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APPENDIX A: AN OVERVIEW OF THE CURRENT STATUS OF THE DOMESTIC PV MARKETS

In 2000, total renewable energy represented approximately 90 GW (generating 320 billion kWh), or 12 percent of U.S. generating capacity. The bulk of this was derived from hydroelectric power. Solar photovoltaic (PV) power is currently the smallest segment of the domestic renewable power market, with approximately 28 MW of grid-connected systems and 100 MW of off-grid installations.

In general renewable technologies are projected to grow slowly due to the relatively low projected cost of fossil-fueled generation, and because competitive electricity markets favor less capital-intensive technologies. According to the U.S. Department of Energy, Annual Energy Outlook (AEO) 2002, renewable energy is projected to grow by 1.3 percent annually to 2020 (and capacity to increase by <1 percent). While a slow annual growth rate, the AEO 2002 expects solar PV to outpace all other renewable energy sources – PV is forecasted to grow by 27 percent between 2000 and 2010, and by 20% from 2000-2020.

Market Niches

Markets for solar photovoltaic (PV) systems can be roughly grouped into three categories: mobile uses (including consumer products), off-grid or mini-grid, and grid-connected; though many analyses delineate applications among different categories, grid-connected PV as defined here includes both distributed generation and power plant development. Figure 1 indicates shipments of PV systems by each category from 1995-2000.

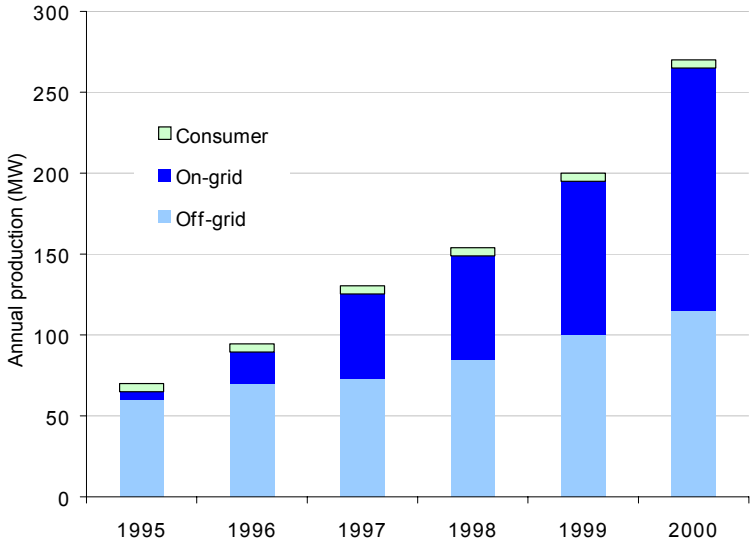

Figure 1: PV production by end-use segment

Mobile Uses

Mobile uses encompass applications where the PV system is portable, including disaster relief, traffic monitoring and control, consumer products, and vehicles. Vehicles having good potential for PV include those with a relatively high ancillary electricity demand, such as RVs, boats, and refrigerated trucks. In these cases, PV is used not to power the vehicle but to supply electric load

and power appliances. For example, Sainsbury PLC installed 4 kW of solar panels on each of three refrigerated trucks, avoiding the need for a separate diesel generator to run the refrigeration unit.[1] Many PV products are designed especially for boat and RV applications, either integrated into the vehicle or as stand-alone products supplying power for DC appliances such as fans or TVs. About 500,000 RVs and registered boats are sold each year.[2] If each boat or RV had 80W integrated or sold as an accessory product, the market would be 40 MW per year.

Consumer products have long been a good application for PV. In this application, the cost of the PV module is small compared to the product cost. There are currently over a billion solar-powered calculators and several million solar-powered watches.[3] The next market segment for PV-powered consumer goods is those with a higher energy use or example, battery-powered devices such as personal data assistants (PDAs) or cell phones. In these cases, PV may take the form of a separate battery charger. Other products suitable for PV are "outdoor consumer goods" camping appliances, home security and walkway lighting, flashlights, and radios. The market for outdoor products was growing at about 15% per year in 1996.[4]

During a natural disaster such as an earthquake or hurricane, utility power is often interrupted. Photovoltaics can serve to provide power to affected residents and to relief workers, enabling crucial applications such as refrigeration, communication, and lighting to continue until system power is restored. Hurricanes and floods represent the most common natural disasters responded to by relief agencies; in these situations, the typical interruption of utility power was 2-6 weeks.[5] An estimated 8,000 generators were in use throughout Dade County, Florida, following Hurricane Andrew in 1992; the vast majority of these were diesel.[6] The Florida Solar Energy Center has conducted extensive research in the possible application of PV to disaster relief efforts. PV is well suited to meet low loads over an extended period of time; in extreme cases where the gasoline infrastructure has been compromised (gas stations destroyed or without power, roads obstructed, etc.), PV may be the only viable option. In disaster relief PV can power individual items (flashlights, radios, etc.) or portable generators to run larger appliances.

Off-grid or mini-grid

Off-grid and mini-grid applications have historically provided a major market for PV. This includes all stand-alone uses such as remote cabins or vacation homes, village power, military and navigation, remote industrial applications, and infrastructure support. In some cases, the PV system is integrated into a product and provides power for a specific application (such as a call box). In others, the PV system provides electricity to a battery or mini-grid, in which case the

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[1] PV Chilled Trailer Quietly Saving Emissions, CADDET Renewable Energy Newsletter, December 2000, available at http://www.caddet-re.org/assets/400art3.pdf.

[2] National Marine Manufacturers Association, Market Statistics Report, April 3, 2000. http://63.236.237.146/facts/insights/insight100.pdf.

[3] Photovoltaics: Advancing Toward the Milennium, NREL, May 1996.

[4] Bowden, Stuart, A High Efficiency Photovoltaic Roof Tile, PhD Thesis, Centre for Photovoltaic Devices and Systems, University of New South Wales, Australia, April 1996. At http://www.pv.unsw.edu.au/thesis/bowden/ch01/1_2.htm.

[5] Young, William, Needs Assessment For Applying Photovoltaics To Disaster Relief, Florida Solar Energy Center, July 1997, available at http://www.fsec.ucf.edu/PVT/resrc/pubs/htmlabs/disas/Disrel04.htm.

[6] Young, William, with Gerard G. Ventre and Michael G. Thomas, Needs Assessment: Photovoltaics in Disasters, FSEC, presented at Solar '98 ASES Conference, Albuquerque, NM.

power is versatile and can be put to any use (as in village power). Of these, the navigation and remote industrial sectors constitute fully developed PV markets. Photovoltaics are often the most economic option for applications such as telecommunications, remote monitoring, and cathode protection. The United States Coast Guard, and those of most other nations, has switched to PV-powered navigational aids to avoid the cost of replacing batteries.

The off-grid market is enormous in developing nations, which is projected to be the largest market for PV in the future. In 2001, BP Solar Spain announced that it will install 2 MW of solar PV in over a hundred villages in the Philippines, funded by a $48 million loan from the Spanish government. The high cost of the project – $24,000/kW – is an indication that this market is still in its early stages.

Remote residential applications remain a primary PV market, particularly for sites located far from the utility grid. Grid extensions are expensive, averaging $60,000 per mile for a rural distribution line,[7] plus a connection service fee and the cost of grid electricity. A PV system may often be more economical. The actual distance at which PV is a superior economic choice depends on the local cost of grid extension, size of the load, and cost of local electricity, but is generally on the order of one to three miles. Numerous sources estimate the distance as low as .25 miles in some cases. In the Pacific Northwest, untapped potential for currently economical applications is estimated at 5-10 MW[8]; this would be expected to change as the economics change. Another viable market is island communities may especially benefit, due to the increased cost of laying underwater cable.

The telecommunications industry is an excellent market for photovoltaics. PV systems provide reliability and can operate as stand-alone systems. In the field of cellular communications, PV has found applications from large repeater towers down to individual batteries and phones. Cellular base stations and repeaters comprise 40% of AstroPower's market,[9] and communications was the end use for 16% of all U.S. PV shipments in 1998.[10]

Two significant off-grid markets in the United States are agricultural applications and the system of parks, forests, and public lands. Photovoltaics can provide power for water pumping, fence electrification, monitoring, and lighting for farms. This is often considerably less expensive than for a rural electric cooperative to run a power line to service a small load. Parks, forests, and recreation areas are often remote from the grid; PV is well suited to serve the needs of facility buildings. The market for PV and energy supply to the recreation and ranging applications is approximately $1 billion.[11]

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[7] PV Technology Overview, at http://www.eren.doe.gov/state_energy/technology_overview.cfm?techid=1

[8] A Northwest Perspective on Solar Electric Industry Market Development, Northwest Solar Alliance, January 2000, http://www.energy.state.or.us/renew/solar/alliance.pdf.

[9] Wall Street Transcript, interview with Allen Barnett, August 1999. Online at http://www.twst.com/sample/GAZ609.pdf.

[10] Renewable Energy Annual 2000, Table 28, Energy Information Administration. At http://www.eia.doe.gov/cneaf/solar.renewables/page/rea_data/table28.html

[11] Renew the Public Lands, Sandia National Laboratories, 1997, http://www.sandia.gov/pv/lib/rnwpblc.pdf.

PV applications for infrastructure, in addition to preserving service in cases of disaster, are potentially an advantageous economical option. Road and highway infrastructure in particular provides a good niche market for PV. PV-powered streetlights, emergency call boxes, and portable changeable message boards all are excellent PV applications to provide crucial reliability to the transportation system. Laying power lines under the street for a school zone flasher light may often be significantly more expensive than installing a PV system, so PV competes favorable based on initial cost. Other transportation applications include rail system and navigational buoys.

Grid-connected

On-grid applications include all applications where the PV power is connected to an energy service provider transmission and distribution network. PV can be part of the utility's generation assets, but more often it is located at the point of use (distributed generation). Markets for grid-connected PV include new homes, residential retrofits, large commercial purchases, government procurement, green pricing or green marketing plans, and utility installations.

As of 1997, there were 61 million single-family owner-occupied homes in the United States.[12] New homes are built at a rate of about 1.2 million per year.[13] Assuming that a new home might have a PV system of 2 kW,[14] then if 1 percent of new homes were built with integrated PV, the market would be 24 MW per year. Although government policy plays a huge role in promoting rooftop solar, some consumers are willing to pay a premium for solar PV.

Solar panels are becoming a feature on new home construction, making alliances with the U.S. homebuilders an attractive strategy (especially in rapidly growing, sunny regions). Demand for housing is determined primarily by two factors, demographics and the economy. Demographics, which ascribe to the need for housing quantity, location and type, are responsible for the secular trends in the housing market: while the economic environment addresses housing affordability (i.e., income levels, employment and interest rates). Table 1 (on the following page) illustrates the 10-year population growth and housing unit growth in the top 14 states.

Also indicated in Table 1 are three major homebuilders (Lennar – recently acquired US Home, Shea Homes and Pardee Homes). US Home recently announced that in 2003 it would build 500 solar homes in California (using AstroPower technology). With increasing on-grid solar power growth due to government subsidies, it allows for bulk orders and pushes the housing industry to adopt PV panels as a standard "option" for homes.

Pre-fabricated housing, with sales of around 300,000 units per year[15], is another market that should not be ignored. Manufactured housing tends to be smaller than other housing, but it has comparable energy demand. In the case of manufactured housing, integrating PV into new construction is easier than for on-site houses. However, the cost of a pre-fabricated home is

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[12] 1997 Residential Energy Consumption Survey, Table HC1-5a, Energy Information Administration. At http://www.eia.doe.gov/emeu/recs/recs97_hc/t1_5a.html.

[13] National Association of Home Builders, at http://www.nahb.com/facts/forecast/annual_starts.htm

[14] Conservative estimate; European and Japanese programs estimate average system size of 3 kW.

[15] US Census Bureau, at http://www.census.gov/pub/const/mhs/shipment.txt. Sales have dropped from 373,000 in 1998 to about 190,000 in 2001.

lower than for an on-site house, so the price of a PV system has a greater impact. FIRST, Inc., a New Jersey-based nonprofit organization, has developed PV-integrated modular housing in partnership with Bradley Builders and Avis America. The 2-kW systems add about $15,000 to the cost of the home, comprising 10-15% of the total cost.[16]

	10 Year Population Growth	10 Year Housing Unit Growth	Lennar Corp.	Shea Holmes	Pardee Homes
Nevada	66%	60%	X		X
Arizona	40%	32%	X	X	
Colorado	31%	22%	X	X	
Florida	24%	20%	X		
Texas	23%	16%	X		
North Carolina	21%	25%	X	X	
Virginia	14%	16%	X		
California	14%	9%	X	X	X
Minnesota	12%	12%	X		
Maryland	11%	13%	X		
New Jersey	9%	8%	X		
Michigan	7%	10%	X		
Ohio	5%	9%	X		
Washington DC	-6%	-1%	X		

Source: Merrill Lynch, Census Bureau

Table 1: Population growth and housing growth, with solar home builder areas of operation

Commercial construction has a higher turnover than residential. There are currently about 4.7 million commercial buildings with a total of about 67 billion square feet of floor space[17]. In 1999, 1.8 billion square feet of commercial construction was completed, or 2.8% of the current total as opposed to 1.2% for single-family homes. Energy usage for commercial buildings averages 13.4 kWh/ft^2 per year.[18] New commercial construction has an energy requirement of 24 billion kWh per year. If 1% of energy requirements for new commercial construction were served by PV then the new commercial construction PV market would be 160 MW per year, assuming an annual yield of 1500 kWh/kWp. ADL estimates a best-case scenario for the commercial building PV market as $2.5B annually by 2010.[19]

[16] Manufactured Homes Go Solar, Home Energy Magazine, November 1994, http://www.homeenergy.org/archive/hem.dis.anl.gov/eehem/94/941105.html.
[17] 1999 Commercial Buildings Energy Consumption Survey, Table B1, Energy Information Administration, http://www.eia.doe.gov/emeu/cbecs/pdf/set1.pdf.
[18] 1995 Commercial Buildings Energy Consumption Survey, Table 10, Energy Information Administration, ftp://ftp.eia.doe.gov/pub/consumption/commercial/ce95tb3.pdf. 1999 Survey energy data not yet available.
[19] Cited by Virginia Alliance for Solar Electricity at http://www.vase.org/areas.html.

In urban areas, PV can find use in redevelopment of "brownfields". There are 450-600,000 brownfields sites in the U.S.,[20] often in urban locations. These sites would have high property value due to location, but are expensive to clean up. By siting PV on these sites, they need only be remediated to utility-grade usage. The avoided cost of further remediation adds value to the PV system.

Military applications for PV emphasize reliability and low maintenance. The nature of military operations often requires stand-alone power, either portable units for field operations or stationary power for a remote facility on a base. For portable units, light-weight and high durability are essential. Carmanah Technologies, a Canadian company, provides solar LED lights for marine, roadway and railway applications. The U.S. Navy has deployed Carmanah PV lanterns in floating nets to protect ships in port. The Coast Guard has switched nearly all of its Aids to Navigation, both shore beacons and sea buoys, to PV power. This avoids the cost of frequent battery replacement. Sandia National Laboratory has identified 3,830 MW of cost-effective PV applications for the military, ranging from small-scale projects averaging 1 kW to grid-tied systems averaging 1 MW.[21]

Competitive PV Market Economics

PV systems must compete first within the market for other distributed generation (DG) power technologies, and then within the larger peak-load electric power market. Figure 2 provides a 2001 cost comparison for alternative DG power technologies. Currently, without incentives, solar PV systems are 4x to 9x greater in wholesale cost then the next cost-effective DG system (fuel cells). The PV power cost is based on a capital cost of $10,000/kW for a 1-kW system. The wholesale power costs do not take into account the potential value of power for DG applications, the need to develop peaking power, or for the technology's degree of intermittence; the wholesale power cost for PV does represent 100 percent debt financing.

PV systems in the United States generally perform well, near the value indicated by the "low latitude" bar in Figure 2 – the U.S. has the best solar resource of any industrialized nation, and the yield for a given system in the U.S. is close to double what it would be in Europe.[22]

As discussed in Appendix B, there are various forms of assistance available to PV systems, including tax credits, fixed price tariffs or renewable energy commitments or targets. A typical solar PV subsidy is $2,500/kW, which yields a power cost of $350/MWh in lower latitudes (from the levelized cost of $472/MWh without incentives).

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[20] American Institute of Architects, Issue brief, May 2001, http://www.aia.org/gov/FEDERAL/legissues/brownfields.asp.

[21] Chapman, Richard, Photovoltaics in the Department of Defense, Sandia National Laboratories Quarterly Highlights, October/December 1996, http://www.sandia.gov/pv/hot/Pvq_197.htm#anchor520921.

[22] On average, over a year a 1-kWp will produce about 1250 kWh in the Northwest, 1500 kWh in the densely-populated Northeast, and 2000 kWh in the Southwest, far above the yields of 800-1200 kWh/kWp encountered in Northern and Western Europe.

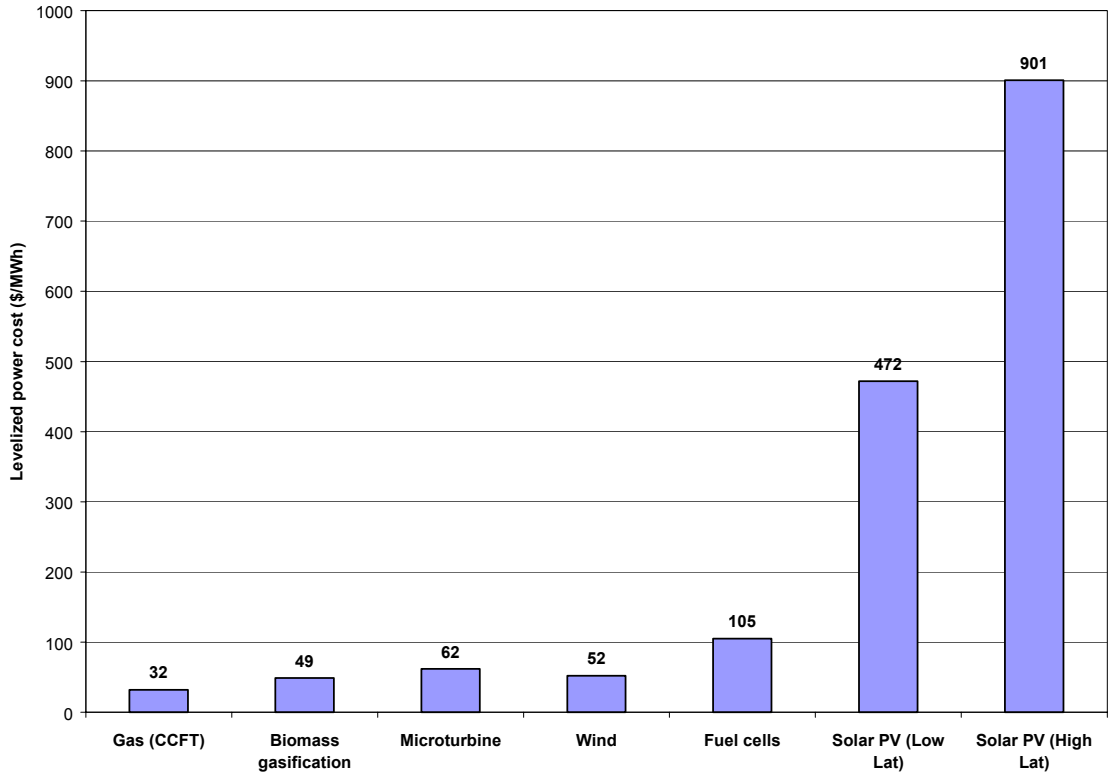

Figure 2: Installed cost comparison of DG systems

Because the cost per kWh is really determined by both the amount of sunshine as well as the capital cost, industrial customers that enjoy lower PV costs per watt can produce power for less than residential customers (excluding rebates and subsidies). Table 2 illustrates this fact.

Customer	Type of Installation	System Output	Total Cost	Cost per kW	Sunny Climate ($/kWh)	*Very Cloudy Climate ($/kWh)
Residential	Roof retrofit	2 kW	$19,500	$9,700	$0.41	$0.90
Commercial	Ground mounted	50 kW	$377,600	$7,550	$0.30	$0.67
Industrial	Flat roof mounted	500 kW	$2,553,000	$5,100	$0.22	$0.48

Source: Solarbuzz. *Includes cloudy cities such as Buffalo and Seattle.

Table 2: Approximate costs of PV systems by size

Beyond the capital costs, the economics of grid-tied systems depend on local sunshine and local subsidies. A 1-kW system generates approximately 1,300 kWh of electricity in upstate New York per year, but over 2,000 kWh (50% more) in many parts of the West or Southwest. To calculate the savings from installing a PV system, the following must be considered:

- Amount of sunshine or energy generated per year
- Size of PV system
- Local utility rates, net metering ability, tax credits

Market Forecasting

Forecasting alternative power technology penetration is a difficult task. On the skeptical side, energy technologies take many years to mature. Fossil fuels and nuclear power have been perfected over the course of decades, and they continue to show improvements in cost and environmental performance, continually raising the bar for alternative power technologies. Yet the cycles of technological hype and gloom appear to bear little relationship to the long time scale of actual progress in alternative power technologies. On the optimistic side, it appears that alternative power technologies have quietly continued to improve in cost and sales. Even solar PV, with minimal widespread use in electric power generation, is on a fast growth curve.

There are several key forecasting pitfalls that should be avoided when examining alternative power technology markets:

- **Current trends will continue.** The current growth rates for most alternative power technologies are related to government support, and to the stage of development of the technologies. While more government support is possible, there is always the risk that it will either diminish, or more likely, that it will support only incremental or haphazard growth.

- **Comparison of alternative technology to fixed benchmark**. This error is more egregious when the comparison is to an older plant (coal or nuclear), rather than the type being built today – natural gas combined cycle turbines.

- **Set the bar for alternative technologies unrealistically high.** Alternative power technologies will not dominate electric power production during the next two decades, nor will they dominate new additions. Solar PV cannot be used as baseload power, and hence would not dominate new additions without competitive energy storage. The proper metric for solar PV is not whether it dominates new additions by 2020, but whether it will capture a meaningful share of the DG or broader electric power market.

For example, according to Deutche Banc Alex. Brown, solar PV production for mobile and remote rooftop locations is in the range of 115 MW annually, growing at around 20% per year.[23] Five years ago, the market for PV was totally dominated by off-grid applications. However, today the on-grid distributed generation side of solar PV accounts for over 50 percent of annual PV shipments (165 MW of 275 MW in 2000), and is the fastest growing PV segment at around 60 percent growth annually. Most of this growth has been driven by government programs, but has also been spurred by falling PV prices and improved technology for interconnection.[24]

Current PV growth rates suggest a total installed capacity in 2010 comparable to that of wind presently (~20 GW). With government subsidies equivalent to $3,000/kW, this market size requires annual spending of $5 billion worldwide – assuming a flat level of additions and no change in capital costs. This level of funding is not likely, so capital costs must decline to achieve a 20 GW market in 2010.

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[23] Deutsche Banc Alex. Brown, *Alt-Power – The Alternative Power Generation Sector* (October 10, 2001).
[24] Deutsche Banc Alex. Brown, *Alt-Power – The Alternative Power Generation Sector* (October 10, 2001).

APPENDIX B: INCENTIVES SUPPORTING PV

Many state and Federal policies and programs have been adopted to encourage the development of markets for PV and other renewable technologies. These consist of direct legislative mandates (such as renewable content requirements) and financial incentives[25] (such as tax credits). Financial incentives typically involve appropriations or other public funding whereas direct mandates typically do not. In both cases, these programs provide important market development support for PV.

Federal Incentives

Federal incentives in the form of Federal tax credits and production incentives have provided important support for PV markets.

Production Tax Credit: The Energy Policy Act of 1992 (EPAct) provides an incentive of 1.5 cents/kWh (1993$) for generation from solar and other renewable sources during their first 10 years of operation. The incentive – Renewable Energy Productive Incentive (REPI) – is only available to tax-exempt publicly owned utilities, local and county governments and rural cooperatives.[26]

Qualifying facilities must use solar, wind, geothermal (with certain restrictions as contained in the rule making), or biomass (except for municipal solid waste combustion) generation technologies. Taking into account inflation, the current incentive is equivalent to 1.7 cents/kWh. This is not very significant incentive given the current cost of PV electricity, but it might be as high as 10% of the system cost in some cases. SMUD, among others, has benefited from this.

There are two tiers or technology classifications in REPI: Tier 1 is solar, wind, geothermal, and closed-loop biomass. Tier 2 includes open-loop biomass technologies, such as landfill methane gas, biomass digester gas, and plant waste material that is co-fired in a generation facility to generate electricity. REPI funds are first distributed to qualifying Tier 1 facilities; then, remaining funds are allocated to Tier 2 facilities. Historically, Tier 2 facilities have been the major recipient of the funds, but this is changing as wind installations increase. Table 3 shows REPI payments to PV systems.

Federal Business Investment Tax Credit for Qualifying Energy Property: EPAct also provides a tax credit for business investment in solar and geothermal generating equipment. Up to 10% of the investment or purchase and installation amount of qualifying energy property can be claimed by a business when filing annual tax returns. Qualifying energy property includes equipment that:

- Uses solar energy to generate electricity, to heat or cool (or provide hot water for use in) a structure, or to provide process heat; or
- Produces, distributes, or uses energy derived from a geothermal deposit.

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[25] DOE has defined a financial incentive as one that: (1) transfers economic resources by the Government to the buyer or seller of a good or service that has the effect of reducing the price paid or increasing the price received; (2) reduces the cost of producing the good or service; and/or (3) creates or expands a market for producers. EIA, "Renewable Energy 2000: Issues and Trends," section on "Incentives, Mandates, and Government Programs for Promoting Renewable Energy," Mark Gielecki, Fred Mayes, and Lawrence Prete.

[26] For FY 02, the House Energy and Water Appropriation Committee recommended $4M for REPI.

Year of production	Year of payment	PV Facilities	PV Payments (thousand $)	Tier 1 Payments (thousand $)	Total REPI
1994	1995	2	8	101	693
1995	1996	4	15	219	2397
1996	1997	9	28	196	2490
1997	1998	2	31	155	2854
1998	1999	3	91	122	4000
1999	2000	5	46	603	1500
2000	2001	6	53	1339	3991

Source: Office of Power Technologies, http://www.eren.doe.gov/power/repi.html

Table 3: REPI Payments for PV Systems

For electricity produced from geothermal power, equipment qualifies only up to, but not including, the electrical transmission stage. There are exclusions for public utility property and reductions on the amount of credit claimed if the qualifying property is/was financed by subsidized energy financing or by tax-exempt private activity bonds.

Federal Modified Accelerated Cost Recovery System: Section 168 of the Internal Revenue Code contains a Modified Accelerated Cost Recovery System (MACRS) by which businesses can recover investments in solar, wind, and geothermal property through depreciation deductions. The MACRS establishes a set of class lives for various types of property, ranging from three to 50 years, over which the property may be depreciated. For solar, wind, and geothermal property placed in service after 1986, the current MACRS property class is five years. The property (equipment) allowable by MACRS must meet the same standards for eligibility required by the Federal Investment Credit (see above), with the inclusion of wind energy systems.[27]

Federal Tax Exemption for Nontaxable Energy Grants or Subsidized Energy Financing: Energy grants and subsidized energy financing received by a business from Federal, state, or local government entities may be exempt from Federal taxation. Such grants and financing must be for the principal purpose of conserving or producing energy. The administrator of the grant or financing must report disbursements of such funds to individual businesses using IRS Form 6497. The business/recipient of the grant or financing should ensure that the administrator of the grant or financing files Form 6497 with the IRS. It is the administrator's responsibility to notify the recipient of the grant or financing that the grant or financing is nontaxable.[28]

[27] For more information on and to claim MARCS see IRS Form 4562: Depreciation and amortization and Instructions for Form 4562, and Internal Revenue Code Sec. 168 (e)(3)(B)(vi).

[28] Generally, reporting on Form 6497 is required only for nontaxable energy grants and subsidized energy financing made for Section 38 property, as defined in Section 48 and the regulations under Section 48, of the Internal Revenue Code.

Federal Support for Renewable Energy Project Development: The Federal government has various programs and mechanisms that may provide funds or financing to support renewable energy projects. In general, these funds are available under specific programs of specific agencies and are dependent on annual appropriations from the U.S. Congress. The U.S. Department of Energy (DOE) has funding programs focused on developing new technologies, and from time-to-time may have funds available for project feasibility studies and even technology demonstrations. Most focus on specific technologies or applications, and are often cost-shared.

State Incentives

Many state and local governments offer one or more of a broad range of financial incentives for investment in PV and other renewable energy technologies. These incentives include:

- ***Income Tax Credits,*** which allow personal income tax deductions for PV and other renewable investments. Hawaii, for example, allows individuals to deduct 35% of the cost of equipment and installation of residential PV and solar heating systems, up to a maximum deduction of $1,750 for houses and $350/unit in multi-unit complexes.

- ***Property Tax Exemptions,*** which exempt the value of PV and other renewable systems from the property values on which taxes are assessed. For example, Texas exempts taxpayers from any value added by a qualified solar and wind energy equipment for property tax purposes.

- ***State Sales Tax Exemptions***, which exempts sales of qualifying renewable energy generating or heating equipment from state retail taxes. Arizona, for example, exempts PV and solar heating equipment from state retail taxes, up to equipment values of $5,000.

- ***Loan Programs***, which provide low-interest loans to residential and commercial investments in PV and other renewable equipment. Whatcom County, Washington, for example, offers a revolving loan fund for low-interest loans for grid-tied PV and solar thermal systems in residential and commercial applications. Loans are available for up to $5,000 with up to 25 years for repayment.

- ***Investment Rebates***, in which a portion of the cost of solar projects is rebated by the government. Delaware, for example, rebates 35% of the cost of qualified PV and solar hot water systems to residential and commercial investors. It provided a $1 million budget for the rebate program in 2000.

- ***Industry Recruitment Incentives***, which essentially exempt qualifying renewable-industry businesses from corporate and/or other taxes. Texas, for example, exempts solar equipment manufacturers, sellers or installers from its franchise tax (essentially equivalent to a corporate tax). There is limit to the value of this exemption in Texas.

- ***Project Development Grants***, which provide funding for a portion of the cost of new qualifying PV and other renewable projects. These grants are typically funded by “public benefit funds” or "system benefits charges" on electricity sales. These funds are most common at the state level, having been created through states’ electricity restructuring or reliability legislation. Delaware’s 1999 restructuring law, for example, provides $1.5 million annually for efficiency and renewable programs, funded by an average 0.178 mills/kWh charge on power sales in the state.

Of the types of incentives described above, investment rebates are among the most commonly used – at least 37 states, in all regions of the country, have such programs in place. Property tax exemptions, corporate tax exemptions, personal tax exemptions, loan programs and grants are also fairly commonplace among states that support renewable power development – in each case, over 20 states have at least one of these programs in place. Eighteen states offer sales tax exemptions for renewable investments, 15 offer grants based on public benefits funds, and 9 states offer industrial recruitment incentives. Table 4 summarizes the incentive programs offered by state governments.

TABLE 4: STATE FINANCIAL INCENTIVES FOR RENEWABLE ENERGY

S = State L = Local U = Utility

State	Personal Tax	Corporate Tax	Sales Tax	Property Tax	Rebates	Grants	Loans	Industry Recruit.	Leasing Programs	Equip. Sales	Production Incentive
Alabama	1-S					1-S	1-U				
Alaska							1-S				
Arizona	2-S		1-S		1-U				1-U	1-U	
Arkansas		1-S			1-S			1-S			
California	2-S	1-S		1-S	3-S, 8-U	5-S	1-U	1-S	2-U	1-U	
Colorado	1-S	1-S									
Connecticut		2-S	1-S	1-S			1-S				
Delaware											
DC											
Florida			1-S		1-S, 2-U				1-U		
Georgia											
Hawaii	2-S	2-S	1-S		3-U		1-L				
Idaho	1-S						1-S				
Illinois				1-S	1-S	2-S		1-L			
Indiana				1-S		3-S					
Iowa			2-S	3-S		1-S	3-S				
Kansas				1-S		1-S					
Kentucky											
Louisiana											
Maine											
Maryland	2-S	2-S	3-S	1-S			2-S				
Massachusetts	2-S	3-S	1-S	1-S			1-L				
Michigan						1-S					
Minnesota			2-S	1-S	1-S	1-S	2-S				1-S
Mississippi							1-S				
Missouri		1-S					1-S				
Montana	4-S	2-S		1-S			1-S	1-S			
Nebraska							1-S				
Nevada				2-S	1-U						
New Hampshire				1-S		1-S					

State	Personal Tax	Corporate Tax	Sales Tax	Property Tax	Rebates	Grants	Loans	Industry Recruit.	Leasing Programs	Equip. Sales	Production Incentive
New Jersey			1-S		1-S						
New Mexico											
New York	1-S	1-S			1-S, 1-U	1-S	1-S				
North Carolina	1-S	1-S		1-S				1-S			
North Dakota	1-S	1-S	1-S	2-S							
Ohio		1-S	1-S	1-S							
Oklahoma											
Oregon	1-S	1-S		1-S	2-S, 4-U		1-S, 4-U				
Pennsylvania						1-S					
Rhode Island	1-S		1-S	1-S	2-S	2-S					
South Carolina					1-U						
South Dakota				1-S							
Tennessee							1-S				
Texas		1-S		1-S	1-U		1-U	1-S		1-U	
Utah	1-S	1-S									
Vermont			1-S	1-S							
Virginia				1-S			1-S	2-S			
Washington			1-S		1-S		1-L	1-S			
West Virginia		1-S		1-S							
Wisconsin				1-S	1-U	1-S					
Wyoming									1-U	1-U	
Totals	**23**	**18**	**18**	**27**	**37**	**21**	**28**	**9**	**5**	**4**	**1**

Source: North Carolina Solar Center, North Carolina State University research based on information in the Database of State Incentives for Renewable Energy (DSIRE) (2001).

Table 4: State Financial Incentives for Renewable Energy

As indicated in Table 5, local governments use many of these same financial incentives to encourage investment in PV and other renewable power. Local programs, however, tend to be more tailored to local circumstances and interests than state programs. Nearly all of them exist in states that offer incentives or other programs to support renewables, such as California (at least 6 local incentive programs), Oregon, Florida, North Carolina, Ohio, Virginia and Washington (at least 2 local incentive programs each). A December 2000 study[29] identified 33 local programs offering financial incentives for renewable energy, most of which relied on grants, loans or rebates to support PV and other renewables. Some of these are PV-specific incentives, while others applied to broader categories of renewables that included PV. It is anticipated that many more local programs have been established since the December 2000 study was undertaken.

[29] Gouchoe, S., "Local Government and Community Programs and Incentives for Renewable Energy – National Report," North Carolina Solar Center, North Carolina State University (December).

TABLE 5: LOCAL INCENTIVE PROGRAMS FOR RENEWABLE ENERGY

				INVESTMENT & AWARENESS				FINANCIAL INCENTIVES			
State	**City/Community**	**MSRI Partner**	**Municipal Utility**	**Green Pricing**	**Education & Assist.**	**Green Power Purch.**	**Local Projects**	**Grant, Rebate, Loan**	**Tax Incentive**	**Green Building**	**Industrial Recruit.**
AZ	Scottsdale			IOU							
AZ	Tucson			IOU							
CA	Los Angeles										
CA	Palo Alto										
CA	Sacramento										
CA	San Diego			IOU							
CA	San Jose			IOU							
CA	Santa Barbara			IOU							
CA	Santa Clara			IOU							
CA	Santa Monica			IOU							
CO	Aspen			IOU							
CO	Boulder			IOU							
CO	Denver			IOU							
CO	Fort Collins										
DC	Washington										
FL	Gainesville										
FL	Jacksonville										
FL	New Smyrna Beach										
IL	Chicago										
IA	Cedar Falls										
IA	Waverly										
MA	Cape & Vineyard										
MI	Traverse City										
MN	Moorhead										
NE	Lincoln										
NM	Albuquerque										
NY	Long Island										

NC	Chapel Hill										
NC	Greensboro										
OH	Bowling Green										
OH	Westerville										
OR	Ashland										
OR	Eugene										
OR	Portland			IOU							
PA	Philadelphia			IOU							
RI	Block Island										
TX	Austin										
TX	San Antonio										
VT	Burlington										
VA	Cape Charles										
VA	Loundon County										
WA	Olympia										
WA	Seattle										
WA	Tacoma										
WI	Madison			IOU							

Local Program State program Local and State programs Investor-owned utility IOU

Table 5: Local Incentive Programs for Renewable Energy

APPENDIX C: REGULATIONS AND POLICIES IMPACTING PV

Federal Regulations and Policies

Federal Legislation

Existing laws provide price support for PV markets through the power-purchase provisions of the Public Utility Regulatory Policies Act and the production tax credits of EPAct. As U.S. electricity markets have become increasingly competitive, these price supports have provided limited benefit to PV commercialization. However, various legislative proposals have been recently introduced that include new programs to support PV markets. The bills that contain such provisions, and currently remain viable in Congress, are the Democratic and Republican energy supply bills.

The Democrat bill (S. 1766) would require electricity suppliers to offer net metering nationwide, promote the development of solar energy production on Federal and Indian land, and extend existing renewable energy production tax credits. It would also provide funding for technological advancement and commercialization, with the goal of making PV and other renewable energy sources competitive with fossil sources. Most importantly, S. 1766 would establish two RPS programs: (1) a RPS for Federal government consumption starting at 3 percent in 2003 ramping up to 7.5 percent in 2009; and (2) a RPS for electricity generators starting in 2003 at a level to be set by the Secretary of Energy, but no less than 2.5 percent after 2004. Bill S. 1766 would also establish a renewable crediting program to support compliance with the RPS requirements.

The Republican bill – H.R. 4 – does not contain RPS or other mandates for renewable energy consumption. Instead, it provides funding for the development and demonstration of PV and other solar technologies, aiming to increase their efficiency and reduce their manufacturing cost. It would also provide a 15% tax credit for residential solar investments starting in 2002.

Emission Crediting/Trading Programs

Opportunities for developing PV markets arise through environmental regulations as well. At the Federal level, EPA's sulfur dioxide (SO_2) trading program provides special credits for renewable projects. Under the program, utilities must hold a number of allowances corresponding to their level of emissions. EPA established a "Conservation and Renewable Energy Reserve" that provides "bonus" allowances for PV and other renewable-based generation, as an incentive for conservation and renewable energy.

Because allowances are necessary for compliance and generators must reduce their emissions, allowances have important value (currently about $170/allowance) in the marketplace. Sources such as PV that earn allowances but have no emissions can sell bonus allowances they earn for a profit. For example, a 300 kW plant running at 20% capacity factor could thus earn about 100 allowances annually, with a market value of about $17,000. There are 300,000 allowances available in the EPA reserve; each allowance is earned by generating 500 kWh of electricity from PV or other renewable sources. Applications for allowances from this reserve can be made through 2009.

EPA's NO_x SIP Call rule, which requires reductions of nitrogen oxides (NO_x) emissions in 20 eastern states[30] and the District of Columbia, also provides incentives for PV and other renewable technologies. Like the SO_2 trading program, the NO_x SIP Call rule requires generators to hold allowances sufficient to "cover" their emissions. There are two opportunities for PV under this rule.

First, any direct displacement of existing generation by renewable sources (e.g., by plant replacement or other "offsetting" activities) will earn the existing sources' allowance allocations. This is attractive in cases where the marginal cost of renewable generation over existing generation is less than the value of the NO_x allowances earned. Second, in implementing the SIP Call rule, many states have "set aside" a portion of their total budget of NO_x allowances to support new plants. Some states (such as Ohio) have also set aside NO_x allowances to support renewable energy as well. New PV and other renewable plants may be able to obtain allowances from either or both of these set-asides, depending upon the design and criteria of the rules of the state in question.

Opportunities exist at the regional level as well. In particular, northeast states participating in the regional Ozone Transport Commission[31] (OTC) have implemented their own multi-state NO_x trading program. Some of these states have elected to set aside allowances for renewable sources, similar to the Federal program. New York, New Jersey and Massachusetts have dedicated portions of their respective NO_x budgets to energy efficiency and renewable energy projects, including PV. New York, for example, set aside 3% of its budget in the years 2003 through 2007 for allocations to such projects.[32]

The lack of regulatory mandates for carbon dioxide (CO_2) emission reductions has not prevented some regional carbon-reduction markets from developing, which could provide additional opportunities for PV. As non-emitting technologies displace or offset emissions from traditional fossil-fuel based generating technologies, credits may be earned and sold in such markets. Currently, credits are transacting at about $5.00 per ton of carbon dioxide.

Local environmental regulatory programs around the country provide incentives for PV and other renewable power generation. Some of these programs function as the EPA programs described above, in which renewable plants earn credit for displacing or offsetting emissions from traditional fossil-fired plants. Other such programs provide incentives for residential and commercial applications of PV and other renewable technologies. In some cases, both programs can be used together, when utilities claim credit for offsetting emissions from an aggregation of new small-scale residential and/or commercial applications that they supported.

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[30] These states include Alabama, Connecticut, Delaware, Illinois, Indiana, Kentucky, Maryland, Massachusetts, Michigan, Mississippi, North Carolina, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Virginia and West Virginia.

[31] Participating states include Connecticut, Delaware, the District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and the Northern Virginia suburbs of Washington, D.C.

[32] NREL, "The Clean Air Act Amendments of 1990: Opportunities for Promoting Renewable Energy," NREL/SR-620-29448 (January 2001).

Emissions Credit Recommendations

Despite the benefits of these programs for PV, various actions could be taken that would make them even more supportive of viable PV markets. In the Federal sulfur dioxide trading program, the Conservation and Renewable Energy Reserve could be improved in a number of ways for better utilization. Currently, only traditional utilities are able to participate, which excludes many developers unless they are able to team up with a utility. Participation should be available to any generator that has the renewable output necessary to qualify for the program. Eligibility is also currently tied to least-cost planning and utility income neutrality requirements, which should be eliminated to increase access to the reserve. A reserve that provided a greater number of allowances, for a longer period of time (perhaps ten years) could also improve the use and market impact of the reserve.

Alternatively, the reserve could be replaced with another program to better support PV. For example, the entire allowance program could be based on heat output-based (rather than input-based) allocations that included PV and other renewables. This would recognize the value of renewables' environmental attributes and build them directly into the program, rather than making them participate through an allowance reserve program.[33]

As with the sulfur dioxide trading program, the NO_x SIP Call rule and OTC program could better support PV markets by requiring states to use output-based allocations that include renewables, or to set aside allowances specifically for renewables. Credit for PV and other renewables-based generation could also be provided under other air regulatory programs such as those to reduce regional haze and reduce ambient particulate matter.

Other Policy Developments Critical for PV at the Federal and State Level

Distributed Generation Policies

Distributed generation interest is on the increase. Distributed generation – the use of electric generating facilities located within the utility grid, usually installed at or close to an end user, and interconnected directly to the utility distribution system – can provide benefits to utilities and their customers alike. PV is one of many generation technologies that are well suited for distributed generation. For utilities, strategically-located distributed generation reduces energy losses in transmission and distribution lines, provides voltage support, reduces reactive power losses, defers substation and equipment upgrades, defers the need for new transmission capacity, and reduces the demand for spinning reserve capacity.[34] Utility-sponsored studies have concluded that under some circumstances (particularly where the utility's distribution system is operating near capacity) distributed benefits are comparable in scale to traditional energy and capacity benefits.[35] Where the distributed generating technology is fueled by a renewable

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[33] These and other alternative approaches are discussed in greater detail in NREL, "The Clean Air Act Amendments of 1990: Opportunities for Promoting Renewable Energy," NREL/SR-620-29448 (January 2001).

[34] Howard J. Wenger, Thomas E. Hoff & Brian K. Farmer, *Measuring the Value of Distributed Photovoltaic Generation: Final Results of the Kerman Grid-Support Project*, Conference Proceedings, First World Conference on Photovoltaic Energy Conversion (December 1994), p. 793.

[35] See E. Prabhu, *Finding High Value for Grid-Connected PV: Southern California Edison's Innovative Solar Neighborhood Program*, Presented at the American Solar Energy Society Annual Conference (1995); J. Oppenheim, *PV Value Analysis: Progress Report on PV-COMPACT Coordinating Council's Consensus Research Agenda*,

resource, it offers the additional benefit of potentially displacing fossil-fuel generation or other generation technologies with greater environmental impacts.

PV is an excellent distributed generating technology. It can be located anywhere the sun shines with few (if any) environmental or siting restrictions. PV is modular (a utility or customer can install as much PV as needed), installs quickly, requires no fuel delivery or cooling facilities, and produces no emissions or noise. Recognition of the benefits of distributed generation by utilities, utility regulators, and other stakeholders in the electricity industry is seen to be one of the driving forces in the expansion of PV markets. Although the cost of PV technology is still very high – approximately ten times the least expensive bulk-power technologies – its unique technical and environmental attributes, ease of siting, rapid deployment potential, and its tremendous popular appeal are combining to create viable markets for grid-connected PV applications.

The Solar Electric Power Association (SEPA) and others in the PV community seek to have the following list of items be part of the national agenda for utilities, states, local communities, and all customers:[36]

- Provide the opportunity for utilities to offer net metering or other pricing policies that recognize the higher value of distributed generation;
- Institute standardized technical criteria for utility interconnection of distributed systems;
- Encourage utilities to offer simplified power purchase agreements (PPA's) between electricity service providers and the owners of distributed PV Systems;
- Encourage utilities to minimize the imposition of additional fees and other charges associated with the permitting, installation, and/or operation of distributed systems;
- Ensure that homeowners associations' rules and other private codes, covenants, and restrictions (CC&R's) do not prohibit or inappropriately discourage the use of solar distributed systems in residential housing developments;
- Enact and enforce solar zoning laws to protect solar access rights for PV system owners; and
- Develop new regulatory regimes for distribution utilities that encourage – or at least do not discourage – customers that seek to generate part or all of their own electricity using PV or other distributed generating technologies.

PV System Interconnection

Interconnection policies play an important role in encouraging – or discouraging – the development of distributed PV applications. Utilities historically have exercised a great deal of discretion in determining the terms and conditions under which non-utility owned generating facilities are connected to their distribution networks. However, policymakers in some states recently have started limiting the utilities' traditional control over interconnection by developing and adopting uniform, standardized interconnection policies for certain distributed generating facilities.[37]

Presented at the American Solar Energy Society Annual Conference (1995); H. Wenger, T. Hoff & B. Farmer, *Measuring the Value of Distributed Photovoltaic Generation: Final Results of the Kerman Grid-Support Project*, First World Conference on Photovoltaic Energy Conversion (1994).

[36] "Expanding Markets for Photovoltaics: What To Do Next." Renewable Energy Policy Project. December 1998.

[37] Thomas J. Starrs, *Barriers and Solutions to Interconnection Issues for Solar Photovoltaic Systems*, Report for the Solar Electric Power Association (2000)

The Public Utility Regulatory Policies Act of 1978 (PURPA) required utilities to interconnect non-utility generators to their transmission and distribution networks. Most of the non-utility generators developed under PURPA were large multi-megawatt-sized, cogeneration or utility-scale bulk power facilities designed and built to sell power to utilities at the approved avoided cost. The PURPA facilities predominately utilized natural gas-fired turbines, but also included biomass, geothermal, solar thermal and wind powered generators, and most were also megawatt-scale facilities. The interconnection of small-scale facilities, sized to serve an individual home or small business (including farms or ranches), was relatively unusual.

The electric utility industry's response to PURPA was the development of interconnection requirements (usually by each individual utility) that allowed the connection of this non-utility generation to the utility grid, but these requirements, in general, included predominately prohibitive mandates for co-generators.

These strict interconnection requirements, developed for multi-megawatt generators, were considered burdensome by many PV customers, system manufacturers, and installers. Relatively small PV system installations were, in many cases, severely impacted by these burdensome requirements. PV installations of 20kW and smaller were required to comply with the same rules that utilities had written with large rotating machinery in mind, machinery that has large fault capability and has the potential of serious impacts on the utility grid. These rules ignored the inherent capabilities of PV system solid-state inverters that can stop output current flow nearly instantaneously if there are disturbance conditions and also, during normal operation, can precisely control the output voltage, frequency, and harmonics. This "one-size-fits-all" interconnection approach by utilities failed to recognize that small to medium sized PV inverter-based systems do not have the capability to impact the utility distribution system. Requirements, such as utility grade relaying, telemetry, and in some cases supervisory control like transfer trip, imposed severe cost penalties on medium/small PV systems.

In addition, the varied requirements from each utility necessitated that inverter manufacturers develop inverter models that would comply with the various and disparate requirements such as voltage window, frequency window, disconnect and reconnect times, and test procedures. PV system designers would also have to take into consideration the "rules" of the particular utility site requirements, also adding cost and complexity. A common set of requirements were needed to allow "standardization" of an inverters and designs, leading to better reliability, lower cost inverters, and "standardized" PV system designs.

With the advent of Round One of SEPA's TEAM-UP program in 1995, DOE, SEPA, the PV industry, utilities, and many others were cognizant of the cost burden that varied interconnection requirements were having on the residential and commercial-sized PV systems. The DOE provided the stimulant to establish the Institute of Electrical and Electronic Engineers (IEEE) 929 Working Group, tasked to develop an interconnection standard to alleviate many of the costly concerns related to PV system interconnection. The development of IEEE 929, conducted through an extensive consensus process of many stakeholders, is now, fortunately, history and we now have IEEE 929-*2000 Recommended Practice for Utility Interface of Photovoltaic (PV) Systems*. IEEE 929-2000 includes very specific requirements for systems of up to 10 kW, but it

is relevant to PV systems of all sizes. In fact, the IEEE 929-2000 standard makes three distinctions based on the size of PV systems:

- systems rated at 10 kW or less
- systems rated between 10 kW and 500 kW
- systems rated above 500 kW

This technical standard required a dedicated effort of many people, which was a representative grouping of manufacturers, users, utilities, code officials, and others over a 3 ½ year period for draft and final document development and nearly another year to ballot and fine tune to obtain the IEEE approved document. The document was approved in January 2000 and is available through the IEEE (www.ieee.org).

In parallel with the development of IEEE 929, the Working Group also assisted Underwriters Laboratories to establish a companion testing procedures document, UL 1741 *Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems*, to ensure that inverters comply with the IEEE 929 technical requirements. The availability of IEEE 929-2000, the UL tests, and adequate coverage of PV systems in the National Electrical Code (NEC Article 690 in particular), however are not the end of the path for PV system interconnection. In order for there to be anything similar to a national requirement this IEEE 929 document must be voluntary adopted and/or required by states, commissions, utilities and communities.

It is important to note, with the recent emphasis on distributed generation that IEEE 929 covers only small to medium sized PV inverters. Another similar, but much expanded effort is now under way to develop an interconnection standard for a variety of distributed generation (DG) sources. This new development is for an IEEE 1547 *Standard for Distributed Resources Interconnected with Electric Power Systems* document. The breath and depth of this proposed standard is increased by orders of magnitude beyond IEEE 929. System sizes for many of the DG technologies are large enough to have a very significant impact to the local distribution and transmission grid and therefore the scope of IEEE 1547 is significantly increased.

While the development of IEEE 1547 is important for the future of distributed generation, there is a need to ensure that the requirements of IEEE 1547 do not invalidate the items in IEEE 929 that lead to low cost PV installations. For example, there had been some discussion in the IEEE 1547 development efforts that a standard interface connection box may provide value, and the protection equipment internal to the box would be dependent on the size and generation technology utilized. The PV system inverter (complying with IEEE 929) contains all the necessary protection equipment and functions and therefore the expense of this box/installation is unnecessary for small to medium sized PV systems.

SEPA Interconnection Position Statement

There is much to do. Utilities and energy service providers need to adopt and require inverters to comply with IEEE 929-2000 and they need to develop policies and procedures that are simple and cost effective for small to medium PV installations. SEPA has developed a Position Statement on Interconnection that outlines the steps needed to allow easy interconnection of PV systems. The SEPA Position Statement focus on the need for utilities and energy service

providers to adopt IEEE 929 and gives guidance and examples for additional efforts needed to remove the non-technical barriers to PV system interconnection. The statement briefly covers the technical requirements of interconnection, and also covers the non-technical issues of interconnection, issues such as insurance requirements, power purchase agreements, metering, and fees and charges. In addition the position statement provides example documents that can be utilized for interconnection agreements.

The SEPA Position Statement states:

> "The Solar Electric Power Association's Position Statement on Interconnection consists of two companion documents. The first, Technical Aspects of PV Interconnection, explains how technical issues such as safety and power quality have been dealt with by standards-making bodies and how these standards have been implemented by utilities. The Association finds that three national standards – the Institute for Electrical and Electronic Engineers Recommended Practice 929-2000, the Underwriters Laboratories Test Procedure 1741, and the National Electrical Code Article 690 – are sufficient to form a basis for uniform, simplified technical interconnection guidelines. Moreover, several utilities have successfully translated the standards into practical application. Substantial field experience confirms that these standards ensure safe operation of PV systems connected to the grid…The Solar Electric Power Association encourages all utilities to methodically simplify and streamline the contractual aspects of small PV system interconnection. Reducing costs associated with contractual aspects of PV interconnection is in the best interest of both customers and utilities".

The SEPA Interconnection Position Statement is available on the SEPA web site, www.SolarElectricPower.org.

Energy Metering

Net Metering is a policy that allows homeowners to receive the full value for the electricity that their solar energy system produces. The term, net metering, refers to the method of accounting for the photovoltaic system's electricity production. Net metering allows homeowners with PV systems to use any excess electricity they produce to offset their electric bill. As the homeowner's PV system produces electricity, the kilowatts are first used for any electric appliances and loads in the home. If more electricity is produced from the PV system than is needed by the homeowner, the extra kilowatts are fed into the utility grid.

Under Federal law, utilities must allow independent power producers to interconnect with the utility grid and purchase any excess electricity they generate. Many states have gone beyond the minimum requirements of the Federal law by allowing net metering for customers with PV systems. Under net metering, the electric meter of the customer will run backwards when their solar electric system is producing more energy than they need to operate their home at that time. The excess electricity produced is fed into the utility grid and sold to the utility at the retail rate.

At the end of the month, if the customer has generated more electricity than that used, the utility credits the net kilowatt-hours produced at the wholesale power rate. If the customer uses more electricity than they generate, they pay the difference. The billing period for net metering may

be either monthly or annually. In some states, the excess generation credits at the end of each billing period will be carried over to the next billing period for up to one year.

Net metering allows homeowners who are not home when their systems are producing electricity to still receive the full value of that electricity without having to install a battery storage system. The power grid acts as the customer's battery backup, which saves the customer the added expense of purchasing and maintaining a battery system.

Generally, the preferred method of accounting for the electricity under net metering is with a single, reversible meter. An alternative is dual metering, in which customers or their utility purchase and install two non-reversing meters that measure electrical flow in each direction. This adds significant expense to installing a PV system. The current trend around the country is toward a single, reversible meter.

Some utilities are opposed to net metering because they believe it may have negative financial impacts on them. However, a number of studies have shown that net metering can benefit utilities. The benefits include reduced meter hardware and interconnection costs, as well as reduced meter reading and billing costs. Grid-connected PV systems can also help them to avoid the need for additional power generation, may increase the reliability and quality of electricity in the grid, and produce power at peak, when utility generation costs are higher and they often need the extra power.[38]

As of November 2001, thirty-three states have net metering legislation.[39] Net metering is also receiving attention on the nationwide level, with Federal legislation introduced in the 107th Congress by both the Senate (the Home Energy Generation Act, S. 1403) and the House (the Home Energy Generation Act, H. R. 954).

Net metering simplifies both the metering process (by eliminating the need for a second meter) and the accounting process (by largely or entirely eliminating the need for the utility to purchase excess power). Perhaps most importantly, net metering also is easy for customer generators (the end user) to understand. Net metering eliminates the need for complicated buy/sell agreements and complicated contracts that require specialized attorney's to review and interpret.

Critics are quick to point out that net metering is inconsistent with the move towards competition and market pricing of wholesale energy supplied to the grid. In particular, they object to net metering because it allows customers to use excess energy being fed back into the transmission and distribution system at one point in time to offset energy dispatched and delivered at another point in time.[40]

Time of Day, or time-of-use (TOU) metering also offers substantial opportunities for PV applications. Many utilities peak demand period, especially in the summer months, coincides

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[38] www.MillionSolarRoofs.org.
[39] "Database of State Renewable Energy Incentives." Interstate Renewable Energy Council. www.dsireusa.org. Updated 11/30/01.
[40] "Expanding Markets for Photovoltaics: What To Do Next." Renewable Energy Policy Project. December 1998.

well with a PV system's output shape. The ability to have net metering occur along with Time of Day metering allows a PV system to capture the financial incentive afforded by the peak demand period rates and thereby increasing the value of the installed PV system to both the customer and the utility.

State and Local Policies

In addition to financial incentives, many state and local governments have adopted regulations and policies to support renewables. These either (1) require a portion of electricity sales to be based on PV or other renewables (through an RPS), or (2) provide a regulatory structure that better supports markets for PV and other renewables (through other mechanisms).

These regulations and policies commonly coincide with states in which retail competition has been introduced. While introducing retail electricity competition is not directly undertaken to promote renewables, it tends to create regulatory environments that are much more conducive to viable renewables markets. This is because competitive markets and consumer choice naturally create opportunities to market PV and other renewable-derived power as a distinct and "premium" product at prices that cover its costs. States frequently adopt regulatory mechanisms (such as green pricing and credit trading programs, described below) to reinforce and encourage opportunities for renewable power in competitive electricity markets.

In terms of recognizing renewable power as a premium product, 12 states have introduced retail competition,[41] creating opportunities to market renewable power directly to consumers. At least 25 states also require electricity providers to disclose the source of (and resulting emissions from) their production to their customers. This is known as generation disclosure. It provides an important information base to support retail choice, drawing particular attention to the environmental attributes of competing electricity products. It also distinguishes PV and other non-or low-emitting sources of electricity as having added environmental value, despite their marginally higher price.

Maryland's 1999 generation disclosure rules, for example, are fairly representative. They require all retail suppliers to disclose to each customer every six months the fuel sources and emissions from the electricity provided to the customer. A standard format is provided that compares the provider's fuels and emissions with the state or regional average.

In terms of marketing the renewable attributes as a separate commodity, at least 16 states have adopted RPS requirements, requiring electricity suppliers' sales to include a minimum content of renewable energy. RPS content requirements range in stringency, typically begin with a low standard (0.5% to 1.0%) and increase annually or biannually (to as much as 10%, depending upon the RPS's design and schedule. One state – Nevada – requires a portion (5.0%) of each utility's annual RPS compliance to be based on solar sources, beginning in 2003. To be creditable under its program, the renewable power must be generated and sold in Nevada.

[41] As of January 2002, twelve states had introduced full retail competition: Pennsylvania, New York, New Jersey, Maine, Massachusetts, California, Rhode Island, Michigan, Texas, Ohio, Virginia and New Hampshire. At least twelve other states had scheduled the introduction of retail competition or were pursuing legislative or regulatory actions to do so. EPSA, Retail Competition Matrix, January 8, 2002.

Many states that have adopted RPS requirements also use "green certificate" or "credit" trading programs in which certificates or credits represent the renewable attribute of electricity and can be transacted among electricity providers separately from the electricity itself. These transactions allow electricity providers to comply with the RPS requirements without actually generating electricity from PV or other renewable sources themselves.

Another popular regulatory tool is net metering, which requires utilities to purchase excess power generated by residential and commercial applications. Net metering programs allow residential and commercial PV generators to sell their net excess output to the utility, which utilities can sell in some cases as a premium product or use to meet their RPS obligations. As of December 2001, 43 states have adopted net metering programs.

Montana's 1999 net metering law, for example, allows net metering for customers with solar, wind, and hydropower systems of 50 kilowatts or less. All customer classes are eligible and there is no limit on enrollment or statewide installed capacity. While some state do impose limits on the amount of renewables utilities are obligated to purchase from customers under net metering, most use rated capacity (kilowatt) limits. Only Indiana uses an output maximum, limiting net metering purchases to 1,000 kWh per customer by utilities. As indicated in Table 6, at least 43 states currently have net metering requirements in place.

Some states also require renewable generation facilities to have access to the transmission system. These rules, known as access laws, allow property owners with wind or solar energy systems to apply for permits that guarantee unobstructed access to solar and wind resources – essentially allowing unrestricted rights to building solar devices on property, unless obstructing structures are preexisting or already under construction. Access laws have been adopted by 45 states, primarily to ensure access to solar and wind resources.

Related to access laws are easement laws, under which parties can enter into voluntary solar easement contracts. Such contracts, once created, are perpetual unless otherwise specified in the easement. Some states' (such as Utah's) laws stipulate that local zoning authorities may adopt regulations that mandate solar access to the transmission grid.

Some states also use construction and design requirements to promote the incorporation of PV and other renewable applications to new building projects and renovations. Minnesota law, for example, requires the state to utilize building designs that incorporate active and passive solar energy and other alternative energy sources where feasible in new buildings and buildings undergoing major renovations. The statute also mandates energy efficiency programs in selected state buildings. Construction and design requirements have been adopted by 27 states.

Other, less widely used policies have also been adopted by various states to promote PV and other renewable power markets. These are identified in Table 6, below, along with the states in which they are used.

TABLE 6: STATE RULES, REGULATIONS AND POLICIES FOR RENEWABLE ENERGY

S = State L = Local U = Utility

State	PBF	Gen. Disclos.	Port. Std.	Net Metering	Exten. Analysis	Contract. License	Equip. Certific.	Access Laws	Constr. & Design	Installer Certif.	Req. Green Power
Alabama											
Alaska								1-S			
Arizona		1-S	1-S	1-S	1-S	1-S	1-S	1-S	1-S, 2-L		
Arkansas		1-S		1-S		1-S	1-S				
California	1-S	1-S		1-S, 1-L		1-S, 1-L	1-S	1-S, 5-L	4-L	1-S	
Colorado		1-S		3-U	1-S	1-L	2-L	1-S, 1-L	3-L	1-S	
Connecticut	1-S	1-S	1-S	1-S		1-S					
Delaware	1-S			1-S							
DC				1-S							
Florida		1-S		2-L		1-S	1-S	1-S, 1-L	1-S	1-S	
Georgia				1-S				1-S			
Hawaii			1-S	1-S		1-S		1-S	1-S		
Idaho				1-S				1-S			
Illinois	1-S	1-S	1-S	1-S							
Indiana				1-S				1-S			
Iowa			1-S	1-S				1-S			1-S
Kansas								1-S			
Kentucky								1-S			
Louisiana							1-S				
Maine	1-S	1-S	1-S	1-S		1-S	1-S	1-S			
Maryland		1-S		1-S				1-S	1-S		
Massachusetts	1-S	1-S	1-S	1-S				1-S			
Michigan		1-S				1-S				1-S	
Minnesota		1-S	3-S	1-S			1-S	1-S	1-S		1-S
Mississippi											
Missouri								1-S			
Montana	1-S	1-S		1-S				1-S			1-S
Nebraska								1-S	1-S		
Nevada		1-S	1-S	1-S		1-S		1-S			
New Hampshire		1-S		1-S				1-S			
New Jersey	1-S	1-S	1-S	1-S				1-S			
New Mexico	1-S	1-S	1-S	1-S	1-S			1-S			
New York	1-S	1-S		1-S				1-S		1-S	

State	PBF	Gen. Disclos.	Port. Std.	Net Metering	Exten. Analysis	Contract. License	Equip. Certific.	Access Laws	Constr. & Design	Installer Certif.	Req. Green Power
North Carolina									1-L		
North Dakota				1-S							
Ohio	1-S	1-S		1-S, 1-U				1-S		1-S	
Oklahoma				1-S			1-S				
Oregon	1-S	1-S		1-S, 1-L				1-S, 3-L	3-L		
Pennsylvania	1-S	1-S	1-S	1-S							
Rhode Island	1-S			1-S		1-S		1-S	1-L		
South Carolina											
South Dakota											
Tennessee								1-S			
Texas		1-S	1-S	1-S, 1-U	1-S		1-S		1-S, 1-L	1-S	
Utah						1-S	1-S	1-S			
Vermont				1-S							
Virginia		1-S		1-S				1-S, 1-L	2-L		
Washington		1-S		1-S				1-S	1-L		1-S
West Virginia		1-S									
Wisconsin	1-S		1-S	1-S		1-L	1-L	1-S, 1-L	1-L	1-S	
Wyoming				1-S				1-S			
Totals	**15**	**25**	**16**	**43**	**4**	**14**	**13**	**45**	**27**	**8**	**4**

Source: North Carolina Solar Center, North Carolina State University research based on information in the Database of State Incentives for Renewable Energy (DSIRE) (2001).

Table 6: State Rules, Regulations and Policies for Renewable Energy

As indicated in the tables above and below, many local governments also use some of the same regulatory programs used at the state level. Due to the specific local circumstances and interests of many communities, however, municipalities have often adopted their own distinct programs to promote the generation and use of renewable energy.

For example, some local governments have imposed mandatory-content purchase requirements for renewable energy at the city-government level, much as the RPS has been used statewide for utility sales. As shown in Table 7, several local governments in California have taken this approach. The City of Chicago has also done so, joining with 47 other local government entities to contract collectively for electric power, to meet a self-imposed minimum renewable-content requirement of 20% by 2005. Many other communities have set renewable-purchase goals or voluntarily set out to increase their consumption of renewable power, often by teaming with others to increase their demand and thus contract leverage. Most municipalities and counties, however, use financial and other incentives rather than regulatory mandates to promote investment in PV and other renewable technologies.

TABLE 7: LOCAL RULES AND REQUIREMENTS FOR RENEWABLE ENERGY

				RULES, REGULATIONS & POLICIES			
State	**City/Community**	**MSRI Partner**	**Municipal Utility**	**Green Pricing**	**Equip. Certification**	**Net Metering**	**Construct. & Design**
AZ	Scottsdale			IOU			
AZ	Tucson			IOU			
CA	Los Angeles						
CA	Palo Alto						
CA	Sacramento						
CA	San Diego			IOU			
CA	San Jose			IOU			
CA	Santa Barbara			IOU			
CA	Santa Clara			IOU			
CA	Santa Monica			IOU			
CO	Aspen			IOU			
CO	Boulder			IOU			
CO	Denver			IOU			
CO	Fort Collins						
DC	Washington						
FL	Gainesville						
FL	Jacksonville						
FL	New Smyrna Beach						
IL	Chicago						
IA	Cedar Falls						
IA	Waverly						
MA	Cape & Vineyard						
MI	Traverse City						
MN	Moorhead						
NE	Lincoln						
NM	Albuquerque						
NY	Long Island						

NC	Chapel Hill						
NC	Greensboro						
OH	Bowling Green						
OH	Westerville						
OR	Ashland						
OR	Eugene						
OR	Portland			IOU			
PA	Philadelphia			IOU			
RI	Block Island						
TX	Austin						
TX	San Antonio						
VT	Burlington						
VA	Cape Charles						
VA	Loundon County						
WA	Olympia						
WA	Seattle						
WA	Tacoma						
WI	Madison			IOU			

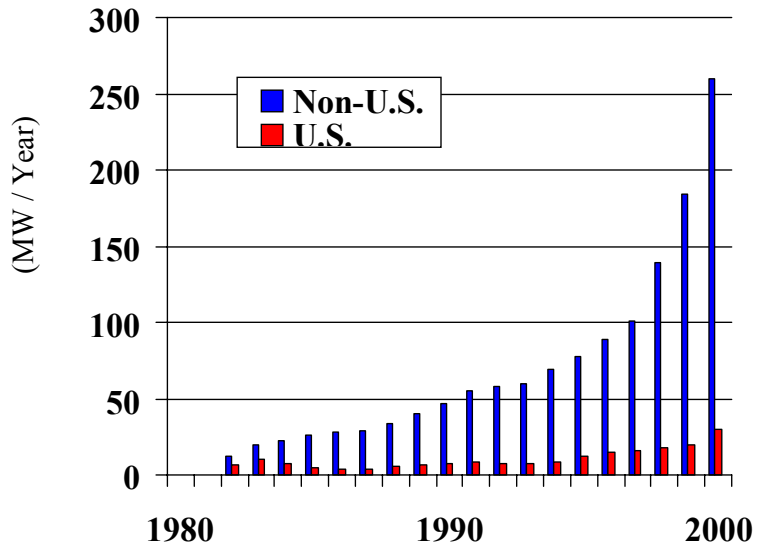
Local Program State program Local and State programs Investor-owned utility IOU

Table 7: Local Rules and Requirements for Renewable Energy

APPENDIX D: LESSONS FROM INTERNATIONAL EXPERIENCE

International Markets

International markets have emerged gradually since about 1975, becoming more than 50% of global PV installations by the early 1980s, and representing over 90% of annual installations today, as shown in Figure 1. Until about 1996, the international markets were dispersed around the world, principally in the developing countries for off-grid rural applications. More recently, however, market demand has been booming in Japan and Europe, especially in Germany, for grid-connected applications such as residential rooftop and BIPV on commercial buildings. The non-U.S. market is forecast by most sources to grow faster than the U.S. market in the coming decade.



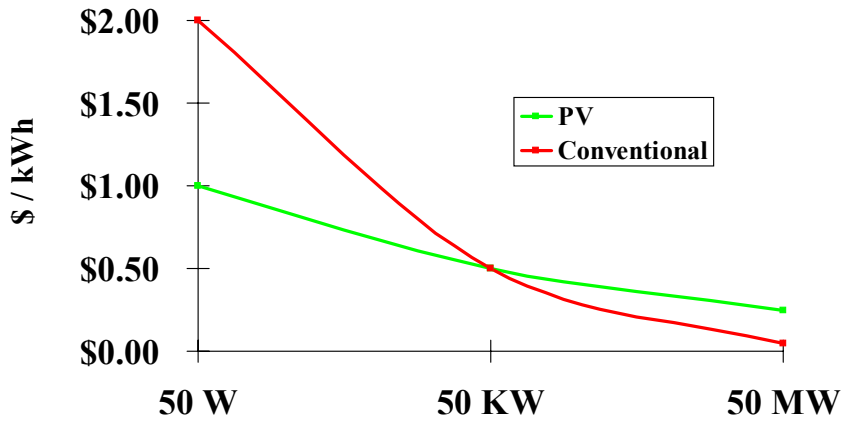
Source: Renewable Energy Outlook, DOE/EIA and Solar International Management, Inc.

Figure 1: World and U.S. PV installations

Market conditions are generally more favorable for PV outside the U.S., in two ways. First, the other OECD countries have been more progressive in the role of government in stimulating societal change in favor of renewables. Examples where governments have taken strong actions in mobilizing social change – a role that is typically taken by foundations and nonprofit organizations in the U.S. – include Japan, Germany, the Netherlands, Spain, Italy, and Switzerland, where there are incentives for the use of PV. In these countries, PV can be an acceptable economic choice for grid-based electricity with incentives from the government and strong environmental motivations on the part of the end user.

Second, the developing countries have vast areas not served by conventional grid electric service. For approximately two billion people, the economic advantages of PV electricity can be attractive. In fact, PV can be the least-cost electricity option for many of the homes,

farms, schools, clinics, small factories, and municipal buildings in rural areas of the developing countries. PV has an inherent economic advantage for smaller, off-grid applications, as illustrated in Figure 2, showing approximate cost of electricity by PV and conventional alternatives. Also of note, one of the keys facilitators of international PV market growth in the future might be the emergence of emission credit trading mechanisms. This is starting to take shape in Europe today, especially in the Netherlands, Germany, and Denmark.

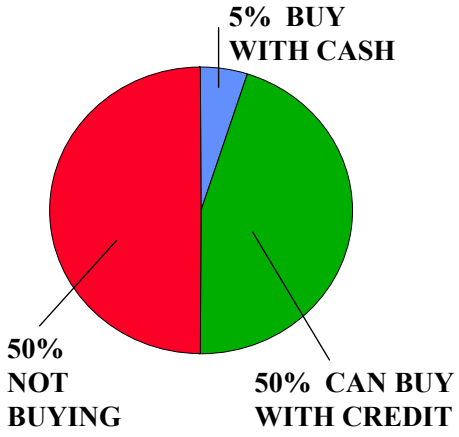


Source: Solar International Management, Inc., 2001

Figure 2: PV vs. Conventional Electricity by System Size

International Financing of PV

The 1995-2005 period is a significant time of innovation in the financing of solar PV in the international markets. It has been found that the provision of financing – credit on reasonable terms – has the effect of increasing PV demand by ten-fold, as illustrated in Figure 3.



- **Germany:**
  - 10x increase in PV demand
- **Dominican Republic:**
  - 5% can buy for cash
  - 50% can buy with credit
- **India:**
  - 5% can buy for cash
  - 50% with 1-2 year loans

Markets increase from 5% to 50% of the population if credit is available

Source: Solar International Management, Inc.

Figure 3: Financing Increases PV Markets 10-Fold

In the OECD countries, where credit is widely available, the key financial incentive tends to be low interest rates for PV loans, often some 2% to 4% below prevailing market rates. This helps improve the economics for buyers requiring financing.

In the developing countries, the key financial challenge is making credit available on a reasonable and sustainable basis in the rural areas – which are areas lacking in infrastructure, where the administration of lending can be prohibitively costly, and where repayment rates can be low. Nonetheless, due to PV's potential importance to the development of such areas, a tremendous number of organizations are now involved in PV financing, such as:

- Multilateral development banks and institutions such as the World Bank, International Finance Corporation (IFC), Global Environment Facility (GEF), InterAmerican Development Bank (IDB), and Asian Development Bank (ADB) (a summary of PV programs of the World Bank and GEF is shown in Figure 5);
- Bilateral aid agencies such as USAID, Japan's OECF, and the many European aid/donor agencies;
- The international governments, as exemplified by India, which has a Ministry of Non-Conventional Energy Resources (MNES) and the Indian Renewable Energy Development Agency (IREDA). Other countries having active government programs in PV financing include Morocco, South Africa, and China;
- Local financial institutions including banks, non-bank finance companies, and micro-credit lenders; and
- A number of solar PV finance specialists including GEF's PV Market Transformation Initiative (PV/MTI), the IFC's Solar Development Group, and the proposed SolarBank Program.

This phase of innovation in the financing of PV is going on around the world, resulting in many different models being suited to local culture, customs, and lending practices, as summarized in Figure 4.

Type	Country	Example
• Bank Lending	India	Syndicate Bank
• Microcredit lending	Sri Lanka	SEEDS
• NGO Financing	Bangladesh	Grameen
• Cooperatives	Bolivia	CRE
• Fee-for-Service	South Africa	Shell-Eskom
• Rental/ leasing	Morocco	Sunlight
• Rural energy stores	South Africa	RAPS
• Tax-driven leasing	India	Polyene

Figure 4: Innovative PV Financing in the Developing Countries

One of the key financial issues is the amount of capital required to support the likely growth rate of PV markets and industry. A preliminary analysis by Solar International Management indicates that approximately $25 billion will be required between 2000 and 2010 to support growth of the PV market and industry. Approximately $20 billion of that is required for end-user financing.

Country	Amount	Type
• Argentina	$40 million	PV concessions
• Benin	$3.3 million	PV concessions
• Cape Verde	$22.2 million	PV concessions
• China	$135 million	PV and wind
• India	$30 Million	IREDA loan
• Indonesia	$118 million	PV lending
• Loa PDR	$2.2 million	PV battery charging
• Sri Lanka	$30 million	PV financing
• Togo	$3.3 million	PV concessions
• Global	$16 million	Solar Development Group
• Global	$1.5 million	SME Program
• Global	$30 million	PV/MTI Program

Figure 5: PV Financing by the World Bank and GEF in the Developing Countries

International Incentive Mechanisms

International incentive programs take many forms, but the most successful programs tend to include low-interest loans and a high guaranteed feed-in rate.

Low-interest loans (around 2%) support the installation of PV in both Japan and Germany. Germany maintains this as the primary incentive mechanism, as the administration felt that this mechanism would be more efficient and more easily processed than a rebate program. However, a cash rebate equal in value to the interest savings is available instead of a loan, if the applicant so desires. The loan program has had some difficulties but continues to increase deployment of PV with participation increasing rapidly.

The guaranteed feed-in rate, also called a preferential tariff, requires a utility to purchase power from the PV system at a specified premium. In Japan, Germany, and Spain, this price is over twice the residential retail price of electricity and several times greater than the wholesale price. This mechanism effectively subsidizes the cost of PV through increased rates paid by other utility customers, often either after a ratepayer approval process or with some cap on the rate increase.

The preferential tariff provides an incentive for photovoltaics to produce. Durable, reliable, well-sited systems will benefit the most, while inexpensive but inferior products will not benefit as much. Long-term tariffs provide security to the investor. Reducing the preferential tariff for newer systems encourages cost reduction in a way that fixed tariffs do not. If such a system were proposed in the U.S., it would be important to consider

ratepayer perspective and to limit the potential utility rate increase needed to pay for the tariff. Note that the main difference between a production tax credit and a preferential tariff is the source of the funding. A production tax credit comes from the government's coffers and so is supported by the public through their taxes. A preferential tariff is supported by the public through their utility rates.

Australia and Japan both require the reporting of system performance data for systems receiving government rebates. Beyond the usefulness of the data provided to the government or utility, the involvement of the customer in the performance of the system could be valuable in terms of encouraging energy efficiency and maintaining the system.

The two largest PV incentive programs, Japan and Germany, both provide for reductions in subsidies to encourage and account for reductions in system cost. In Germany, the feed-in rate declines by 5% per year for systems installed after 2000. In Japan, rebates decline over time and will be phased out in 2002 or 2003.

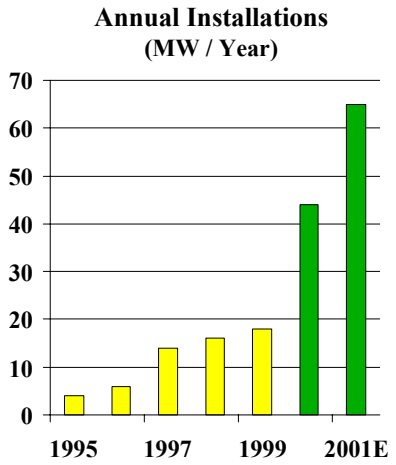
International PV Deployment Programs

Japan has employed a comprehensive national strategy, led by the government. This began as the New Sunshine Project in the early 1990s, subsequently retooled in 1996 to establish Japan as the world leader in PV. The program includes R&D support for Japanese PV companies, system installations by government agencies, and incentives for private purchases for residential rooftop and commercial applications. The program includes a direct subsidy, low-interest loans, and a preferential tariff. The residential subsidy has been reduced gradually from 50% in 1996 to about 10% in 2001. As a result of this initiative, the Japanese PV market has increased from about 5 MW in 1993 to an estimated 130 MW in 2001 (37% of the estimated world market), as shown in Figure 6. The Japanese government's goals for 2010 are remarkable in the relative proportion of PV compared to other renewables. The goals for PV are half those for cogeneration and equal to those for waste, one to two orders of magnitude above PV's typical relative position in this sort of planning.

Germany has focused on end-user incentives, allowing the supply side to emerge on a competitive basis. Germany employs a DM 0.99/kWh feed-in tariff (50¢/kWh purchase rate) for PV electricity, plus low-rate loans provided by the national development bank KfW. The German market has increased from about 5 MW in 1996 to an estimated 65 MW in 2001, as shown in Figure 7. A system benefits charge was implemented to support the guaranteed feed-in rate. The .5 mill/kWh cap on the SBC means that 1000 kWh of conventional power can support 1 kWh of PV electricity. Initial participation was below expectations, but interest in the program began to increase rapidly. The preferential tariff greatly increased the number of applications, and the 300 MW goal may be reached a year early.

In both cases, government programs were successful in creating demand for PV systems, while allowing the market to select the winning suppliers based on competitive forces.

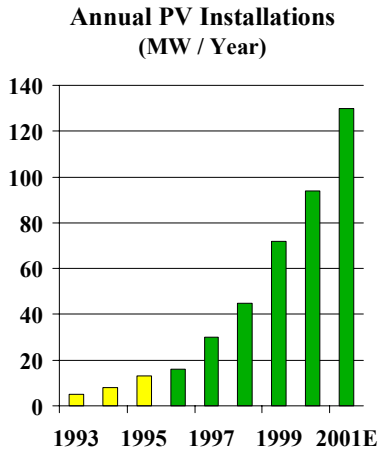
Other programs function through regional actions or a combination of national and regional actions. Spain maintains a preferential tariff on the national level, and direct subsidies of about 35% are administered on the regional level. Spain's previous efforts to increase PV production have exceeded expectations, and the current initiative sets a relatively modest goal of doubling PV capacity to 19 MW by 2010. Australian programs are administered at the state level, most commonly featuring direct rebates. These programs include a significant component of remote electrification. In February 2002, China announced a $241 million three-year plan for rural electrification using solar PV. Manufacturers have increased capacity, and the Chinese government forecasts annual growth rates of up to 30% over the next ten years.



Source: Photon, 2001

- **2010 Goals:**
  - 100,000 roofs
  - 350 MW
- **Incentives:**
  - DM 0.99 feed-in tariff
  - 2.5% interest rates
- **Results:**
  - Booming market
  - Emerging PV suppliers

Figure 6: PV Incentives in Japan



Source: PV Energy Systems, 2001

- **2010 Goals:**
  - 5,000 MW
- **Programs:**
  - End-Use subsidies
  - Low interest rates
  - Government installations
  - R&D Funding
- **Results:**
  - Growth Market
  - Strong installer base
  - World leader manufacturing

Figure 7: PV Incentives in Germany

Transferability

Individual mechanisms may be more or less applicable in the U.S. A national preferential tariff of twice the retail rate would be excessive and probably not necessary. However, a production-based incentive in some form may be appropriate. Production-based incentives

support high-value systems and encourage maintenance and care of the systems. It will be necessary to consider the relative merits of a production tax credit as compared to a preferential tariff. A preferential tariff funded by a system benefits charge is directly visible and distributes the cost of PV to those benefiting from it – the other customers of the utility. A production tax credit is less visible and distributes the cost of a PV system to all taxpayers across the country. Both approaches will find support and opposition; however, the preferential tariff approach would find greater support if using a ratepayer approval process or allocation of existing SBC funds.

A national low-interest loan program would be possible, provide effective support to the industry and marketplace, and would likely find public acceptance. Similar to the program in Germany, government funds could focus on subsidizing a low interest loan developed by the government and industry and granted by local banks, rather than providing a direct rebate.

Continued research and development funding is necessary to ensure that U.S. companies remain competitive. While the U.S. industry and academic institutions can compete on a level playing field with any in the world in terms of research, they cannot match the potential of a determined government/industry research partnership such as that in Japan. It is therefore necessary that the United States continue the research and development support that has made the U.S. a world leader in photovoltaic technology.

State-based incentive programs will be important and effective in the U.S. due to the domestic political climate and the regional markets for PV. However, some national policies and initiatives will be necessary in areas such as interconnection standards and installation certification. Collection of performance data, if determined to be of use, would certainly be most effective if funneled to a national clearinghouse such as NREL/NCPV, EIA, or EREN.

APPENDIX E: FINANCING OF PV

Financing is an important, but generally overlooked, barrier to the expansion of PV markets. Lowering the cost of financing is a critical element to increasing the market acceptance of PV because financing costs are greater for PV installations than for conventional power plants. This is due to the fact that most of the cost of a PV installation is the initial capital outlay (which generally needs to be financed), whereas fossil fuel-fired power plant can pay for fuel with operating revenues. This section will discuss the need for development of more favorable financing to stimulate consumer purchases of PV, and will outline some innovative financing strategies that can lower the cost of money for PV projects.

The Context for PV Financing

The high capital cost of PV installations means that most PV systems, especially for residential buyers, require third-party financing. To illustrate the impact of low-cost financing on the affordability of a PV system, consider the monthly payments of financing a $38,000 4-kW residential PV installation. Table 8 demonstrates affordable financing requires not only reducing the interest rate, but also lengthening the term of loan.

		Rate			
		18 percent	11 percent	8 percent	5 percent
Term	5 years	$1000	$858	$801	$746
	10 years	$725	$558	$494	$433
	20 years	$633	$433	$356	$284

Table 8: Monthly Payments for a $38,000 PV system (including cost of insurance at 1.5%/year).

The above table illustrates the large impact that two characteristics of financing – the interest rate and the term or length of financing – have on monthly payments for PV systems. For households, the highest cost financing available is a credit card with an interest rate of about 18%. More conventional financing, if available, is closer to 11%, though securing loans at this rate may involve a lengthy loan application process and generally requires that homeowners provide collateral or guarantees beyond the PV system itself.

If homeowners or commercial builders can roll the cost of the PV system into the cost of a home mortgage or building loan for commercial properties, they can secure a rate close to the cost of a mortgage – about 8% (residential rates are higher and commercial rates are somewhat lower). Even better, some state loan buy-down programs allow qualifying homeowners to secure long-term loans with 5% interest rates. The impact of rate reduction on monthly payment is large, especially as the term of loan is extended. For example, going from a 5 year, 11% loan to 10 year 5% loan cuts the monthly cost of a PV system in half.

The cost reduction due to favorable financing terms is potentially greater than can be achieved with either a 50% increase in the average efficiency of a solar panel or a 50% reduction in costs potentially available economic efficiencies gained by scaling up manufacturing output. Furthermore, the cost benefits of low interest rate-long term financing can be realized immediately, while cells with 50% higher efficiencies are probably a decade away, and large scale manufacturing plants that allow a 50% unit cost reduction are unlikely to be built in the next 5 years (Eckhart, 1999).

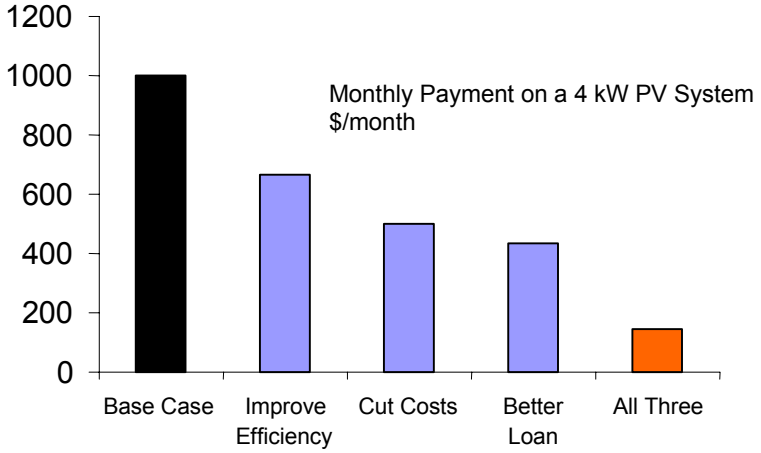


Figure 8: Impact of Improved Financing Terms vs. Other Factors on the Monthly Payment for a 4 kW residential PV system.
The base case assumes an 18%, 5 year loan, while the improved efficiency case assumes a 50% increase in module efficiency. The cutting cost case assumes that increase manufacturing volumes will reduce the cost by half. The better loan case assumes an 8% 10 year loan. (Modified from Eckhart, 1999)

Risk and Financing Terms

Interest rates and loan payback terms are largely determined by the borrowing party's perceived risk of default. The risk of default is governed by a variety of factors, including the borrower's cash flow, the collateral value of the borrower's assets and whether the borrower is backed by a third party who is willing to assume the debt if the borrower cannot meet his or her payments. Lenders tend to assume the worst case scenario about the borrowers ability to repay the loan and will therefore offer more unfavorable financing terms to unfamiliar technologies.

The key to improving financing terms is reducing the borrower's perceived risk. While the real risk of default can be decreased or eliminated through programs like loan guarantees, the borrower's perceived risk of default can also be reduced by minimizing factors which contribute to lender uncertainty.

Factors that Contribute to Lender's Uncertainty

- **Lack of Standards** – One of the factors that can help a lender reduce the perceived uncertainty is a manufacture's compliance with the industry's technical and best practices standards. Since the PV industry is immature when compared to other energy

industries, many of these technical and best practices standards do not exist at an industry-wide level. For example, no uniform standard for utility interconnection exists and the setting of these standards is often left to individual utilities. Some utilities have shown a strong reluctance to interconnect PV installations, and delays and unexpected charges can dramatically increase the cost of a project. The lack of certainty in the financial costs and time required for interconnection can make a lender reluctant to finance a PV installation. Issues where standards need to be addressed:

- Performance standards – the lender must have some assurance that the financed system's performance will meet minimum manufacturer specifications. These can be accomplished if the manufacturer's PV equipment is certified by an independent third party like Underwriter Laboratories (UL) as meeting industry standards and rated specifications.
- Installation, maintenance & inspection standards – including training and certification of installers, service and inspection personnel.
- Interconnection standards – the lender must be reasonably certain that the utility will interconnect the PV system to the grid for reasonable fees and within a reasonable timeframe.

- **Uncertainty in Future Markets** – Historic price volatility in the fossil fuel markets makes it more difficult for a borrower to assess future market viability for PV generated electricity. Exclusive markets for PV electricity can help insulate the price for PV from the rest of the electricity market. One such policy is a Renewable Portfolio Standard, which guarantees PV and other renewables a minimum share of electricity production. RPSs are currently implemented in 14 states. In order for a RPS to insure a relatively stable price for PV, tranches for different technologies must be constructed, so that PV does not have to directly compete with less costly renewable technologies like wind.

- **Lack of Collateral Value –** The perceived value of and confidence is PV system can also be increased through making PV systems more easily removed for resale, thereby increasing residual and collateral value and facilitating financing. If a system has collateral value, then firms will be more willing to finance it based on the system value itself – rather than requiring recourse to the home, for example. Higher PV system valuation will also lead to higher appraiser valuation of homes – in turn encouraging higher home resale value from the PV system. This is also important for home owners who may sell their homes in a few years and want to recoup at least part of the value of their PV investment.

Instruments to Increase Lender Confidence

Loan Guarantees

Loan guarantees insure that the lender will be repaid if the borrower defaults and the collateral value of the assets are worth less than the balance of the loan. Loan guarantees lower the cost of a loan by reducing the borrower's risk that the loan will not be repaid. Loan guarantees have the advantage that they can leverage a much larger amount of money in low-interest long-term loans. It is important that loan guarantees leave significant level of risk with the borrower to incentivize system maintenance.

Warranties

Warranties lower borrower uncertainty by guaranteeing that the PV equipment will meet minimum performance specifications. Warranties allow the manufacturer to assume product risk that would otherwise be borne by the lender. The creation of industry wide standards for warranties and their certification would encourage development of lower cost, third party financing. Warranties should be offered by manufacturers and should be extended to match the length of desired loan terms – preferable 20 years (BP provides a limited 20 year limited product warranty on its PV panels). Longer and more standardized warranties would increase PV system standardization and facilitate creation of lower cost financing and insurance products for PV systems.

Leases

Leases are an alternative to customer ownership. Like a loan, a leasing agreement allows the customer to pay a reoccurring fee to minimize or eliminate initial capital outlays. Leases can be financed by third parties in what is known a leveraged lease. In a leveraged lease, the lessor puts out a small portion of the equity and captures the tax benefits of depreciation, while the lender receives the future cash stream from the PV installation. Leases can help lower the cost of financing because the lessor can aggregate individual projects when seeking funds from the lender. Aggregation decreases transaction costs and helps mitigates the risk of default of any single project.

Insurance

In order to maintain the collateral value of a PV system, a lender usually requires that the borrower obtain an insurance policy to cover theft and damage. Because residential PV systems are uncommon, and are varied in design and configuration, insurers often do not have the data to calculate appropriate premiums, and may either charge prohibitively high premiums or refuse to insure the PV system. PV manufacturers, perhaps in partnership with insurance firms, can help overcome this problem by bundling an insurance policy on PV output (project output insurance) or perhaps residual system value - with the PV system. Several national insurance firms are looking at developing these types of insurance products for DG systems – including PV. Federal or state encouragement of this type of development across multiple manufacturers would help create the volume necessary to aggregate insurance policies and secure favorable premiums for PV systems.

Addressing Other Financing Issues

Some buyers are not fully informed of the PV system's performance characteristics and maintenance requirements, such as gradual PV performance degradation and the need to replace the inverter after about 10 years of operation. This reduces trust in PV system performance and contributes to an unwillingness of some financiers and building appraisers to attribute residual or collateral value to PV systems. This in turn makes it harder to get loans for PV systems and discourages PV purchase since owners do not see a concomitant increase in home or business valuation.

Volt Viewtech, a firm that provides PV financing in California, requires that customers sign an acknowledgement of disclosure of PV system performance and cost characteristics.

This reduces the risk of unsatisfied customers and reduces the possibility of lawsuits about misrepresentation.

Instruments to Increase Consumer Access to PV

Financial Mechanisms to Encourage Access to Low-Cost Long-Term Capital

The best source of low-cost long-term capital for the residential PV market is home mortgage financing. Mortgage financing allows the borrower the opportunity to amortize the high capital cost of a PV system over a large number of years at a relatively low interest rate. Some programs developed by Fannie Mae allow PV systems to be folded into home mortgages, though terms and availability are still limited. Fannie Mae in some areas provides unsecured mortgage loans for up to $20,000 and 20 year terms for PV systems. Federal and state support to expand these mortgage extension programs through training, buy down and other measures would allow much more widespread availability of mortgage-based financing for PV systems. An additional valuable step is to support modification of these loans to allow them to be secured (rather than unsecured) in order to provide home owners or financing parties additional tax benefits.

Incentives

The ultimate goal of any incentive program is to accelerate the market penetration and reduce the costs of a new technology to the point where incentives are no longer necessary for it to compete with established technologies. Incentive programs have greatly aided in the price reduction of other renewable technologies. The U.S. wind industry, for example, was jump-started in the early 1980's with investment tax credits. While wind generated electricity cost 40 cents per kWh in 1980, it can currently be produced for around 4 cents/kWh in areas with favorable winds – a price that is competitive with electricity produced from coal or gas fired power plant.

Valuing the Benefits of PV Generated Electricity

Incentive programs designed to increase the market penetration of PV should reflect PV's advantages (distributed generation, production profile matches peak demand) that are generally not fully valued. PV systems have several attributes that the market currently undervalues, including:

1) They produce no SO_x, NO_x, mercury, carbon dioxide, particulates or waste by-products when generating electricity.
2) They can be implemented in distributed generation configurations that help relieve grid congestion and enhance grid reliability
3) PV systems produce peak power during times of peak demand.
4) They reduce electricity price risk by locking in fixed rate long term power.

Internalizing Environmental Externalities

PV systems would be more competitive with conventional power generation technologies if those technologies prices reflected their full environmental and health costs. The U.S. government's SO_x and NO_x trading programs help place a price on these emissions and thus increase the costs of conventional technologies relative to PV. While there currently

is no national CO_2 trading program, there are a growing number of CO_2 trades and the development of more formal CO_2 trading systems, such as the Chicago Climate Exchange. The Exchange is being designed by Midwest-based utilities that represent almost 20% of the CO_2 emission in the region, along with large energy players BP, Calpine and Alliant Energy. SO_x and NO_x caps and mandated reductions can be expected to increase the price of electricity from technologies which produce these pollutants.

A number of states, such as New Jersey, are moving towards creation of statewide, four pollutant (CO_2, NO_x, SO_x and Mercury) registry programs. Use of standardized systems design and measurement and verification would help these statewide programs more full recognize and monetize the full emissions benefits associated with PV investments.

Following are some policy steps that Federal and state agencies have taken or can take to develop consumer markets for PV.

Renewable Portfolio Standards

A renewable portfolio standard (RPS) is a policy mechanism that encourages the development of renewable energy sources by mandating that electricity generators produce a certain percentage of their annual output from renewable sources. Fourteen states currently have an RPS and all of them mandate that the percentage of electricity derived from renewable sources must increase over time. There is currently no national RPS, although there are currently four RPS proposals before Congress. A national RPS would likely include a renewable energy credit (REC) trading program so that electricity distributors could buy credits on the open market from producers.

The system encourages competition among renewable energy producers because credits can be bought from the cheapest source. It is estimated that a national RPS that mandated 3 percent renewables in 2005 and 4 percent in 2010 would only add $0.10 - $0.20 per month to the average residential electricity bill of 500 kWh (EIA 2001). PV would benefit from an RPS which guaranteed PV a fraction of the total mandate, a feature in some states such as Arizona. Such a system would provide PV with predictable market that would encourage investment and help reduce lender uncertainty that increases financing costs.

Government PV Purchases

The Federal agency responsible for coordinating energy upgrades at Federal facilities, FEMP (Federal Energy Management Program) encourages agency inclusion of PV funding as part of energy efficiency upgrades. FEMP provides technical support and a small amount of funding for PV projects at Federal facilities. However, neither FEMP nor Federal agencies quantify or explicitly value the benefits that PV offers in terms of increased reliability of power, health or environmental benefits. Given the heightened concern over security and power reliability, Federal agencies should look closely at identifying critical load that can be partially met with on-site PV generation. The value of critical load in terms of maintaining communication and other essential services is large and PV can play an essential role in an on-site generation capability that would allow critical functions to continue even when power grids are down – whether from accidents or acts of terrorism.

Federal agencies now generally buy PV as part of a bid process from energy service companies as a small part of a larger energy efficiency retrofit bid (ESPCs). It makes sense for agencies to collectively pool demand for PV and seek bids directly from PV firms - rather than from energy efficiency firms. The larger volume purchases and installations would allow lower unit prices. For the tens of thousands of hotel and lodging rooms on Federal lands, guests may be willing to pay a small premium to use green power – from PV and other sources that could offset the additional price of PV systems. Such a PV offer would also afford a very good education message about the environmental impact of power generation consistent with park educational objectives.

Another model for competitive bidding is to purchase power from renewable sources rather than equipment. This concept was implemented in the UK's Non-Fossil Fuel Obligation (NFFO), which ran a series of auctions in which vendors of the same type of renewable energy technology bid for contracts to deliver power from newly constructed facilities at bid price for a fixed number of years. Later auctions extended the purchase period from 7 years to 15 years, which reduced the cost of financing for the projects. The competitive nature of the NFFO auctions had a significant impact in reducing the price paid for electricity from wind was reduced from over 18 cents/kWh in the 1991 auction to under 5 cents/kWh in the 1998 auction.

Systems Benefit Charges

A systems benefit charge (SBC) is an access charge levied on all consumers of grid-connected electricity. SBCs have traditionally been used to fund low-income energy bill payment assistance, weatherization programs, energy efficiency incentives, and energy technology development. Recently, 15 states have instituted SBCs in order to promote renewable energy and ease the transition to deregulated electricity markets. For example, California's SBC will fund $135 million/year through 2012 for solar and other forms of renewable energy.

Because electricity is such a large commodity in the U.S., even a small SBC for supporting PV and other renewable energy would generate substantial revenues. For example, a national SBC of 0.1¢/kWh would generate an estimated $3 billion per year (DOE 1998).

Rebates

SBCs often provide funding for rebates that defray the high capital costs of PV installation. Rebates provide a straightforward mechanism for expanding PV markets because the programs are easy to administer and the owner receives an immediate financial benefit. Several states have instituted rebate programs. For example, New Jersey provides a fixed subsidy for PV installations of $5000/kW for systems <10 kW, $4000/kW for systems >10 kW and <100 kW and $3000/kW for systems >100 kW or 60% of installed costs (which ever is lower). The California Emerging Renewable Rebate and the California Self-Generation Program will fund $4500/kW or 50% of the installed cost, whichever is less. The systems must be grid-connected to be eligible. In Illinois, the state Renewable Energy Resources Program offers $6000/kW or 60% of the installed costs for PV with caps of $5,000 for systems of less than 2 kW, and $300,000 for systems of more than 2 kW.

State rebate programs should be based on long term predictable commitments of funding to specific technologies. This stability allows capacity to increase and avoids the situation in California and New Jersey where limited supply of renewables (including PV) means that the large rebates programs are not very cost-effective.

Utility Incentives and Programs

Net Metering

Net metering, or the process of charging a consumer only for the net power consumed from the grid, is one way to promote distributed power generation by allowing small power producers to sell their excess electricity to the utility at the retail rate. Net metering helps lower the costs of PV systems by allowing them to operate at higher capacities, and would have its most significant impact on the costs of small home installations where retail rates are the highest. So far, net metering has been instituted in thirty two states, but it has not been the driver for expanding PV markets that its advocates have hoped. This is due to the fact that institutional barriers and lack of grid interconnection standards has prevented the creation of net metering agreements between utilities and customers. A Federal law that allowed customers to net meter systems up to 100 kW, and also required simple standard interconnection agreements would make PV a much more viable technology for the residential power market.

Real Time Pricing and Time-of-Use Rates

Real time pricing and time-of-use rates charge the consumer different prices for electricity during periods of peak demand and off-peak periods. The difference between the two pricing schemes is that where time-of-use rates generally divide a day into 2 to 4 periods with different set electricity prices, real-time pricing is determined by current market price of electricity. The price differential between off-peak and on-peak demand can be substantial. For example, the Wisconsin Public Service Corporation offers time of use rates where on-peak demand is 12.4 cents/kWh and off-peak demand is 3.05 cents/kWh. Because PV generates most of its electricity during on-peak hours, a customer with real time pricing or time-of-use rates can displace higher priced electricity with the PV system, while using cheap grid electricity to meet his off-peak demands.

Green Pricing

Green pricing is a mechanism that allows consumers the option of paying a premium for electricity that is generated by renewable energy technologies. Even if only a small percentage of customers opt for green power, it has the potential to significantly increase the market for these technologies. Customers are often given the option of buying a percentage of their electricity from green sources. For example, PG&E's Clean Choice 20 plan, which guarantees 20% of the energy provided is derived from renewables, adds 0.17¢/kWh to the consumer's bill plus a $2.95/month fixed fee.

Supporting Green Power Marketers

An important and fast growing category of buyers of PV electricity are green power marketers, who purchase wholesale electricity generation from renewable energy sources and market this "green power" at a premium to residential, commercial and public clients. From only a few examples in 1995, there are now about 100 green power products supporting 450 MW in existing and planned renewables nationwide. The Center for Resource Solutions has projected that demand for green capacity from green power marketers will reach 960 MW by 2005. Green power marketers typically include PV (even just one or several percent) as part of their green power offering, despite its substantially higher price. Each percent of green power would add about 10MW of PV, roughly equal to half the new PV installation in the U.S. in 2000.

Several ways to strengthen green power include:

1). Green-e (www.green-e.org) is the consensus standard and very credible and well structured. Critically, by providing a consensus definition of what green power is in a way that reflects regional differences, it creates credibility about green power, which is essential to creating consumer confidence. Federal government, when buying green power, should buy only Green-e certified green power. This will avoid providing Federal support for unaccountable, competing and confusing claims about what constitutes green power and well help ensure credibility and integrity of green power products. By defining green power as a distinct product with distinct attributes, Green-e also makes it easier for agencies to specify purchase of green power and to seek competitive pricing specifically for a green power project.

2) The ability of green power marketers to purchase new renewable energy, including PV, is constrained because green power marketers must enter into long term, (e.g. 10 year) purchase power agreements to buy new sources of green power, but their contracts with clients are only for one to two years. To address this problem the US DOE in 1999 and 2000 worked with a range of corporate and insurance partners to develop a proposal involving Federal/state support for development of private insurance to cover a portion of the green premium (the extra amount charged for green power) to allow green power marketers to secure long term contracts for new green power. The *Financial Times,* in a review of the proposal, described it as "remarkably high leverage". Each $10 million in Federal /state support is projected to leverage about 300 MW of new green power investment – of which some small but significant amount would be expected to be PV. The proposal was also favorably reviewed in a detailed study by the former head of planning for FERC in the Reagan Administration. (See: www.repp.org/articles/means/means.pdf) This initiative should be reexamined and perhaps re-launched by DOE and states.

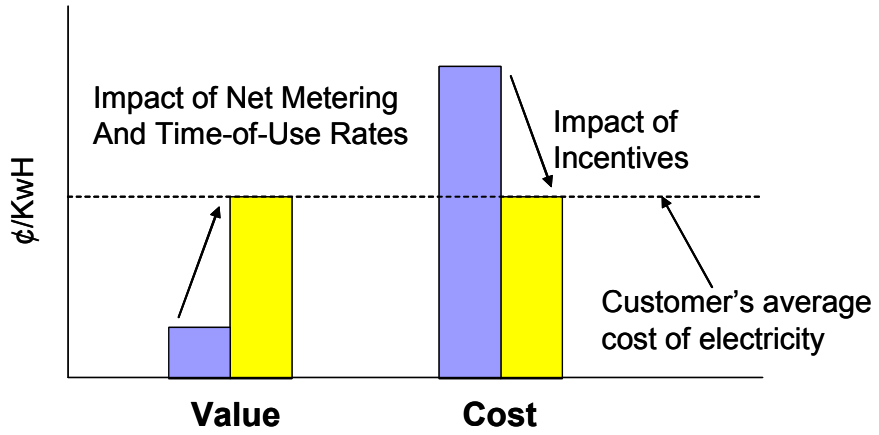


Figure 9: Increasing PV value Proposition by increasing value and lowering costs. (Modified from Eckhart, 1999)

Standardization of Measurement and Verification of PV Systems

An initiative to overcome similar barriers to energy efficiency financing offers a valuable model to cut transactions costs, financing costs and facilitate pooled financing for PV projects. The initiative, called the International Performance Measurement and Verification Protocol (www.ipmvp.org) developed a consensus protocol establishing consistent methodologies, language and approaches for installing measuring and verifying energy efficiency. Initiated in 1996, it is now the U.S. standard, and has helped cut project transactions costs, allow pooled project financing and resulted in more flexible and lower cost financing for several billion dollars of projects.

Substantial project analysis demonstrates that energy efficiency projects conducted using rigorous standard measurement and verification (M&V) practices have significantly higher and more reliable savings than projects without. (Kats et al.) The consistency, higher reliability, persistence of savings all allow lower cost, more flexible forms of financing and facilitate financing of pooled projects – particularly important for PV systems which are generally large in number and small in size.

The need for a standardized consensus M&V approach to improve project financing, especially for smaller PV systems, is likely to increase for two major reasons:

1. Emissions reductions (e.g., CO_2 and NO_x) are becoming more important and more valuable. Being able to measure and demonstrate exact power production through a standard accepted M&V approach would help system owners secure the financial value associated with the reduced emissions from PV.
2. PV projects are often most cost-effective when integrated with energy efficiency (e.g., for building retrofits). An expanded and widely adopted M&V protocol developed as an integrated part of the MVP would provide a common approach to integrating, developing and financing mixed efficiency and PV projects.

DOE should expand support for the IPMVP process, especially focusing on building up and promoting and adopting the IPMVP work on integrating renewable – including PV – with energy efficiency upgrades.

Tax Incentives

Commercial firms which invest in or purchase qualified solar energy property can claim a 10% tax credit. However, residential customers are generally not eligible for this credit. Because the investment tax credit can only be realized if the firm is profitable, it is less useful than a rebate. Several proposals have advocated allowing unprofitable firms to sell their investment tax credit to firms which can exercise the credit.

Production tax credits have not been extensively used for PV, but a production tax credit of 1.5 cents/kWh (inflation adjusted) is credited with expanding the markets for wind in the United States. A production tax credit has the benefit of rewarding systems based on performance rather than in dollars invested in the system would have substantial value in promoting PV installation.

Specific Incentives and Initiatives Developed by Lenders and Government Agencies

Off-Grid/Mini-Grid Applications

- Major market for PV
- Includes: remote cabins, vacation homes, village power, military and navigation, remote industrial:
    - Navigation and remote industrial have fully developed PV markets
    - Remote residential is a primary market. Several investment programs available[42]
- Fannie Mae runs a Residential Energy Efficiency Improvement Loan program to provide below-market interest rates for PV (and other), including grid-independent, systems. Energy loans up to $15,000, 10-year term.
- Freddie Mac provides low interest short and long-term mortgages (up to 10% above base loan) to individuals who install PV (including grid-independent systems)
- The U.S. Department of Veteran Affairs instituted a loan program that enables veterans to increase their loans by up to $3,000 for energy efficiency (including PV) improvements and by up to $6,000 if the increase in mortgage payment is offset by the expected reduction in utility costs.
- Agricultural applications for power for water pumping, fence electrification, monitoring, and lighting for farms.
    - The U.S. Department of Agriculture, Rural Business-Cooperative Service offers a Rural Economic Development Loan Program that provides zero-interest loans to rural utilities service borrowers to promote rural economic development.
    - The Small Business Administration administers an energy loan program that makes or guarantees loans to assist small businesses who want to install energy saving devices in designing, manufacturing, installing, servicing energy devices, including PV. End users can finance energy measures by obtaining small business loans.

[42] *The Borrower's Guide to Financing Solar Energy Systems A Federal Overview*, Department of Energy

Grid-Connected Applications

- For new homes, residential retrofits, large commercial purchases, government procurement, utility installations, and others.
- The Fannie Mae, Freddie Mac, Department of Veteran Affairs, and Small Business Administration loan programs and products are available for grid-connected applications as well as off-grid applications.
- Federal buildings that use PV can utilize the services of ESCOs who would install the equipment, at their cost, under performance agreements.
- HUD FHA mortgages can exceed their normal loan amounts by up to 20% if energy efficient systems (soon to include use of PV) are installed on homes owned by low income occupants.
- Several lenders are offering Energy Star mortgages that involve special underwriting guidelines that allow home buyers to purchase homes with mortgages 10% to 24% higher than they would have qualified for if the homes were not Energy Star rated. In addition, several Energy Star lenders offer cash discounts at closing that cut closing costs almost in half while offering competitive interest rates.

The Federal programs mentioned above allow borrowers to increase their lending power and, in some cases, reduce their mortgage interest rates.

State Initiatives[43]

A variety of incentives are offered by states for manufacture or purchase of wind energy systems (many apply equally to PV). The types of financial incentives offered include:

- **Revolving loan funds** to provide zero or low loans to local utilities, local governments or IPPs for the development and upgrade of electric power facilities (e.g., AK, Iowa) and for equipment manufacturers (AZ). Wind and PV are included in some of the "upgrade" definitions.
- **Retail sales tax exemptions** for wind systems installation (e.g., AZ, Iowa).
- **Income tax credit** (usually stated as a percentage of the equipment cost up to a ceiling level) (e.g., AZ)
- **Credit against personal tax** (usually stated as a percentage of the equipment cost up to a ceiling). (e.g., AZ, ID)
- **Corporate income tax credits** allowing expenditures on renewables from their taxable incomes (e.g., MA). Some states provide **franchise tax exemptions** that allow manufacturers or purchasers of renewable energy systems to deduct the cost of the systems (e.g., TX)
- **Low interest commercial loans** for demonstration or commercial use of equipment (e.g., CA, ID). In some cases, the intent is to provide loans that can be repaid from energy savings from installing the systems (e.g., IA)
- **Low interest consumer loans** support residential installation of PV. Energy Finance Solutions, a nonprofit organization energy services company, has teamed up with NYSERDA's interest rate buy down program to offer 5% loans of up to $20,000 for PV

[43] *Inventory of State Incentives for Wind Energy in the U.S., a State By State Survey*, American Wind Energy Association, March 12, 2001, with additions.

systems with terms ranging from 3 to 10 years. The loans do not require collateral and can finance up to 100% of the installation cost of a PV system.

- **Customer credit** for the purchase of green power (usually defined in terms of cents/kWh of green power purchased up to a ceiling) (e.g., MI)
- **Production tax credits** providing credit against state income or corporate taxes based upon electricity produced from the systems (e.g., MN)
- **Rebates or buy-downs** for the purchase of renewable energy (usually using systems benefits charges collected) (e.g., CA, IL)
- **Property tax exemptions** for use of renewables (e.g., CT, IN, MN). Some states offering this allow renewable energy systems to be valued at no more than the value of a conventional system.
- **Green power rates** higher than standard electric power rates (e.g., MI)
- **Accelerated depreciation** for purchasers of renewable energy systems (e.g., MN)
- **Full cost accounting of environmental externalities** (e.g., MN)
- **Consumer aggregation** that allows consumers to aggregate their green power purchases (e.g., VA).

Federal Financial Interventions in the Energy Transformation and End-Use Markets[44]

Three broad categories of energy programs: direct subsidies (i.e., direct payments from the Federal Government to producers or consumers or by tax expenditures that reduce the liability of persons or corporations undertaking certain actions):

- Direct payments under Department of Health and Human Services' Low Income Home Energy Assistance Program
- Direct payment under two DOE programs
  - The Weatherization Program
  - State Energy Program
- Tax programs
  - Exclusion of interest on energy facility bonds from Federal taxation
  - Exclusion of conservation subsidies provided by public utilities from the taxable income of the recipients
  - Tax credits and deductions for clean-fuel, alternative-fuel, and electric vehicles

Indirect subsidies

Indirect subsidies include: the provisions of energy services or energy at below market prices; loans or loan guarantees; insurance services; and research and development activities. Some indirect subsidies that are not considered in the EIA report include:

- Accelerated depreciation of machinery and equipment (not considered a subsidy because many industries are provided with this tax break)
- Deferred taxes (temporary differences arising from Federal income tax accounting and financial accounting treatment of a property item (also applied widely to many other industries)

[44] *Federal Financial Interventions and Subsidies in Energy markets 1999: Energy Transformation and End Use*, EIA, May 2000.

- Exemption from Federal income tax (municipal electric utilities, rural electric cooperatives, PMAs and TVA)
- Lower capital costs for municipal utilities because they acquire their capital through tax-exempt bonds.

Electricity support involves providing preferential treatment to TVA, BPA, and the other PMAs and Federal facilities to produce large quantities of power for producing low cost electricity.

Low Income Energy Assistance Program – annual grants (over $1 billion per year) provided by the Federal government to states, Indian tribal organizations and others to provide home energy assistance for needy households. National average benefit in 1996 for the more than 4.3 million recipients who received heating assistance, over 100,000 who received cooling assistance, 31,000 households who received summer crisis aid and 59,000 households who received weatherization assistance amounted to $180.

Weatherization program – DOE provides approximately $1,700-2,000 in grants for each of about 77,000 low income homes for installation of energy conserving devices and materials.

State Energy Program – grants from DOE to promote innovative state energy efficiency and renewable energy activities. About $37 million was appropriated in FY 2000 for the program.

Preferential Tax Treatment

- Exclusion from gross income of interest on private activity bonds issued by state or local governments to finance certain energy facilities (e.g., efficient heating or cooling systems), often built by investor-owned utilities, from Federal taxation. This incentive has been used both to reduce energy usage during peak-demand periods and for load management by acquiring more efficient energy appliances.
- Federal tax exemption for subsidies provided by public utilities to non-business consumers to reduce the costs of energy conservation measures.
- Tax credit for purchases of electric, clean fuels and alternative fueled vehicles. This was coupled with mandates that certain vehicle fleets gradually acquire and use such vehicles. Tax credits of 10% (up to $4,000) were provided for purchase of qualified electric vehicles and hybrid electric vehicles. EPACT provided Federal income tax deductions for clean-fueled vehicles that ranged from $2,000 for automobiles, small vans and pick-up trucks to $50,000 for buses with a seating capacity of more than 20 adults and trucks and vans with gross vehicle weight more than 26,000 pounds.

Federal Policies Affecting Power Costs and Pricing

- PMA electricity is required to be sold at the lowest possible rates consistent with sound business principles (typically less than the cost of alternative supplies). This hurts any competitive advantages that PV, and other options, may have in the PMA service areas.
- Federal utilities have been able to borrow funds at interest rates below prevailing Treasury rates. Their creditworthiness is enhanced by an implicit Federal guarantee

that they will not default on their borrowings. Rural electric cooperatives are eligible for low interest long-term loans from the Federal government.

Mandates

- FEMP – EPACT required each agency to achieve levels of energy consumption reductions by given dates (e.g., 20% reduction in Btu per gross square foot by fiscal year 2000). Executive Order 13123 encouraged efficient energy management at Federal facilities, setting goals including the following:
    - Through life-cycle cost-effective energy measures, each agency shall reduce its greenhouse gas emissions attributed to facility energy use by 30% by 2010, compared to 1990 emissions levels.
    - Each agency shall reduce energy consumption by 30% by 2005 and 35% by 2010 relative to 1985.
    - Each agency shall try to expand the use of renewable energy within its facilities and in its activities by implementing renewable energy projects and by purchasing electricity from renewable energy sources. In support of the Million Solar Roofs initiative, the Federal government shall strive to install 2,000 solar energy systems at Federal facilities by the end of 2000 and 20,000 by 2010.
- Appliance standards
- Building codes
- Guidelines

Federal Financial Interventions in the Primary Energy Markets[45]

Three principal forms of Federal energy subsidies exist:

- Direct payments to consumers or producers including: (a) payments from the government directly to producers or consumers and (b) tax expenditures.
- Tax expenditures – provisions in the tax code that reduce tax liability of firms or individuals who take specified actions that affect energy production, consumption, or conservation in ways deemed to be in the public interest.
- Research and development

Tax Expenditures

Tax expenditures are reductions in government revenues resulting from preferential tax treatment for particular taxpayers. These include the following tax credits:

- Credit on the production of alternative fuels, primarily gas from coal bed methane and tight sands. Section 29 of the Internal Revenue Code provided tax credits for nonconventional fuels production between January 1, 1980 and December 31, 1992 and sold through the year 2002. The amount of credit was dependent upon the market price of oil.
- Credit for enhanced oil production. Section 43 of the Internal Revenue Code provides an EOR credit of 15% of their qualified EOR costs. The credit is phased out if oil prices exceed $28/barrel.
- Credit on the production of alcohol fuels. The production credit for alcohol fuels is the only income tax expenditure for which there is also a preferential excise tax, in the

[45] *Federal Financial Interventions and Subsidies in Energy Markets 1999: Primary Energy*, EIA, September 1999.

form of an exemption. Motor fuels containing at least 10% alcohol are exempt from 6 cents of the per gallon Federal excise tax on gasoline, diesel fuel, and other motor fuels. The income tax credit (provided to producers of alcohol fuels – distributors who blend the alcohol and motor fuels) is 60 cents per gallon for alcohol used as a motor fuel and can be taken in lieu of the excise tax exemption. A new Federal income tax credit of an extra 10 cents per gallon is available to eligible small producers of ethanol.

- Credit on the use of new technology (i.e., solar and geothermal). The Energy Tax Act of 1978 established a 10% investment tax credit for PV and a 15% energy tax credit added to an existing 10% investment tax credit for solar thermal and wind systems. The tax reform Act of 1986 eliminated the 10% investment tax credit and extended to 1988, but reduced to 10% and eliminated wind, the energy tax credit. EPACT made the 10% business credit for solar (PV and thermal) and geothermal permanent. It also provided a credit of 1.5 cents/kWh for electricity produced from renewable resources.

Income-Reducing Measures

- Excess of percentage over cost depletion. Only energy-related tax expenditure that reduces taxable income. Entitles some oil, gas and royalty owners of some other natural resources the right to take percentage depletion deductions rather than cost depletion deductions to recover their capital investments. Under cost depletion, the annual deduction is equal to the reduction in the remaining value of the resource that results from the current year's annual production. Under percentage depletion, taxpayers deduct a percentage of gross income from resource production at rates of 10% for coal, 15% for oil and gas and 22% for uranium. Other stipulations apply.

Trust Funds and Energy Excise Taxes

- Mechanisms for internalizing some of the social costs of energy production and consumption. The government imposes a tax on an industry and then assumes some of the liability, often related to environment, health and safety.
- This category of subsidy includes: Leaking Underground Storage Tank Trust Fund, Oil Spill Liability Trust Fund, Nuclear Waste Fund, Abandoned Mine Reclamation Fund, Black Lung Disability Fund and others.

APPENDIX F: SOLAR PV COMMUNITY POLL – SUMMARY OF PERSPECTIVES

A total of twelve (12) communities spanning from New Jersey to Hawaii, all of which are participants of the Million Solar Roof Program, contributed to the Solar PV Community Poll their perspectives on the many factors that affect the constituent's and stakeholders acceptance of Solar PV within their community and the effectiveness in penetrating the consumer market. A listing of the communities and the points of contact are summarized in the last Section.

The following summarizes the various perspectives from the participants of the Solar PV Community Poll:

Description of Solar Program (PV) in the Community

Solar PV programs within the various communities are tailored to fit the state's initiatives for the Utilities (Renewable Portfolio Standard, Public Benefits Fund), the market within the community (individual consumers, builders, public buildings), available financial instruments for funding Solar PV construction (utility rebates, state tax credit, consumer buy-downs), and avenues for education (Internet websites, information clearinghouse).

The program elements serve multiple functions:

- Administering rebates for Solar PV installations from funds collected from Public Benefits Programs;
- Public awareness, education, and training on the benefits of Solar PV;
- Formation of cooperatives and coalitions of municipal Utilities, builders, and architects for implementation of Solar PV.

Factors Affecting Community Acceptance of Solar PV

Maturity of Solar Technology Development

In general, the amorphous and crystalline solar PV technologies are matured and available to the community on a limited scale. The ancillary equipment such as inverters, however, is not durable or reliable and requires more development. Also requiring optimization is the overall manufacturing technology for producing large-scale Solar PV panels.

Other technologies such as thin film application require more development before large-scale commercialization.

Market Penetration Barriers

There are many barriers preventing large-scale acceptance of Solar PV:

- Lack of financing instruments for consumer purchase
- Lack of public education and awareness of Solar PV benefits
- Lack of training of building inspectors
- Lack of national standards for certification of Solar PV performance and benefits

- Lack of a national net-metering policy
- High capital investment for equipment
- Lack of understanding regarding return-on-investment

Current and Future State Policy and Regulation

Two important initiatives implemented at the state level that favors consumer adoption of Solar PV technology are 1) Renewable Portfolio Standard for the Utilities, and 2) tax credit for the purchase of Solar PV equipment.

Utilities' Role, Acceptance, and Provision of Supporting Infrastructure

In general, Utilities serve as the intermediary conduit for the installation of Solar PV at the consumer level. As the implementer of the Renewable Portfolio Standard, the utilities establish and collect funds for equipment rebate through Public Benefit Fund surcharges. The Utilities also establishes local net metering and interconnection standards.

In some communities, Utilities administer the sale of Solar PV equipment and recommend certified field technicians for installation and maintenance of Solar PV at their consumer's site.

Community Awareness of Solar Program

The Community Poll indicates that community awareness can always be improved with more public seminars, training, and education.

Financing Options and Incentives

Current financing options and incentives are:

- State tax credit for equipment capitalization
- Utility rebate programs
- Loan interest loans for renewable energy equipment

The cost of Solar PV ranges from $6000 - $20,000 per kW installed.

Suggested Actions for the Federal Government to Support the Community Program

The Federal government can help by creating a "National Certification of Standards", which should include a) licensing certification for PV electricians, b) national testing standards implemented for every state, and c) local level certification of building inspectors. Another key role for the Federal Government is to create a national net-metering law for utilities so that there is a uniform standard for pricing.

A Federal Tax Credit program needs to be adopted for the consumers and developers embracing Solar PV. The Federal government should provide a national standard for training solar installers and building inspectors. Applied RD&D rather than fundamental or basic RD&D, such as a demonstration program on a community scale illustrating how all factors from regulations to financing incentives affect PV, can help the community understand, implement, and use Solar PV.

The following summarizes various Federal Government action items outlined by the community stakeholders:

- Implement a Federal Residential Tax Credit (15%);
- Marshal the lending and financing institutions to provide low-interest loans for Solar PV(e.g., a revolving loan fund);
- Institute a systematic certification process to provide a "Consumer Reports" for solar technology;
- Continue the MSR program and provide real, demonstrable incentives on a community scale;
- Provide a program to educate building inspectors, public officials, and other stakeholders of Solar PV;
- Adopt a National Net Metering Policy;
- Develop programs to fund real-time performance feedback (like TEAM-UP did);
- Install PV systems on military housing and other Federal facilities to increase the visibility of the technologies; facilitate municipal installations such as solar-powered bus stops would also accomplish this goal;
- Have DOE sponsor workshops to address technical and policy issues and fill the role of information provider in some cases;
- Provide region-specific information and recognize regional characteristics; in the mid-Atlantic and Northeast, load is driven by AC, which increases the value proposition of PV (since it is peak-producing).

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APPENDIX G: ASSESSMENTS BY BROKERAGE HOUSES

Most of the large investment brokerage houses have completed analysis of the electric power sector, and some on renewable energy and PV, providing insights of value to the PV industry to determine the potential for investor interest in the technology. The following summarizes the current views of some of them and provides insights on the implications of their views on investment in PV. In general, the brokerage houses from which analyses could be obtained believe:

- The potential of PV is great as a result of increased interest in power reliability, quality, and cleanliness and improvements in PV cost
- The risks associated with PV are high, especially the ability to further reduce capital and power costs significantly before government subsidies begin to disappear
- The PV industry must demonstrate continued progress in increasing sales, reducing costs, and maintaining government subsidies.

Salomon Smith Barney[46]

Salomon Smith Barney is bullish on distributed generation, especially those companies that have adequate cash reserves to cover their expenses for the next several years and those that have commercial revenues. PV does not fit into Salomon's "winners" lists, except possibly for the longer term (beyond 5 years).

The financial markets have significantly punished the group of companies in this sector (including companies that supply the following technologies: fuel cells, hydrogen conversion, superconductors, flywheels, microturbines, power reliability, reciprocating/diesel engines, and PV systems). Salomon's views on the reasons for investor souring include:

- Concerns over reduced electricity prices (and introduction of wholesale price caps) and potential oversupply of electricity (and lack of expected blackouts)
- Negative effects of the economic downturn on industries that require power quality and reliability (i.e., server farms, internet companies, data storage), the principal drivers for distributed generation
- Revised product delivery dates and commercialization timelines of some companies in the sector concerning investors that these, and other companies in the sector, may not have the cash reserves to survive the delays
- Announcements of lower earnings estimates by companies in the sector raising fears about the longer-term viability of the industry.

All of these concerns are raising flags among investors that this sector could follow the path of the high tech sector. As a result, the Salomon Smith Barney has increased the discount rates for companies in the sector, like the PV industry, that have early commercial products today and are expected to lose money for the foreseeable future to around 20% from previous 15%-18% assumption. This is due to risk associated with: (a) an uncertain economy, (b) funding risks, and (c) the timing of profitability and long-term free cash flow.

[46] *Power Technology and the Cash Burn Conundrum*, David B. Smith, Salomon Smith Barney, September 28, 2001.

However, Salomon Smith Barney is optimistic about the future for distributed generation and the companies that service the DG market, especially those companies that have significant cash balances, low cash burn rates, commercial revenues and near-term profitability. The reasons for its optimism include:

- The primary near-term benefits of the DG technologies, improved power quality and reliability, remain critically important and growing concerns of many electricity consumers;
- The economics of DG technologies are improving, in terms of capital costs of DG equipment and lower natural gas prices (the latter being a negative for PV);
- Improvements in the economy that will increase the overall demand for electricity, and increase demand for DG systems; and
- Low capacity reserve margins.

Lehman Brothers[47]

Lehman has not analyzed renewables or PV markets. However, they have completed an in-depth analysis of the U.S. electric power markets. Although it does not discuss renewable energy or distributed generation, it provides some insights that may be valuable in developing a PV strategy.

Lehman is of the opinion that, as a result of stiff competition among many entrants in the electric power sector, electricity costs will decline. Existing coal and nuclear capacity will continue to dominate, especially because of the low cost of electricity from these plants. Turbine availability is not an issue beyond 2004. However, the major issues associated with new plants are: (1) lack of suitable sites, and (2) availability of skilled labor to build the plants. As a result of these issues and an increasing proliferation of new power plant proposals, the capital cost of new greenfield construction for baseload capacity has risen to $550-$700/kW from about $500/kW and for peaking generation to $300-$500/kW from $250/kW.

Lehman has projected new electric power capacity additions through 2009. They project that a total of 385,000MW of new capacity will be installed of which 93% (358,000 MW) will be gas-based and 2.7% (10,000 MW) will be renewables. The mix of renewables was not analyzed.

Lehman estimates that reserve margins will stay above 20% through 2006. However, several NERC regions are projected to have reserve margins well below 20%. (These regions with low reserve margins should be among the best regions for distributed generation and therefore PV because electricity availability and reliability issues should be more prominent there). For example, the following reserve margins are projected for 2006:

- SERC – 19%
- FRCC – 18%
- MAPP – 10%
- SPP – 11%
- WSCC – 13%

[47] *More Than You Wanted To Know, The Generation Market is Down, but Not Out*, Daniel Ford and Po Cheng, Lehman Brothers Global Equity Research, November 28, 2001.

Lehman has also projected U.S. power prices by NERC region through 2006. In all but the MAPP region, Lehman estimates that power prices will decline by 10%-20% by 2006 for base load, mid-merit and peak power production. In the MAPP region, currently the lowest price region, prices are projected more than double for baseload and mid-merit power, and rise more than 30% for peak power. Lehman also ran sensitivity cases for increases and decreases in GDP forecasts, changes in gas prices, and changes in new capacity that actually gets installed. If Lehman's projections are accurate, it can be concluded that PV will come under even more price pressure in the future.

Finally, Lehman identified serious constraints with the U.S. electric power grid system that will add costs and uncertainties about electricity deliverability (which could lead one to conclude that distributed generation should play an important role in relieving the constraints). First, the 3 main U.S. interconnects, the Eastern, Western and Texas interconnects effectively operate as independent systems. In addition, constraints exist within the interconnects. These include: (1) pancaked rates, which require transactions to incur multiple charges (ranging from $2-$7/MWh per system and $11-$12/MWh total above the cost of generation. This represents ¼ to almost ½ of the peak and baseload economics that Lehman forecasts assuming gas prices of $3.00/Mcf) as they pass across the transportation grid, (2) loop flow constraints which lead to uncompensated costs and reliability issues, and (3) poor congestion management, which can result in curtailment of load or rerouting of transactions to more costly paths as well as reliability problems.

Deutsche Banc Alex. Brown[48]

Deutsche Bank is of the opinion that alternative power technologies will not challenge the dominance of traditional generation before 2010, at the earliest. However, it believes that they will fill niche roles, providing 55-75 GW of capacity in 2005 (2%-2.5% of global installed capacity). Wind and biomass already are filling niche roles and microturbines, fuel cells and solar PV will follow in that order. Deutsche Bank is of the opinion that all of the technologies remain noncompetitive without significant government subsidies. Deutsche Bank considers solar PV to be economical today only for remote power, portable, and off-grid applications. However, on-grid rooftop PV applications are growing dramatically.

Deutsche Bank identifies positive attributes of solar power to include: (1) fuel free, (2) zero emissions, (3) low O&M costs and (4) its distributed generation qualities, especially for on-grid rooftop applications. However, it views as negatives: (1) its high cost, (2) intermittence, (3) need for interconnection standards, and (4) geographic variation.

Prime among Deutsche's concerns with PV is its high capital cost. It estimates its current capital cost to be $10,000/kW, resulting in levelized power costs of $472/MWh for low latitudes and $901/MWh for high latitudes. As shown in Figure 2, Deutsche Bank's estimate of PV's levelized power costs compare with $150/MWH for fuel cells, $52/MWh for wind, $62/MWh for microturbines and $32/MWh for gas combined cycle plants. The Bank's analysis does not consider applications such as distributed generation, reliability and backup or remote power.

[48] *Alt-Power, The Alternative Power Sector*, Global Utilities, October 10, 2001

Deutsche Bank views the need for technologies, like PV, to be able to achieve benchmarks over time to maintain and grow investment in the technologies. For solar PV, the Bank identifies the following benchmarks as critical to its continued commercial progress:

- Demonstrations by major PV manufacturers of more efficient thin-films
- Ramp-up of thin-film manufacturing capability
- Thin-film cost improvements (installed costs of $10,000/kW and then $5,000/kW for 2001-2005 and $1,000-$2,000/kW and power costs of $47-$94/MWh by 2010)
- Continued government support/subsidies
- Improvement in grid interconnection standards
- Continued growth of on-grid PV sales overall.

Deutsche Bank expects solar to provide approximately 20 GW of power worldwide by 2010 and mass production of solar PV to grow at between 30% and 50% annually over the next 5-10 years. However, the Bank points out that investors will not accept many disappointments (stretched out achievement of research goals, slowing sales, etc.) as the technology advances.

Merrill Lynch[49]

Merrill Lynch research indicates that the U.S. continues to be faced by an energy crisis associated with a degrading electric power transmission system, grid vulnerability, power quality, environmental protection demands, and deregulation. As a result, it views solar power use to be on an increasing slope driven by its ability to produce distributed power, and address environmental issues, especially climate change. In addition, the fact that it is a self-sustaining energy source that could decrease reliance on foreign oil, and receives significant government support, add to its attractiveness.

Merrill Lynch notes that, although PV represents the smallest segment of renewable energy, annual growth surpasses that of any conventional power generating technology. They also point out that, although recent PV industry growth surpassed 40%, they expect long-term growth to average closer to 20%. As grid reliability decreases due to congestion and reduced capital expenditure, and environmental pressure is expanded on new power plants, solar power will benefit. In addition, PV's role in distributed generation, a market growing at 20% per year, should position the technology to grow with distributed generation growth.

However, Merrill Lynch views PV-generated power to have several advantages over traditional technologies that will give it an edge in the future:

- High reliability;
- Low operating costs;
- Clean power source;
- Modular in size; and
- Low construction cost.

[49] *AstroPower Inc., Blinded By the Light*, Merrill Lynch Comment, November 30, 2001 and *AstroPower Inc., Blinded By the Light, In-Depth Report*, Merrill Lynch, December 10, 2001

Merrill Lynch believes that government subsidies are critical to the success of PV. It notes that, since U.S. subsidies are diffused at a state level rather than a Federal level, the risk of a national reversal is unlikely. Merrill rates PV a better distributed generation play than wind because it better fits the lower end of the distributed generation profile.

Goldman Sachs[50]

Goldman Sachs projects a $10-15 billion market for stationary distributed generation applications in the next 3-5 years, with potential for longer-term growth. It sees the market for stationary generating equipment in the less than 1 MW to up to 5 MW size range to be growing at about 5% annually throughout the world. Although solar PV plays a role in the distributed generation market, its high price relative to other energy sources, will limit its use to remote and green power applications.

Goldman Sachs is of the opinion that power quality will be the largest power technology market. It quotes market value estimates of Sandia National Laboratory and the Electric Power Research Institute of $150 billion and $400 billion respectively. It points out that, in the new economy, with the proliferation of digital networks, the availability of reliable backup power and the quality of power have become crucial. It also believes that power quality is important for old economy companies like manufacturing operations that are controlled by power quality sensitive microprocessors. Goldman believes that power quality has enough on- and off-grid applications to become a tremendous market and attract significant investor interest.

Goldman Sachs has listed PV as a well-established technology that has gone through two generations of technology development and is well into the third generation. However, the ability to significantly reduce PV capital costs is the main uncertainty with the technology. Recently, there has been a growing demand for solar power from customers who are already connected to the grid, but desire clean, renewable alternative or supplemental electricity.

[50] *Utilities Power Technology*, Goldman Sachs, April 28, 2000

APPENDIX H: CASE STUDIES OF SUCCESSFUL PV INTEGRATION

Set forth below are two examples which illustrate how the critical success factors above have been addressed in two cases of effective PV market penetration. One case study examines a successful geographic market, and the other examines a successful applications market. Following these case studies is a summary of lessons learned from the TEAM-UP program, applicable to the design and operation of a successful community program.

Sacramento Municipal Utility District

The Sacramento Municipal Utility District (SMUD) has instituted one of the most successful U.S. programs in installation of PV. Examination of this case demonstrates actions toward achieving all critical success factors.

Technology Development: SMUD's commitment to long-term, predictable, sustained demand has encouraged manufacturers to increase capacity to support the program. Energy Photovoltaics, Inc. (EPV) secured a 5-year 10-MW contract with SMUD. As a result of this contract, EPV has opened the CalSolar thin-film module manufacturing plant in the Sacramento area.[51] The bulk purchases by SMUD have enabled EPV to supply thin-film modules at low cost, with decreases in cost over time. SMUD has recently had some difficulty obtaining adequate numbers of systems at the contracted cost. Manufacturers have not been able to produce modules at the given price, or have found it more economical to sell them at a higher price elsewhere. Whether this is a result of unreasonable cost expectations by SMUD or excessive hesitancy to expand production by the manufacturers is debatable. Still, significant cost reductions in Sacramento have been realized.

Market Targeting: In SMUD, PV is targeted to appropriate markets in terms of both applications and geographic location. Two central PV generating stations provide field experience for SMUD in the operation of PV systems, and demonstrate the technology to educate the public. The current focus is on installation of systems to existing grid-connected homes and community buildings, and integration of PV into new grid-connected homes. Rooftop installation is a suitable application for PV, and building-integrated PV is especially suitable. As a regional market, California has high solar insolation, favorable political climate for solar power, high availability of systems and service personnel, a relatively high cost of conventional electricity, and significant concerns over system reliability. For these reasons, California is an excellent location for PV.

Utility Acceptance: As a municipal utility, SMUD is owned by the ratepayers and considers their input in determining strategic focus. SMUD has built on its connection with ratepayers to develop a marketing channel for the PV Pioneers program. A simple insert in the monthly billing statement provides a ready means of communicating the details of the program, including directions on how to apply. The consumer recognizes SMUD as an energy provider and as a logical and trusted source for purchase of a PV system. As a utility, SMUD has a range of expertise relevant to installation of power systems and is the main decision-maker for interconnection standards. SMUD's rate

[51] SMUD mid-year update, August/September 2001.

structure includes a higher rate for summer usage as well as optional time-of-use pricing, both favorable to PV. SMUD has also designed a number of programs to support PV, including the PV Pioneers, Community Solar, and Greenergy (Green Power) programs.[52]

State Policy and Regulations: California has a range of incentives and programs to encourage development of PV. Although some incentives are not available to municipal utility customers, SMUD has developed equivalent benefits. SMUD was recently tapped to direct a new $13.6 million state RD&D project for renewable energy focusing on solar, receiving matching funding from industry.53 California law mandates that energy service providers develop and offer net metering to customers. Tiered pricing was introduced in the investor-owned-utility service areas; SMUD chose to implement this in 2001 in response to the state's electricity shortages. Under a tiered pricing system, consumers with PV may benefit because the net usage for the month is reduced, enabling the consumer to stay in the lower pricing tier. State law also exempts PV systems from property taxes.

Federal Policy and Regulations: SMUD primarily benefits from one Federal program, the Renewable Energy Production Incentive (REPI). Similar to a production tax credit, this incentive of 1.7 ¢/kWh is available to renewable energy resources owned by not-for-profit entities such as municipalities.[54] Preference is given to certain renewable technologies such as wind and solar. SMUD receives payments through REPI for production of electricity from SMUD-owned facilities.

Downstream Infrastructure: Through volume purchases and installation of a single technology, SMUD reports great progress in the service capabilities of regional workers. Traditional tradesmen such as electricians and roofers can routinely install the systems purchased by SMUD.[55]

Informing the Market: SMUD informs its ratepayers of the program through inserts in monthly bills. SMUD reports high levels of interest and favorable public response, and the PV Pioneers program is oversubscribed. SMUD's customers are generally informed about the benefits of PV power and the means to procure a system; the systems are guaranteed. SMUD's PV Pioneers program is an excellent example of one-stop shopping for PV.

Financing Options: SMUD offers a rebate on systems and provides loans for the remainder of system cost. SMUD's photovoltaic and renewable energy programs are financed by a charge on all ratepayers' bills.

The Telecommunications Market

The telecommunications market is an established and relatively mature market for PV systems. PV is a cost-effective option and is preferable due to many of its characteristics. Due to the nature of the remote industrial applications market, not all players needed to be

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[52] SMUD's websites at www.smud.org/pv and www.smud.org/green/index.html provide information on these programs.
[53] SMUD mid-year update, August/September 2001.
[54] http://www.eren.doe.gov/power/repi.html
[55] Don Osborn, SMUD.

involved to the extent that will be necessary for other markets.

Technology Development: In the 1980s, costs for PV systems were brought down to the point that it was the most economical choice for many remote industrial applications, including telecommunications. From this time through the 1990s, rapid increases in the telecommunications industry and the growth of cellular communications required construction of repeater stations and antennas. These stations may be located in remote locations such as mountain peaks, and are often miles from the transmission system. For systems up to about 10 kW, photovoltaics-battery hybrid systems are ideal for providing constant power.[56] Communications applications include repeater towers, highway call boxes, telemetry stations, military communications centers, and relay stations.

Market Targeting: The same characteristics that made PV a viable choice for satellite power made it a viable choice for telecommunications. PV is reliable and low-maintenance. With battery storage, it can provide all the power needed for a 10 kW repeater tower or a 10W highway call box, at a lower cost than diesel generation or disposable batteries. Telecommunications applications are less price-sensitive and more performance-focused than residential grid-connected power. A telecommunications company can justify spending more for a high-performance low-maintenance system due to the potential losses from a system failure, whereas a residential consumer will prefer a low-cost system and simply draw more from the grid if the system performs below expectations. This aspect allowed high-value systems to develop a market niche.

Utility Acceptance: Utility involvement was not necessary as these applications were not grid-connected.

State and Federal Policy and Regulations: The major effect of government involvement was not policy or regulation, but rather the Federal procurement of PV communications systems for its own needs, based on the merits of the technology. The Department of Defense, National Parks Service, National Forest Service, and other agencies all installed PV systems for remote communications applications.

Downstream Infrastructure: Remote telecommunications installations must be periodically serviced. The personnel trained to do so can also perform any needed maintenance or replacement of the PV systems or batteries.

Informing the Market: The market – in this case the telecommunications industry – sought innovative solutions to fill a need, and selected the best-value proposition. In Federal applications, education efforts by FEMP and applications research by Sandia National Laboratories have served to increase awareness of the viability of PV for remote telecommunications.

Financing Options: The purchasing entities were generally able to procure PV systems without need for external financing.

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[56] Sandia report, at http://www.sandia.gov/pv/power/Telecommunications.pdf

TEAM-UP – Creating a Successful PV Program

The Solar Electric Power Association

In an effort to accelerate the use of solar electric (photovoltaic, or PV) power generation, a small group of utilities, the U.S. Department of Energy (DOE), and industry organizations created the Utility PhotoVoltaic Group (UPVG) in October 1992. (The UPVG was changed in October 2000 to the Solar Electric Power Association, or SEPA.) The need for industry support to expand the fledgling industry arose from the realization that, although off-grid applications were technically proven and economically competitive, they alone cannot provide the volume that the PV industry needs to become economical for grid-connected applications. In addition, by that time, only a few of the nation's 3,100 electric utilities had PV generation experience, and early SEPA members indicated a critical need for information and education about PV technology as well as a clear understanding of where the technology was in its development and commercialization cycle.

SEPA, with more than 130 energy service provider, utility, and PV industry members, has as its mission the acceleration of the use of PV business models for the benefit of energy service providers and their customers, thereby establishing PV as a practical sustainable energy option and a thriving domestic industry. SEPA programs increase the experience of energy service providers and their customers with PV and stimulate growth in demand for solar power.

The TEAM-UP Program

To help address barriers to widespread PV installations, DOE and SEPA initiated the program named TEAM-UP (Technology Experience to Accelerate Markets in Utility Photovoltaics) in 1994. TEAM-UP was a first-of-its-kind partnership between the public and private sectors to lead to earlier sustainable PV markets.

The four main goals of TEAM-UP were:

1. Increasing Involvement by expanding electric energy service provider use of photovoltaic systems;
2. Documenting Costs and Value by encouraging utilities and energy service providers to take advantage of the economic development potential, business opportunities, and environmental benefits offered by PV;
3. Improving Collaboration by facilitating interaction among communities with energy service providers to remove barriers to PV commercialization; and
4. Providing Strategic Advice by replicating successful approaches to PV.

TEAM-UP focused on deployment of photovoltaic hardware and systems, development of venture teams, development of PV industry infrastructure, creation and expansion of markets, and identification of customer demand for PV. By documenting the experiences – both positive and negative – of actual PV installations, the TEAM-UP program significantly increased the success of energy service providers, PV manufacturers, and PV system suppliers. In addition, TEAM-UP helped energy service providers recognize the economic benefit of using PV to serve their customers.

The ventures funded under TEAM-UP installed many applications under several types of initiatives, including:

- Green pricing programs;
- Packaged and standardized PV product/system deployment;
- Dealership network programs;
- Energy service provider/PV industry business alliances;
- Off-grid market development programs for rural applications; and
- Community-based programs.

TEAM-UP systems involved a number of different PV technologies ranging from single-crystal silicon to cadmium telluride. Roof- and ground-mounted systems (both fixed and tracking) have been installed under TEAM-UP.

Sharing Their Experience

The TEAM-UP ventures have first-hand experience with the key factors to developing and sustaining a successful PV program. Through written reports and interviews with SEPA staff, the ventures have provided a wealth of information that SEPA has used to create this tool for your use in developing your own program.

TEAM-UP accomplishments include:

- 35 venture teams
- 130+ partner organizations (including more than 80 utilities)
- $14.2 million in DOE funds
- $60.3 million in industry cost share
- $74.5 million total project value
- 7.2 MW of new PV capacity
- 1162 PV installations
- 38 states with TEAM-UP installations
- 20+ community partnerships

Lesson #1: Establish Clear Program Goals and Realistic but Flexible Schedules

Two key requirements a venture needed to have to be awarded TEAM-UP funding for their PV programs were:

1. Clear goals, and
2. A well-developed and attainable installation schedule.

In hindsight, participants praise the clear goals requirement that led to the successful implementation of their plans, but are dissatisfied with the schedules that, for most part, turned out to be impossible to stick to.

Clear Project Goals

Before starting any program within an organization, your first step must be to establish clear goals. What are your organization's goals in general and how do they fit with what you hope to gain from the financial, time, and other resources that you will invest in this program?

TEAM-UP ventures name two main, yet very different, goals an energy service provider may have when considering the creation of a PV program:

1. Image building/public relations; or
2. Energy production/generation of kilowatt-hours.

While it is possible to accomplish both goals, you must determine which is your priority and shape your program around this goal. Each of these goals requires significantly different types of projects within your program.

Companies looking to build their image as a "green" or "environmentally friendly" company should create a program with projects that elicit maximum exposure with minimal expenditures. If your main concern is not the kilowatt output of the systems, a reliable, low-maintenance PV system is needed. It is not necessary to have large systems, spend thousands of dollars for a consultant to design custom systems for you, or to buy the most expensive PV equipment available. Of greatest concern should be selecting highly visible sites for your PV systems – such as schools, community centers, and other public facilities – and selecting systems that are visually appealing. Equally if not more important than spending money on the systems themselves is allocating funds to an education and public relations campaign. Examples used by TEAM-UP ventures include developing a school curriculum to teach students about solar electricity, creating a solar or renewable section on their web site, and holding dedication ceremonies for their systems to increase awareness of their solar installations. All of these efforts increased the perception of the company as green or environmentally friendly.

Organizations which are more interested in the kilowatt-hours of energy that the systems will produce than the image they will help build should select large systems for their program. Large systems are more cost-effective due to numerous factors including volume purchase discounts, reduction of labor expenses and task duplication, and less frequent troubleshooting needs. Projects should also be replicable to minimize the cost of future installations.

Lesson Learned:

- *Step one of planning a PV program is to determine if your primary goal is:*
  - *Image building/public relations, or*
  - *Energy production/generation of kilowatt-hours.*
- *Individual, small-scale, grid-connected systems generate most of their value as a customer education and public awareness tool, not as an energy generation source.*

Flexible Schedules

As the infrastructure for solar electric technologies develops, it will become easier and easier to create installation schedules that can be met. However, in this relatively early stage for solar electric markets, unexpected hurdles tend to come up throughout the life span of PV projects.

When developing PV installation schedules, you should anticipate and allow for unexpected delays, including but not limited to:

- Approval and permitting problems;
- Backlogs in PV system and component orders;
- Difficulty finding contractors who can complete the work on your schedule;
- Construction delays when putting PV on new buildings; and
- Inclement weather that delays the installation process.

Lesson Learned:

- *Avoid promising specific project completion dates in proposals to outside funding sources unless you are certain they can be met.*
- *Information and education programs for approval and permitting agencies can reduce delays in the installation process.*
- *Do not announce dates for dedication ceremonies, press conferences, or other events until the system is nearly complete.*

Lesson #2: Secure Support from Upper Management

Building any program, or even a single project, from the ground up without support from upper management can be a difficult process. Given that many people do not consider PV as a mainstream technology, gaining upper management support for your PV program may seem like a potential showstopper.

However, those who have already built successful PV programs and installed numerous PV systems will tell you that this is not a technology of the future, but a technology of today, and support from upper management was their first key to building a successful program.

The TEAM-UP ventures suggest two strategies to help in your cause:

1. **Show government support for the technology**. Many of those involved in the TEAM-UP ventures were grateful for the ability to take part in the TEAM-UP program not because they needed the funding to help pay for the system, but because their participation in the program showed their Board of Directors or other upper management that this technology is supported by SEPA and the Federal government. It was this Federal support that provided the companies' upper management with the comfort level that allowed them to approve and support the program.

2. **Provide case studies showing how the installation of PV has benefited similar energy service providers**. Now that many companies have established successful programs, there are many case studies and business models that can be used to help persuade your management that the development of a PV program is in the best interest of your company.

Once you have gained the support of your upper management, it will be much easier to obtain better resources to expand your PV program. Once your program is approved and under way, continuously show your management how the program is helping the organization to meet its goals.

Lesson Learned:

- *Obtaining funding from the government – be it local, state, or Federal – for your PV program will provide your upper management with an increased comfort level and willingness to support your efforts.*
- *There are many case studies available from SEPA and other organizations about successful PV programs that can be used to show your upper management the benefits of developing a program.*

- *There are numerous PV business models available to show your upper management that this is a real business opportunity, not just a means to improve your environmental reputation.*
- *Once your program is underway, keep your upper management informed of your successes.*

Lesson #3: Know What to Expect from the Technology

Looking back, most of the TEAM-UP ventures wish they had done better homework on PV-related technologies before signing contracts and installing systems. In general, there are still many glitches with inverters that can be worked around if they are acknowledged during the planning phase of the project, and certain nuances with modules which you should be aware of.

Inverters

TEAM-UP ventures agree that inverters are the major weak link in PV technology. Problems include poor reliability, poor power tracking, blown fuses, inconsistency between the quality of inverters for large and small systems, manufacturing and assembly mistakes (poor workmanship), and nuisance trips, for which the causes of many are unknown.

The inverter problems also seem to occur at many different phases in the life of the technology. While some TEAM-UP ventures reported that inverters were faulty upon delivery, others failed after working properly for weeks, months, or years.

TEAM-UP ventures relate these problems to:

- The lack of sufficient testing by manufacturers before the product is sent to market;
- The lack of a sufficient number of inverter manufacturers in the market to force the creation of a superior product;
- The lack of a large demand of inverters; and
- The fast-paced evolution of inverters, which has models becoming outdated very quickly.

Until the inverter industry makes changes to its testing procedures and/or new manufacturers enter the market, there is little that companies can do to avoid inverter failures. There are several performance standards in the development process that will help in the future. TEAM-UP participants learned that, by anticipating some failures during the planning phase of projects, the impact of these failures was greatly reduced.

Lesson Learned:

- *Spend the extra money for a longer inverter warranty.*
- *Plan for inverter failures:*
  - *Schedule regular maintenance visits to the system to check for failures.*
  - *Monitor the output of your systems to determine proper operation (see lesson #7).*
  - *Include an operations and maintenance line item in your budget, including labor, travel, and replacement parts that may not fall under the inverter warranty.*

Modules

Module failures are rare. However, across the board, TEAM-UP ventures are disappointed that many modules do not perform up to their performance rating. While a few modules perform better than their rating, the majority perform below, reaching outside the accepted +/-10 percent range. Like the problems with inverters, there is little that PV program managers can do to correct this problem. It lies in the hands of the manufacturers to put realistic performance ratings on their modules.

Lesson Learned:

- *Select inverters that are capable of handling output both slightly above and well below the performance rating of the modules used.*
- Select components that have worked well together in other systems.

Lesson #4: Integrating PV into New Home Construction

Many of the TEAM-UP ventures – including Austin Energy, GPU Solar, Ascension Technology, and Sacramento Municipal Utility District – included the installation of PV on existing homes as part of their PV programs. Despite the significant demand for PV on residential rooftops, several TEAM-UP ventures that worked with retrofitting homes reported numerous and significant difficulties with this type of project.

Austin Energy sent a letter to more than 1,000 Solar Explorer (green power program) participants announcing its Residential Rooftop Program. Included in the letter was a list of criteria to qualify for the program, including roof size, orientation, shading, etc. Over 100 customers responded, indicating that their home met the criteria. Unfortunately, after performing a site visit to every respondent, Austin Energy determined that only 16 of these 100 homes actually met the criteria. Most were disqualified because they did not have a large enough south-facing, unshaded roof space for the PV array.

Lesson Learned:

- *If you want to install residential PV, there are fewer hassles if you do so on new homes rather than existing homes.*
- *Do a complete site inspection before agreeing to install a PV system on an existing home.*
- *If you do choose to put PV on existing homes, use flexible designs and options for modifying the installation to fit site-specific conditions such as roof size, roof design, roofing materials, roof penetrations, etc.*

Lesson #5: Use Experienced PV Installers

Most general electrical contractors are not trained in the installation of PV systems. Although installing a PV system is not difficult, there are nuances that make it different from other electrical work. Incorrectly installed systems can result in significant costs later on that could have been avoided through the use of a qualified installer.

The North American Board of Certified Energy Practitioners (NABCEP) is working on developing a national PV installer certification program, which is expected to be underway soon. In the meantime, there are many training programs available, including those provided by the International Brotherhood of Electrical Workers and the Florida Solar Energy Center. Although

it may take some searching to find a contractor who has received training from one of these organizations and has experience installing PV systems, it will pay off in the long run through avoided troubleshooting costs. Some energy service providers involved in TEAM-UP have paid for the training of local installers to ensure quality work from their contractors.

Lesson Learned:

- *Select contractors who are skilled and knowledgeable about photovoltaics, interconnection, and regulatory issues. When possible, select contractors who are certified in PV installation.*

Lesson #6: Make Interconnection Simple

Inconsistent and excessive energy service provider requirements for interconnection are creating unnecessary barriers to wider use of PV. Many energy service providers are unfamiliar with the technology and, because of their concern for safety, require extreme precautions before connecting even a small system to the grid. For programs where customers own the systems, compliance with the energy service provider's interconnection requirements can greatly increase the cost of the system. A better understanding of the technology and the safety issues specific to PV needs to be attained to dissolve this barrier.

To create a successful PV program, energy service providers should simplify interconnection, including technical and business/contractual simplification. Technical simplification requires implementing the three important standards and codes: IEEE 929, UL 1741, and NEC Article 690. Contractual simplification requires eliminating onerous interconnection policies and contractual procedures that are barriers to easy market transactions and that are costly or impractical for smaller-sized PV systems.

In October 2000, the Solar Electric Power Association Board of Directors issued a "Position Statement on Photovoltaic Interconnection Issues in the U.S." This document, covering both technical and contracting policies, is available at www.SolarElectricPower.org or by contacting SEPA, and references important standards, policies, and sample procedures that have been successfully implemented to simplify interconnection for PV. It also provides draft agreements that may be used by energy service providers.

Lesson Learned:

- *Simplify both your technical requirements and business/contractual procedures for interconnecting to the grid.*

Lesson #7: All Systems Should be Monitored

Regardless of size, all systems should be monitored to determine if they are functioning properly. Data analysis systems (DAS) are one option to do this. The DAS receive signals from a weather station and the electric meter to calculate the electrical output of the PV system. However, the cost of a DAS (approximately $3,000 to $5,000) can be significant in relation to the total system cost, especially for smaller systems, where the added cost of a DAS can easily be a quarter of the total cost. For larger systems, the cost of a DAS is usually insignificant when compared to the overall cost, and is worth the added expense to ensure that the system is working properly.

Lesson Learned:

- *All PV systems should have some form of monitoring.*
  - *For large systems, a DAS is worth the added cost.*

Lesson #8: Don't be Afraid to Ask for Help

There are many regional and national organizations that can provide useful photovoltaic information, including:

- The National Center for Photovoltaics (www.nrel.gov/ncpv).
- The U.S. Department of Energy's Energy Efficiency and Renewable Energy Network (www.eren.doe.gov).
- Your local Solar Energy Industries Association chapter (www.seia.org).
- Your state energy office (www.naseo.org/members/states.htm).
- The Solar Electric Power Association (www.SolarElectricPower.org).

With one phone call or email, members of the Solar Electric Power Association can get technical advice from staff and dozens of other SEPA members who have experiences just like their own. If you run into a problem during any phase of your PV program, SEPA is a resource to help get the problem solved. Please contact SEPA for help starting or expanding your PV program.

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APPENDIX I: MARKET TARGETS FOR U.S. APPLICATIONS

The domestic PV market in 2000 was about 30 MW of PV, up from sales of 20 MW in 1999. The cumulative on-grid installed capacity was about 27 MW. Sustained industry growth of 25% per year would result in domestic sales of nearly 300 MW in 2010. How might this goal be attained given the value proposition of PV?

- In Japan, between 5 and 10% of new homes have solar. Shea's solar homes in California represent about 5% of their home construction nationwide. So 5% seems an appropriate target for new homes in the best markets. By 2010, economics may have improved to the point where the top two tiers (representing half the population) can realistically expect 5% penetration. DOE should support the formation of an alliance among the PV manufacturers, electricians, home builders, and developers and encourage them to set a specific goal for PV on new homes; a target of 5% or higher for the best market areas is reasonable. If PV is a superior economic choice for a consumer buying a new house, as it is in some states, the new homes market could be even larger. Let us then consider 3% of new homes nationwide to have 2.5-kW systems. This is **90 MW/year**.

- Target a retrofit market equal in volume to the new homes market. The potential market is far larger; with effective financing options, the economics for home retrofits can be as good as for the new homes market. If these financing options are developed, we can posit a retrofit market of **90 MW/year.**

- For commercial buildings, PV is less likely to meet the building's entire energy load; target mid-sized systems on a larger number of commercial buildings. Aim for 10% of building electricity needs on 2% of all new commercial buildings. This is **30 MW/year** (equal to about 1% of a year's total new commercial roof area being covered with PV).

- Large commitments by a few major cities can have a major market impact: San Francisco (10 MW), Sacramento (30-40 MW), Los Angeles (5-7 MW) have plans for significant amounts of grid-connected PV. In San Francisco, the project is funded through the sale of revenue bonds, which were approved through a referendum. Developing partnerships and securing commitments from cities will create sustained orderly demand; the exact scale is hard to predict, but let us assume **10 MW/year.** This is equivalent to one city making a commitment equal to San Francisco's each year.

- Moderate increases by a number of cities of all sizes can also have a significant impact: set a goal of each year getting 2% of state and local governments to commit to meeting 1% of their electricity demand with PV (so perhaps one state and a number of smaller cities and towns would commit to 1% PV each year). With such a commitment, this market would be **13 MW/year**.[57] Such an effort might involve PV panels on schools

[57] According to Rebuild America, state and local governments spend about $8 billion per year on electricity; this is roughly 100 billion kWh per year. 1% of the demand for 2% of these governments is 20 million kWh. At 1500 kWh/kW, the needed PV capacity is 13.3 MW/year.

(educational), solar-powered streetlights (cost-effective and durable), highway infrastructure, or off-grid PV in state parks (cost-effective, reliable, and low-maintenance). States should also consider applications where they currently use portable diesel generators. State and community partners in the Community Solar Solutions Initiative could be encouraged to set the 1% target. For States, communities, and large cities, the Clean Cities program provides an excellent model for PV deployment. The trajectory for community commitments to PV may or may not be similar to that of Clean Cities, which showed a rapid spike, a lower plateau, and an eventual decline.

- If the Department of Defense makes the effort to install the 470 MW of cost-effective small and medium-scale PV identified by Sandia over the next ten years, that is 47 MW/year. Adding in new PV purchases each year equal to .05% of current civilian government electricity demand (ramping up the PV capacity from 0% to .5% of total non-defense Federal electricity demand over the next 10 years, and assuming no increase in overall demand), for 8 MW/year, the total is **55 MW/year**. The Federal government has many agencies that require off-grid applications for remote power supply, monitoring, and communications.

- Rural Electric Cooperatives (RECs) may choose to install PV/propane hybrids rather than maintaining expensive transmission systems in areas of very low load density. Remote water pumping is another good application for PV. Off-grid rural applications have a very large potential and PV is often cost-effective, so we can consider **20 MW/year** to be a conservative goal. (Sarasin Bank considers 60 MW/year of OECD off-grid PV sales to be a reasonable prediction.) The total PV market for REC power is estimated at 500-950 MW if installed system price (for a hybrid system) reaches $3/W.

- Sarasin Bank predicts that the worldwide telecommunications/signal and consumer products markets will grow to 150 MW/year and 80 MW/year respectively by 2010. . If the U.S. domestic market were 20% of the world market for these applications, the total would be **46 MW/year.** RVs, boats, camping, and hiking applications continue to be good segments of the consumer products market with high U.S. potential. The transportation infrastructure market should be developed along with telecommunications and signal applications.

- These market targets, by no means including all market sectors, indicate grid-connected PV sales of **218 MW/year** and off-grid sales of **66 MW/year**. The government purchases are a mix of on- and off-grid, for another **70 MW/year**. The sales for 2010 would be over ten times the sales for 2000, thus exceeding 25% growth annually. Additionally, this analysis has not considered the addition of PV to existing commercial buildings, though BIPV and new building PV seem to be better options for commercial buildings. Many other niche markets exist, providing the potential for even greater growth.

APPENDIX J: RESOURCES FOR THE SOLAR POWER SOLUTIONS BLUEPRINT

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Trade Organizations and Business Partnerships

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Emerging Technologies Coordinating Council – www.ca-etcc.com
EPRI – www.epri.com
European Photovoltaic Industry Association – www.epia.org
Green Power Market Development Group – www.thegreenpowergroup.org/pv.html
National Association of Home Builders – new homes data at www.nahb.com/facts/forecast/annual_starts.htm
Solar Energy Industries Association – www.seia.org
Solar Energy Society of Canada, Inc. – www.solarenergysociety.ca/
Sustainable Energy Coalition – www.sustainableenergy.org/
U.S. Export Council for Renewable Energy
American Wind Energy Association – www.awea.org
Utility Wind Interest Group – www.uwig.org

Consulting Firms

List of solar power consultants at www.gridwatch.com/cproc.asp?cid=66
Antares group – www.antares.org
Besicorp Limited – www.besicorp.com
Climate Solutions – www.climatesolutions.org
EFI, Inc. – www.efinc.com
The Leonardo Academy – www.leonardoacademy.org/
PV Energy Systems, Inc. – www.pvenergy.com
Strategies Unlimited – www.strategies-u.com
Tellus Institute – www.tellus.org

Government Agencies and Programs

AGORES (European Commission) – www.agores.org
California Energy Commission – www.energy.ca.gov/links/solar.html
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International Energy Agency –www.iea.org/techno/renew/index.htm
Interstate Renewable Energy Council – http://irecusa.org/
Massachusetts Renewable Energy Trust Fund – www.mtpc.org/massrenew/massrenew.htm
NREL – www.nrel.gov
REPIS – www.eren.doe.gov/repis/
Sandia National Laboratories – www.sandia.gov
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Texas State Energy Conservation Office – www.infinitepower.org/
World Energy Council – www.worldenergy.org

Non-Governmental Organizations

Center for Energy Efficiency and Renewable Technologies – www.cleanpower.org
Center for Resource Solutions – www.resource-solutions.org/programs.html
Clean Energy Funds – cleanenergyfunds.org/html/html/index.htm
Greenpeace – www.greenpeace.org/~climate/climatecountdown/solargeneration/
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Natural Resources Defense Council – www.nrdc.org
Northeast Sustainable Energy Association – www.nesea.org/
PVpower.com – www.pvpower.com/
Regulatory Assistance Project – www.rapmaine.org
Renewable Energy Policy Project – www.repp.org
Resources for the Future – www.rff.org/nat_resources/energy.htm
Resource Renewal Institute – www.rri.org
Rocky Mountain Institute – www.rmi.org
Union of Concerned Scientists – www.ucsusa.org/energy/0renewable.html
Utility Consumer Action Network – www.ucan.org
Virginia Alliance for Solar Electricity – www.vase.org

Energy Providers

Sacramento Municipal Utility District – www.smud.org
Tucson Electric Power – www.tucsonelectric.com
Long Island Power Authority – www.lipower.org

Universities

- Art Center College of Design – Solar Dome – www.solardome.com
- Florida Solar Energy Center – www.fsec.ucf.edu/PVT/index.htm
- MIT – Technology and Policy Program – http://web.mit.edu/tpp/www/introduction.html; Center for Energy and Environmental Policy Research – http://web.mit.edu/ceepr/www/

- North Carolina Solar Center – www.ncsc.ncsu.edu, also has Database of State Incentives for Renewable Energy at www.dsireusa.org/
- Princeton University Center for Energy and Environmental Studies – www.princeton.edu/~cees/ and http://es.epa.gov/ncer/fellow/progress/98/dukeri00.html
- Stanford University Energy Modeling Forum – www.stanford.edu/group/EMF/home/index.htm
- University of California at Berkeley, Energy and Resources Group – http://ist-socrates.berkeley.edu/erg/, http://socrates.berkeley.edu/~rael/, and http://socrates.berkeley.edu/~rael/renewables_forum.html
- University of Delaware Center for Energy and Environmental Policy – www.udel.edu/ceep/energy.htm, www.udel.edu/ceep/renewable.htm, www.udel.edu/ceep/reportlist.htm
- Washington State University Energy Program – www.energy.wsu.edu/

Major manufacturers:

Siemens Solar – www.siemenssolar.com
AstroPower – www.astropower.com
BP Solar – www.bpsolarex.com
Kyocera – www.kyocerasolar.com
PowerLight Corporation – www.powerlight.com
Solar Century – www.solarcentury.co.uk
Shell – interview at http://pubs.acs.org/hotartcl/est/99/dec/vahr.html

Journals and News Sources:

The Solar Energy Journal – publication of ISES. Available online at www.elsevier.com/gej-ng/10/40/35/show/
The Energy Journal – The quarterly journal of the IAEE's Energy Economics Education Foundation. www.iaee.org/publications/enerjor.asp
Annual Review of Energy and the Environment – http://energy.annualreviews.org/
Green Power Newsletter – www.rapmaine.org/green.html
PV News – www.pvenergy.com/news.html
PVpower.com – www.pvpower.com/
Photovoltaic Insider's Report – http://www.pvinsider.com/AboutUs.htm
Renewable Energy from the World News Network – www.renewableenergy.com/
Resource and Energy Economics – www.elsevier.com/homepage/sae/econbase/resen/menu.sht
Solar Buzz – www.solarbuzz.com
Solar News – www.solarpower.com
Solar Today – www.solartoday.org
The Source for Renewable Energy – http://energy.sourceguides.com/index.shtml – extensive list of businesses and organizations associated with renewable energy

Contacts

The Solar Power Solutions Initiative process is a compilation of work performed by the Solar Electric Power Association (SEPA), Global Environment and Technology Foundation (GETF), Technology Transition Corporation (TTC), their partners, industry stakeholders, and others.

Along with the internal development and research process performed by SEPA, GETF, and TTC, two focus sessions were held with industry stakeholders, and a brainstorming session was staged with analysts, consultants, and industry professionals. Through our conversations at each of these events we have received input from numerous people. Those who participated in the development of the report are listed here (in alphabetical order):

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