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Introduction

The popularity of solar energy has skyrocketed during recent years. A combination of factors has contributed to this interest in solar as a source of electric generation including increased equipment productivity, decreased manufacturing and installation costs, and the enactment of favorable energy policies. Although solar is still a relatively expensive power source, public support driven by the desire for more environmentally-friendly electric generation alternatives has led to a groundswell of support for financial incentives. This paper examines the various mechanisms offered by state and local governments, as well as utilities, to help spur the market for solar energy.

These policies can be categorized as follows:

- Renewables portfolio standards and goals;
- Tax credits, deductions and exemptions;
- Rebates and grants;
- Production incentives;
- Loans and loan subsidies;
- PV as educational tools; and
- Green power pricing programs.

The Benefits of Solar Power

Unlike electricity produced from fossil fuels, solar power offers multiple benefits instead of additional burdens to our economy, our health, and our environment. Generating electricity from solar energy will:

- Improve air quality by deferring generation from fossil fuel plants,
- Avoid water requirements of additional power plants,
- Lower dependency on foreign petroleum products,
- Reduce the need to tap into domestic oil supplies,

- Stimulate economic development and create jobs,
- Help keep electricity costs low by avoiding fuel price volatility, and
- Minimize investments in transmission and distribution infrastructure.

Airborne pollutants from coal-fired power plants impact our quality of life by degrading the environment and contributing to respiratory illnesses. Credible studies have linked the effects of ozone and particulate matter to increased mortality risk from cardiopulmonary disease and lung cancer as well as more cases of asthma and hospitalizations for respiratory illnesses. The cost associated with exacerbating existing medical conditions and contributing to increased rates of respiratory illness are ultimately borne by society in a variety of ways including higher insurance premiums, greater Medicaid and Medicare expenses, and lost productivity in the workforce and in our schools.

But the true costs we face are not only confined to the medical arena. Researchers at Lawrence Berkeley Laboratory have identified a wide range of "insults and stresses to the physical and human environment"[1] ranging from the effects of fuel mining and transportation all the way to the handling of effluents resulting from the process of electricity generation.

Many states have begun to recognize that the harmful effects caused by traditional power resource options may, in fact, outweigh the perceived benefit of low-cost power. Therefore, the incremental cost for solar power, through the subsidization of financial incentives, needs to be equitably borne by all members of society, because many, if not all, residents will realize the benefits of this renewable energy source.

What is PV?

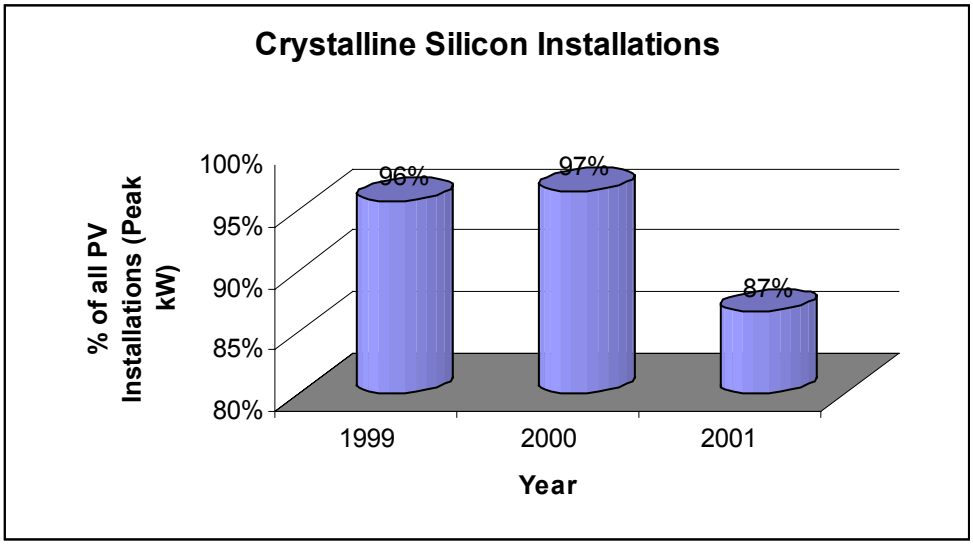
Of the various ways to harness the sun's energy to create electricity, photovoltaic or PV technology, is the most common. Photovoltaic systems convert sunlight into electricity by utilizing an array of solid-state devices called solar cells made of semi-conducting

[1] Jonathan Koomey and Florentine Krause, Introduction to Environmental Externality Costs, Energy Analysis Program, Applied Science Division, Lawrence Berkeley Laboratory, 1997.

materials, which are typically composed of silicon with trace amounts of other elements. Two primary types of PV technologies are commercially available: crystalline silicon and thin-film.

Crystalline silicon applications can be individual PV cells cut from large, single crystals or from ingots of crystalline silicon and combined into modules and arrays. This is known as mono-crystalline technology. With polycrystalline or multi-crystalline modules, sheets of silicon crystals are used instead of single crystals wired together. The advantage of this technology over mono-crystalline PV is that less purified silicon is used, thereby lowering production costs. However, due to the increased number of junctions between the cells, the efficiency of these modules is not as high as that of the mono-crystalline type. Either of these flat-plate type of PV arrays can be mounted at a fixed angle facing south, or on a tracking device that follows the sun allowing them to capture the most direct sunlight over the course of the day. Although this mature technology still constitutes the vast majority of the solar cell market, there is an increasing trend toward the next generation, which is thin-film technology. (See Figure 1.)

Figure 1



Source: Energy Information Administration, U.S. Dept. of Energy, Renewable Energy Annual 2001, Table 28.

Thin-film technology is the other method of producing photovoltaic power. Amorphous silicon, the most widely-used thin-film technology, is an alloy of silica and hydrogen that can be deposited in layers which are only a few micrometers thick to produce photovoltaic cells on glass, metal or plastic substrates.[2] Research and development efforts at universities and government laboratories continue to improve equipment efficiencies. In addition, manufacturing firms are introducing advances in integrating the arrays into buildings to decrease installation time and lower up-front costs.[3] It is now possible for solar cells to double as rooftop shingles, roof tiles, building facades, or the glazing on skylights or atria.[4] Building-integrated PV is more costly, but by fully quantifying the additional benefits including reduced power needs, the comparison to its non-solar counterpart may become more attractive.

Figure 2

Mary Ann Cofrin Hall
University of Wisconsin

[2] Energy Information Administration, U.S. Dept. of Energy, Renewable Energy Annual 2001, November 2002, Glossary.

[3] Astropower Unveils New Rooftop Solar Systems, Business Wire, November 12, 2002.

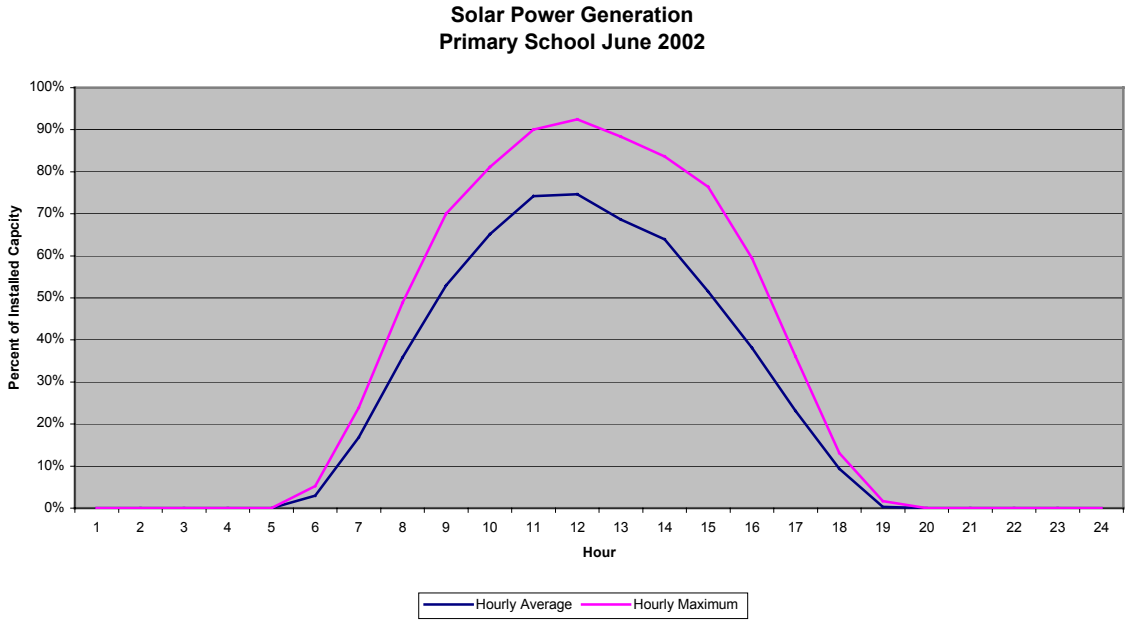
[4] National Renewable Energy Laboratory, Clean Energy Basics, Introduction to Photovoltaic (Solar Cell) Systems, http://www.nrel.gov/clean_energy/photovoltaic.html.

In an innovative application of PV technology, the Mary Ann Cofrin Hall (Figure 2) at the University of Wisconsin has substituted a thin-film, semi-transparent photovoltaic panel for traditional double-pane exterior glass in their atrium. Rated at 11 kW[5], it produces 12,500 kWh per year.

Electricity Output from a PV System

Given daily variations in weather, a stationary solar system will produce less than its capacity-rated value even in favorable conditions. Figure 3 depicts the kW output at each hour of the day for a 9 kW system at a Virginia primary school in June 2002. The higher line illustrates the maximum output compared to system capacity for each hour over this 30-day period. The lower line shows the average kW output at each hour during the month of June. It emphasizes that PV systems are generally unable to deliver the maximum rated output capacity for the unit and that power generation is frequently dependent upon factors beyond human control such as weather conditions.

Figure 3

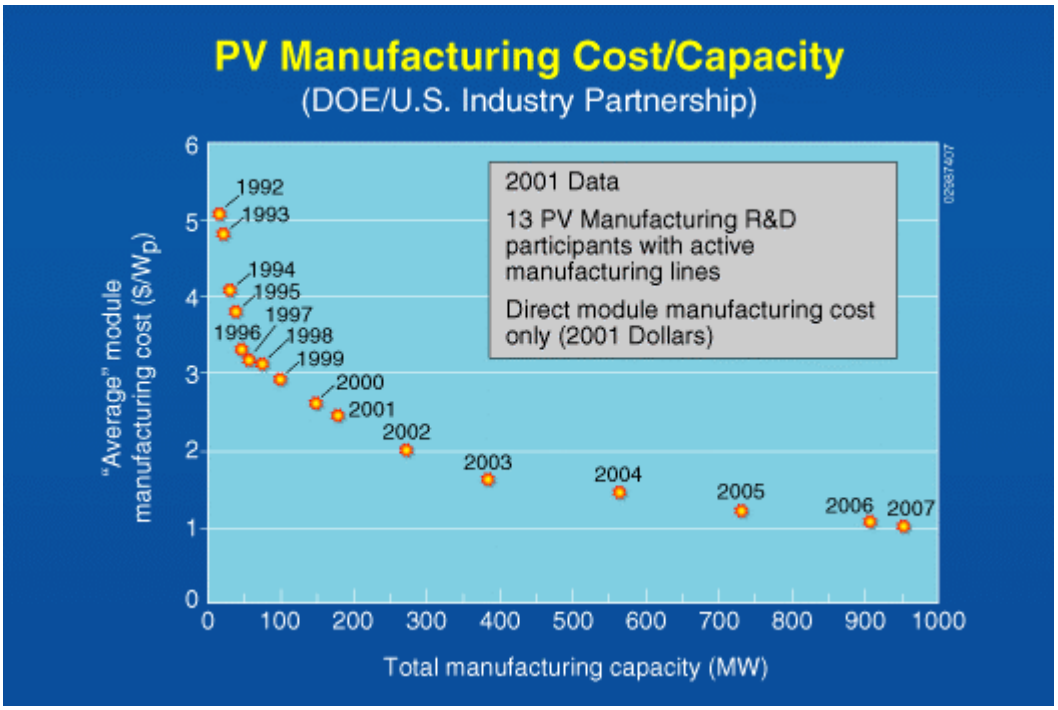


[5] kW is the abbreviation for kilowatt which is equal to 1000 Watts and kWh is the abbreviation for kilo-Watt-hour.

PV Research and Advances

The National Renewable Energy Laboratory first began its research into solar cells in the 1970s. Since that time, significant technological advancements have been made, manufacturing costs have decreased, and implementations have increased. Historically, costs have been dominated by the relatively high cost of semiconductor material, but both improvements in conversion efficiencies and manufacturing technology are expected to help lower costs in the future. Since 1992 average manufacturing costs have been reduced by about 52% from $5.10 to $2.46 per peak Watt and are expected to decline to approximately $1.00 per peak watt by 2007.[6] At the same time, manufacturing capacity is expected to increase. (See Figure 4.)

Figure 4



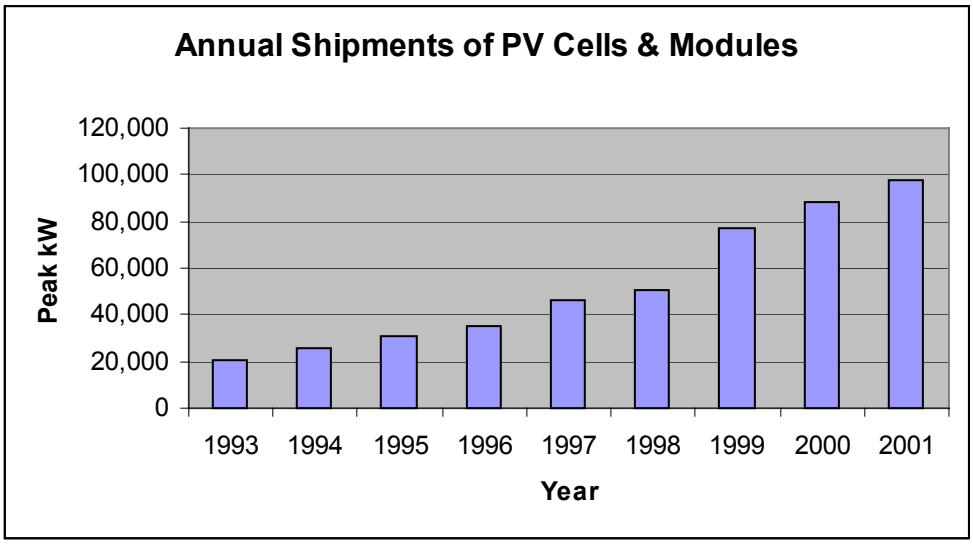
Source: National Center for Photovoltaics website (www.nrel.gov/pvmat)

[6] National Center for Photovoltaics, Cost/Capacity Analysis for PVMaT Participants, http://www.nrel.gov/pvmat/pvmat_frame.shtml?publications.html.

Energy Policies for a Cleaner, Healthier Environment

Although technological advances have greatly increased equipment productivity while decreasing costs, energy policy at the state and local levels has also been a significant factor in the increase of solar installations. The impetus for encouraging renewable energy, particularly solar energy, is clear and many states have adopted policies that attempt to further the objectives of assuring a reliable electricity supply with minimal damage to our environment. Eleven states have enacted renewables portfolio standards that require energy suppliers to provide a specified percentage of their power from renewable resources. Further, most states offer some type of financial incentive for solar power ranging from property tax credits to grants and loans. These policy efforts have also made an impact on the dynamics of supply and demand. Figure 5 displays annual shipments of solar equipment and clearly demonstrates an increasing demand.

Figure 5



Source: U.S. Dept. of Energy, Energy Information Administration, Renewable Energy Annual 2001, Table 26.

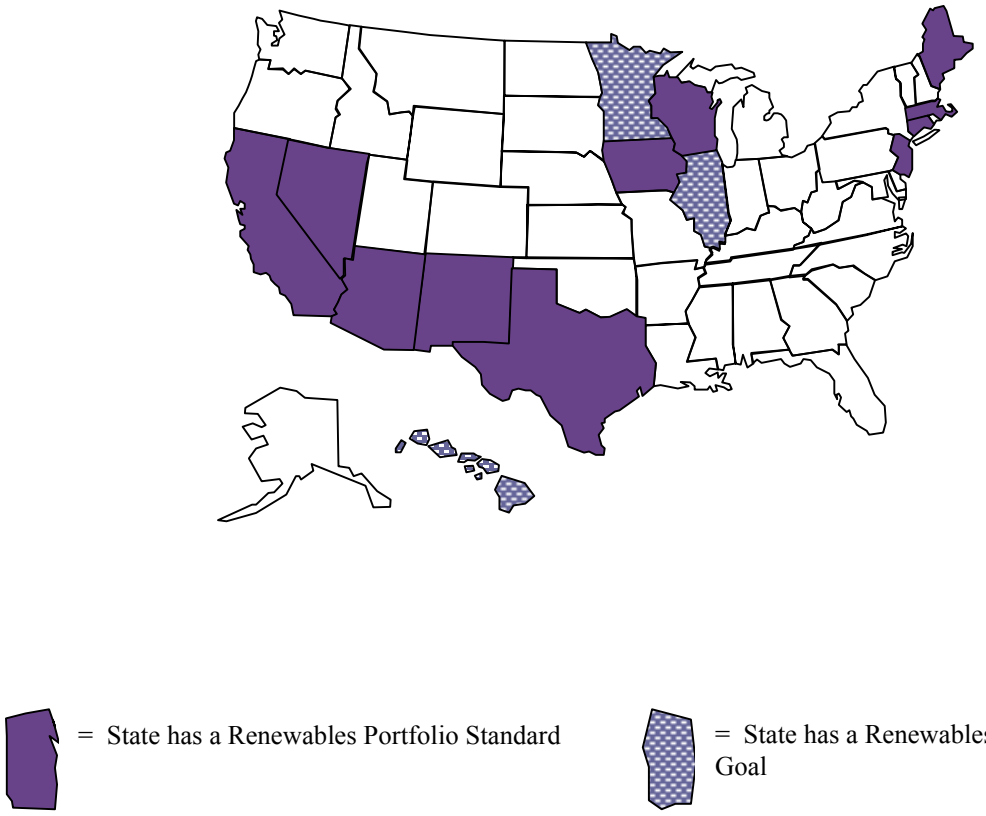
Renewables Portfolio Standards and Goals

Many state legislatures have mandated renewables portfolio standards, which require electric providers to produce a specified percentage or nominal value of electricity from renewable energy sources. (See Figure 6.) They are state mandates. Renewables

portfolio goals, on the other hand are not state mandates, but merely target amounts for power to be produced from renewable energy resources. Unlike renewables portfolio standards, they may not have specified implementation schedules or clearly-defined compliance and verification methods. Hawaii, Illinois, and Minnesota are the three states with renewables portfolio goals.

Figure 6

States with Renewables Portfolio Standards or Goals

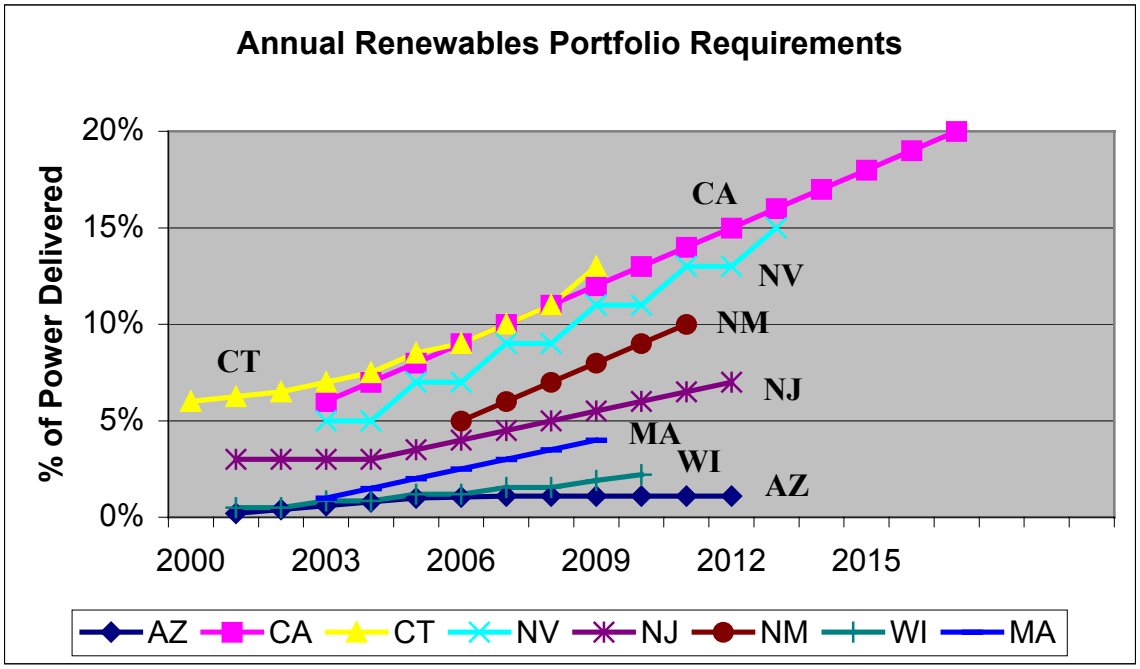


Eleven states currently have renewables portfolio standards. Figure 7 depicts the percentage levels and timing of renewable portfolio standards in eight of them. Iowa and Texas have not been included because they specify a set amount of generation that must come from renewable resources instead of a percentage as required by the other states. For example, Texas required 400 MWs[7] of new renewable generation by January 1, 2002

[7] MW is the abbreviation for MegaWatt which is equivalent to 1,000,000 Watts.

with 2,000 MWs by the end of 2007. Maine has also been excluded from the graph because of its unique circumstances. It already has the highest percentage of renewables use in the country at over 50% of total capacity, most of which is hydropower and biomass. Thus, while Maine's renewables portfolio standard is the highest in the country at 30%, it is in fact, actually lower than its current level of renewable energy use.[8]

Figure 7



Source: Database of State Incentives for Renewable Energy (www.dsireusa.org)

Financial Incentives

Not only have states mandated the use of renewable energy sources as supply options, many have passed legislation to support it with a variety of funding mechanisms. For example, the same legislation that created the Renewables Portfolio Goal in Illinois also authorized up to $500 million in new state revenue bonds to support the development of wind, biomass and solar power technologies.[9]

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[8] Database of State Incentives for Renewable Energy (www.dsireusa.org), Maine Incentives for Renewable Energy, Renewables Portfolio Standard, Last Review: 1/21/2003.

[9] Illinois House Bill 1599, enacted 6/22/01 and effective 7/1/01.

Financial support for solar power from state and local governments including public utility commissions has grown significantly since the mid-90s. There are currently at least 190 programs in the U.S. offering a variety of financial incentives. Over 120 of these programs have become effective since 1999.

As of December 2002, forty-four states currently offer one or more incentives for solar power.[10] With the exception of Maine and West Virginia, the southeast represents the states that do not offer any type of non-federal financial incentives for solar power. The remaining four states are: Alabama, Georgia, Kentucky, and South Carolina. Even Alaska has a state loan program offering low-interest loans to municipals and utilities to purchase and install solar systems. Of the existing programs, there are many ways they can be structured. Table 1 demonstrates the numerous ways that financial incentives can be provided to encourage solar power resources.

Tax Assessments, Credits and Exemptions

Twenty-three states offer some type of reduction in property tax or change in property reassessment for land with solar systems. In eighteen of these states, commercial and residential sectors are eligible for these property tax incentives. Programs in New Hampshire and Texas are only available to residential consumers. In New Hampshire, the state gives the authority to local governments to offer property exemptions in the amount of the assessed value of the renewable energy system. Fifty-nine cities and towns have adopted it to encourage solar technologies in their communities. On the other hand, Nevada and Ohio offer property tax incentives for commercial and industrial market segments only. Nevada has enacted legislation which allows a 50% property tax exemption for any business that has a biomass, solar or wind facility with a generating capacity of at least 10 kW and uses renewable energy as its primary power source.

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[10] Database of State Incentives for Renewable Energy, www.dsireusa.org

Table 1

Solar Financial Incentives by Type

Type of Financial Incentive	Number Of Programs	States with One or More Programs
Corporate Deduction	3	MA, TX
Corporate Exemption	2	MA, OH
Corporate Tax Credit	14	CA, CT, HI, MD, MT, NC, ND, NM, NY, OK, OR, UT
Direct Equipment Sales	5	AZ, CA, MT, WY
Green Building Incentive	1	VA
Industry Recruitment	8	AR, CA, HI, MT, NC, TX, VA, WA
Leasing/Lease Purchase	4	CA, TX, WY
Local Grant	3	PA
Local Loan	6	HI, PA, WA
Local Rebate	2	CO, PA
Personal Deduction	3	CA, ID, MA
Personal Tax Credit	14	AZ, CA, HI, MA, MD, MT, NC, ND, NY, OR, RI, UT
Production Incentive	6	CO, OR, PA, RI, WA,
Property Tax Assessment	1	IL
Property Tax Credit	1	RI
Property Tax Exemption	22	CA, CT, IA, IN, KS, LA, MD, MN, MT, NC, ND, NH, NV, NY, OH, OR, SD, TX, VA, VT, WI
Sales Tax Exemption	10	AZ, FL, MA, MN, NJ, NV, OH, RI, VT, WA
State Grant	16	CA, IL, IN, KS, MA, MI, MT, NY, WI
State Loan	20	AK, CA, CT, IA, ID, MD, MO, MS, MT, NC, NE, NY, OH, OR, TN, VA, WI
State Rebate	15	CA, DE, IL, MA, MD, MN, NJ, NY, RI, WA, WI
Utility Grant	1	FL
Utility Loan	7	CA, OR, WA
Utility Rebate	26	AZ, CA, FL, HI, NV, NY, OR, TX, WA, WI
TOTAL PROGRAMS	**190**	

Thirteen states from Rhode Island to Hawaii offer a total of 17 personal tax deductions or credits. In 1999, North Carolina changed a renewable energy statute that was initially enacted in 1977 and it now offers a generous tax credit for renewable technologies and transportation fuels with the maximum limit determined by the equipment. Residential PV systems can obtain tax credits up to $10,500. Utah offers a corporate as well as a

residential tax credit for PV systems. It allows a credit for 10% of system installation costs up to a maximum of $50,000.

Rebates and Grants

Rebate programs seem to be the most popular by far with 43 local, state or utility programs available. Also known as "buy-downs", these types of programs, offer the equipment purchaser a rebate to help reduce the up-front cost of the system. Many times, funding for these rebates comes from the portion of public or system benefits funds dedicated to renewable energy.[11] For example, the New York State Energy Research and Development Authority (NYSERDA) administers two programs, one applicable only to new buildings. In the majority of cases where utilities are offering a rebate, the utility is municipally-owned such as Pasadena Water & Power in California, Boulder City Public Works in Nevada, and Grays Harbor Public Utility Department in Washington.

Buy-down programs have become quite popular because they can be relatively easy to implement and impose minimal transactions costs on the system owner. They also have the potential to provide quick and tangible results. The drawback to these types of programs is that the actual production results may vary from expected output. Poor installation by unqualified technicians is one of the reasons for this problem as well as over-estimated system production forecasts. To address this problem, some states have required certification of installers, and combined performance-based payments to incent both the owner and the installer to assure proper system maintenance and high production levels over the life of the system. Pennsylvania offers a good example of this hybrid buy-down/production incentive program. In the PECO service territory, an owner can receive $3/Watt upfront with $1/kWh produced after one year. The installer must be pre-certified and will receive 10 cents/kWh after one year. The program also requires that the system be sited so that it will produce at least 70% of its potential optimal output.[12]

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[11] Public benefits or system benefits funds receive revenue from a minimal charge per kWh consumed or flat fee added to a customer's bill.

[12] Clean Energy Funds Network, Ernest Orlando Lawrence Berkeley National Laboratory, Customer-sited PV: A Survey of Clean Energy Fund Support, May 2002.

Production Incentives

Another way to incentivize solar power is with production tax credits. Five states currently use this mechanism with Washington offering two types of programs. The purpose of this type of program is to pay for the system output instead of equipment and installation costs. Therefore, if installation is performed in a less than adequate manner or if a lack of maintenance reduces system performance, the financial incentive is lessened as well. Table 2 shows how much these programs vary in design. All programs listed here are available to commercial and residential customers, except for the program in Rhode Island, which is not open to the residential market segment.

Table 2

Solar Production Incentives by State

State	Program Administration	Production Payment	Limits
Colorado	The Community Office for Resource Efficiency	25 cents/kWh	Maximum of $1,000 per year or $4,000 per system for up to 4 years
Oregon	The Bonneville Environmental Foundation (BEF) and the Northwest Renewable Energy Cooperative (NWREC)	10 cents/kWh for the Green Tags	Producer signs a three-year production agreement.
Pennsylvania	The Energy Cooperative (ECAP)	20 cents/kWh	Producers must be a member of ECAP and must purchase power from "EcoChoice 100", their Green Power Program.
Rhode Island	The Rhode Island State Energy Office	3 cents/kWh	Production payments not to exceed 5 years
Washington	The Bonneville Environmental Foundation (BEF) and the Northwest Renewable Energy Cooperative (NWREC)	10 cents/kWh for the Green Tags	Producer signs a three-year production agreement.
Washington	Chelan County Public Utility Department	Up to $1.50/kWh	Payments amounts dependent on total number of producers participating in Sustainable Natural Alternative Power (SNAP)

Loans and Loan Subsidies

As with any other power production source, funding is generally obtained to finance the project over the life of the equipment. Providing up-front funding to reduce the initial loan amount can reduce financing costs by as much as 65%. There are at least 33 loan programs across the U.S offered by utilities or state and local governments to help stimulate the market for solar power by reducing these financing costs. Twenty of these programs are state sponsored. Even in states that have no other solar incentive programs, such as Alaska, Missouri, Mississippi, and Tennessee, they offer loan programs to help minimize project costs.

Financial Incentives for All Market Sectors

Another important element in designing effective solar financial incentive programs is to target them at the market sectors most likely to participate, and tailor these programs so that they overcome obstacles facing that sector. Table 3 shows that all market sectors are covered in at least a few states. In most cases, the characteristics of a program make it applicable to multiple market segments. But there are some instances where programs are targeted to specific areas only. For example, Yellowstone Valley Electric Cooperative in Montana offers financial assistance for solar stock watering units to pump water for livestock. An example in another sector is the Green Schools Initiative in Massachusetts which will pay up to $500,000 per project for the incremental costs of incorporating eligible renewable energy technologies, including solar systems, into a school design.

Table 3

Financial Incentives by Market Sector

Market Sector	Number of Programs
Agriculture	5
Commercial	132
Construction	4
Hospital	4
Industrial	85
Local Government	42
Non-profit	32
Residential	123
Schools	29
State Government	18
Transportation	7
Utility	14
TOTAL	**495**

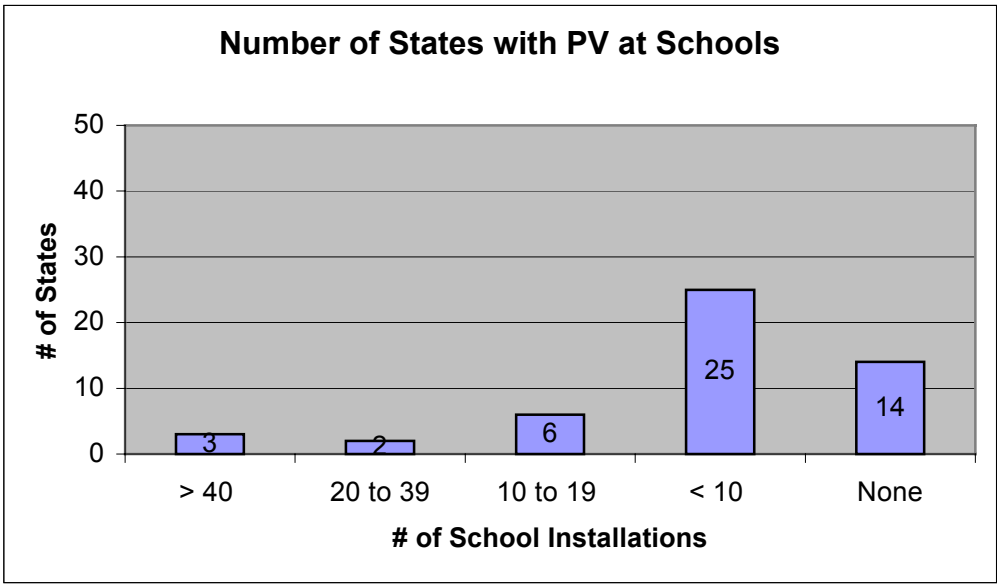
PV at Schools

One market segment that has seen increased interest in photovoltaic systems in recent years is the educational sector. More and more elementary and middle schools across the nation are using it as an interactive educational tool to help teach science and math principles in addition to offsetting their facilities' electricity requirements. Figure 8 demonstrates the interest in PV systems at schools. Across the United States, there are more than 365 schools that have installed PV systems. Colorado, New York, and Wisconsin each have more than 40 schools and only 14 states have no installations at all.[13]

[13] Interstate Renewable Energy Council, Schools Going Solar, (http://www.irecusa.org/schools)

Figure 8

Number of States with PV at Schools



In some cases, the most effective way to get PV installed at schools is to develop a joint partnership between government and business. The Chicago Solar Partnership, for example, consists of six main partners that initiate PV installations in the city. The partners are a diverse group of organizations including: the U.S. Dept of Energy; the state of Illinois; the city of Chicago; the solar manufacturer, Spire Corporation; the Electrical Joint Apprenticeship Training Center; and the electric provider, Commonwealth Edison Company.

The first Chicago Public School to have PV panels installed on its roof was the Frank W. Reilly Elementary School with 136 modules and a capacity of 8.6 kW. The average electrical output of this system is 11,130 kWh annually. Since then, there have been three more installations at elementary schools in Chicago. By posting the system output on the Internet, these students have even been able to learn about economics and business by establishing pseudo-trading companies to buy and sell power in addition to learning science and math.

Financial Incentives in the Southeast

Florida

In 1997, Florida re-enacted a previously repealed sales tax exemption for solar energy equipment. It was originally available from 1980-85, but was repealed in 1986 along with all other Florida sales tax exemptions.

In 2002, Florida supplemented its portfolio of financial incentives for solar energy by instituting a program that offers eligible schools approximately $5/Watt for systems up to 4 kW with a maximum rebate of $20,000. Some schools may receive an additional $1/Watt for battery back-up systems to be used in case of emergencies or disasters.

A couple of utilities in Florida also offer financial incentives for solar power. Gainesville Regional Utilities provides a minimal rebate of $300-$450 for the installation of a solar water heating unit that is converted from electric. A more impressive program, however, is one offered by Jacksonville Electric Authority, which offers incentives up to $4/Watt for PV and $20 per square foot for solar water heater collectors, with a maximum of $50,000 for each installation.

Louisiana

Louisiana offers an incentive to residential owners of solar energy systems by exempting solar equipment from ad valorem taxation. Solar space heat, water heat and photovoltaic equipment are included in this program.

Mississippi

The state of Mississippi offers a loan program for solar and other renewable energy technologies. This program, which is available to the commercial and industrial sectors only, provides loans up to $300,000 at an interest rate that is 3% below the prime market rate with a ten-year payback period. This $7 million revolving loan fund was established in 1989 from federal oil overcharge funds.

North Carolina

With five programs, North Carolina offers the most financial incentive programs of any state in the Southeast. The property tax exemption, which is available to all market sectors, requires that solar equipment not be assessed at greater value than a conventional heating and cooling system.

Another incentive available to residential customers is a 35% personal tax credit for the cost of renewable technologies, including solar equipment that is constructed, purchased, or leased by the taxpayer. A corresponding tax credit, with a maximum of $250,000 is also available for commercial entities.

Beginning in 2000, North Carolina passed an additional corporate tax credit as an incentive to renewable energy equipment manufacturers, which is an expansion on the Photovoltaic System Manufacturer Incentive that was originally enacted in 1991.

Lastly, North Carolina offers an energy improvement loan program to businesses, local governments, schools, and non-profit organizations in the state. Loans of 1% are available for biomass, wind, solar, and small hydro projects meeting specified criteria. Projects not meeting the eligibility requirements for this program may possibly qualify a 3% loan.

Tennessee

Participating TVA[14] power distributors in Tennessee provide a $500 one-time payment for each qualifying residential customer site with a PV system less than 150 kW. In addition, 15 cents will be paid for each kWh produced and metered.

Tennessee also has a state program offering loans up to $100,000 for renewable energy technologies including solar.

Green Power Pricing Programs

Green Power Pricing programs offer customers the opportunity to purchase blocks of power or a percentage of their facility load from renewable energy resources. For customers who are interested in supporting renewable energy, they can use the

[14] Tennessee Valley Authority

marketplace to establish their preferences for electric generation sources. Green Power is generally sold for a premium over typical power rates to cover the higher production costs of renewable energy resources.

There are over 117 Green Pricing programs across the nation offered by rural membership cooperatives and municipal electric providers as well as investor-owned utilities. Each Green Power program establishes regulations for its mix of resources within its portfolio of options. Many programs are a mix of biomass, wind, and solar resources with heavy emphasis on biomass fuels due to their relatively low cost.

Financial incentives for solar power help reduce production costs, which may result in a lower premium charged in a Green Power Pricing program. As the premium is minimized, more customers will choose to purchase green power and those who already buy a portion of their energy from green power may be able to purchase even more.

Conclusion

It is difficult to estimate the current number of PV applications around the U.S. because they are generally small, and primarily provide service to the site at which they are located. This is changing however with the advent of Green Power pricing programs, renewables portfolio standards, and a host of wide-ranging financial incentives. This groundswell of support originates from the collective societal interest in power generation sources that create little or no pollution. Over 80% of consumers report that they would be willing to purchase green power if the cost was comparable to conventional power sources.[15] But in reality, electricity generated from sources causing minimal environmental impacts can be significantly more expensive because all costs associated with power production from coal-fired and nuclear sources are not explicitly captured in each kilowatt-hour of electricity purchased by consumers. Although solar power avoids the toxic emissions of coal-fired power plants, as well as the radiation and spent fuel disposal risks facing nuclear generation, financial incentives are necessary to

[15] Patrick N. Lilly, Regional Economic Research Inc., Timothy Tutt, California Energy Commission, and Brenda Gettig, Regional Economic Research Inc., California's Green Power Market: Where are we now.

offset the increased costs of this production source. A desire to minimize the detrimental effects of power production by creating a more level playing field for renewable energy has led to the adoption of these public policies that support and encourage solar power. When financial incentives from state and local governments, as well as utilities, are available, every member of society ultimately benefits.

Given Georgia's water constraints and air quality problems, it's surprising that the state has not yet tapped into the potential offered by solar resources. Although critics claim that Georgia's existing low-cost energy supply deters investment in solar power, others argue that the economic analyses have not adequately incorporated the costs of harmful effects caused by fossil-fuel generation. Despite this controversy, many states across the nation have recognized that public policies promoting solar energy are beneficial to society. Georgia needs to consider the programs implemented by others and craft a policy suitable for this state.