobs, and continue our leadership in the field of clean energy.

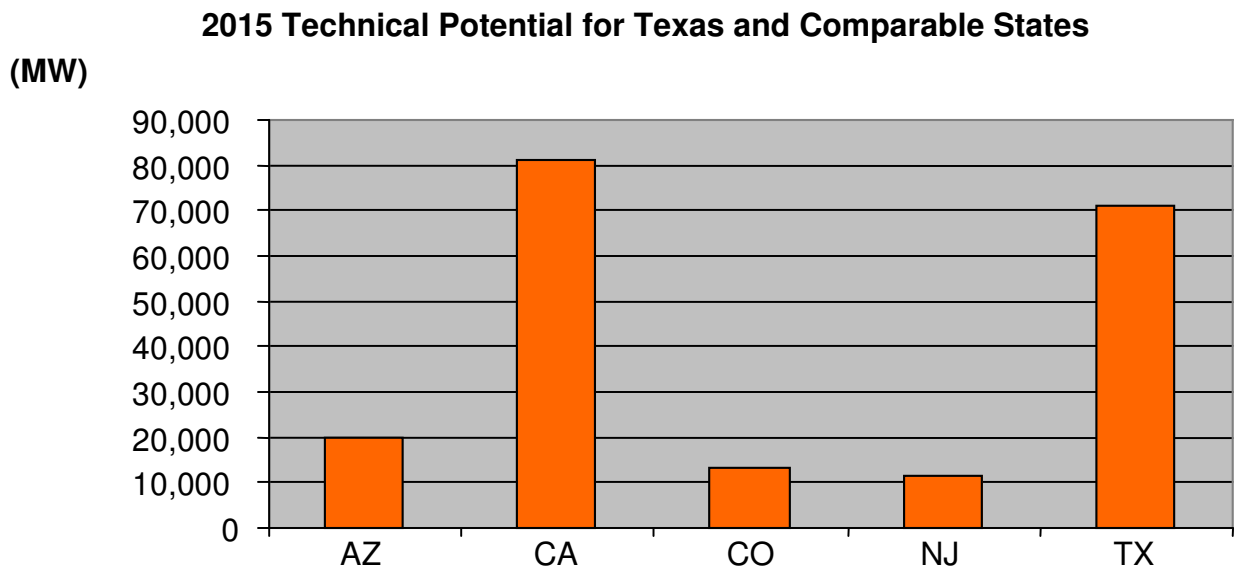
**The energy from
sunshine falling on a
single acre of land in
West Texas is capable
of producing the
energy equivalent of
800 barrels of oil each
year.**

⁷ Baseline & Associates, Inc., *Texas Voter Survey, January 11-15, 2007*, downloaded from http://www.votesolar.org/linked-docs/TX_Solar_Poll.pdf, 29 December 2008.

Texas' Solar Energy Potential

Texas has tremendous potential for solar energy. According to the State Energy Conservation Office, Texas has the greatest solar natural resource potential in the nation.⁸ Texas has the potential to support as much as 148,000 megawatts of electric generating capacity from concentrating solar power alone, more capacity than currently exists in the state.⁹ Energy from sunshine falling on just a single acre of land in West Texas is capable of producing the energy greater than 4000 barrels of oil each year.¹⁰ Photovoltaic plants covering 30 miles by 30 miles could power the entire state.

Figure 1. Solar PV Technical Potential for 2015¹¹



Texas also has exemplary human and technical resources for solar development. Our large microprocessor industry, as well as our experienced engineering workforce, gives Texas the potential to become a world center for solar production and installation.

⁸ Texas State Energy Conservation Office, *Texas Solar Energy*, downloaded from www.seco.cpa.state.tx.us/re_solar.htm, 29 December 2008.

⁹ “148,000 megawatts” based on Mark S. Mehos and David W. Kearney, “Tackling Climate Change in the U.S.: Potential Carbon Emissions Reductions from Concentrating Solar Power by 2030,” in Charles F. Kutscher, ed., American Solar Energy Society, *Tackling Climate Change in the U.S.: Potential Carbon Emissions Reductions from Energy Efficiency and Renewable Energy by 2030*, 2007. Assumes that CSP power plants require about 5 acres of land area per megawatt of installed capacity; “more capacity than currently exists” based on U.S. Department of Energy, Energy Information Administration, *State Electricity Profiles: 2006 Edition*, November 2007.

¹⁰ Texas State Energy Conservation Office, *Texas Solar Energy*, downloaded from www.seco.cpa.state.tx.us/re_solar.htm, 28 December 2008.

¹¹ Charlie Hemmeline, U.S. Department of Energy, Solar Program, *Texas Solar Forum: Economic Development and Job Creation*, Powerpoint presentation, 24 April 2008.

Texas is presently home to approximately 11.5% of the world's silicon processing capacity, including a facility for one of the world's largest silicon processors-MEMC Pasadena¹² and a leading producer of high performance specialty glass products needed for PV production such as Guardian Industries.

¹² 11.5 percent: Texas Governor's Office, *Texas Wide Open for Business: Advanced Technology & Manufacturing*, downloaded from www.texasone.us/site/PageServer?pagename=KeySectorsTechAndManufacturing, 29 December 2008.

Solar Energy Technologies and Their Role in Texas' Energy Future

There are a variety of solar energy technologies that can help Texas meet its energy needs. Solar energy technologies can be classified by how they work – capturing energy from the sun's heat or its light – and by where they are located – in large, central station power plants or in smaller increments distributed throughout the energy system.

Photovoltaics

Photovoltaics (or “PV”) convert the sun's light directly into electricity. There are several types of PV technology but all types convert sunlight directly into electricity: silicon-based (crystalline and amorphous) and thin-film. Both types convert sunlight directly into electricity without using any (or very few) moving parts, and both have as their basic building block the photovoltaic cell. Cells can be connected together to form modules, and modules can be connected to form arrays. A few PV cells will power a hand-held calculator, while interconnected arrays can provide electricity for a remote village or serve as a power plant for a city.

Photovoltaics have several advantages as an energy production technology:

- **Simplicity** – With no moving parts (or very few, for some applications), operation and maintenance costs are minimal.
- **Versatility** – PV can connect to the existing infrastructure of the utility grid and serve as an alternative power source during peak periods of power demand or it can operate remotely (off the utility power line grid).
- **Reliability** – First developed for U.S. man-made satellites in the 1950s – where low maintenance was an absolute necessity – and now with over 40 years of technical advancements improving performance, PV has very high online availability.
- **Scalability** – PV is modular and can be easily scaled according to the amount of power needed.

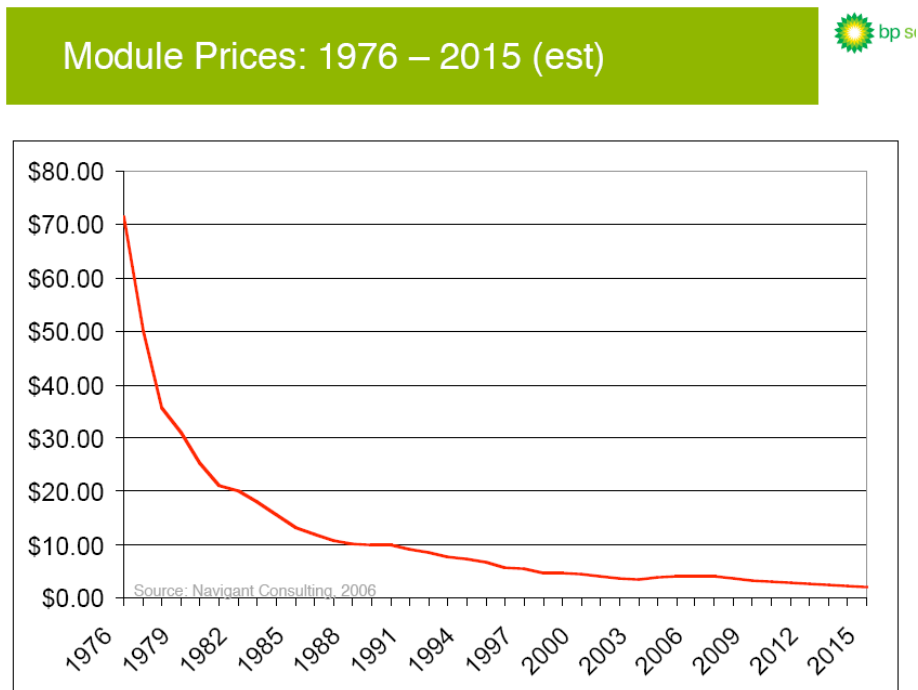
PV systems only generate electricity when the sun is shining, meaning that, to provide all of a home or business' energy needs, the energy created by PV systems during the daytime must be stored, or the building needs to maintain a connection to the electric grid. On the other hand, PV systems often generate enough power during the daylight hours that they can supply excess power to the grid. That is particularly important because electricity demand tends to be highest on the hot, sunny days when PV power production is at its peak, meaning that solar power can effectively reduce the need to operate fossil fuel-fired power plants to meet peak demand.

Silicon-based PV

Silicon-based PV systems are the ones most familiar to Texans, making up the majority of PV systems in the United States. Silicon-based PV technology has advanced dramatically over the years. Over the past two decades, the price of silicon-based PV energy has declined, despite the high cost of silicon. Crystalline silicon-based systems have also become significantly more efficient (converting a greater share of the sunlight that strikes the panel into electrical energy). As a result, silicon-based PV is an increasingly attractive and practical alternative for homeowners, businesses and utilities.

Amorphous solar panels are a special type of silicon solar cell using unique microscopic particle process, they are very versatile and can be made in flexible rolls that allow them to be directly bonded to curved or irregular shapes. This allows them to be directly attached to a roofing structure with little or no supporting structure. They do have a lower efficiency and require larger areas to produce the same output as a crystalline array

Figure 2. Solar PV Module Prices¹³



¹³ Geoff Slevin, BP Solar, *Solar PV Manufacturing*, Powerpoint presentation to Texas Solar Forum, 24 April 2008.

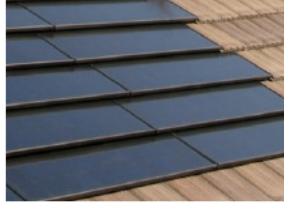
Figure 3. Some Applications for Silicon-based Solar Systems¹⁴

Segments and Channels

Residential Retrofit



New Production Homes



Commercial & Public



Power Plants



Thin-film PV

Thin-film PV technologies have the potential to further reduce the cost of solar power and to allow solar energy to be harnessed in new and exciting applications.

Thin-film photovoltaic systems use semiconductor layers only a few millionths of a meter thick to produce electricity. By reducing the amount of expensive materials needed to produce solar cells, thin-film systems can reduce the cost of solar power. They can be manufactured using high speed depositing or printing process significantly decreasing production costs and time to manufacture. In addition, thin-film PV can be applied to a variety of surfaces – including in flexible plastic sheets – dramatically expanding the number of potential applications for PV. Thin-film PV's main drawback is that it is less efficient at converting sunlight to electricity than silicon-based systems, but researchers are continuing to improve the efficiency of both types of systems at producing energy from the sun.

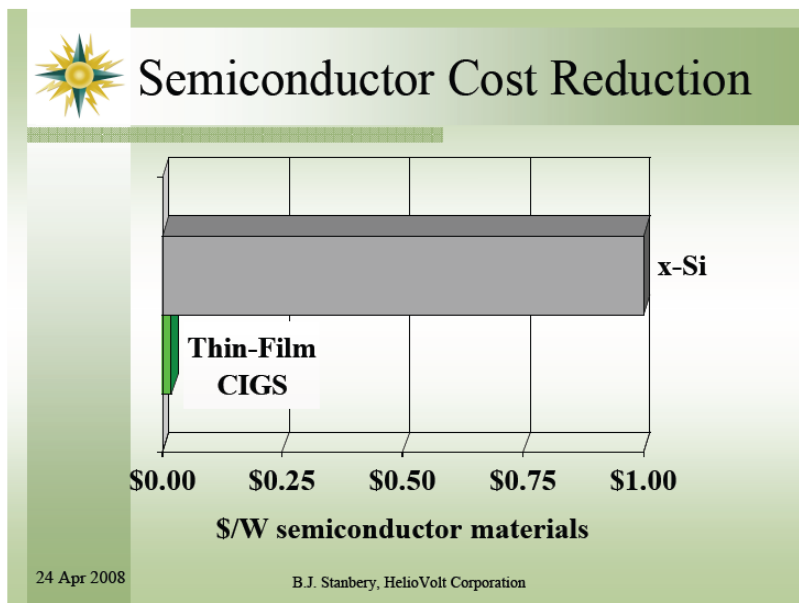
¹⁴ Julie Blunden, Sunpower, Power Point Presentation to KEMA Executive Forum, 12 March 2008.



Thin-film PV “skins” can be used to turn the exterior surfaces of buildings into power plants. Credit: HelioVolt Corporation

The U.S. Department of Energy (DOE) estimates that U.S. production of thin film solar modules may exceed that of crystalline silicon modules by 2010.¹⁵ While thin film efficiencies are lower than silicon’s, the lower cost may tip the balance in thin film’s favor. Research scientists also are working on a variety of “next generation” technologies – including the use of nanomaterials and multijunction cells – that could dramatically boost the efficiency of PV cells or reduce their cost.¹⁶

Figure 4. Thin-film PV Systems Have the Potential to Cut the Cost of Solar Power¹⁷



¹⁵ U.S. Department of Energy, Energy Information Administration, *Solar Photovoltaic Cell/Module Manufacturing Activities 2007*, December 2008.

¹⁶ R. McConnell and R. Matson, National Renewable Energy Laboratory, *Next-Generation Photovoltaic Technologies in the United States*, June 2004.

¹⁷ B.J. Stanbery, HelioVolt Corporation, *HelioVolt Corporation: The Future of Photovoltaic Power*, Powerpoint presentation to Texas Solar Forum, 24 April 2008.

Manufacturing silicon cells today costs roughly \$3 a watt. However, some companies plan to streamline the manufacturing process to produce solar cells at \$1 per watt. HelioVolt, an Austin-based company, is developing a faster and more efficient way to manufacture thin-film solar cells at lower costs. Their process is called FASST, which they claim is a lower-cost process for applying a thin-film PV coating known as copper-indium-gallium-selenide (CIGS) to construction materials such as roofing, steel, and flexible composites in 80 to 98 percent less time than conventional processes. This would position the company to bring economical building products featuring integrated PV cells to the market. HelioVolt recently opened a new manufacturing facility in Austin that will employ 160 workers making thin-film solar products.¹⁸

Concentrating Solar Power

In the direct sunlight of the southwestern United States, concentrating solar power (CSP) plants are harnessing the thermal energy of the sun. The concept behind CSP is familiar. Just as a magnifying glass focuses the sun's hot rays to ignite a scrap of paper, CSP focuses and collects the thermal energy of sunlight. But CSP creates far more heat than a magnifying glass, concentrating sunlight up to 1,000 times its initial intensity.¹⁹

Concentrating PV

Entech Solar, Inc., a Fort Worth based company, uses crystalline solar cells in its concentrating PV systems, which it has been designing and installing for the last 25 years. Entech's suite of products produce only electricity, electricity and heat, or heat only. Entech has completed the build out of a new 71,000 square foot facility and is now finishing up a production line that will produce 50 MW per year of concentrating PV. Entech's PV terrestrial products use mono-crystalline solar cells under Fresnel lens at 20 suns concentration. Entech uses high-efficiency multi-junction solar cells under its Fresnel lens in the Company's space solar systems for NASA and U.S. DOD.



Crossing Boundaries: Concentrating PV

*The mirrors used in CSP plants to focus and capture the sun's heat can also be used to focus sunlight on photovoltaic modules – reducing the amount of silicon needed for PV systems. **Entech Solar**, a Fort Worth-based company, has developed technology that focuses sunlight on a string of photovoltaic solar cells using Fresnel refractors.*

¹⁸ HelioVolt, HelioVolt Opens First Solar Thin Film Factory in Austin, Texas (press release), 24 October 2008.

¹⁹ U.S. Department of Energy: Energy Efficiency and Renewable Energy, *DOE Solar Energy Technologies Program: FY2006 Annual Report*, 2007, 107.

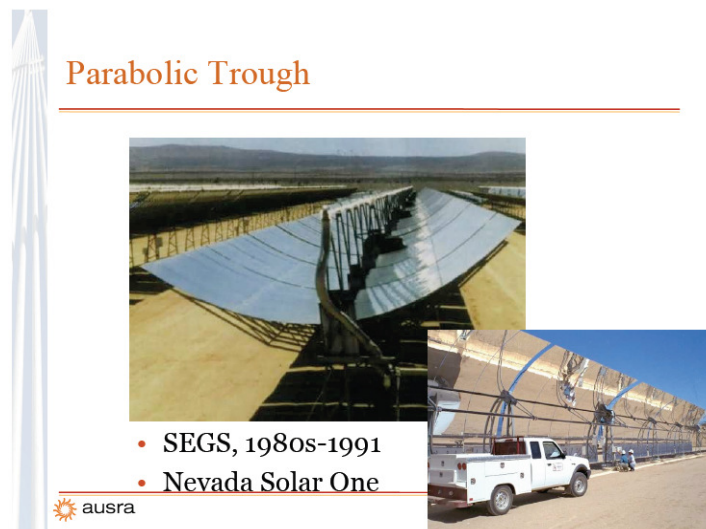
While solar photovoltaic systems convert light directly into electricity, CSP systems concentrate and capture the sun's heat. In typical CSP plants, mirrors angle sunbeams to heat a liquid (usually water, oil or molten salts) to about 400° Celsius. This extreme heat is used to generate steam to drive large, conventional turbines or to power Stirling heat engines. Unlike electricity, which is currently costly and difficult to store, heat can be stored easily and relatively cost-effectively, making CSP a unique solar technology that can provide electricity even during cloudy weather and after sunset.

With the use of CSP, less than 1% of the world's deserts could generate as much electricity as the world is currently using.²⁰ In the United States, an area of southwestern desert 100 miles to a side could produce enough electricity to power the entire country.²¹

As with photovoltaics, there are several CSP technologies, each with their own unique characteristics and advantages.

Parabolic Troughs

Parabolic troughs are the form of CSP with the longest track record for delivering utility-scale power. In parabolic trough systems, special mirrors shaped as linear parabolas reflect the sun's rays toward an absorption tube suspended at the center of the trough's arc. The concentrated sunlight heats fluid inside the tube, generally a synthetic oil. The superheated fluid then travels to a collecting unit, where it heats water and generates steam to power turbines. The troughs are typically arrayed on a north-south axis and track the sun throughout the day.



Parabolic trough systems have been delivering reliable power in California for decades. Credit: Austra, Inc.

²⁰ Peter Meisen and Oliver Pochert, Global Energy Network Institute, *A Study of Very Large Solar Desert Systems with the Requirements and Benefits to those Nations Having High Solar Irradiation Potential*, June 2006.

²¹ U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Solar FAQs – Concentrating Solar Power – Applications*, downloaded from www.eere.energy.gov/solar/cfm/faqs/third_level.cfm/name=Concentrating%20Solar%20Power/cat=Applications, 26 March 2008.

Parabolic troughs are effective at collecting heat from sunlight, but have been hampered by relatively high costs. Typically, the fluids used to transfer heat from the troughs to the collecting unit cannot operate in excess of 400° Celsius (which limits plant efficiency and raises costs). Because the trough's absorption tube must remain fixed in relation to its mirrors, transfer fluid has to flow through flexible joints that shift throughout the day—joints that are expensive and require maintenance. Special curved mirrors are also expensive, and, because of their shape, hard to clean.

Recent technological advances, however, are making parabolic troughs more efficient and cost effective. New plants such as Nevada Solar One, a 64-MW facility that went on line in July 2007, have demonstrated increased efficiency at turning solar energy into electricity. Further, new trough designs are in development to eliminate ball-joints and increase thermal capacity.²² Engineers in Europe and the United States are experimenting with molten salts for use in higher-efficiency transfer fluids and heat storage systems, and they are testing the possibility of directly generating steam inside absorption tubes in order to reduce costs.²³ Several CSP developers are directing their efforts at increasing the durability and minimizing the costs of parabolic trough mirrors.²⁴

Proposals are moving forward for several new parabolic trough plants, including a 550-MW plant in California and a 280-MW facility in Arizona.²⁵

²² U.S. Department of Energy: Energy Efficiency and Renewable Energy, *Development of the Focal Power Point Trough (FPPT) & PT-2 Advanced Concentrators for Power Generation* (PowerPoint presentation), DOE Solar Energy Technologies Program Peer Review, 17-19 April 2007.

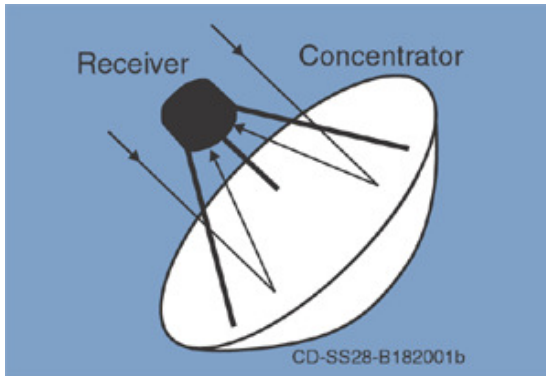
²³ Greenpeace, European Solar Thermal Industry Association and SolarPACES, *Concentrated Solar Power – Now! Exploiting the Heat from the Sun to Combat Climate Change*, September 2005, 15.

²⁴ U.S. Department of Energy Solar Technologies Program, *DOE Concentrating Solar Power 2007 Funding Opportunity Project Prospectus*, 28 November 2007, 24.

²⁵ 550 MW plant from Pacific Gas & Electric Company, Solel, *PG&E Signs Agreement with Solel for 553 Megawatts of Solar Thermal Power* (press release), 25 July 2007; 280 MW plant: APS, *APS Announces New Solar Power Plant, Among World's Largest* (press release), 21 February 2008.

Parabolic Dish/Stirling Engines

Figure 5. A parabolic dish CSP system



*This parabolic dish collector reflects sunlight to drive a Stirling heat engine, located on the arm above the dish.
(Credit: Thomas Mancini, McDonnell Douglas/Sandia National Laboratories)*

Shaped like a satellite dish, parabolic dish receivers work on a principle similar to the parabolic trough: curved mirrors bounce sunlight to a central collecting location. But instead of a long absorption tube, parabolic dishes focus light rays on a single area, the heater head of a Stirling engine, which is suspended above the bowl of mirrors. As the high light concentration raises temperatures at the focal point to upward of 750° Celsius, it heats a thermal transfer fluid which in turn moves a piston to power the engine.²⁶

While relatively efficient (with demonstrated peak solar to net AC electric conversion of over 30 percent), parabolic dishes have in the past been considered most useful as independent, off-grid units, particularly in remote and developing areas, or coupled with larger power plants.²⁷ This is because an individual dish is a self-sufficient unit: all the mirrors track as a unit, and the system generates electricity at the same site as its mirrors. The dishes are therefore modular and can be installed in places where there is not room for vast fields of mirrors. Since electricity is generated in the dish unit rather than at a central location, however, the dishes also have limited storage ability.

Construction of several new, high-capacity parabolic dish plants is planned for the coming years. In 2005, Stirling Energy Systems announced two contracts with utilities in southern California for 800-

²⁶ Greenpeace, European Solar Thermal Industry Association and SolarPACES, *Concentrated Solar Power – Now! Exploiting the Heat from the Sun to Combat Climate Change*, September 2005.

²⁷ Greenpeace, European Solar Thermal Industry Association and SolarPACES, *Concentrated Solar Power – Now! Exploiting the Heat from the Sun to Combat Climate Change*, September 2005.

1,750-MW of parabolic dishes.²⁸ The construction of a 500-MW Stirling dish facility in Victorville, CA (later to be expanded to 850 MW) will provide enough power to serve 278,000 homes per year.

Central Receivers

Central receivers (or “power towers”) also use mirrors to direct sunlight to a focal spot. Instead of using a dish to harvest solar power, central receivers rely on a stationary tower and nearly flat tracking mirrors (heliostats) arrayed around the tower. Each heliostat in the array is free-standing, and is able to independently track the sun. Inside the receiving tower, a heat transfer fluid (usually water or molten salt) absorbs the sun’s thermal energy and is used to generate steam for a turbine.

Because so much sunlight is concentrated in a small area, the tower fluid becomes superheated, reaching 650° Celsius. These higher temperatures help to reduce the cost of thermal storage. Also, the heliostats used in central receivers are nearly flat, rather than curved, reducing their manufacturing cost. These features combine to give central receivers the potential to be produced inexpensively.

Demonstration central receiver plants have been built around the world, beginning in 1981 with a 0.5-MW test plant in Spain. Since then, several countries including France, Italy, Japan, Russia and the United States have also constructed pilot central receiver plants, ranging from 1 to 10 MW.²⁹

Between 1982-1988 and 1996-1999, the Solar One/Solar Two test facility was operational in the desert near Barstow, CA. (Solar Two involved a molten salt thermal storage retrofit on the Solar One plant.) The facilities successfully generated 10 MW of power and demonstrated increasing rates of generation and storage efficiency. Most recently, in March 2007, an 11 MW central receiver plant, the PS 10 Solar Power Tower, went on line to deliver power to the city of Seville, Spain—the first commercial power tower system in the world. In southern California, developers have filed an application to build a series of power tower systems, with a total of 400 MW of capacity and completion planned for 2012.³⁰

²⁸ California Public Utilities Commission, *PUC Approves Renewable Power Contract for Edison, Moving Utility Closer to Meeting Clean Power Goal* (press release), 27 October 2005; Stirling Energy Systems, *Stirling Energy Systems Signs Second Large Solar Deal in California* (press release), 7 September 2005.

²⁹ U.S. Department of Energy, Energy Efficiency and Renewable Energy, Office of Utility Technologies,

Renewable Energy Technology Characterizations, December 1997, 5-8.

³⁰ California Energy Commission, *Siting Cases: Ivanpah Solar Electric Generating System*, 07-AFC-05, downloaded from www.energy.ca.gov/sitingcases/ivanpah, 3 March 2008.



Solar One/Two Central tower plant

Linear Fresnel Reflectors

Linear Fresnel (frə-něl') reflectors (LFRs) use long rows of nearly flat, rotating mirrors to reflect light at absorbers elevated above the plane of mirrors. Absorbers use either a thermal transfer fluid or directly generate steam to power turbines.



A linear Fresnel reflector solar thermal power plant. (Credit: Ausra)

While not as efficient as parabolic dishes, troughs or central receivers, LFRs offer many potential cost and structural advantages.³¹ Like central receivers, their mirrors are made of standard glass in large, flat sheets—which require fewer steel supports than parabolic troughs and can be mass-produced cheaply. The mirrors' flat shape renders them more resistant to wind damage and makes them easier

³¹ Inefficiencies due to LFR mirror shape from Andreas Haberle et al., SolarPACES, *The Solarmundo Line Focusing Fresnel Reflector, Optical and Thermal Performance and Cost Calculations*, downloaded from www.solarpaces.org/CSP_Technology/docs/solarpaces_fresnel_9_2002.pdf on 28 December 2007, 9.

to clean.³² LFRs' fixed absorbers also do not have moving joints, which simplifies fabrication and avoids the cost and maintenance challenges presented by joints in parabolic trough arrays.³³

In the past, shadows caused inefficiencies in LFR arrays since all the mirrors in an array had to aim at a single absorber. A common solution was to increase the distance between the mirror rows—but this took up more surface area, decreasing the land efficiency of the system. The compact linear Fresnel reflector (CLFR) addresses this problem by adding multiple absorbers spaced at intervals above the mirrors. Because the mirrors no longer must be aimed at the same point, neighboring mirrors can be angled in opposite directions, minimizing shadows and allowing mirror rows to be placed closer together.³⁴ Demonstration LFR arrays have been built in Australia, Spain and Belgium. America's first LFR power plant – a 5 MW system in California – went on line in October 2008.³⁵ And developers have applied for permits to build a larger, 177 MW CLFR plant in California.

Solar Water Heaters

Energy from the sun can do more than create electricity. Indeed, proper management of solar energy can go a long way toward reducing the need for fossil fuel use. For example, buildings with light colored “cool roofs” reflect sunlight rather than absorb it, reducing the need for air conditioning use in hot climates during the summer time.

Solar energy can also reduce fossil fuel use by harnessing the sun's heat for household and commercial water heating. Solar water heaters use simple rooftop collectors to pre-heat water used for laundry, bathing and other purposes. Solar water heaters can reduce the amount of energy used for water heating in a home or business by 75 percent or more.³⁶

Worldwide installations of solar water heaters are on the rise, growing by 14 percent in 2005, led by China with almost 80 percent of today's world-wide market.³⁷ On a per-person basis, Israel leads the way with 90 percent of all homes taking advantage of the technology.³⁸

Types of solar water heaters

The most visible difference among systems is the type of collector used. Collectors fall into four main categories: unglazed, flat plate, batch, and evacuated tube.

Unglazed collectors – The simplest collectors are unglazed; water passes through dark tubes or sacks that absorb sunlight without any glass or plastic cover. Unglazed collectors are cheaper than other types and are the most efficient option for heating water to just less than 20° F above the temperature

³² Clean Energy Action, *Concentrated Linear Fresnel Reflectors: The Next Generation of Concentrating Solar Power* (fact sheet), downloaded from www.cleanenergyaction.org, 26 December 2007.

³³ U.S. Department of Energy Solar Technologies Program, *DOE Concentrating Solar Power 2007 Funding Opportunity Project Prospectus*, 28 November 2007, 8.

³⁴ David R. Mills and Graham L. Morrison, *Advanced Fresnel Reflector Powerplants – Performance and Generating Costs*, Proceedings of Solar '97, Australian and New Zealand Solar Energy Society, 1997, 2.

³⁵ <http://www.ausra.com/pdfs/KimberlinaOverview-101108.pdf>

³⁶ Bernadette Del Chiaro and Timothy Telleen-Lawton, Environment California Research & Policy Center, *Solar Water Heating: How California Can Reduce its Dependence on Natural Gas*, April 2007.

³⁷ Eric Martinot, The Worldwatch Institute, for the Renewable Energy Policy Network for the 21st Century, *Renewables Global Status Report: 2006 Update*, 2006.

³⁸ Bernadette Del Chiaro and Timothy Telleen-Lawton, Environment California Research & Policy Center, *Solar Water Heating: How California Can Reduce its Dependence on Natural Gas*, April 2007.

of the outside air. Unglazed collectors are ideal for heating pools, which don't require high water temperatures.

Flat plate collectors – Flat plate collectors are essentially squat, water-filled boxes with a clear glass or plastic top facing the sun. The translucent top or “glazing” is designed to let sunlight in while preventing heat energy from getting out. The bottom of the collector is a black surface designed to absorb sunlight and release the energy as heat, which is in turn absorbed by the water and trapped by the glazing. Water flows into a lower corner of the collector and becomes heated before exiting through a higher corner. The insulation provided by the glazing allows flat plate collectors to heat water as much as 130° F above the surrounding air temperature.

Instead of water, flat plate collectors can also use a solution of water and propylene glycol, a non-toxic chemical, to prevent the pipes and collector from freezing during extremely cold temperatures. The heat absorbed by the solution is transferred to water in a hot water tank, then pumped back to the collector to be heated again. Solar hot water systems that only use water are “direct” systems, while those that use an antifreeze solution such as diluted propylene glycol are “indirect.”

Batch collectors – Batch collectors are sometimes called “integrated collector-storage” (ICS) systems because they house a storage tank for the hot water inside a flat plate-like collector. Solar hot water systems with batch collectors are often simpler and cheaper than flat plate systems since the collector and extra tank are combined, but are usually not quite as efficient.

Batch collectors are best suited to climates with only mild freezes. They also work best in buildings that require more hot water during the day or in the evening rather than early morning, since storing the hot water outside causes it to lose more heat on cold nights.

Evacuated tube collectors – Evacuated tube collectors are made up of long, clear glass tubes containing a colored glass or metal tube to absorb the sun's energy. The space between the outer glass tube and the inner absorber tube is evacuated (contains almost no air), making heat loss much slower and enabling the system to heat water to as much as 350°F or more. Residential systems include measures to ensure that water used in the home does not rise above standard hot water temperatures.

Evacuated tubes can either circulate water directly through the absorber tube or be filled with a non-toxic solution that heats water as it passes by the top of each tube. Evacuated tubes are more expensive per unit area than other collectors, and are ideal for cold climates or buildings that use the hot water as an energy source for air conditioning or heating.



*A solar water heating system.
(Credit: VELUX/ESTIF)*

Energy Storage

In our fossil fuel-based energy system, we've come to take energy storage for granted. Energy is stored in a lump of coal, a barrel of oil, or a cubic foot of natural gas, waiting to be released whenever and wherever we want it. Many renewable energy sources, however, don't work that way. The sun does not shine and the wind does not blow all the time. So we need to think a bit harder about how to integrate renewable energy into our energy system.

The first piece of good news is that the need for energy storage is often overrated – for example, the addition of utility-scale solar power in West Texas would be a good complement for the wind power already being generated there. Since the sun and wind resources peak at different times, the two renewable technologies can act as a team helping to meet Texas' energy needs.

The second piece of good news is that energy storage technology is advancing rapidly. Concentrating solar power (CSP) technology is particularly ripe for cost-effective energy storage, since it is easier and cheaper to store heat than it is to store electricity. With solar thermal plants such as parabolic troughs or linear Fresnel reflectors, heated fluid can travel directly to a boiler and generate steam to drive turbines, or it can travel to a storage unit. The storage unit serves as, essentially, a large thermos: a structure that will store heat for later use.

Among other characteristics, an ideal thermal storage medium possesses high density, high heat transfer capacity, mechanical and chemical stability, and low cost.³⁹ Molten salts and concrete blocks in particular provide many of these qualities and are the subject of deepening scientific research.⁴⁰ Molten salts have been used in several recently constructed solar thermal plants.

Most current CSP technologies have the potential to provide at least six hours of thermal storage—enough to help meet electricity needs during the evening hours, when electricity consumption is high but the sun is not shining. While not all new or proposed CSP plants include thermal storage, several new plants with extended storage are either under construction or in the planning stages. In Spain, two 50 MW parabolic trough plants are under construction that will employ six-hour thermal storage.⁴¹ Also in Spain, the 15 MW Solar Tres molten-salt central receiver plant will incorporate 15-hour thermal storage, using technology demonstrated at the Solar Two central receiver plant in California.⁴² Abengoa Solar's proposed 280 MW parabolic trough plant in Arizona will also incorporate thermal energy storage.⁴³

³⁹ Ulf Herrmann, Michael Geyer and Dave Kearney, *Overview on Thermal Storage Systems* (PowerPoint presentation), Workshop on Thermal Storage for Trough Power Systems, 20-21 February 2002, 4. Available at www.nrel.gov/csp/troughnet/pdfs/uh_storage_overview_ws030320.pdf.

⁴⁰ Ulf Herrmann, Michael Geyer and Dave Kearney, *Overview on Thermal Storage Systems* (PowerPoint presentation), Workshop on Thermal Storage for Trough Power Systems, 20-21 February 2002, 4. Available at www.nrel.gov/csp/troughnet/pdfs/uh_storage_overview_ws030320.pdf.

⁴¹ Solar PACES, *AndaSol-1 and AndaSol-2*, downloaded from www.solarpaces.org/Tasks/Task1/ANDASOL.HTM, 28 March 2008.

⁴² SENER, *Projects: Solar Tres*, downloaded from www.sener.es/SENER/detalle_proyectos.aspx?id=cw75fa0c5e1ac34743af81&lang=en, 28 March 2008.

⁴³ Abengoa Solar, *Our Projects: United States: Arizona*, downloaded from www.abengoasolar.com/sites/solar/en/our_projects/usa/arizona/index.html, 23 December 2008.

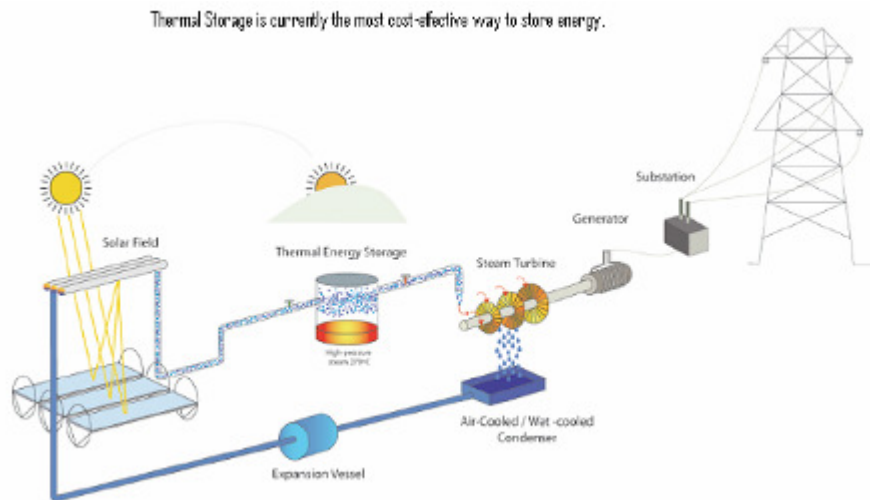


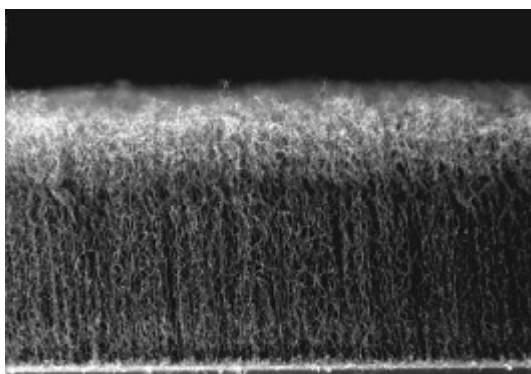
Figure 6. A Thermal Storage System for Concentrating Solar Power Plants⁴⁴

Engineers are working to further extend the length of time that utility-CSP plants can generate power, with the U.S. Department of Energy setting a goal of developing technology to provide 12 to 17 hours of thermal storage by 2020 and of reducing the cost of thermal energy storage.⁴⁵

Other Types of Storage

There are several other renewable energy storage technologies that can increase solar power's market share.

Capacitors are devices that store energy in electrical fields between a pair of conductors (plates). They build up a charge and then can release the energy quickly or slowly.

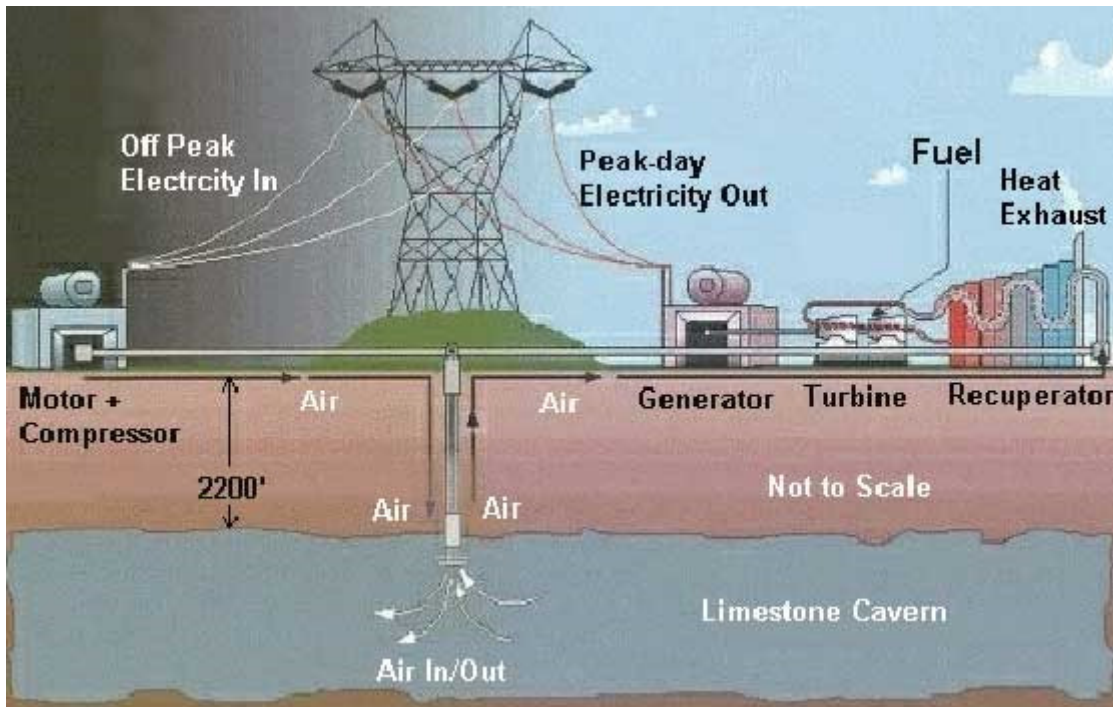


A “hairy” capacitor covered in nanotubes, developed by MIT. (Credit: MIT/Riccardo Signorelli)

Compressed air energy storage (CAES) is a method of storing energy by compressing air to be used later for generating electricity. Shell Wind Energy and Luminant Energy want to utilize CAES in their new 3,000 MW wind megaproject in the Texas Panhandle. CAES can be utilized by nearly any mass electrical generation technique, including solar.

⁴⁴ Ausra, Inc., *Solar Thermal Power*, Powerpoint presentation to Texas Solar Forum, April 2008.

⁴⁵ U.S. Department of Energy, Energy Efficiency and Renewable Energy, *Concentrating Solar Power Funding Opportunity Announcement* (press release), 25 May 2007.



Compressed air energy storage allows renewable energy to provide electricity even when the sun is not shining or the wind is not blowing. (Credit: Imperial College of London via Texas State Energy Conservation Office)

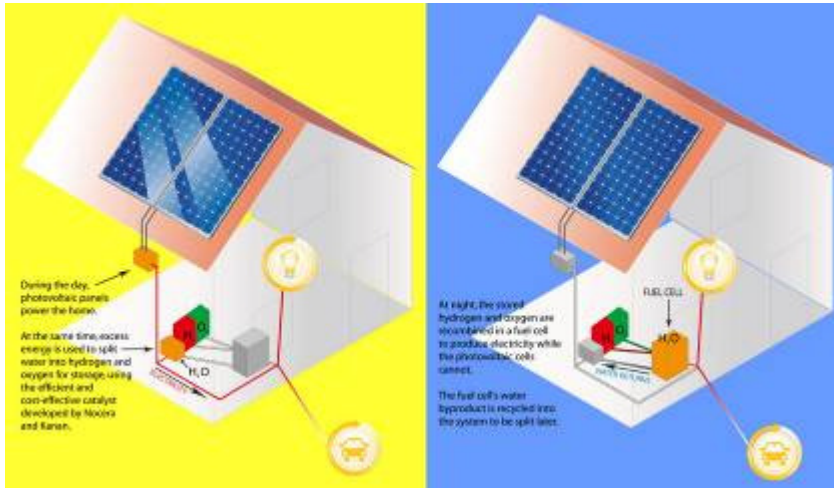
Flywheels store energy by accelerating a rotor to very high speed and maintaining the energy in the system as rotational energy. Energy is then recovered by slowing down the flywheel. Researchers at our own University of Texas are making great steps forward in this technology. They beat previous flywheel records by 70% in 2003, spinning a flywheel at 3,000 mph. This research is ongoing and advancements in flywheel materials constantly make this a more feasible technology for energy storage.

Batteries – Advancements in conventional batteries are being made all the time. Xcel Energy is currently developing and testing new sodium-sulfur and other batteries for use with wind farms. There are many other battery types such as flow batteries and new advances in lithium ion, support of battery research and development is extremely important to our energy future.



This large battery is used to store large amounts of electricity for release back into the grid. (Credit: AEP)

Hydrogen/fuel cells –Researchers at MIT have developed a method whereby homeowners could use their solar panels during the day to power their home, while also using the energy to split water into hydrogen and oxygen for storage. At night, the stored hydrogen and oxygen could be recombined using a fuel cell to generate power while the solar panels are inactive.



Excess solar power could be used to produce hydrogen, which could then be used to power automobiles. (Credit: Patrick Gillooly, MIT)

Central Station Solar vs. Distributed Generation

One of the great benefits of solar power is its flexibility – solar power can be produced virtually anywhere there is sunlight. Solar power technologies can serve two important needs within the electric system, producing power on a large scale in central locations, as current power plants do, and serving as a form of “distributed generation,” producing power right where it is used.

Central station solar

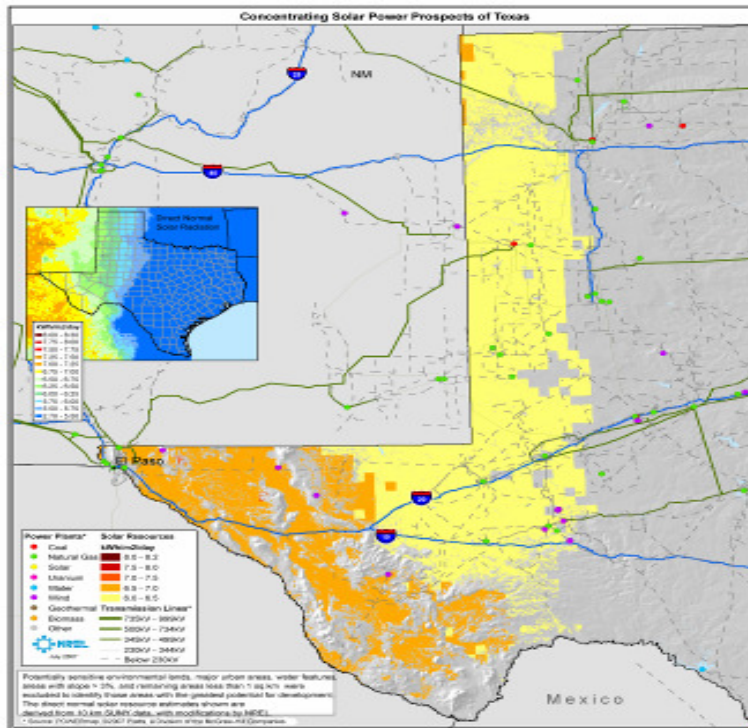
Both photovoltaics and concentrating solar technologies can produce power centrally and distribute it to the grid. The benefit of central-station solar power is that Texas can use its vast solar resources to generate power used across the state, as well as far from Texas’ borders.



Central-station CSP power plants, like the one above, can deliver large amounts of power to the grid. (Credit: Ausra)

Concentrating solar power can play a particularly important role in providing bulk power for the grid, particularly if it is paired with thermal storage, allowing power to be generated from the sun even at night.

Figure 7. Areas of Texas with Potential for Concentrating Solar Power⁴⁶



But even without thermal storage, central station solar power plants – both PV and CSP – can play an important role in providing power to Texas’ electricity grid by balancing the vast amount of wind-powered electricity coming from West Texas. West Texas wind blows strongest and most consistently at night, whereas solar energy comes on strongest during the day. The two renewable energy sources would be able to effectively balance the Competitive Renewable Energy Zone (CREZ) transmission lines currently under development, providing reliable, consistent, renewable electricity for Texas and beyond.

While utility-scale solar does raise land use issues, because large tracts of land are needed to spread out solar thermal collectors or PV panels, it represents minimal environmental impact when compared to virtually all other large-scale power plants. For example, utility-scale solar has none of the local, regional, or global emissions that fossil fuel-based power plants have. It also produces no waste, as nuclear plants do.

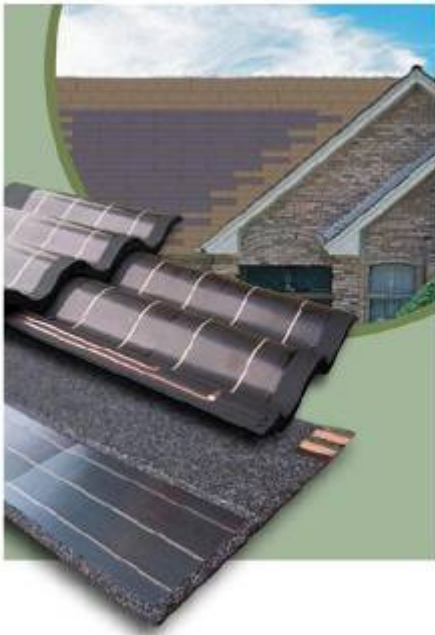
Distributed Generation

While solar power can be a good source of renewable electricity for the Texas grid – enabling the state to eventually back out more polluting sources of generation – it also has one trait that most

⁴⁶ National Renewable Energy Laboratory, *Concentrating Solar Power Resource Maps*, downloaded from www.nrel.gov/csp/maps.html, 23 December 2008.

conventional power generating technologies lack: solar power can be generated right at the location where it is used and scaled to fit local power needs.

The potential to generate solar electricity from Texas' existing homes, schools, big-box and office park rooftops, parking lots and other open, built-up spaces is immense. As thin-film PV enters the market, building materials themselves can become electricity generators. While most CSP technologies are less well-suited to small-scale applications, parabolic dish systems could be used to generate distributed solar power as well.



A growing variety of products allow solar power to be integrated directly into the structure of a building – for example, through roofing materials. Credit: Dow Chemical

There are many benefits to distributed generation (DG). The farther electricity has to travel along transmission lines to reach a home or business, the greater the amount of energy that is lost along the way. By locating more energy generation closer to the places that use the energy, PV reduces the energy losses inherent in transmission lines. In addition, the more DG is implemented, the less the utilities have to spend building and maintaining transmission lines.

Land issues dog all centralized power plants, and renewable energy power plants are not immune to them. DG from solar, however, eliminates the issue because it is built on top of land that is already developed (houses, parking lots, etc.).

DG also has an inherent advantage over large-scale power plants in terms of reliability. As has been demonstrated numerous times during natural disasters, tornados, hurricanes, and droughts frequently knock power plants off line, leaving thousands of homeowners in the dark until they are repaired. With DG, city buildings themselves become mini-power plants, reducing a city's reliance on only a few large-scale plants.

Benefits of Solar Energy

Technological advances are making solar energy an increasingly viable and cost-effective alternatives to fossil fuels. Making a strong commitment to solar energy would have a significant payback for Texas: job creation, economic benefits, the ability to meet energy demand, pollution reduction, and ultimately lower energy costs.

Job Creation

Texas is well-situated to take advantage of the global boom in solar energy, especially if we develop a strong solar market right here in the state.

Photovoltaics - According to a PV industry analysis, with the correct incentives in place, the solar photovoltaic market could attract more than a \$34 billion investment by 2015. Of that, Texas could attract almost \$5 billion.⁴⁷

Under business-as-usual conditions, by 2015 Texas will have 251 MW installed, Texas' technical potential for 2015 is an amazing 70,882 MW.⁴⁸

A study by the Center for American Progress reports that an investment in renewables would create roughly four times more jobs than an investment in traditional sources of electricity.

(http://www.americanprogress.org/issues/2008/09/green_recovery.html) Furthermore, an analysis by the Vote Solar project finds that by 2020 under a 2000 mw program the solar energy industry could create almost 21,500 new jobs in Texas.⁴⁹

Job Type	Direct Jobs	Indirect/Induced	Total
Manufacturing	2,700	9,400	12,100
Installation	2,100	7,200	9,300

A white paper released by the IC² Institute at the University of Texas at Austin highlights two studies that project major solar job growth in Texas. The first states that by becoming a world leader in solar manufacturing and construction, in concert with a suite of climate protection strategies, Texas could generate 123,000 net new high-wage jobs in the technology advanced manufacturing and electrical services industries. The second study states that by 2015 Texas could capture more than 13% of all new jobs and more than 13% of all investment in the solar industry. In these scenarios, workers whose jobs have been outsourced offshore would regain employment opportunities, and high-tech manufacturing employment in Texas would return to pre-recession (pre-2001) levels.⁵⁰

As mentioned earlier, Texas is also already home to approximately 11.5% of the world's silicon processing capacity, and companies that produce silicon will be among those likely to prosper as a result of the expansion of solar power.

⁴⁷ George Sterzinger and Matt Svrcek, Renewable Energy Policy Project, *Solar PV Development: Location of Economic Activity*, January 2005.

⁴⁸ Charlie Hemmeline, U.S. Department of Energy, Solar Program, *Texas Solar Forum: Economic Development and Job Creation*, Powerpoint presentation, 24 April 2008.

⁴⁹ <http://www.votesolar.org/>

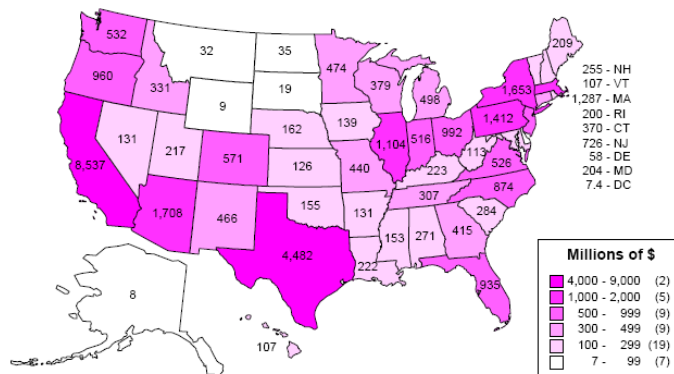
⁵⁰ Bruce Kellison, et al., IC2 Institute, *Opportunity on the Horizon: Photovoltaics in Texas*, June 2007.

Photovoltaics could provide job growth across Texas. In West Texas, workers would be needed to install and maintain large PV farms, silicon plants along the Gulf Coast would benefit from increased demand, thin-film manufacturing centers in Central Texas would continue to grow, and the demand for rooftop solar installers would increase throughout the state. The Renewable Energy Policy Project published a study of PV development in the U.S. and Texas is primed for job growth in manufacturing, with robust industries for producing plastics, glass, semiconductors, sheet metal products, and other components of solar energy installations.⁵¹



*A utility worker checks a rooftop solar power installation.
(Credit: CPS)*

Figure 9. Total Solar Investment Under a PV Industry Roadmap for 2015⁵²



Analysis using NREL's Jobs and Economic Development Impact model shows that during construction, CSP will bring ten times the amount of jobs to Texas as the construction of a comparable conventional power plant. Even after a CSP plant is built it continues to keep five times as many Texans employed as would a conventional plant. By building 4,000 MW of CSP, Texas could attract almost 82,000 jobs during construction and 2,700 permanent jobs in West Texas. ⁵³

Indirect jobs – In addition to jobs directly related to the industry, solar development in Texas would generate a large, incalculable number of indirect jobs in accounting, banking and legal assistance, for example. Other types of indirect jobs would result from the increased wealth and expenditures of land lessors (to solar companies) and of people profitably employed, directly or indirectly, in solar industries.

A robust solar market could also bring billions of dollars in investment to the state and create thousands of jobs. A recent study by the Renewable Energy Policy Project found Texas second to California in jobs created and revenue generated if we were to aggressively pursue solar photovoltaic (PV) development.

Table 1: Total Investment and Jobs by State Based on Nationwide Increase of PV to 9,260 MW by 2015⁵⁴

State	Manufacturing		Construction and Installation		Totals	
	Jobs	\$ Millions	Jobs	\$ Millions	Jobs	\$ Millions
California	6,858	5,500	3,578	3,037	10,437	8,538
Texas	5,205	4,175	361	307	5,567	4,481

Other Economic Benefits

Importantly, new investments and job opportunities deliver economic benefits in addition to job creation. For example, an analysis of the potential benefits of 4 GW of CSP deployment in California projected an increase of \$2 billion in state tax revenue.⁵⁵

In Nevada, a study estimated that construction of 1000 MW of CSP capacity would provide a long-term boost of \$9.37 billion to total personal income in the state and add \$9.85 billion to the Gross State Product.⁵⁶

Another significant benefit of solar deployment is its effect on the price of natural gas. Solar power can substitute for some of the natural gas used to generate electricity and heat water in Texas. As demand for natural gas goes down, so inevitably does its price. A study by the American Council for

⁵³ See Bernadette Del Chiaro, Sarah Payne and Tony Dutzik, Environment America Research & Policy Center, *On the Rise: Solar Thermal Power and the Fight Against Global Warming*, Spring 2008.

⁵⁴ George Sterzinger and Matt Svrcek, Renewable Energy Policy Project, *Solar PV Development: Location of Economic Activity*, January 2005.

⁵⁵ L. Stoddard, J. Abiecunas and R. O'Connell, Black & Veatch, *Economic, Energy and Environmental Benefits of Concentrating Solar Power in California*, National Renewable Energy Laboratory, April 2006.

⁵⁶ R.K. Schwer and M. Riddel, University of Nevada–Las Vegas Center for Business and Economic Research, *The Potential Economic Impact of Constructing and Operating Solar Power Generation Facilities in Nevada*, February 2004, 14.

an Energy-Efficient Economy found that an intensive energy efficiency and renewable energy effort could reduce electricity consumption nationwide by 3.2 percent and natural gas consumption by 4.1 percent within five years – leading to a 22 percent reduction in wholesale natural gas prices.⁵⁷

Table 2. Economic Impacts of Concentrating Solar Power Deployment (California)⁵⁸

Deployment level	2 GW	4 GW
Increase in Gross State Output	\$11.7 billion	\$22.2 billion
Creation of construction jobs	6,800	12,800
Creation of permanent operations jobs	500	1,100
Increase in State Tax Revenues	\$1 billion	\$2 billion

Meeting Energy Needs

Demand for electricity in Texas grows with every passing year. According to ERCOT, which manages most of Texas’ electric grid, demand for energy is growing at a rate of 1.8% each year.⁵⁹

The growth in the housing sector is a major part of this increased demand, with more than 120,000 new homes built each year.⁶⁰ Even with the current slow down in new home construction, these new buildings add considerable strain to our electric grid, but they also provide the state with the opportunity to leverage private home investments to add distributed generation. By encouraging solar installations on homes and businesses, the need for transmission capacity upgrades and new power plants can be lessened.

Solar that is integrated into the building design should be the goal for new construction in Texas. As mentioned earlier in this report, companies in Texas can manufacture building materials that collect the energy of the sun through photovoltaic construction products that can be integrated into a building directly, like solar electric roof shingles and slates. Builders will still be able to construct a traditional looking home while getting dual use out of a building material to reduce construction costs and generate electricity at the same time.

According to a recent study by the American Council for an Energy Efficient Economy, all of Texas’ projected growth in electricity demand could be offset through energy efficiency and on-site renewable energy. The report highlighted photovoltaic panels for their “statewide applicability, extreme versatility, and unlimited potential, and the prospect of providing a highly desirable emission-free, onsite generation source for congested urban settings” and called for “special consideration of incentives for PV.”⁶¹

⁵⁷ R. Neal Elliott, et al., American Council for an Energy-Efficient Economy, *Natural Gas Price Effects of Energy Efficiency and Renewable Energy Practices and Policies*, December 2003.

⁵⁸ Western Governors’ Association, *Clean and Diversified Energy Initiative: Solar Task Force Report*, January 2006.

⁵⁹ R. Neal Elliott, et al., American Council for an Energy-Efficient Economy, *Potential for Energy Efficiency, Demand Response and Onsite Renewable Energy to Meet Texas’ Growing Electricity Needs*, March 2007.

⁶⁰ TAMU Real estate center 2007 single family building permits.

⁶¹ R. Neal Elliott, et al., American Council for an Energy-Efficient Economy, *Potential for Energy Efficiency, Demand Response and Onsite Renewable Energy to Meet Texas’ Growing Electricity Needs*, March 2007.

Figure 10. Potential Electricity Savings in Texas Metro Regions⁶²

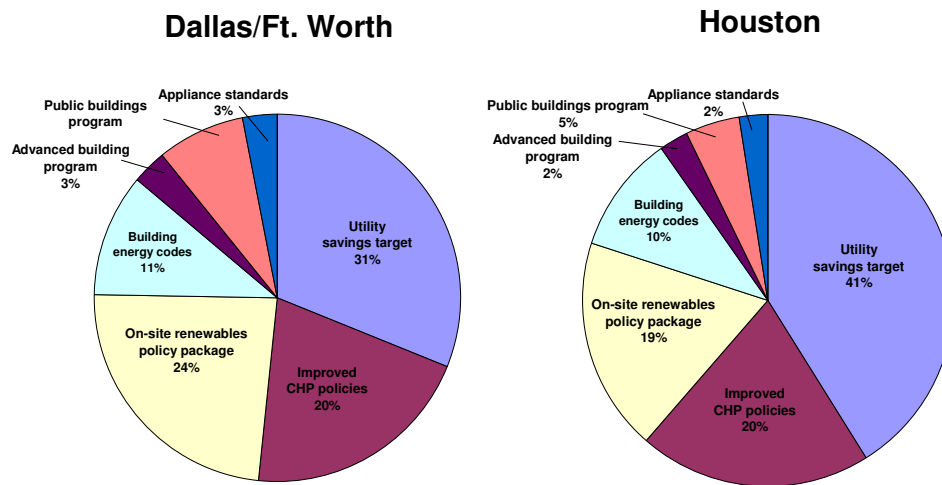
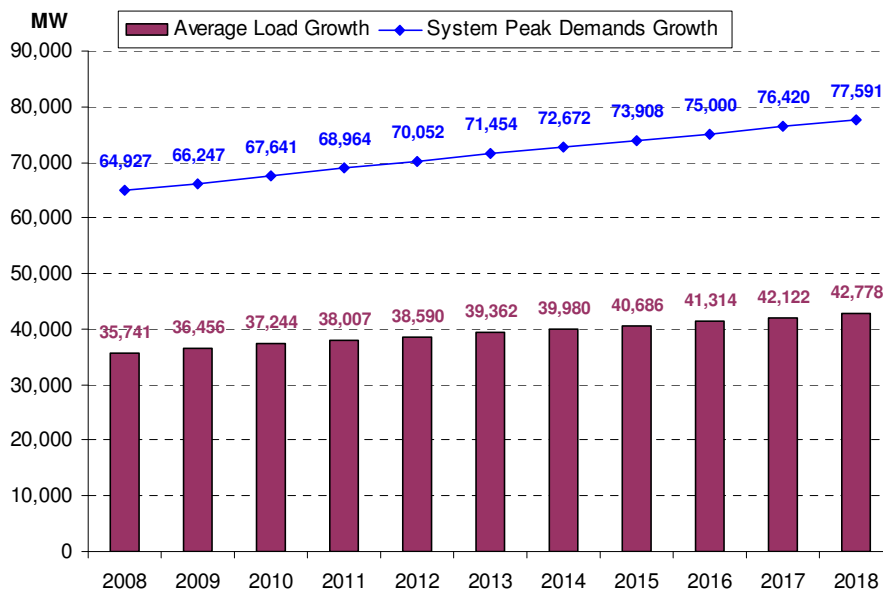


Figure 11. Projected Growth in Average and Peak Load, ERCOT⁶³



Solar energy is uniquely fitted to provide electricity when it is needed most. Typically, the hottest days of the year correspond to the greatest electricity demand as homes and businesses need more energy to power air conditioning systems. This is known as peak load. ERCOT forecasts average load to increase by 7,037 MW, whereas they forecast peak load to increase by 13,294 MW. Peak

⁶² R. Neal Elliott and Maggie Eldridge, American Council for an Energy-Efficient Economy, *Role of Energy Efficiency and Onsite Renewables in Meeting Energy and Environmental Needs in the Dallas/Fort Worth and Houston/Galveston Metro Areas*, September 2007.

⁶³ Electric Reliability Council of Texas, *2008 ERCOT Planning: Long-Term Hourly Peak Demand and Energy Forecast*, 13 May 2008.

load is growing at a faster rate than average load. These data show us that the more generation is needed to meet peak load in the next ten years.

Fortunately, solar capacity is also greatest during peak, providing fuel-free energy when we need it the most. While it is true that solar capacity is reduced when it is cloudy, electric demand is also reduced for the same reason: the sun is not heating things up. Solar power is uniquely fitted to supply much of the peak power needs of the state. When compared to costs of peak power from other generation sources – such as natural gas-fired power plants – solar power proves its value.

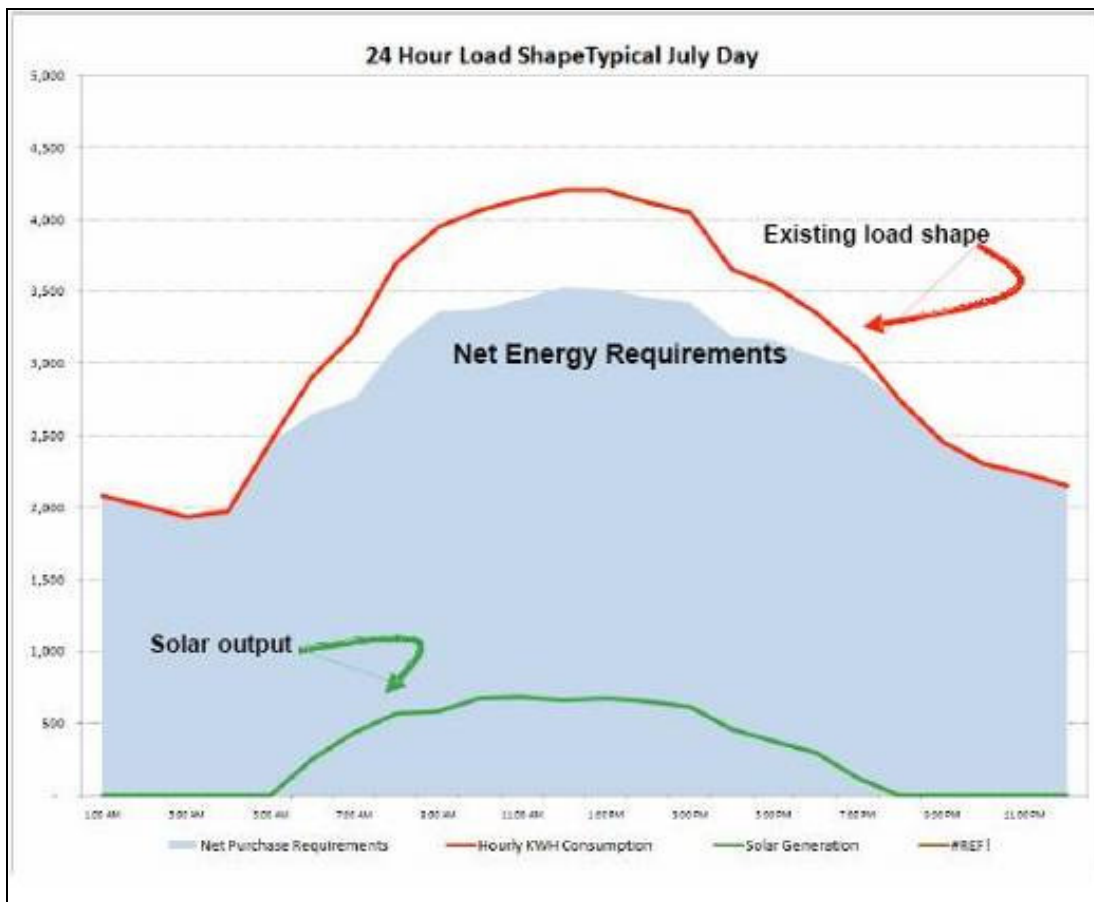


Figure 12. Solar Power's Contribution to Meeting Peak Demand⁶⁴

Pollution Reduction

With more than half of Texas' population living in areas that are failing or close to failing federal air quality standards, solar can play an important role in clearing the air. Solar energy systems emit no pollution. By replacing natural gas, oil and coal use, solar power will reduce the pollution that causes smog, soot, global warming, and mercury contamination of our lakes, rivers and fish.

Solar power reduces emissions at a time when smog is at its greatest concentration. Sunlight hours often coincide with peak power demands, so solar panels produce electricity when it is needed most.

⁶⁴ ION Consulting, as presented in P.A. Nugent, Dow Chemical, *Texas Solar Forum: From Sand to Demand: Economy Wide Opportunities in the Solar Future*, Powerpoint presentation to the Texas Solar Forum, April 2008.

The U.S. Department of Energy estimates that a photovoltaic system meeting half of the electrical needs of a typical household would eliminate approximately half a ton of soot-forming sulfur dioxide pollution, a third of a ton of smog-forming nitrogen oxides, and 100 tons of carbon dioxide from the air over its 28-year lifetime.⁶⁵

From a national perspective, building just 80 gigawatts of CSP capacity by 2030 would be enough to displace carbon dioxide emissions from electric power plants by 6.6 percent compared to year 2000 levels.⁶⁶

Solar water heating can also greatly reduce Texas' greenhouse gas emissions. Solar hot water systems capture energy from the sun to heat water for homes and businesses, thereby displacing the use of natural gas, or in some cases electricity, with free and limitless solar energy. In California it is estimated that solar hot water could reduce the state's global warming pollution by 6.8 million tons of carbon dioxide per year. That amount is equivalent to the annual emissions from over one million cars.⁶⁷

Emissions Benefits of 2000 MW in TX		
CO₂ Avoided (tons)	Methane Avoided (tons)	NO_x Avoided (tons)
29,072,576	523	29,336

Texas' existing solar installations have considerably improved air quality and reduced CO₂ emissions. According to a 2007 study by the Energy Systems Laboratory at Texas A & M University, of the existing PV and solar thermal systems in Texas, many of which are installed at educational institutions, a total of 427,005 kilowatt hours (kWh) are consumed each year. This power avoids a total of 632 pounds of nitrogen oxides, 436 pounds of sulfur dioxide, and 502,876 pounds of carbon dioxide each year.⁶⁸

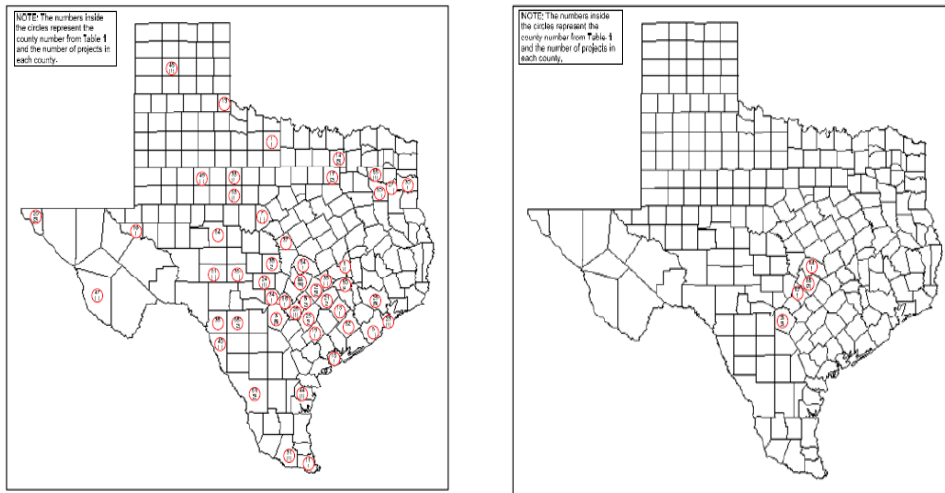
⁶⁵ U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *PV FAQs*, January 2004.

⁶⁶ Bernadette Del Chiaro, Sarah Payne and Tony Dutzik, Environment America Research & Policy Center, *On the Rise: Solar Thermal Power and the Fight Against Global Warming*, Spring 2008.

⁶⁷ Bernadette Del Chiaro and Timothy Telleen-Lawton, Environment California Research & Policy Center, *Solar Water Heating: How California Can Reduce its Dependence on Natural Gas*, April 2007.

⁶⁸ Jeff Haberl, et al., Energy Systems Laboratory, Texas A&M University, *Statewide Air Emissions Calculations from Wind and Other Renewables: A Report to the Texas Commission on Environmental Quality for the Period September 2006 – August 2007*, August 2007.

Figure 13. Solar Photovoltaic and Solar Thermal Projects in Texas⁶⁹



⁶⁹ Jeff Haberl, et al., Energy Systems Laboratory, Texas A&M University, *Statewide Air Emissions Calculations from Wind and Other Renewables: A Report to the Texas Commission on Environmental Quality for the Period September 2006 – August 2007*, August 2007.

Barriers to Solar Power Development

Solar energy has great promise for Texas, but a number of barriers have thus far kept solar energy from playing a bigger part in Texas' energy system.

The biggest barrier to solar energy is cost. The price of solar panels has declined dramatically over the last two decades. The 1970 cost of a PV watt was \$100. By 2002 it was close to \$4. In inflation adjusted dollars, this is a staggering reduction. However, from a homeowner's perspective, the cost of solar panels is still frequently too high.

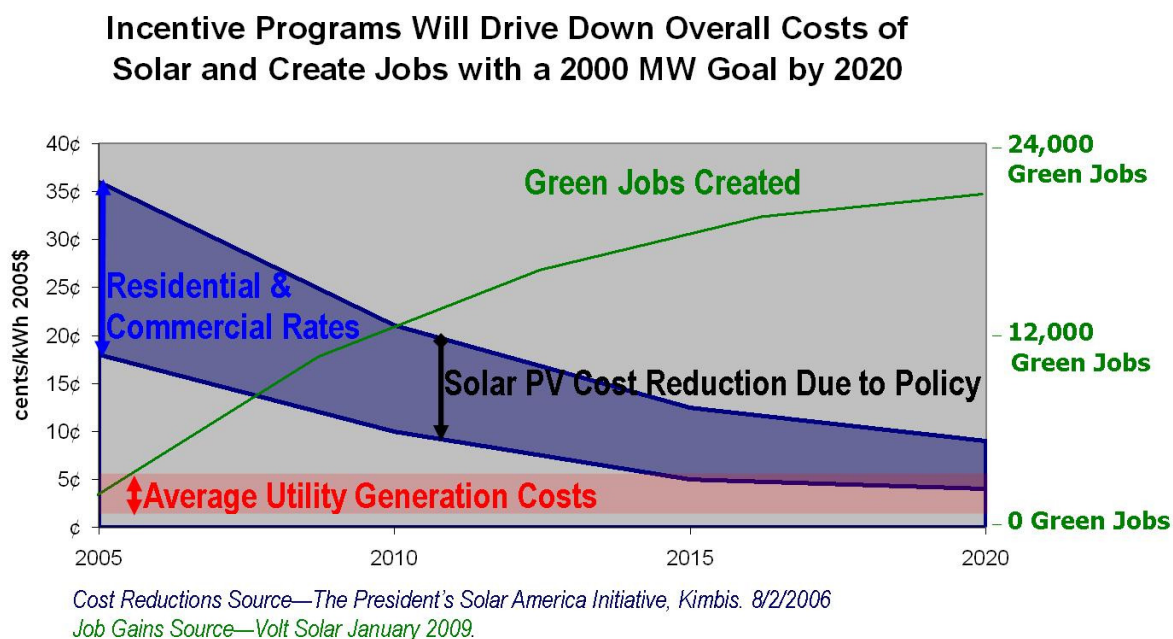
Part of the problem is that a person who installs solar panels on his or her roof is not compensated for all of the benefits their choice creates for society. Replacing fossil fuel-fired electricity with solar electricity reduces air pollution, alleviates the need for expensive investments in electric power plants and transmission lines, and creates a host of other benefits. If individuals or businesses who install solar panels were compensated for providing these benefits, the economic picture for solar power would look much brighter.

Even so, for some homeowners, the up-front cost of a solar power system or solar hot water system may not be worth it in strictly economic terms, particularly if the homeowner only plans to stay in his or her home for a few years. Solar energy investments may pay themselves off over a period of many years, but if the homeowner does not see the potential to save money over the lifetime of their residency in the house, he or she will be unlikely to make the investment.

A portion of the large up-front cost associated with solar power systems is retrofitting older homes by upgrading the electrical system, reinforcing the roof and creating connections between the electrical system and the panels installed on the roof. Creating "Solar Ready" homes by ensuring that new houses are built with proper wiring, south facing roofs that take advantage of sunlight, and proper landscaping to avoid shade on the roof can significantly cut the installation cost of solar power systems.

In addition, investments in solar energy now can help reduce the cost of solar power in years to come, making it a more cost-effective option for Texas homeowners and businesses. As companies that make solar energy equipment reach large-scale production – and as they gain valuable experience in making and installing solar power – they are able to reduce their costs, eventually resulting in reduced prices. The experience of the personal computer, which went from expensive luxury to reasonably priced necessity over the course of a couple of decades, is a fine example of this dynamic at work.

Figure 14. Projected Cost Reductions for Solar PV with Job Creation⁷⁰



There are policy options that can reward consumers for the decision to install solar power, provide financing to help homeowners and businesses make smart investments in solar, and help bring the solar industry to the point of cost-competitiveness with other sources of energy. Net metering policies require utilities to compensate consumers for the excess solar power they supply to the grid. Unfortunately, Texas has poor net metering policies. Under new rules recently passed by the Public Utility Commission of Texas, integrated investor-owned utilities (IOU) will be required to provide specific net-metering options for customers that produce excess electricity from solar installations. However, as a result of deregulation, less than 25% of Texas is currently served by integrated IOUs, so the policy has limited applicability.

Furthermore, owners of solar panels may need to pay for separate meters that measure the outflow of any power they send to the grid. The new rule also fails to exempt solar panel owners from paying distribution charges to their local utility in months when they feed more electricity into the grid than they receive. Texas' net metering policies create heavy burdens on customers wanting to install solar panels but provides no guarantee that customers who generate surplus electricity will ever get paid. They also don't currently allow excess energy produced during high production times of the year to be credited or banked for lower output months. Schools use very little electricity during the summer but would be able to produce large quantities of electricity during peak months when it is needed most. The rules also don't require the retail electric provider to pay a fair price for the electricity produced.

⁷⁰ Steve Chalk, U.S. Department of Energy, Powerpoint Presentation to State Energy Advisory Board July 2006 Board Meeting, 25 July 2006.

Despite the lack of strong legislative incentives, Texas has seen some progress. For example, Austin Energy provides net metering to customers with on-site generating systems that are powered by renewable energy resources and interconnected with the municipal utility's electric system. If a renewable-energy generating system produces more power than the property consumes, then the extra power will flow into the Austin Energy electric grid. The difference is credited on the customer's electric bill.

Meanwhile, some homeowners who wish to install PV panels are facing resistance from Homeowners' Associations, citing concerns over aesthetics, insurance liability, deed restrictions and city regulations. The legislature should pass a bill banning HOAs from denying homeowners' from installing PV panels on their homes.

Ultimately, the health of Texas' solar energy industry depends upon there being a sizable demand for its products and services and upon the costs associated with meeting that demand. Meager state incentives present significant barriers to all types of solar energy development in Texas, including distributed solar power.

Germany's Solar Success

Gloomy-skied Germany is the global leader in solar-generated electricity. The country's journey to this achievement began with a commitment to the Kyoto Protocol and a decision, as a matter of ethics, to move away from nuclear energy.

The "100,000-roofs program," begun in 1999, was one of Germany's first steps toward solar prominence. The program offered interest-free 10-year loans for the purchase of solar panels, with waivers of the last installments of payment. It also guaranteed generous "feed-in" incentives. That same year, the federal government initiated the "environmental tax reform" by which it increased taxes on oil, gas and electricity. Further increases occurred each year through 2003.

In 2000, Germany's Renewable Energy Sources Act (EEG) was passed. The EEG mandated that electricity companies buy a certain amount of electricity from renewable sources, and it increased the price of "feed-in" incentives. The law also required grid operators to guarantee connection to the grid even if that meant upgrading their transmission facilities.

A Market Incentive Program (MAP) provided enticements to businesses. In 2003 alone, MAP offered government grants totaling €203 million for the commercialization and deployment of renewable energy systems.

By the end of 2004, Germany had become the world's No. 2 PV producer and No. 1 PV installer. Germany's incentives are considerably better than California's and have been cited for attracting a large proportion of the worldwide solar PV supply. While incentives in California are based on the installed kW size of a project, Germany's method provides a rebate price per Watt delivered by a particular project to the local electric grid.

Incentives for Solar Power

The remarkable promise of solar power can become a reality through the creation or expansion of Federal and state incentives. The policies below have a proven track record of success.

Federal investment tax credit. The federal investment tax credit for renewable energy is the most meaningful incentive for solar power installations at the federal level. The U.S. government recently renewed the 30% federal investment tax credit for commercial and business solar installations while keeping the Modified Accelerated Cost-Recovery System (MACRS) to 5 years, and eliminated the \$2,000 cap for residential installations additionally it extended the credit to be included in AMT calculations. It also eliminated the prohibition on utilities from benefiting from the credit. The tax credit was set to expire at the end of 2008. Now it is extended for eight more years. For example, after a commercial facility in Titusville, NJ, installed 500 kW of photovoltaics, its federal investment tax credit came to \$922,500, shortening the payback period for the PV system from 9.6 years to 4.8 years.⁷¹

New Clean Renewable Energy Bonds (“CREBs”). \$800 million of new clean renewable energy bonds to finance facilities that generate electricity from renewable resources, including: solar are available through December 31, 2009

Low interest loans. Low-interest loans can lower the financial bar for individuals and businesses seeking to install solar energy. California has recently given this policy a new twist by passing a new, innovative solar loan law that allows *cities and counties* to make low interest loans to homeowners and businesses. Already, the cities of Berkeley and Palm Desert have taken advantage of this law. If other local governments follow suit, enormous growth in solar power installations is likely.

PV rebate programs. In Texas, Austin Energy, Bryan Texas Utilities, CPS Energy of San Antonio and Oncor offer PV rebate incentives. Austin Energy offers customers one of the country’s best solar photovoltaic rebates, at \$4.50 per Watt. This pays between 45% and 75% of the cost of installing a system. The utility also offers rebates from \$1,500 to \$2,000 for solar water heaters.

Property tax exemption. Provides that the value of on-site solar energy systems are not included when calculating property taxes. Available in Texas.

Property tax financing. Allowing homeowners' to defer the cost of installation through property taxes. The city pays the upfront cost and the homeowner pays the city back over a period of 20 years through increased property taxes. The idea is that the property owner saves the same amount on their utility bill as they pay in increased property tax, allowing the city to recoup its cost plus a small amount of interest.

Net metering. An allowance that grants individual owners of solar systems the privilege of selling excess electricity to their utility at a predetermined level or prevailing rate and receive a credit on their bill. Few Texas utilities offer net metering.

Feed-in tariff (FIT). Small to midsize producers of solar power, whether businesses or homes, receive a guaranteed price (usually above the market rate) for the clean energy they supply to the grid.

⁷¹ Dennis DuBois, “Guide to On-Site Renewable Energy Incentives in the Energy Policy Act,” *Energy Priorities Magazine*, 12 April 2006.

In countries where they exist, feed-in tariffs have been extremely successful in promoting distributed PV installations. After the introduction of a feed-in tariff in Germany, the growth of that country's solar industry skyrocketed. FIT policies are costly, but if well designed offer tremendous promise for ramping up renewable energy installations quickly. FITs have been implemented worldwide, in a total of 41 countries, provinces and states. In the United States, Michigan, Illinois, Minnesota, and Rhode Island have proposed measures that would enact such a system.

Renewable Electricity Standard (RES) aka Renewable Portfolio Standard (RPS). Requires a certain portion of a state's electricity to come from renewable sources. The 2005 Texas Legislature increased the total renewable energy goal to 5,880 MW by 2015 and set a target of 10,000 MW in 2025. Twenty nine states have an RPS.

Solar Carve Outs. A specification in an RPS requiring that a certain percentage of a state's electricity come from solar energy. 15 of the 29 RPS states now include solar carve-outs. The Texas RPS does not include a solar carve-out.

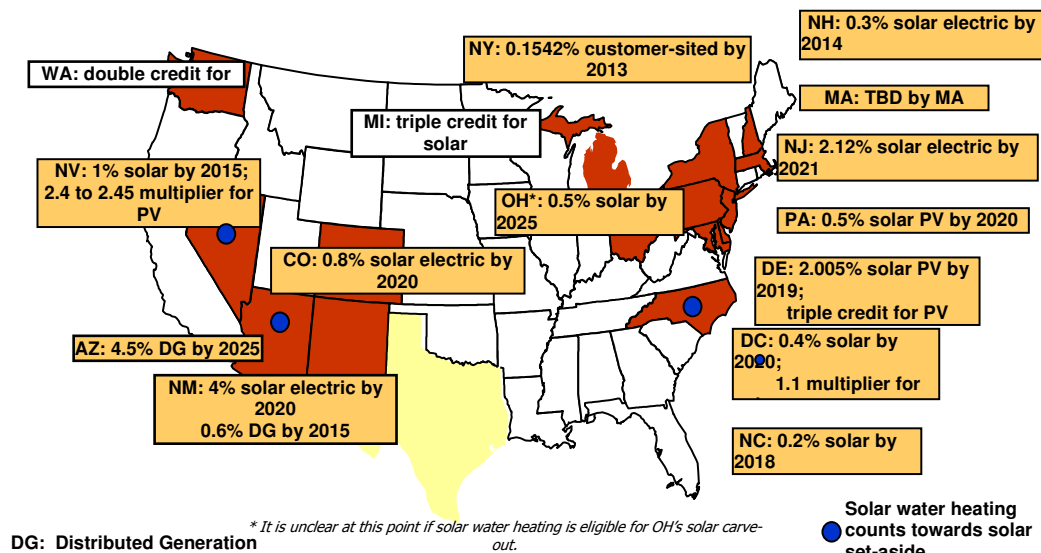
Renewable Energy Credit (REC) trading. Included in many RPS laws is a REC trading program. Every REC represents one megawatt-hour of qualified renewable energy that is generated and metered. The credit can be sold to utilities that have not met their renewable energy obligations. 16 states, including Texas, allow utility companies to trade RECs with one another. [In some states, such as New Jersey, REC sales are the main means by which individuals and businesses are provided incentives to install solar power.]

Caps on global warming pollution. These caps will require utilities and other polluters to reduce heat-trapping gases, and encourage installation of global warming pollution-free sources, such as solar power.

Funding of research, development and deployment. For a time, no other country in the world promoted photovoltaic technology more than Japan. Within nine years, from 1994 to 2003, Japan became the world leader in both production and installation of solar cells. This achievement would not have been possible except for the country's research program, the "New Sunshine Project," started in 1993.

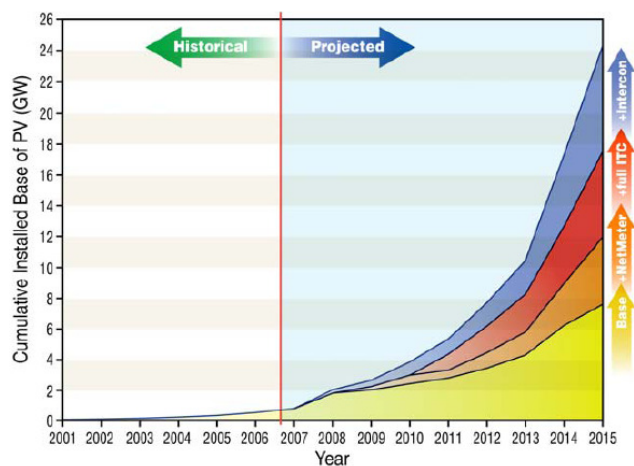
Power purchase agreements (PPAs). Long-term agreements for utilities to buy power from a company that produces electricity. PPAs have played a key role in attracting new CSP projects to particular locations, for example to Nevada and areas of California. PPAs provide the market stability needed for capital-intensive solar power development. By guaranteeing a revenue stream, PPAs (especially long-term ones) encourage the construction of new solar power plants.

Figure 15. Solar/DG Provisions in RPS Policies⁷²



There is no need for Texas to rely on one policy measure to spark the state's solar industry. In fact, a combination of incentives would likely be the best approach, as different incentives appeal to different actors.

Figure X. Influence of System Pricing, Net Metering Policy, and Federal Tax Credits and Interconnection Rules on Cumulative Installations in the U.S.⁷³



Note: "Intercon" indicates favorable interconnection rules and "NetMeter" indicates a removal of Net Metering Caps

⁷² NC Solar Center, *Database of State Incentives for Renewables & Efficiency*, downloaded from www.dsireusa.org, October 2008

⁷³ Charlie Hemmeline, U.S. Department of Energy, Solar Program, *Texas Solar Forum: Economic Development and Job Creation*, Powerpoint presentation, 24 April 2008.

Recommendations

Texas is in a prime position to become a world solar leader and simultaneously make significant environmental, public health, and economic strides. Action is needed to make those things happen.

Policies targeted at increasing demand for solar power installations are the best way to simultaneously increase solar generating capacity and drive down the cost of solar technologies in the long-term. Such policies will increase the amount of electricity generated from clean, distributed sources, build the strength of the solar industry, and pave the way for further growth of clean solar power in the decades ahead. To harness these gains, The Texas Solar Forum Partnership recommends the Texas Legislature and Congress:

- 1.Include solar-specific requirements to an increase of Texas' existing and highly successful Renewable Portfolio Standard.
- 2.Establish goals and create incentives for building-integrated solar at the time of construction as part of the PUC's advanced buildings incentive program. This can be accomplished by creating a rebate program. A declining rebate should be planned over 10-year period to give the industry confidence to invest in production, research and development. At a minimum, new buildings should be "solar ready."
- 3.Allow third party ownership of PV systems
- 4.Make solar systems and installations exempt from state and local sales tax.
- 5.Create fair buyback rates for energy produced by solar. Direct utilities to employ metering programs that provide time-of-use billing and buyback, which rewards owners of PV systems for producing lower cost solar power during the periods of highest demand. Require all of the state's utilities to offer net metering.
- 6.Improve contract and interconnection standards and consumer protections for owners of solar systems while banning Home Owners Associations from denying homeowners the right to install PV panels.
- 7.Provide for the construction of solar ties to new Competitive Renewable Energy Zone (CREZ) transmission lines in West Texas.
- 8.Promote new ways to store the excess energy produced by the sun for later use, such as thermal storage technologies, flywheels, and compressed air energy storage.
- 9.Increase funding of research and development. Create an R&D technology center similar to the micro-computer consortium that was so successful in developing the microchip industry in Texas.
- 10.Create a PUC program to provide incentives for solar installations on new and existing Buildings.