Solar Power Solutions:

A Business Case for Capturing Total Value

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I. INTRODUCTION

The Solar Power Solutions Project recommends to U.S. DOE a new approach, founded on the premise that photovoltaic (PV) power holds strong market potential. Its primary focus is not on what government can do for the PV industry, but rather how key stakeholders in the public and private sectors can collaborate to harness the benefits of solar. Based upon history and experience, this analysis sets forth a way of systematically focusing on the customers and end-use markets of PV to facilitate targeting the most promising markets and identifying the primary stakeholders whose decisions or actions are necessary for stable growth of PV purchases and installations.

This paper focuses on the factors critical to the success of a constructive and focused path forward for PV in the years ahead. This sector has been a challenge for policy makers. On the one hand, arguments have been made that PV has been the recipient of major public investments and is still not expected to be competitive without heavy subsidies. On the other hand, there exists evidence that PV is on a steadily improving market growth path. The data do show that PV is the most preferred source of energy in poll after poll, and provides real benefits, including: good jobs, domestic energy sources, avoidance of environmental and health damages associated with fossil fuels, and grid-related benefits such as solar coincidence with peak that provide real benefits to grid stability. This broad popular support has translated into a growing number of local, business, and state programs to accelerate adoption of PV. State and local support for renewables have now surpassed Federal support. Federal funding and policies need better to leverage, support, and link together the now extensive state and local activities.

The data also show that the "learning curve" concept has merit, and that increases in system purchases and manufacturing output will continuously reduce the cost of PV systems. Therefore, removing market impediments to demand growth should increase sales volume and reduce costs. The challenge of this project, then, is to identify ideas for a path forward for the Federal Government and public/private stakeholders that appropriately supports what appears to be momentum for PV without making unfocused or unaccountable investments in an industry or a group of companies.

This strategy will be implemented at the local level in communities that offer the highest potential of success for deployment. (See Critical Success Factors.) This new strategy focuses on the utilization of PV systems by U.S. customers and communities, while maintaining the world-class science and technology base that underpins the entire PV initiative. Furthermore, the government's role, which in the past has been involved with RD&D, manufacturing process development, and technology commercialization, needs to be much more focused to accelerate the development of application-defined end-user demand in order to remove impediments to private sector investment in commercialization and to provide the best customer-focused data to inform future investments.

This report is based on the collective views of industry and sector experts who have decades of experience in the solar business. It also builds on the best thinking and analysis in recent industry roadmap projects and focuses on market conditions today. The approach in this report has been to review extensively the history of PV and public investments in this industry, particularly by the U.S. Department of Energy. We also talked to a wide range of people in the PV industry, energy providers, communities with active PV markets, Federal and state officials, and others to gain a sense for the prospects for PV today and what factors may be holding it back. The report sets forth major findings and several practical recommendations for constructive government involvement.

The recommendations herein are grounded in several premises:

- Any actions must be consistent with a limited Federal role beyond research in working with the PV industry.
- Recommendations must be tied to "critical success factors," or addressing the key obstacles which may be impeding market penetration.
- The emphasis must be on public/private partnerships, identifying and engaging the right public and private stakeholders, sharing costs, carefully defining the scope of projects, and identifying which stakeholder is the most appropriate lead for particular actions.
- Actions must promote other government priorities, including, measurable results in terms of pollution reduction, energy security, economic growth, and industry progress towards self-sufficiency; projects must not favor particular companies.
- Recommendations are not designed to try to create markets, but rather to focus on markets where commitments have already been made and customer interest already exists.
- Recommendations take lessons learned from existing programs and create a more focused new approach that is less fragmented and creates direct feedback loops from the customer to the RD&D team.

In developing a business model which defines public and private roles for PV, RD&D plays a significant role. In fact, the continued successful development of PV requires rapid continuous improvement in the quality and cost-effectiveness of the technology. A demand-oriented PV Strategy will reveal other development needs, some of which are appropriate for RD&D and some which are more appropriate for competition in the commercial marketplace. The business model described here therefore does not directly address RD&D, but rather focuses primarily on the demand end of the value chain and how strategies must be customer-focused and targeted on end-use markets. It presumes that the work on RD&D must continue to go forward.

The key to a winning U.S. national strategy for the next 25 years is to recognize that PV has become a global industry, and chart a course that maximizes the national and regional benefits from the use of the technology, while maintaining a world-class technology base. The $1.7 billion investment the U.S. has made has helped spawn a $2.5 billion industry growing in excess of 20% per year. Recently, the benefits of these investments seem disproportionately to be reflected in the rapid growth of competitors' manufacturing

capacity and PV markets in regions such as Europe and Asia. The U.S. needs to focus with industry on where obstacles in the U.S. markets may be fueling growth in offshore markets.

At the end of the day, as in all business and especially in energy, there are no guarantees about the future size or role of PV and no certainties. Given the depth of public interest and tangible support in numerous communities, data on sales trends and the presence of obstacles in the marketplace, focused and better-coordinated action and Federal collaboration with industry and interested states and communities appears well advised.

II. THE PV VALUE PROPOSITION

Solar photovoltaics (PV) offers the U.S. a material source of high-value energy. It is an attractive part of the U.S. energy portfolio for an array of reasons which include customer value, as well as benefits from an environmental, reliability and energy security perspective. The U.S. has pioneered and developed the technology, and public opinion of solar power is extremely favorable. Findings from market research indicate that the American people *want* solar energy, consistently giving solar energy a 90+% positive rating, the highest rating for any energy option.

Further, the United States has considerable energy demand and the manufacturing infrastructure to produce PV systems. The hallmarks of PV's unique value proposition include the following:

- **Economic Value:** the generation of solar electricity coincides with the normal peak demand during daylight hours in most communities. It therefore mitigates peak energy costs, brings total energy bills down, and obviates the need to build as much additional generation and transmission capacity as would be the case without PV. PV combined with efficiency can realize significant economic benefits and contribute to the goal of zero-energy buildings.
- **Environment:** PV-based electricity is produced in a clean and silent manner;
- **Resource Economics:** PV harvests a free and abundant energy source and puts it to work, reducing the rate at which society is depleting the world's increasingly scarce fossil fuel resources;
- **Infrastructure Reliability and Efficiency:** PV is best sited at or near the point of load, thereby freeing up utility investment in distribution systems and enhancing the reliability and cost-effectiveness of the grid. PV can increase grid reliability, resulting in increasing value in the future as reliable high-quality power becomes more valuable;
- **Energy Security – Infrastructure:** Distributed power generally offers security benefits due to multiple generating sources, less transmission and distribution to disrupt, and greater security because on-site PV generation is harder to disrupt, more stable, and less brittle than full reliance on centrally generated power;
- **Energy Security – Economic:** A renewable resource such as PV reduces dependence on all traditional sources of energy inputs and creates a source of energy secure against any external supply interruption or price manipulation;
- **Choice:** PV gives consumers the power to choose the source of the electricity they use and to act on their stated preference for renewable energy;
- **High-Value Jobs**: as a sophisticated semiconductor technology, PV offers the opportunity to build an industry of high-technology companies and jobs in science, engineering, manufacturing, and services. Table 1 indicates the high annual growth potential for solar PV, with a consequent increase in jobs created.

Source	2000-2010	2010-2020	2000-2020
Hydropower	0.1%	0.0%	0.0%
Geothermal	2.3%	4.1%	3.2%
Municipal Solid Waste	3.2%	1.0%	2.1%
Biomass	2.2%	1.3%	1.8%
Solar Thermal	0.9%	1.3%	1.0%
Solar PV	**27.1%**	**9.4%**	**19.8%**
Wind	12.2%	1.7%	6.8%
Total	0.9%	0.4%	0.6%

Source: EIA

Table 1: Projected annual growth rates of renewable energy resources

The value of PV to the nation should increase dramatically over time as the cumulative base of installed systems grows. Such volume increases are expected to reduce system costs; beyond this, the economic value will also be enhanced to the degree that national policy encourages the monetization of environmental attributes through trading mechanisms or other means. These environmentally-derived economic benefits will augment the other, system-oriented benefits of PV.

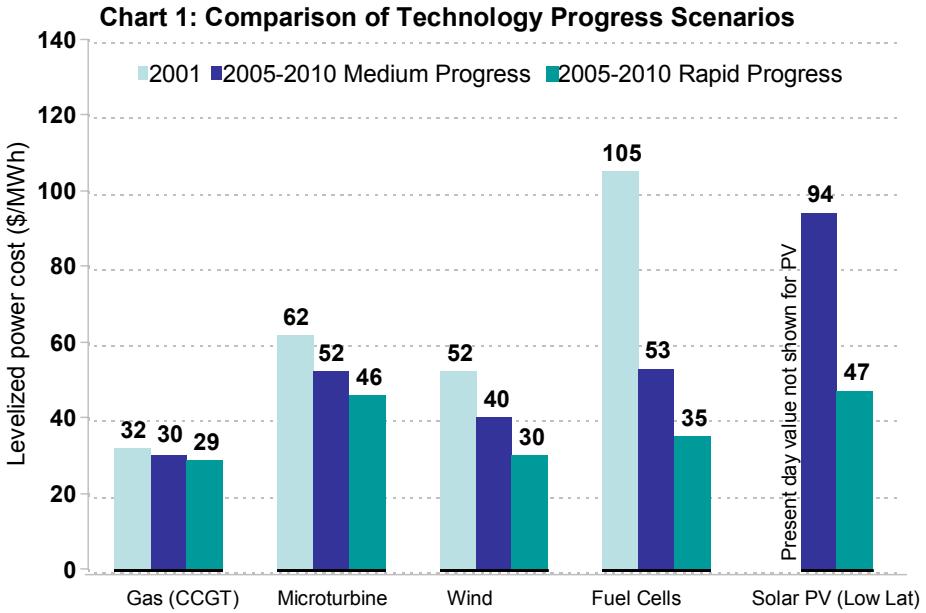
PUBLIC CHOOSES SOLAR OVER OTHER FORMS OF ENERGY

Surveys indicate that consumers prefer solar power over all other forms of energy. Public perception of solar power, including PV, is extremely favorable but is affected by a misunderstanding of its availability to individual private and business consumers. Surveys have repeatedly shown that customers support both government research and utility development of solar power, even if it costs more. A survey by the National Council on Competition and the Electric Industry found that customers rated solar above all other forms of energy, when compared to wind, coal, oil, natural gas, nuclear, hydro, biomass, waste-to-energy, and geothermal. Solar was rated as both the most environmentally benign energy source and the most preferred energy source. 92% of respondents favored environmental protection even if the electricity costs increased. Consumers were not very knowledgeable about the source and impact of their electricity generation; they tended to overestimate the contribution of solar power, with 10% believing it to be among the top three resources used for electricity. Consumers also generally believed that the air pollution caused by electricity generation was relatively small compared to other sources (Winneg et al., 1998). In a California poll, 84% of respondents favored doubling the share of electricity produced by renewable energy to 20% by 2010; in every political and ethnic group, at least 67% supported this goal. 71% of respondents would be willing to pay an additional $1.50/month towards this goal, and 70% believed that developing new renewable energy should be a higher priority than building more fossil-fuel plants. (Fairbank, Maslin, Maullin & Associates, 2001).

The Cost and Full Value of PV Electricity

The cost of PV electricity is significantly higher than the wholesale rate for conventional electricity, but this is not the most meaningful comparison. PV provides power at the point of demand and is thus better compared to the retail rate for electricity. The cost of PV-generated electricity ranges from 10¢/kWh (with good solar resource and a State buy-

down) to over 40¢/kWh for a low solar resource and no State incentives.[1] A longer or shorter system lifetime will impact the cost of PV electricity, though lifetime data is currently limited. Chart 1 illustrates the projected costs of distributed generation (DG) technologies in the near and medium term, as forecast by Deutsche Banc Alex. Brown; PV has the potential to rapidly approach the cost of other DG technologies.



Source: Deutsche Banc Alex. Brown estimates

PV electricity differs in crucial ways from traditional grid electricity and from DG technologies such as microturbines; the generation of PV electricity is clean, quiet, and emissions-free. It is also domestic, safe, renewable, and ubiquitous. As a modular distributed generation resource, PV allows mitigation of risk in planning and avoidance of increased generation capacity. As a peak-producing energy resource, PV produces high-value electricity. An operating PV system produces no air pollutants or greenhouse gases. The economic value of the environmental benefits of PV can be calculated, but the calculation depends on the economic value of emissions avoided. Though there is no clear consensus on the cost of emissions, there is wide agreement that the value is a positive value and needs to be considered.[2] In addition to the emissions value, PV has value as a domestic resource, as an inexhaustible resource, and as a distributed resource.

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[1] A system costing $4,000/kW after a 50% rebate, with an annual production of 2000 kWh/kWp, a 10-year 8% loan, and a 30-year system lifetime, would produce electricity at $.10/kWh. Such a system might be installed in Southern California. On the other hand, a system with a higher installed cost and no rebate costing $10,000/kW, with an annual production of 1250 kWh/kWp (among the lowest yields for the contiguous U.S.), and a 10-year 12% loan, would produce electricity at $.46/kWh over 30 years.

[2] The cost of emissions varies greatly by state, as does the actual quantity of emissions offset by a PV system. The assessed cost of control value for SO2 is $.75/lb in Massachusetts, and $2.20-$11/lb in California; market prices of SO2 allowances tend to be about $.10/lb. The cost of NOx ranges from $1.35/lb in Wisconsin to $4.50-$15/lb in California, with market prices between $.45/lb and $3.50/lb in 1999. The markets for CO2 are not yet developed, but are expected to be about $1-10/ton; state cost-of-control values tend to be higher, from $9/ton in California to $22/ton in Massachusetts. The National Park Service uses values of $.85/lb SO2, $3.75/lb NOx, and $14/ton CO2. Using these values, the cost of emissions nationwide would be about 3¢/kWh.

Therefore, other factors such as reliability and security benefits, while not yet accurately quantified, are also materially positive. The fact that these other classes of benefits are material, yet remain the subject of speculation and debate has led to Recommendation 3, below, regarding improving quantification of the full value of PV. DOE's Office of Power Technologies is developing an assessment of the cost of externalities associated with conventional electricity generation. These impacts include: the effect of emissions on human health and welfare, agricultural productivity, and infrastructure; the security costs of ensuring a reliable oil supply and a safe nuclear resource; and the potential costs of adjusting to global climate change. A preliminary survey of the literature found a value of 7.6 cents per kWh.

The favorable consumer opinion of PV has resulted in an increasing market volume for PV systems and an increasing interest in homes with PV. Initial evidence suggests that a PV system on a home can build home equity and significantly increase the resale value of the home; in new housing developments featuring homes with building-integrated PV or other PV systems, foot traffic and other metrics of consumer interest are far above average. A recent survey in California found that 50% of consumers would be willing to pay more for a house featuring a solar or wind power system, and 60% indicated they would be more interested in a house with a renewable energy system than a house without one.[3]

[3] "Survey Finds California Homeowners Would Pay More for a Home With Solar or Wind Technology," Power Marketing Association OnLine Power Report, March 7, 2002. Survey conducted by Maryland Marketing Research, Inc., for the California Energy Commission.

III. THE CONTEXT FOR PV IN U.S. MARKETS

PV is becoming increasingly competitive in defined markets. Over the past few decades, the U.S. has invested approximately $1.7 billion in public funds in the development of photovoltaic technology. While there are cost reductions yet to be achieved, this investment has paid off in many ways and the rapidly accelerating progress of the technology and markets offers the potential for a much greater return on investment.

Historical Perspective

Photovoltaic technology has evolved from its original applications in satellite power to a wide range of applications including consumer products, off-grid power, and grid-connected power. The U.S. DOE PV RD&D plan, as originally conceived in 1975, has resulted in the development of a technology base from which the understanding of the basic science of PV, the integration of technology components, and the improvement of manufacturing processes have been achieved, thereby creating a new industry for both space and terrestrial, consumer and military applications.

FASTEST GROWING PV – UP ON THE ROOF

Photovoltaic products for the highest-growth applications – grid-connected distributed generation – are primarily roof-mounted systems, with a growing number of building-integrated photovoltaic (BIPV) products available. Roof-mounted systems typically consist of a number of modules attached to a roof. These systems may be incorporated into a building's design at its construction or added later by a PV installer. Although some systems are raised at an angle from the roof (to capture maximum incident sunlight), a more common practice is now for systems to be flush with the roof.

The vision and implementation of the program laid out in 1975 have yielded significant progress for the PV market. New PV technologies have been developed, research has expanded internationally, and new markets have emerged. Research in PV technology, along with dramatic and innovative improvements in manufacturing, has produced significant cost reduction in the past 25 years. The industry has continued to improve efficiency, reduce costs, and develop innovative technologies through years of up-and-down support from government and industries. Several well-developed and growing markets for PV power exist and will continue to form the backbone of the industry for the immediate future. Advances in manufacturing, such as increasing automation, and products such as building-integrated PV, show great promise in developing new markets of a much greater scale. Although the economies of scale for cost-optimized manufacturing of PV components have yet to be reached, the advances made in multi-component cross-platform manufacturing have propelled the PV industry into a near-competitive commercialized business.

TYPES OF PV

PV is a broad family of technologies displaying differing characteristics of cost and performance. The range of technologies can adapt to changing market conditions and fit with the needs of the different applications including:

- **Single-crystal silicon**, with its high efficiency, is the technology of choice for telecommunications and other industrial applications, where "best performance" is a criterion.
- **Multi-crystalline or polycrystalline silicon** is a prevalent technology for rooftop applications, where there are some space limitations – hence relevance of efficiency – but also price sensitivity. Similar technologies developed with new manufacturing processes include "ribbon" or "sheet" silicon.
- **Amorphous silicon (a-Si)**, a thin-film technology, tends to have lower efficiency than crystalline silicon but also tends to have a lower cost per peak watt. It has been the technology of choice for small-demand consumer products such as watches and calculators, and for applications requiring performance under low-light conditions or partial shading.
- **Thin-film technologies** such as cadmium telluride (CdTe), and copper indium diselenide (CIS) are valid for many of the same applications as a-Si. Some environmental concerns exist about the materials used in their manufacture.
- **Concentrator PV** may use a number of technologies; a small area of cells receives sunlight under high concentration. Concentrator PV is most effective where sunlight is intense, direct, and rarely interrupted, and so is well-suited to geographic areas such as the Desert Southwest.
- **Multi-junction cells** include emerging technologies such as gallium arsenide and gallium indium phosphide. These cells show high conversion efficiency, either under concentration or normal sunlight, and are a promising technology for the future.
- **Dye-sensitized solar cells** include a number of emerging technologies such as the TiO2-based Grätzel cells and new developments such as self-assembling organic PV layers.

The Future of PV

Various plans, projections, and models have been put forth to forecast or advocate a specific trajectory of energy development. Most analyses predict an increasing deployment of renewable energy technologies, especially PV. Because PV starts at such a low point in terms of total energy supply, even projections including a significant growth rate for PV do not necessarily forecast a significant PV component of energy production in the near or even long term. Energy has been notoriously difficult to predict, given the wide range of options, the diversity of factors influencing decisions, and uncertain trajectories for developing countries.

The most ambitious attempt to consolidate these factors into forecasts are put forward in the report "Energy Needs, Choices, and Possibilities: Scenarios to 2050," by Shell. In both scenarios, renewable energy increases as a share of both electricity and overall energy production; in one scenario, renewables reach 1/3 of primary energy production by 2050. In other instances, Shell has estimated that renewables will provide half of all primary energy by 2050. It is on the basis of this conviction that Shell has increasingly expanded its PV manufacturing and marketing efforts to become a top-tier PV company.

The PV industry, currently a $2.5 billion worldwide industry[4] with a cumulative installed capacity of around 1 GW, has come through a long "shakedown" period and is poised for potentially dramatic growth. Most industry and financial analysts forecast 20% annual growth over both the near and long term.[5] Some analysts predict even higher growth.[6] Most analysis concludes that, although a large potential exists for off-grid PV, especially in developing countries, the grid-connected market is likely to grow faster in the near term. Sarasin Bank predicts 19% annual growth for PV as a whole, and 25% growth for grid-connected PV. Statistics from the Electric Power Research Institute (EPRI) indicate current off-grid growth at 15-20% per year, and grid-connected growth at 25-30% per year.[7] The proposed 15% tax credit for solar energy systems, recommended by the National Energy Plan and incorporated in the President's FY 2003 Budget and the Global Climate Change Policy Book, will likely contribute to realizing or even exceeding these growth rates in the domestic market. A strategic approach of coordinating and informing the development of community-based programs will leverage the tax credit to improve system economics and performance while providing real benefits to communities.

[4] Makower, J., and R. Pernick, "Clean Tech: Profits and Potential," Clean Edge, April 2001.
[5] Arthur D. Little, Merrill Lynch, Sarasin Bank, Shell all have estimates between 19% and 22%
[6] Union of Concerned Scientists predicts 25% growth, Clean Edge predicts 30% growth through 2010
[7] "Photovoltaics Rising—Beyond the First Gigawatt," EPRI Journal online

IV. THE PV MARKET AND COMPETITIVE ENVIRONMENT

The global and domestic markets for PV are experiencing rapid growth, averaging 33% per year since 1996. Market growth is, however, uneven around the U.S. and around the world, generally tied to local conditions and government incentives.

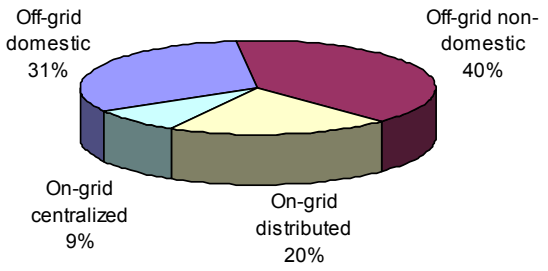
The U.S. Market for PV

The United States has the best solar resource of any developed nation. The overall U.S. solar insolation is considerably higher than in most of Europe and Japan; a system in New York City can be expected to produce over 1500 kWh/kWp per year[8], 13% more than a system in Tokyo and 40% more than a system in Berlin.[9] Systems in the Southwest can produce over 2000 kWh/kWp per year.

Market Momentum Exists

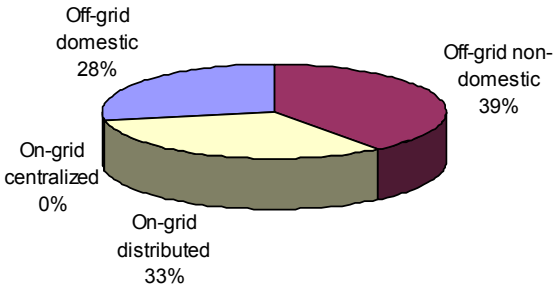
PV in the United States is a proven business, repeatedly branching out to new and innovative applications and showing growth and increasing momentum in recent years. Out of world total shipments of 390 MW, U.S. companies shipped about 100 MW of modules in 2001.[10] Approximated 70 MW was exported and 30 MW installed domestically, much of it grid-connected and installed with support from the California Energy Commission's Emerging Renewables Buy-Down Program. The market for PV has been building rapidly in recent years, and now is the time to ensure that this momentum is not artificially constrained.

Chart 2: Cumulative Installed PV in US (as of December 2000); total 138.8 MW



Source: IEA

Chart 3: Installations of PV in US in 2000; total 21.5 MW



Source: IEA

Charts 2 and 3 illustrate the historic trends in the domestic market for PV as well as the current market momentum of grid-connected PV.[11] Relatively small targets for market penetration into key segments – such as .5-1% of new homes, .2% of new commercial building energy demand, or .1% of Federal electricity demand – can easily surpass this figure, supporting a high industry growth rate through 2010 and beyond. See Appendix 9 for an illustration of these targets. By removing unnecessary impediments to PV deployment, the industry can demonstrate even greater growth in the future.

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[8] PVWatts application, NREL, http://rredc.nrel.gov/solar/codes_algs/PVWATTS/
[9] BP Solar, "Building for the 21st Century," September 2000.
[10] Paul Maycock, PV News, March 2002.
[11] Tucson Electric Power installed a 1.4 MW PV central generation plant in 2001, and plans to expand it by 1 MW in 2002; still, the rate of installation of central PV remains small compared to other applications.

Market Realities

As set forth in Section V, below, the ability of PV to meet consumer interest and build market volume is, to say the least, a task requiring multiple factors and partners to move forward on several fronts at once. For example, the markets require the numerous stakeholders to act in partnerships to make systems user-friendly, including the manufacturers, vendors, community leaders, and energy providers. Recommendations of key actions by the various stakeholders are detailed in Section XI.

The Market is Regional and Application-Specific

The PV market is not a commodity market but rather a collection of regions and applications where the value proposition is most attractive. The market for PV has until recently been dominated by off-grid applications such as remote residential power, industrial applications, telecommunications, and infrastructure such as highway lighting and pipelines, as described in Appendix A. PV is cost-effective in these applications and the market shows continuing growth potential. New business partnerships and models can increase the volume of PV deployment and provide avenues to develop new technologies.

The markets for grid-connected PV are less mature but have increased tremendously in recent years and provide the largest potential for growth. With applications including PV for residential and commercial buildings and government facilities, these markets require targeted approaches to develop and expand.

BUILDING-INTEGRATED PV CONTRIBUTES TO ZERO-ENERGY BUILDINGS

4 Times Square, NYC

Building-integrated PV includes diverse technologies such as PV shingles or slates, semi-transparent PV architectural glass and skylights, and standing seam roofing panels. BIPV provides numerous advantages over roof-mounted modules. It is often included at building construction, allowing for inclusion in the building design, incorporation into a mortgage, lower labor costs, avoidance of an extra support structure, and displacement of building materials. The building material value may be especially significant in, for example, displacement of roofing tile or glass curtain walls. Designing new homes and commercial buildings with BIPV can contribute significantly to the goal of developing Zero-Energy Buildings. BIPV products can be significant components of Zero-Energy Buildings going forward. Research should continue to focus on products such as BIPV that are well-suited to widespread deployment in high-growth markets.

Importantly, market growth is not dependent upon the sale of PV-only systems. The development of hybrid systems for off-grid power generation also represents a significant opportunity to expand the markets for PV. A PV-microturbine hybrid system can realize significant savings in operation and maintenance expenses and fuel costs, while maintaining extremely high availability and reliability. The system will have lower life-cycle costs and emissions than a microturbine alone. PV hybrid systems thus provide economic savings, environmental benefits, and increased reliability.

Markets Vary by Region, Electricity Costs

The markets for PV vary by region. The economic value of a PV system is greatly impacted by the alternative cost of conventional electricity, the local solar resource, the absence of significant barriers, and the available government incentives for PV installation. If environmental costs are included by calculating the value of emissions avoided, then these can be viewed regionally through the local grid electricity portfolios and the local costs of attainment for pollutants. Work at NREL has identified the regional economics for PV technology; the results are shown in Figure 1.[12] These break-even turnkey costs included calculations of solar insolation, retail cost of electricity, policies including net metering, and state incentives for PV.

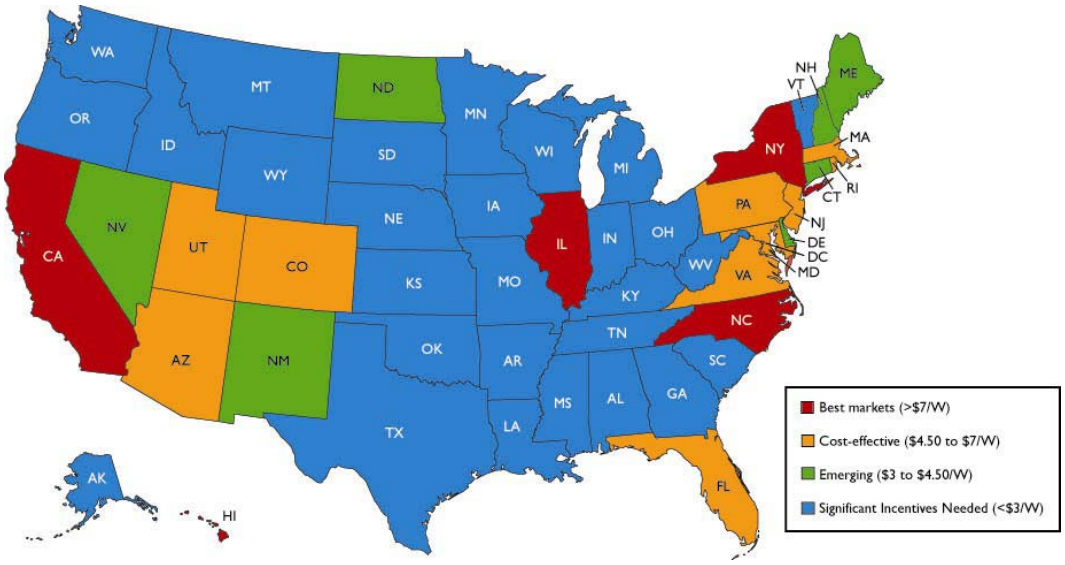

Figure 1. The Best Markets for PV, by break-even turnkey cost

LOCAL INCENTIVES ENCOURAGE PV MARKETS

Local incentive plans can create local markets for PV. For example, due to a relatively low solar resource and an abundance of low-cost low-emissions hydropower, the state of Washington would appear to be among the least favorable sites for PV development. Despite these factors, Chelan County is actually one of the best markets in the nation for photovoltaic systems. The Chelan County Public Utility District's Sustainable Natural Alternative Power (SNAP) program collects green power premiums from participating customers and redistributes the funds to participating solar and wind power producers based on their share of SNAP power generated. The resulting payment is expected to be $.25-.30/kWh,[1] but may be as large as $1.50/kWh.[1] In other states as well, community initiatives may exist to create viable markets for PV even when the state as a whole is not a primary market. Refer to Appendix 2, "Incentives Supporting PV."

A quarter of the U.S. population lives in the top five states for PV, those where PV is cost-effective at an installed cost of $7/W (assuming long-term financing as in a mortgage). Half of the population lives in states in the top two tiers, where PV is cost-effective at a cost of $4.50/W.[13]

[12] Data from Christy Herig, Richard Perez, Howard Wenger, "Residential customer-sited photovoltaic markets 1999," June 1999.
[13] Based on data from US Census 2000.

Clearly, there are many regional markets, as large as California or as small as a single town, where PV is an attractive and economically viable choice today or in the near future. Communities such as Chicago, Long Island, Sacramento, and Tucson have invested in PV and are encouraging the development of markets for PV. These community-based markets result from partnerships and significant public-private commitments. They can provide focal points for efforts to understand and address marketplace challenges. A poll of community-based initiatives is included as Appendix 6, "Solar PV Community Poll – Summary of Perspectives."

International Markets and U.S. Industry Positioning

Non-U.S. markets have emerged steadily since about 1975, representing over 90% of annual installations today.[14] Market demand has been booming recently in Japan and Europe for grid-connected applications such as residential rooftop and building-integrated photovoltaics (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.

The initiatives in Japan and Europe, described in Appendix 4, illustrate the considerable impacts of innovative incentive programs and government/industry partnerships. The experience of these countries, while not wholly applicable to U.S. markets, provides important information to the United States in charting a course to a sustainable PV market. It also demonstrates the real possibility that the benefits of U.S. investment in R&D may be primarily enjoyed in overseas markets, depending upon U.S. market penetration in the medium term.

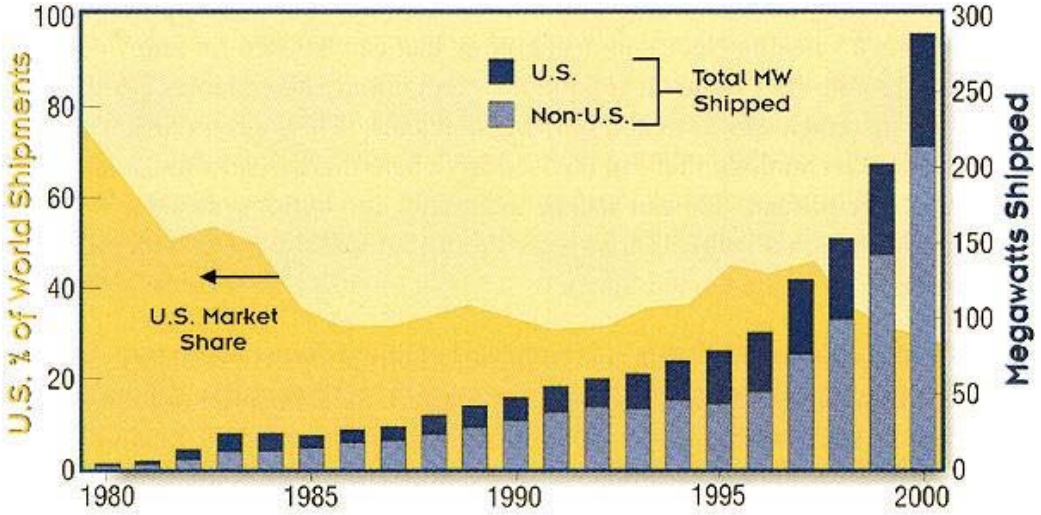

Chart 4. Annual world PV shipments showing U.S. and non-U.S. production (in MW). Percent of U.S. market share is shown in orange in the background.[15]

[14] Renewable Energy Outlook, DOE/EIA and Solar International Management, Inc.
[15] PV Industry Roadmap, May 2001, based on data from PV Insider's Report, Feb 2001.

The Japanese Federal government invested almost $500 million in photovoltaics in 2000, according to the DOE. The U.S. Federal government invested $82 million.[16] Although the RD&D budgets are roughly similar, the Japanese government invests considerably more in PV deployment activity. Given limitations in the current Federal budget for renewable energy research and development, Federal funds should not be and need not be relied upon to provide the dominant source of funding. Investment in PV is increasingly being made at the state and local level and by U.S. and international manufacturers and end-users.

Given the history of offshore growth, it is not yet clear how quickly U.S. industry and financial markets will invest in domestic capacity expansion. AstroPower is considered the only U.S. PV module company that is a global market leader, at #5 in industry ranking.[17] Spire Corporation is the only U.S. company from the U.S. PV industry of the 1970s that still operates in the business under its original name and ownership – many others have withdrawn or been acquired. The continued existence of a strong U.S. manufacturing base, and the high-value jobs it provides, must be a success metric for any initiative. Given the nature of the global economic opportunity, domestic manufacturing leadership appears to be key to capturing the economic benefits of PV growth. Public-private partnerships, including the Thin-Film Partnership, the Photovoltaic Manufacturing Technology Project, and PV:BONUS, have produced significant results in developing this manufacturing base and expanding U.S. expertise.

[16] Cited in "Cutting the Cord," Scientific American, online feature, April 30, 2001.
[17] Paul Maycock, PV News, March 2002.

V. MARKET ISSUES AFFECTING PV DEPLOYMENT

Despite the advances of PV technology in the U.S., PV has not achieved aggressive market penetration. A review of the history and market situation in the U.S. for PV indicates market momentum and potential, but the facts also show several obstacles to more rapid growth in demand and installations.

The primary obstacle to further solar deployment is the high initial cost of the systems. DOE research currently supports the PV manufacturing industry in reducing cost through new manufacturing methods and processes; increased demand will enable manufacturers to expand factories, implement these new processes as well as economies of scale, and reduce costs. As this process continues, many other market challenges can and should be addressed immediately. Widespread deployment of solar faces obstacles in institutional structures and perceptions, regulatory barriers, public perception, installation and service infrastructure, and financing. Successful community programs have found ways to address and overcome many of these obstacles, thereby creating a viable market for PV in those communities. These programs, as discussed in Appendix 6, have shown that key stakeholders and policymakers must communicate and cooperate in a focused way in order to resolve the issues associated with PV deployment.

Other key factors affecting U.S. PV market development include:

Lack of consumer knowledge about PV

In view of this strong public support for publicly-funded renewable energy programs, states and communities have designed a number of initiatives to support PV, often providing rebates or incentives for customer installation of systems. However, even in the best markets and in communities with well-designed programs, a consumer may still lack the information about how to procure a solar power system. In a survey of probable early adopters of PV technology, the National Renewable Energy Laboratory (NREL) identified various reasons these consumers have for wanting PV systems.[18] Respondents also identified several concerns about PV installation which often prevent them from buying. Most mentioned the economic and financial risk of system installation, the quality and performance of the specific PV product to be offered, and health and safety concerns (including roof damage from installation, utility worker safety, and other concerns). Some had questions about legal and regulatory uncertainties, including liability/insurance concerns, and others had questions about the possible environmental impacts of PV related to manufacturing, disposal, and batteries. Others were concerned about their ability to ensure accurate and fair net-metering. Most concerns, other than those related to cost or roof suitability, would not be prohibitive and could be resolved through more detailed information on the system and on regulations. Numerous community programs, referenced in Appendix 6, identified lack of consumer knowledge about PV as a major concern and as one of the best avenues for DOE to add value.

[18] B. Farhar and J. Buhrmann, *Public Response to Residential Grid-Tied PV Systems in Colorado: A Qualitative Market Assessment.* Golden, Colorado, NREL, July 1998.

Lack of institutional familiarity with the technology

The experience of community partnerships suggests that unfamiliarity with the technology continues to be an obstacle in the PV marketplace. In most areas, builders and architects are not comfortable enough with the technology to suggest or offer it in new building designs. Local building inspectors may disallow PV installation if they are unfamiliar with it, insurance companies may be reluctant to provide coverage, and banks are often unsure how to develop a loan for a $20,000 PV investment. Although energy providers are increasingly knowledgeable about PV, there are many regions where the local utility and other local stakeholders are still unfamiliar with PV.

Translation of consumer interest into action

Translation of consumer interest into consumer action continues to be a concern for PV. Green power programs may be held up as an example of how consumers may claim to be in favor of increasing spending for renewable energy, then may refuse to participate. In fact, the problem may be the design and structure of green pricing programs rather than their goal. An October 1998 poll of Texas Utilities customers found that 88% of respondents were willing to pay more for renewables, but only 17% wanted to rely on a green power option. Rather, 79% of respondents wanted all utility customers to pay at least some share of the added costs. As the benefits of renewable energy such as PV are shared by all ratepayers, many see green power programs as unfair. Green power and green pricing programs, while they may have a role to play, should not be seen as indicative of customer preference for renewable energy. Rather, public support of state or utility programs that encourage renewable energy at some shared expense – through a wires charge or through a tax credit – should be viewed as positive.

LEADING GOVERNMENT BARRIERS – LACK OF FAMILIARITY AND COST

Sandia National Laboratories conducted a survey of extant PV systems used by the National Park Service, the Forest Service, and the Bureau of Public Lands (*Renew the Parks*, *Renew the Forests*, and *Renew the Public Lands*, Sandia, 1997). The survey found a large number of cost-effective PV uses and general satisfaction with system performance, but also identified barriers to further deployment. Lack of familiarity on the part of the designers and operating personnel, taken together as one factor, was the largest obstacle to further deployment. The high initial cost of PV follows as the second major concern. FEMP and Sandia work to educate Federal facilities managers about the applications for which PV is the highest-value option. GSA provides procurement of PV for Federal facilities, but this process could be restructured to the mutual advantage of government and industry. Aggregation of government purchases into long-term high-volume contracts would allow manufacturers to expand production capacity with confidence in future demand, mitigating risk and driving down costs in the process. Secretary of Interior Norton and other agencies are focusing on the deployment of renewables on Federal lands. This effort should offer additional insights.

Lack of industry-offered systems to meet consumer needs and concerns

Development of the market for PV has somewhat been hindered by the focus of solar companies on the technology versus a strong customer orientation. The most successful domestic PV companies focus on marketing their product, forming alliances with key

industries such as home builders, and creating a demand for PV. However, there are currently virtually no companies providing turnkey solar solutions from system design and installation to removal and replacement.

Trends in conventional electricity costs

A major factor affecting PV deployment has been the effect of both swings in electricity prices and low overall electricity prices. Swings in supply levels and prices during peak load seasons create alternatively inflated senses of panic and of calm about traditional energy sources and have led to inconsistency in levels of policy focus on renewables. Overall, real electricity prices declined for 1980-1990 when they were projected to rise by eight percent per year. Also, fossil fuel costs have generally declined. As a new round of pollution controls come on line, cost predictions may or may not change. Some stakeholders have argued that the scope of tax credits and other government subsidies for fossil fuels have contributed to its dominant market position and that at least comparable public support for PV is warranted.

PV manufacturing & deployment dominated by other countries

As noted in Chart 4, a distressing PV trend is the extent to which manufacturing and market growth have moved offshore. U.S. technology leadership continues to be a key advantage upon which to build. While the U.S. was the leader in energy technology development in the post-energy crisis era of the 1970s and 1980s, leadership in PV development and deployment began shifting to Japan and Europe (particularly Germany) in the late-1990s as environmental and climate change issues began to drive emerging markets for PV. As a result, PV has evolved into a global industry. Sharp and Kyocera have emerged to capture significant global market share based on their success in the Japanese home market; both companies are now importing to the U.S. market. The number two and four companies, BP Solar and Siemens-Shell Solar,[19] have been established through acquisition of U.S. firms Solarex and ARCO Solar, respectively, plus organic growth on a worldwide scale, with factories in the U.S., Europe, Asia, and Latin America.

Unresolved technology development issues

Key technological requirements today include ensuring that the manufacturing process continuously improves cost and quality and that the systems are developed and integrated to ensure reliable and low-cost installation and operation. The PV manufacturing industry must take actions to ensure that its offerings are reliable, mature, and sophisticated. These include increasing compatibility among system components; providing data on system performance, reliability, and lifetimes; continuing research to improve conversion efficiency and manufacturing processes; and forming partnerships with other industries. For example, industry collaboration can find valuable applications of PV in hybrid systems, in which PV is integrated as a complement to existing installed technology, whether it is base-loaded, peaking, or distributed generation. The connection between users (customers) and the R&D community could be closer, to ensure that real needs are factored into the R&D agenda.

[19] Paul Maycock, PV News, March 2002. Shell has announced a commitment to building a larger solar portfolio.

Technological bottlenecks for PV products and system components

As the deployment of PV requires many factors to come together, a deficiency in any one element creates a technological bottleneck. Though many PV technologies may be used to make cells or modules, the application of PV requires certain other components. These "balance of system" (BOS) components typically include either an inverter or a battery (or both). These two components contribute significant expense to the cost of PV systems and are the elements most likely to need servicing. Although Arizona should be one of the prime markets for PV, Tucson Electric Power has reported significant difficulty in finding inverters with acceptable performance characteristics.[20] Further improvement in inverter performance and battery lifetime is crucial to the success of PV.

Changing electricity infrastructure and distributed energy resources

Many of the challenges facing PV exist because it requires a new and different institutional framework for electricity production. The electricity infrastructure in the U.S. has been centered on two key concepts: first, that an energy provider will own and operate the generation capacity, selling power to the customers, and second, that the generation will take place at central locations and will then be distributed to customers. Photovoltaic systems, unlike most other renewable energy technologies, are often distributed and customer-owned. While central PV stations are possible, as are utility-owned systems on residential houses, our model focuses on systems owned by the end-user or by a third party leasing to the end-user. The historical regulatory framework for electricity has been developed around the central-generation paradigm, and is undergoing change as restructuring moves forward differentially in key regions. The current transitional period creates market confusion, though it also provides an opportunity to craft reasonable and practical policies for the future. PV strategies should be integrated wherever possible and appropriate into initiatives related to distributed generation. Beyond changing the policies, there is a further need for consumer outreach. Customers perceive that taking on PV makes them a resource owner and power merchant. In fact, the reality of PV for consumers is more positive.

Ability to engage energy providers in PV deployment

Based on the existing framework for electricity generation, transmission, and distribution, the energy provider (utility) is a critical player in PV deployment. In fact, the perception is often that the energy provider is opposed to the installation of PV systems. A utility brings a host of assets to the table, including a conduit for communication to the end-users, a position as the traditional and generally reliable provider of energy, and the infrastructure and expertise needed for PV installation. The energy provider also sets the parameters for many of the issues affecting PV. Policies such as net metering, interconnection, and time-of-use pricing all have consequences far beyond the impact on PV, so an energy provider will understandably be cautious in developing these policies. However, making these requirements prohibitively difficult will inhibit the deployment of PV and could affect the energy provider's reputation with its customers.

[20]Public information on Tucson Electric Power's website regarding SunShare program.

VI. CRITICAL SUCCESS FACTORS FOR PV DEPLOYMENT

In a free-market economy, as technologies move to commercialization and mature markets, the Federal role should be minimal. As reflected above, the evidence appears to show some strongly developing markets for PV, but also some significant impediments which appear to inhibit otherwise interested consumers from buying PV systems. These are transitional issues, and the Federal government cannot and should not solve all of them. However, the government is in a position to either be a primary or supporting player in ensuring that PV is able to meet demand on its merits. Set forth below is an analysis which leads to recommendations for a limited, constructive Federal role for this developing industry.

Several focus groups and interviews with industry experts were undertaken to examine the history of PV programs and market development, the institutional obstacles to market penetration, and the roles and interests of key stakeholders. Certain steps were seen as central to increasing penetration of PV in promising markets:

- The best market segments for the technology must be identified and targeted. Market segments can be classified by geographic suitability (e.g., New York City, Chicago, Tucson as primary markets for PV) or by application. For our analysis, the primary application-defined market is grid-connected distributed generation, with particular focus on new homes and BIPV. The best geographic markets are those in which PV has market momentum due to local initiatives. These geographic markets may be on the scale of a state or on the scale of a municipal utility district, but most likely will correlate with the service area of one or a few energy service providers.
- The relationship between end users (customers) from each of the market segments and the stakeholders, both public and private, must be established. Dialogue is essential. Depending on local conditions, the stakeholders involved will vary, but certain key players will always be involved; the system supplier, installer, energy service provider, the end user, and the local government. Financial institutions, insurance companies, builders and architects, retailers, and community leaders and organizations are also likely partners.
- The needs and expectations from each stakeholder must be recognized. The most important, of course, is the customer, but others are also key. The energy provider wishes to maintain a reliable grid; the builder wants a product that can be incorporated into a new design with a minimum of hassle and that provides a marketable value to a home buyer. The insurance company needs data on system performance in order to insure the system. The needs of each stakeholder should feed back into guiding the course of future R&D.
- The total value proposition of PV must be identified and realized. The benefits of PV must be communicated to all the stakeholders, especially the customer (end-user). Policies and practices should be designed to reflect the total value proposition (for example, designing incentives to reflect the value of emissions avoided).

Based upon the analysis performed to date, it makes sense to identify the critical success factors necessary to meet customer needs and increase market penetration – these can serve as a reference point to develop an action agenda. Success depends upon the right stakeholder taking the lead in each action, in coordination with the others.

The following critical success factors (CSFs) are necessary for the development of a market for PV within a given market segment:

- **Technology Development** – customer needs must be understood, and the elements of the PV technology must be fully developed and ready to cost-effectively meet those needs. PV is currently ready to provide grid-connected distributed generation across the U.S.; further research will bring down costs, improve efficiencies, and improve inverter performance, but the current technology is viable.
- **State and Federal Policies Aligned** – the government, at all levels, provides the appropriate mix of incentives, actions to reduce barriers, and procurement to allow PV technology to address target markets. Many States have developed policies for PV, while others are not as far along and would benefit from the lessons of others. Federal policies should serve, among other goals, to support State actions.
- **Electricity Provider (Utility) Acceptance** – the local utility provides cooperation for the end user to insert PV as a seamless addition into the existing power grid. Utility acceptance of PV is a critical factor for market development, as even the highest incentives and most enthusiastic supporters can be stalled by prohibitively difficult requirements.
- **Downstream Infrastructure** – distribution and service network is sufficiently developed to support PV within the market segment. Any initiative to deploy PV requires locally available PV systems and qualified personnel to install and service them.
- **Informing the Market** – the end users and stakeholders within each market segment are informed of the value proposition of PV. In some cases, PV is cost-effective simply on its energy value; in other cases, the total value proposition makes it the highest-value choice. Informing the market of these benefits will create sustained and growing demand for PV.
- **Financing Options** – flexible, tailored, and widely-available finance vehicles open the market to more end users. Because of its high up-front cost but very low O&M costs, PV benefits greatly from the availability of low-cost low-hassle financing options such as mortgage lending or asset-based leasing programs.

Two relevant case studies that illustrate these critical success factors at work are located at Appendix 8. One case study examines a successful geographic market (Sacramento), and the other examines a successful applications market (telecommunications).

VII. FEDERAL PV INITIATIVES

Previous initiatives to develop the markets for PV have had some important successes and provide lessons for the future. Two such programs include the Million Solar Roofs program and TEAM-UP; others such as Clean Cities and PV:BONUS also provide useful sights. The lessons learned from the design and operation of these programs help point to a more focused Federal approach going forward.

Million Solar Roofs

The Million Solar Roofs (MSR) program was instituted in 1997 to establish local markets for solar energy, including PV, solar space heating, and solar water heating. The goal of the initiative is to install one million solar roofs in the U.S. by 2010. To accomplish this, the MSR program aims to enhance the financial tools and resources available for solar energy, increase consumer awareness and understanding of solar energy technologies and their benefits, encourage the widespread adoption of uniform interconnection standards and solar friendly codes, promote net metering, and eliminate restrictive solar covenants. The MSR program also aims to encourage certification and testing programs for solar energy systems, and to encourage builders and developers to include solar energy systems in new housing developments.

The program funds efforts to remove market barriers and develop and strengthen demand for solar energy products and applications. It does not pay for cost of equipment and installation, but often serves to fund consumer outreach or the administration of the local partnerships. The program has formed 60 state and local partnerships, supported by DOE Regional Offices; these partnerships have installed over 150,000 systems and have committed to installation of over 1,000,000 systems.

To date, the MSR program has educated relevant stakeholders about financing, interconnection, building codes, covenants and restrictions. It has developed regional training programs for installers and inspectors, and certification programs for installers. Some MSR partners have worked to develop interest in PV among home builders. MSR partners have developed and published technology brochures, local success stories, solar fact sheets and regional solar information web sites to educate the public, local solar companies, and local governments. MSR partners have taken an active role in developing state net metering legislation.

Some stakeholders suggest that the MSR would benefit from greater utilization of success metrics and a more accurate inventory of installed systems. In some cases, requiring a strict schedule of solar roof installations would not be warranted, due to the large amount of early effort expended on education and outreach to little immediate effect. Once the program is established, however, it is appropriate to require partnerships to meet their commitments. Overall, the Million Solar Roofs program has met with significant success in developing enthusiastic and informed community partnerships.

Key elements of the MSR program that should be part of the new DOE strategy include the following:

- Community-based partnerships
- DOE supporting program development, not hardware installation
- Public outreach and education are a significant component of the program

TEAM-UP

The TEAM-UP program was a joint effort by the Utility Photovoltaic Group (now the Solar Electric Power Association) and DOE to accelerate the deployment of PV systems. Initiated in 1994, the program aimed to increase energy service provider use of PV, with a focus on hardware installation. The specific program goals were to document the costs and value of PV in relation to economic development, business opportunities, and the technology's environmental benefits, increase electric service provider participation and interest in PV, improve collaboration between communities and energy service providers, and provide strategic advice and develop replicable approaches to PV use. Local partners developed ventures such as green pricing, school-based programs, direct-to-customer marketing, utility-based ventures, and product-oriented approaches.

TEAM-UP used a results-oriented approach; payments were based on progress points, with a final payment adjustment based on the actual amount of PV installed and the actual public/private cost share. The initiative reported of interim lessons learned, final lessons learned, costs, and experiences. The initiative documented performance information suitable for use by future project teams and by manufacturers. TEAM-UP determined the potential for the most cost-effective markets, identified the need for public education to achieve desired market expansion, and significantly involved and educated more than 40 SEPA utility members about PV, with additional involvement by 40 other utilities. The initiative provided experience to utilities, integrators, and installers in multiple applications including residential, commercial, BIPV, and parking structures.

The TEAM-UP program did suffer from uneven funding, falling short of its initial goals. Nevertheless, it installed 1,100 PV systems, totaling 7.2 megawatts capacity. The community-based solar programs developed in the initiative will be continued by 75 percent of the TEAM-UP partners. Industry committed $60 million in cost share to DOE's $15 million of funding, for an 80% private-public cost-share, exceeding the original target of 70%. The structure of the TEAM-UP program showed many of the elements that we propose for a successful Solar Solutions program:

- Results-oriented
- Experience-building strategy
- Public-private partnerships
- No mandated mechanisms, but rather a variety of approaches.

The TEAM-UP program achieved many of its critical success factors through the local ventures. Some ventures focused on technology development, others focused on informing the markets. All the ventures either were initiated by or tried to engage the local energy service provider.

Lessons learned from the TEAM-UP program can and should be applied to development of a new Federal strategy for PV, as well as to State plans and initiatives:

- **Establish clear program goals and realistic but flexible schedules** – participants generally felt that clear goals led to successful implementation, but that most initial schedules were unrealistic.
- **Secure support from upper management** – Federal support of a program is a powerful asset in convincing key decision-makers that the PV initiative is deserving of their support.
- **Know what to expect from the technology** – participants expressed a desire for better information on system performance, particularly as regards the inverters. While much work remains to be done in development of reliable systems, TEAM-UP members suggested designing systems using components that have worked well together elsewhere.
- **Integrate PV into new home constructions** – new homes are a key market for PV, enabling design of the home (such as roof shape and orientation) to facilitate installation of PV. Such an installation is also easier for the homeowner, allowing incorporation of system cost into the mortgage.
- **Use experienced PV installers** – TEAM-UP partners suggested locating contractors who are skilled and knowledgeable about PV, certified if possible. Some energy service providers trained local contractors to install PV.
- **Make interconnection simple** – deployment of PV benefits from standardized and reasonable technical standards, such as those defined by IEEE 929, UL 1741, and NEC 690, as well as business and contractual procedures.
- **All systems should be monitored** – a data acquisition system is especially worth the cost for larger systems, to ensure adequate system performance. A simple and inexpensive meter for a smaller system can also provide useful information.
- **Don't be afraid to ask for help** – TEAM-UP identifies several information sources for technical and policy advice.

Stakeholder concerns about the TEAM-UP program focus on the process used to select projects and distribute funds. Future initiatives should employ a competitive and transparent bid process, and should fully engage and communicate with all key stakeholders.

Clean Cities

Clean Cities is a DOE-supported program of locally-based public-private partnerships aimed at increasing the use of alternative-fuel vehicles (AFV) in cities. Clean Cities partnerships bring together key stakeholders with a common interest in AFV in order to create the level of commitment necessary to sustain the partnership. The program secures commitments and assists communities in meeting these commitments. Clean Cities develops a common approach among the stakeholders so that the various members of a partnership work in a coordinated manner towards the same goal and can resolve issues encountered. DOE supports the development of an organizational and management structure and provides guidance as needed. DOE shares information ranging from technical data to program management to materials for community outreach and public education. The lessons learned by the various community programs are shared through

networking and at an annual conference. This allows partnerships to learn from the experience of others. Partnerships and programs are developed at the community level before applying to DOE for support in further development; in this manner, DOE builds on existing momentum and interest. Many attributes of the Clean Cities program provide a useful model for the DOE strategic approach to PV going forward and could be incorporated into our proposed Community Solar Solutions initiative:

- Locally-based public-private partnership;
- Voluntary and enthusiastic participation of interested communities;
- Realistic but ambitious commitments from partnerships;
- High-visibility announcement of new partnerships;
- Appropriate technical assistance, organizational guidance, and informational support from DOE;
- Common approach among stakeholders in each community partnership;
- Exchange of ideas and experiences among the community partnerships at an annual conference;
- Partnerships developed and interest mobilized first at the community level, then supported by DOE.

PV: BONUS

Building Opportunities in the US for PV (PV:BONUS) is a product-oriented initiative designed to accelerate the development of building-integrated photovoltaics (BIPV) through a collaborative effort involving PV manufacturers, system designers, architects and builders, and electricity providers. The PV:BONUS effort is supported by educational and benefit assessment programs. Future RD&D and efforts towards the goal of Zero-Energy Buildings (ZEB) can build on the results of the PV:BONUS program and the lessons learned from the proposed Community Solar Solutions program. Similarly, community programs can incorporate the most promising new products and technologies developed by PV:BONUS into their efforts, evaluating the market potential of these products.

VIII. A NEW STRATEGIC APPROACH - ROLE FOR THE FEDERAL GOVERNMENT

Historical Involvement & Lessons Learned

The primary focus of DOE funding to date has been reducing the installed system cost of PV. For example, the original goal of the ERDA/DOE program, set in the late-1970's, was to drive the cost of PV modules down to 50¢/Wp (in 1975 constant dollars). In 2000, module prices were about $3.50/Wp, or about $1.50 in 1975 constant dollars. DOE estimates the learning curve of PV technology to have a progress ratio of 82%, though certain other calculations place it at 75-80%; that is, after a doubling of cumulative production, the cost per peak watt is about 82% of what it was before.

Despite these cost reductions, PV has not met the goals set for market penetration; this can be explained in part due to low electricity costs and Federal funding inconsistent with original projections. Unpredictable funding is problematic for both R&D and deployment initiatives. Original predictions for cost reductions were based on assumed levels for R&D funding that never occurred. Dramatic decreases in funding will inhibit accomplishment of program goals, disrupt project administration, and create an often incorrect perception that the initiative failed. Substantial increases in funding without a strategic plan can prove equally problematic. For example, states with renewable energy trust funds have recognized the need for strategic priorities and success metrics. Therefore, both in designing its own programs and in assisting states and communities with their programs, the Federal government should ensure predictable and consistent levels of funding tied to specific project goals and durations.

Future Investment Focus

The consideration of alternative strategies for the government role in PV has been taking place since about 1972, resulting in over 25 years of Federal support for research, development and demonstration, plus commercialization activity, and an increasing level of activity by state and local governments aimed primarily at deployment. Looking forward, the question of Federal role should be based on an assessment of the current situation and the challenges that will need to be addressed in coming years. This must be done in the context of a clear understanding of objectives and delineation of roles among all key stakeholders.

An appropriate role for Federal involvement in PV deployment exists beyond its traditional capacity as a supporter of research and development. A focused, targeted approach can foster the conditions in which community initiatives can succeed. The Federal government and DOE in particular, should not serve as the marketing arm of the PV industry, but neither should it turn its back on the benefits of PV, significant market progress, and dramatic public and community support of PV. The Federal government has a stated interest in securing domestic energy supplies, maintaining and improving air quality, and establishing a secure energy infrastructure. The PV value proposition reflects all of these goals.

Reasonable Federal involvement will involve a results-oriented approach, objective performance data with specific targets, rewards and consequences, and a competitive process for funding. Policies will support a sector rather than a specific company. Initiatives supported will be citizen-centered, community-based, market-focused, public-private partnerships. Certain categories of action seem to be the most consistent with Federal jurisdiction and core competencies:

Research and Development

Today's commercially-available PV systems, to a large extent the result of Federal RD&D support in the past, are still too high in cost to have a self-sustaining market in the U.S. today. The task of bringing PV system costs down from the range of $100/watt in the 1970s to generally $5 to $10/watt today is a tremendous achievement. However, it must be recognized that the goal is $1 to $3/watt, so the task is only 90% to 95% complete. Like most trend lines approaching zero or infinity, the challenge becomes greater as progress is achieved. This is also the case for PV RD&D.

The justification for continued Federal government support for PV RD&D is that the national benefits are worth pursuing, that the task is greater and riskier than any company can or will support alone, and that there is a reasonable chance of success. All of these conditions are met in the case of PV. Indeed, evidence suggests that the race among nations for leadership and commercial success (jobs) in PV is quickening, and the amount of funding to maintain global leadership is going up accordingly. The chance for U.S. success in PV is being challenged by recent increases in PV program funding in Japan and Europe. PV is a global industry. PV is an exportable technology. It is imperative that the U.S. establishes a home market and remains a net exporter of PV products, and does not become an importer from factories abroad. Therefore, U.S. funding of PV RD&D needs to continue to take account of the global race in PV technology advancement.

There are many analogies to the justification of continued Federal funding of PV RD&D after commercially-available products have begun to appear in the market. Experience shows that breakthrough discoveries are often made after a commercial industry has emerged. Analogies include:

- The computer industry where the microprocessor was developed nearly 20 years after the invention of the first digital computers which ran on vacuum tubes and later on transistors;
- The biotechnology industry where the value of discoveries is increasing with time, not diminishing;
- The advanced materials industry where there seems to be no end to the discovery of useful new materials.

These examples are analogous to PV because they all deal in the realm of atomic-level science, where the breakthroughs in PV technology will occur. Virtually all parties appear to agree that the horizons of PV technology are virtually limitless, and new developments continue to occur both in the basic science and in manufacturing

processes.[21] This vision of zero-energy buildings and leap frog technologies is compelling. This in our view requires a combination of enhanced basic RD&D spending and a market focus that deals with market impediments created by government and which ensures that the best customer and market input is fed with the RD&D priority-setting process. This ensures profitable applications today while the next-generation technologies are being developed.

Deployment-Based Actions

In the area of deployment, Federal actions must be more circumscribed. It is clear, however, that the benefits of the nation's investment in PV technology will not be realized until, and then only to the extent of, the employment of PV in end-use applications in the nation's electricity system.

Employment of PV is easy to say but, it turns out, difficult to put into practice because the marketplace is not a blank slate. There are two dimensions to the challenges:

- Governance of the electric system: There are over 100 years of cumulative laws, regulations, institutions, and practices for the provision of electricity in America that are based on the public service model of central station, institutionally-financed power plants and the grid. For utility sponsored wholesale PV power stations, there is no problem, but these kinds of installations will only be about 5% of PV installed capacity. The other 95% of PV will be installed on the customer side of the meter, creating an urgent need for the resolution of issues that are a part of government and hence only resolvable by government.

- Technology and engineering solutions: A real opportunity for PV is integrating it into end-use facilities and systems. This will require RD&D at the applications end of the spectrum – including materials, components, structures, and systems solutions. Here, for illustration, a distinction is drawn between putting PV *on roofs*, and the manufacture of "PV roofs." Another is the distinction between adding PV to the skin of a building, and the development of PV-based building materials. And finally, a distinction is drawn between PV-powered battery charging stations for electric vehicles, and the possibility of developing a PV material for paving highways for electric cars. In this context, not only is the PV RD&D job not done, it may be only just beginning. Looking forward, deployment-side RD&D may be as important as supply-side RD&D.

The deployment issues are national in scale, but local in practice and application. Like some forms of politics, it might be said that "all PV deployment is local." National benefits will be the sum total of many local benefits. Whereas the constituency of the PV technology RD&D program is the PV industry, the constituency of a deployment program will be communities and success depends upon building and sharing experience and best practices. Key Federal roles and actions include:

[21] As an example, The Research Institute of Innovative Technology for the Earth, in Kyoto, Japan, has announced the development of a silicon photocatalyst that can produce hydrogen 30 times more efficiently than current technology.

Information

Accurate and clear information is vital for all the stakeholders, including consumers, builders, architects, developers, service personnel (including unions such as the International Brotherhood of Electrical Workers), energy providers, municipal governments and agencies, vendors and manufacturers, financiers, homeowners' associations, and insurance companies. A successful community initiative requires a leader able to bring together all the relevant stakeholders in the community, develop partnerships and foster dialogue, provide answers to all questions, and arrive at a consensus solution to all of the issues affecting the deployment of PV. In some cases, an outside solar developer has arranged this dialogue, such as Solar Century in the UK. Other community initiative leaders have included the Citizens Advisory Panel, an energy NGO on Long Island, and municipal utilities such as Sacramento Municipal Utility District (SMUD) or the Los Angeles Department of Water and Power (LADWP). While the Federal government need not always take the role of leading the creation of these community initiatives, it must be responsive to their needs. By providing the community initiatives with the information needed to develop an effective program, sharing lessons from other initiatives, responding to address obstacles identified, and in some cases providing direct support, the Federal government can enable these community programs to succeed.

The government has an important role to play as a source and supplier of information. As the government is supporting the sector rather than any one company, it is seen as an accurate and trusted source of information on PV system performance, reliability, and characteristics. Sandia National Laboratories' role as an impartial third party in evaluating the performance of PV systems has provided great value to community partnerships. The public in general trusts the government for reliable information on energy supply, environmental benefits, and safety. Therefore, the government can play a key role in education and outreach regarding the characteristics of PV. The extensive informational resources developed to date by DOE and its associated facilities such as NREL can play a key role in public outreach. Equally important is the Federal government's role in providing information to policymakers at the State and community level. DOE has access to extensive information on the features and results of State initiatives; by sharing this information and lessons learned, the Federal government can assist states in developing appropriate and effective PV deployment initiatives.

Coordination/Convening

The Federal government has a key role to play as a coordinator and advisor to community partners. By convening public-private partnerships, the government can leverage its influence and resources to dramatic effect. By focusing on community-based programs, the government recognizes the unique regional concerns and varying conditions for PV, while acting to address nationwide needs and obstacles. The government's role as a convener is especially appropriate; when a given technology or development has a compelling public interest for the nation, the Federal government is well-suited to bring together key stakeholders to address the issues. Where another entity or organization is willing and interested in leading the dialogue, DOE and the Federal government would still benefit from participating. Participation in the dialogue enables DOE to abreast of

local developments, to ensure that local policies and national policies are aligned and to feed information from the markets and communities back into the direction of R&D.

Procurement

The Federal government is the largest single consumer of electricity in the nation. In its role as a consumer, the government can and should procure PV for its own needs. Federal installations of PV increase end-user confidence in the technology to a greater extent than Federal R&D or demand-side support. While investors are leery of any technology that the government supports for political reasons, they are more comfortable with technology that the government uses for its own needs based on its total value proposition. Federal installation of PV also provides high visibility of PV systems and an opportunity to educate the public about the benefits of PV.

Addressing Obstacles

Where obstacles have been created through government action or national policy, it is appropriate for the government to take action to remove these obstacles. These issues may be identified through dialogue with community partnerships.

Set forth below are the priority recommendations based upon the SPS research and interviews. These recommendations focus on appropriately limited and defined roles for the Federal government, but make clear that the Federal government is not turning its back on markets where interest exists but impediments remain.

IX. RECOMMENDATIONS

In light of the critical success factors and related findings identified above, this paper strongly concludes that there is a need for a targeted and defined Federal role in PV beyond basic R&D. The Solar Power Solutions (SPS) team has identified a group of recommendations designed to be high-leverage, focused in scope and designed to integrate the actions of key stakeholders. Set forth below are the categories of priority recommendations, the five top-priority recommended projects, and a listing of the recommendations, categorized by lead actor.

The top five recommendations are specific initiatives aimed at meeting critical success factors. These initiatives are described separately but are interrelated keys to addressing the critical success factors described above. Bringing them into a single initiative would help avoid fragmented focus and achieve better concrete results through sharing lessons, coordinating efforts, ensuring responsible oversight, and leveraging partnerships.

Categories of Recommendations

- Implementing community-focused, cost-shared projects to provide a clear understanding of current markets and a systematic approach of reducing barriers and meeting customer needs;
- Ensuring an informed marketplace with coordinated outreach and education;
- Filling a key information gap through a disciplined effort to quantify the full value of PV;
- Systematically enhancing federal procurement to establish the value of PV in specific applications;
- Addressing major gaps in the downstream infrastructure for PV. Developing customer-friendly systems and a support infrastructure that inspire confidence is largely an industry job, but key initial actions require federal involvement;
- Solving interconnection, net metering and related technical and regulation-based barriers; this requires collaboration among the Federal Energy Regulatory Commission (FERC), NARUC and state PUC's, industry, and other key players, but can be addressed without legislation;
- Mobilizing cooperative efforts among state and federal energy and environment agencies to ensure maximum appropriate emission credit is given both to efficiency and to "green" energy sources such as PV; and,
- Inviting the financial community, including lenders, insurers, and investment banks, to identify financial tools and incentives tailored to PV projects and develop a process for addressing investor/lender questions about PV.

X. TOP FIVE PROJECT RECOMMENDATIONS

1. PROGRAM RECOMMENDATION – COMMUNITY SOLAR SOLUTIONS PROJECT

The program will provide targeted funding to community initiatives that build on successes in the market and emphasize participation by industry, government, energy providers, and financial institutions. DOE can model its programs on a later-stage venture capital approach, supporting the expansion of successful emerging programs rather than trying to develop new ones from scratch. Special focus has been placed on understanding related DOE programs building on successes and avoiding the more difficult "lessons learned."

Program Goal and Strategy

The following are the goals, strategy and features of a proposed new "Community Solar Solutions Project":

- The goal is to encourage the implementation of numerous sustainable solar power programs operating at state and community levels that lead to rapidly growing markets. Sustainable programs are those that address all of the critical success factors identified as leading to long term success.
- The goal of the individual community projects is to place PV systems, and to catalogue and address all issues necessary to progress, including utility regulation, interconnection, net metering, infrastructure, etc.
- The strategy is to provide funding to expand projects that include many or all of these critical success factors to identify and address barriers to progress, develop success metrics, and to have these projects serve as resources for other states and communities.

Premises

- This would be a new initiative, building on experience but replacing earlier programs such as TEAM-UP and Million Solar Roofs, and will be focused, targeted, and results-oriented.

- The critical success factors identified in the SPS Blueprint should also be the focal points for effective outreach and PV system deployment efforts. For example, a project should systematically identify and set goals regarding the conditions and participants necessary to encourage customer purchase of PV including information, barrier elimination, installation and service infrastructure, state policies, financing, etc. The ability to define and measure progress toward addressing these issues is key to achieving the true market potential of PV.

- Broad public Education and Outreach are critical requirements for accelerated market expansion, with both national and state/local audiences targeted.

- State and Local Programs that include a buy-down component should be encouraged, but are not recommended as part of the DOE program.

- The program should be directed towards grid-connected market opportunities and the barriers that exist, not cost-effective off-grid markets.

- The most promising markets identified in the SPS Blueprint report should be targets of the program:
    - New residential roof-tops (without ignoring the larger potential for retrofit of existing homes)
    - Commercial buildings
    - Public buildings, including schools

- The array of building-integrated PV products (BIPV) and their application to the most promising markets must increase:
    - Addresses aesthetics of solar installations
    - Gains benefits of combining building envelope functions
    - Works towards goal of zero-energy buildings

- Continued R&D to reduce product costs and improve efficiency, and efforts to reduce the costs of manufacturing processes also critically serve the objectives of accelerating the development of PV markets and should be continued. These are not, however, subjects of this market acceleration program.

Program Features

- ***Program Name:*** "Community Solar Solutions"

- ***Project Funding and Cost-Sharing***
    - Project co-funding of $250 K per year for 2 years per project
    - Minimum of 50% cost sharing
    - Select 10 high-potential communities based upon those that come forward

- ***Approach***
    - Bottom-up – communities must come forward and not be pre-selected by the Federal government
    - Funding can support overcoming any barrier or missing "critical success factor"
    - No hardware funding - Funding cannot buy-down or support directly the purchase of solar power systems, modules or other components (these are the functions of state and local entities)
    - A major priority should be increasing the availability of acceptable building-integrated PV (BIPV) products for architects and consumers. Developing partnerships with builders will be crucial. The BIPV component of the Community Solar Solutions program has the following features:
        - Tied directly to DOE's Zero Energy Building efforts

        - Addresses the aesthetics of solar installations
        - Gains capital and installation labor benefits of combining building envelope functions
        - Incorporates costs into long-term building financing (mortgage)
        - Less product development and more market acceleration features than the previous PV:BONUS program

    - Downselect – Consideration should be given to a downselect feature of the program where a larger number of projects are funded the first year at a set, relatively low level, and larger remaining funding amounts dependent upon meeting key metrics and other goals:
        - All projects would not receive continuation funding
        - All projects would receive visibility and prominence in the program, and learning from all projects would be obtained

- ***Important Role of Education and Outreach***
    - A significant public education and outreach effort is included and overlays the Community Solar Solutions program to serve the following program goals:
        - At the national level, "market" the Community Solar Solutions program to increase the quality of proposals and promote the replication of successful showcase projects, and undertake broad education and outreach to increase the general public's solar power knowledge:
            - Conference presentations, business press articles, press releases, etc will be important tools
            - Reward organizations that go solar with recognition
        - At the state and local level, in collaboration with Community Solar Solutions projects, serve specific marked development and consumer awareness goals, and reward showcase project participants with recognition for their successes
        - Also at the state and local level, increase the understanding of stakeholders through showcase MSR workshops on topics such as interconnection, codes and standards, financing, and state and local incentive programs

- ***Goals and Metrics of Individual Projects and the Community Solar Solutions Program***
    - Kilowatts of PV installed (minimum of 100 kW in the life of a project, even though there is no program support of the hardware)
    - Consumer awareness
    - Financing deployed for the purchase of PV systems
    - Replications of successful programs by others
    - Streamlining the installation process by addressing local regulatory issues such as siting, permitting, building codes, and fire codes.

- ***Collaboration and Teaming***
  - One entity must propose and contract, but goal-oriented collaboration among stakeholders is a funding requirement
  - Any organization or business can be the lead entity
  - An existing or new Million Solar Roofs partnership or other local community group may be a key partner, energy providers are also required players

- ***Funding Competition, Bidding and Contracting***
  - Funding available to all types of organizations and collaborative entities
  - Competitive bidding - Funding allocated as a result of an open request for proposals and proposals reviewed by an independent group of qualified evaluators
  - Criteria for Funding
    - Measurable success has already been demonstrated and a Community Solar Solutions project can be implemented with additional funding that addresses one or more of the critical success factors
    - Sustainable business strategy which incorporates the critical success factors
    - Partnering with a local Million Solar Roofs partnership or other local community groups that may serve the same purpose; characteristics of the community group include:
      - Inclusive, not just one organization
      - Political, top-down leadership
      - Commitment from all players
      - Resources available locally to support the group
    - Uses sound PV system technical and performance specifications and business practices in hardware deployment
    - Schedule and goals lead to relatively significant, measurable market acceleration targets**,** including the installation of PV systems
    - Strong state and/or local drivers that can include:
      - High cost of traditional energy resources
      - Air quality non-attainment area
      - Security of energy supply
      - Mandated renewable energy or air quality goals
      - Interest in public buildings, such as schools
  - Contracts, not financial assistance, utilized
    - Specific goals and work plan
    - Flexibility in contract management and changes to projects
    - 20% retainer for final results and report
    - Reporting is minimized, but does document sufficient information for program management and DOE to showcase the results for replication by others

- ***Program Management***
  - Led by a broad steering committee of stakeholders
  - DOE offices provide support they are uniquely qualified to provide
    - Regional office support of local needs outside of funded showcase projects
    - DOE laboratory technical assistance
  - Interstate Renewable Energy Council (IREC) provides key community-oriented support
  - Administered and managed by a non-government organization
  - Success in this initiative will depend on a cooperative effort involving SEPA, SEIA, and other industry stakeholders.

2. PROGRAM RECOMMENDATION – INFORMATION AND EDUCATION PROGRAM

Consistent with the conclusions and recommendations of the Solar Power Solutions Blueprint report, including the Community Solar Solutions project, set forth here are the broad goals and activities of a Solar Power Solutions information and education program aimed at providing national tools and public awareness to assist in markets where interest and demand exist but clear information does not. If 90% of the public are supporters of PV but are not buying it, then the information must be as clear as possible.

Program Goals and Strategy

- The goals of this new market-driven information and education program are to:
    1. Provide a centrally accessible, one-stop, web-based information center for potential buyers anywhere in buying decision chain, from curious, to seeking a qualified installer and financing; and
    2. Proactively provide information and public education designed to inform purchase decision-makers about the merits, qualities, economics and availability of solar electric power.

- The program will be driven by the following strategies:
    1. Avoid duplication of efforts through aggressive coordination and use of existing materials, many of which exist at NREL and have been developed with DOE support;
    2. Industry assists in creation of new materials if a need is not met by an existing product; and
    3. Web-based information center is designed as a portal to link to existing websites, developing new "pages" only where they do not already exist.

Premises

- In SEPA workshops conducted for DOE for this report, it was determined that public education and outreach is one of the key elements of a Federal program for the development of widespread solar markets; the public needs to know the "why, what, who and how" of buying solar electric power products.

- The SPS Information and Education "products" should build on materials already developed with DOE funding, including but not limited to:
    - Going Solar Workshop in a Box (IREC)
    - Various brochures including "Creating a Successful PV Program" (SEPA) and "Consumer's Guide to Buying a Solar Electric System" (NREL)
    - Fact sheets (Various Sources)
    - PSAs (IREC)
    - Database of State Incentives for Renewable Energy (IREC)

- The program should target both national and state/local audiences, including consumers.

- The program should be directed primarily towards grid-connected market opportunities and the barriers that exist.

- The groups involved with the most promising markets identified in the SPS Blueprint report should be targets of the program:
    - Homebuilders (new residential roof-tops, with targeted residential retrofit products as well)
    - Corporate executives/facility managers (commercial buildings)
    - Government officials (public buildings, including schools)
    - Financial sector stakeholders including investors, insurers, and lenders

- This program should be managed so that it complements, not duplicates, the project-oriented education and outreach efforts in the Community Solar Solutions program.

<u>Program Features</u>

- ***Program Name***
    - Call this new program the "Solar Source" or "Energy Sun Program" as coined in recent legislation

- ***Program Image and Impact***
    - The program should be modeled after the information and education components of the Energy Star program for energy efficiency
    - The program would have a logo, web site, and toll free phone number that would be utilized in all campaign efforts

- ***Program Components***
    - National web-based and hot line information center with locally-specific information to help potential purchasers, with components directed to:
        - Economic and public value of PV
        - Buy-down sources of funding
        - Installation issues and how to solve them
        - Local utility contacts
        - Local PV sales and service contacts
        - Local/national PV-friendly financing
        - Local builders offering PV as standard or as an option
        - Local installers with information on training and accreditation
        - Special "pages" directed to targeted market segments
        - Issues and FAQs

    - "Community Solar Solutions" event for showcasing specific community experiences, success stories, and metrics

- National public awareness campaign
    - Public service announcements, marketed nationally
    - Public promotion through paid advertising
    - Conference speakers with national "benefits of PV and how to get started" message
        - Designed to preach beyond the choir, to targeted market groups
- Targeted, results-oriented workshops, with home builders and the real estate community involved
- Series of action-oriented sessions with the financial community, including investment bankers, insurers, and lenders including Fannie Mae

- ***Project Funding***
    - Funding of $2 million per year for the production and dissemination of information and education materials and tools (including events or conferences)
    - This funding would be tied to the regions and dependent upon regional results

- ***Goals and Metrics of the Program***
    - Consumer awareness about PV – clearer data on customer attitudes, desires, concerns
    - Use of website and other program "products"
    - Recognition of Energy Sun program name
    - Purchases resulting from increased public knowledge and access to purchase information

- ***Program Management***
    - Led by a broad steering committee of stakeholders
    - Administered and managed by a non-government organization
    - Success in this initiative will depend on a cooperative effort involving SEPA, SEIA, and other industry stakeholders.

3. PROGRAM RECOMMENDATION – MONETIZING THE TOTAL VALUE OF PV

Consistent with the conclusions and recommendations of the Solar Power Solutions Blueprint report, set forth here is a broad strategy and approach to monetizing the total value of PV. This total value proposition will then provide a more solid basis for determining future investment and will allow PV more fully to compete on its merits. It will also inform the solar outreach and education efforts.

Program Goals and Strategy

- The goal of this collaborative effort is to quantify for business and policy decision-makers concrete values for the benefits provided by PV.
- The monetization of total value will be driven by the following strategies:
    - Convene a working group of key stakeholders
    - Develop a dialogue to quantify the total value proposition of PV
    - Based on the total value proposition, develop a benefit-sharing model to justify future investment and incentives for PV
    - Utilize the most accurate data possible
    - Employ models and calculations consistent with those used in other Federal planning
    - Consider the value of PV for both grid-connected distributed generation and off-grid hybrid systems
    - Incorporate all the benefits of PV including:
        - Emissions avoided, including NO_x, SO_2, CO_2, and particulates
        - Oil imports avoided, especially for PV inclusion in hybrid systems or for electricity generation in remote areas
        - Peak load reduction, potentially reducing cost of all electricity
        - Time-sensitive valuation of the energy produced by a PV system
        - Benefits of distributed generation, including grid stability and security
        - Avoidance of transmission and generation capacity expansion
        - Mitigation of investment risk due to modular development
        - Domestic job creation, considering jobs per dollar of investment and jobs per MWh of electricity production
    - A subsequent broader effort could establish through appropriate research the true cost of all forms of energy, for use by Federal agencies in evaluating energy resources. This effort would internalize the social, environmental, economic, and national security costs not reflected in the market price of most forms of energy, thus enabling economic decisions to be made based on the transparency of all costs.

Premises

- One barrier to PV market penetration is the unresolved debate over the total value that PV provides users and society.

- The value of PV is not solely measured by the quantity of energy produced; PV provides many benefits compared to other energy resources.
- Numerous stakeholders and agencies have key information and perspectives to be taken into account in determination of the total value proposition.
- All elements of value will not be equally capable of quantification, but existing gaps in knowledge and opinion can be narrowed substantially.
- A collaborative effort to quantify the value and develop a benefit-sharing algorithm will provide a sound basis for incentives, future research investment, and determination of externalities.

Program Features

- ***Program Name***
  - Call this initiative "Solar PV: Quantifying the Total Value"
  - Call the assembly of stakeholders "PV Value Working Group"

- ***Project Funding and Cost-Sharing***
  - Funding of $300K to develop the working group and conduct roundtables
  - Funding of $500K for technical support, modeling, and calculation

- ***Goals and Metrics***
  - A monetized value of PV in terms of $/kW or $/kWh; this value may vary by region
  - A numerical model for sharing the economic benefits of PV between the end-user and the community

- ***Collaboration and Teaming***
  - DOE should convene the working group; a collaborative approach and the participation of all stakeholders is critical
  - Key partners include the following:
    - Federal agencies and contractors including DOE, FERC, NREL, and EPA
    - The PV community, represented by SEIA and ASES
    - Energy providers and energy service companies, represented by SEPA and NAESCO
    - State and interstate agencies, such as IREC, NASEO, and ECOS, NARUC, STAPPA/ALAPCO
    - Leading academic and research institutions
    - Financial institutions, including investment banks

4. PROGRAM RECOMMENDATION – FEDERAL PV PROCUREMENT PROGRAM

Consistent with the conclusions and recommendations of the Solar Power Solutions Blueprint report, we develop here the broad goals and activities of a Federal PV procurement initiative aimed at identifying the best-value applications for PV on Federal facilities.

Program Goals and Strategy

- Specific goals should be set for a target of energy usage to be met by PV.
- The objectives of Federal procurement of PV are to:
    - Install PV systems where cost-effective, especially in proven applications
    - Explore the application of new and innovative technologies
    - Through the Federal government's role as an energy consumer, contribute to the creation of sustained orderly demand
    - Capitalize on the educational potential of PV installations on public buildings
    - Utilize PV in the development of Federal facilities as energy-efficient or zero-energy buildings
- Federal procurement will be driven by the following strategies:
    - Consider the full value of PV – including emissions avoided, barrels of oil avoided, and peak demand reduction – in making purchasing decisions
    - Take advantage of existing application-based information developed by Sandia and by experience in leading communities; install PV in the cost-effective applications identified
    - Aggregate Federal purchases into long-term higher-volume contracts, enabling suppliers to increase manufacturing capacity; remove Federal obstacles to aggregation of purchases
    - Recognize that some installations have a high value in educating users and the public in addition to the energy value and cost
    - Promulgate accurate data on system performance, issues encountered, and innovative solutions; share this information with the private sector

Premises

- In focus sessions, interviews, and research, the SPS team has identified Federal procurement of PV as a key action to develop sustained orderly demand, increase confidence in the technology among key stakeholders, and educate the public about the reality of PV technology.
- Investors are more attracted to technologies the Federal government procures for its own use based on value than those where the Federal government only mandates or subsidizes the use in the private sector.
- Procurement of PV demonstrates the government's belief in and support of PV's total value proposition, including clean air, energy security, and an efficient infrastructure.
- The Federal government is the largest user of electricity in the United States:
    - The Federal government owns or manages over 500,000 facilities

  - FY 2000 Federal electricity consumption was 30 TWh for the Department of Defense and 26 TWh for all other agencies
  - Meeting 1% of this demand with PV would require 200 MW of PV for Defense and 170 MW for other agencies
- Sandia National Laboratories has identified nearly 4,000 MW of cost-effective PV for Defense (equivalent to about 20% of their electricity demand) based in part on their large requirements for remote power and telecommunications.

Program Features

- ***Program Image and Impact***
  - Federal procurement of PV can continue and expand under the existing guidance of FEMP, GSA, and DOE
  - A greater outreach and education campaign can alert facilities managers to the cost-effective opportunities for PV

- ***Program Components***
  - Installation of PV in all applications where it is the best-value option – identify concrete targets and goals
  - Aggregation of purchases into high-volume long-term contracts (as an example, 10 MW over 5 years)
  - Continued evaluation of best-value applications
  - Demonstration of emerging technologies such as new BIPV products and components of zero-energy buildings
  - Requirement for Federal agencies to perform power procurement based on life cycle cost analysis with renewables as one option to be evaluated
  - Inclusion of "Fostering energy conservation and renewable energy" as a stated annual performance appraisal measurement for Federal executives
  - Federal awareness campaign
    - Facility managers
    - Federal employees
    - Contractors and other users of the facilities employing PV
  - Focus, among others, in high-potential communities targeted for the Community Solar Solutions program.

- ***Project Funding***
  - Funding of $2,000,000 per year for FEMP through the "Technical Guidance and Assistance" allocation for comprehensive assessments of cost-effective opportunities to achieve peak demand reduction and increase renewable energy capacity through installation of PV in Federal facilities; and for audit, design, and implementation assistance for PV projects, training, analytical tools, and communication activities specific to PV
  - Funding of $150,000 per year for FEMP through the "Planning, Reporting, and Evaluation" allocation to support PV deployment reporting and outreach activities

- Funding for PV procurement varies by agency and project; at least a 10-year payback is required for most cost-effective applications, though a different calculus may be applied for demonstrations such as Zero-Energy Buildings
- Funding of a lease financing program

Goals and Metrics of the Program

- Increase Federal procurement of PV
- Increase the fraction of Federal energy demand met by PV to .5% by 2005, or one-fifth of the goal of 2.5% renewable energy for Federal electricity demand
- Increase the fraction of Federal electricity demand met by PV to 1% by 2010
- Install 20,000 Federal solar energy systems by 2010; at an average of 5 kW each
- Increase awareness of PV and its benefits among Federal employees and contractors
- Provide public education and outreach through high-visibility applications
- Contribute to sustained orderly demand

- ***Program Management***
  - Led by FEMP, GSA, Department of Interior, USDA, DOD, and DOE-affiliated laboratories
  - Success in this initiative will depend on a cooperative effort involving SEPA, SEIA, and other industry stakeholders.

5. PROGRAM RECOMMENDATION – PV INFRASTRUCTURE DEVELOPMENT – TRAINING AND CERTIFICATION

The development of the downstream infrastructure to support the local purchase of solar electric power systems has been recognized as one of the key requirements of a mature solar power business. Today, the consumer, commercial business, local park, school, museum, and many other potential buyers face numerous barriers that thwart the solar-interested purchaser. The lack of a fully developed infrastructure is one of the more significant of these barriers.

Infrastructure is defined to include all the necessary support businesses that help a buyer to design, obtain competitive product information, buy, finance, install, and maintain a PV system. The conclusions and recommendations of the Solar Power Solutions Blueprint report deals with many of these infrastructure elements. To a great extent they create an excessive perception of risk by customers that systems will be expensive and will be unreliable without available trained professionals. Private industry, the entrepreneurial spirit and market-driven businesses will create the businesses and systems to address these risks in the emerging solar power market. This Training and Certification program deals with the narrow but important job of building the network of individuals qualified to install PV systems, addressing buyers' need to secure qualified installers and maintenance contractors. Other elements of the infrastructure are either a function of private industry or addressed in other Solar Power Solutions programs.

Program Goals and Strategy

The following are the goals, strategy and features of a proposed Training and Certification program.

- The goals are to remove uncertainty in the infrastructure and to improve the quality, cost, and consistency of installations and to fully understand all infrastructure issues. The program will develop one or more processes where PV system designers, installers, and repair/maintenance personnel can obtain the needed training, experience, and nationally recognized certification recognized by utilities, financial institutions, insurance carriers, local approval officials, and others.

- The strategy employs the following characteristics**:**
    - Training and certification is done at the local or state level and must be created with the support of industry
    - A basic level of certification will be reflected in guidance at the national level, but states may supersede the national accreditation standards
    - Utilize existing standards and training materials that have been developed by DOE, NREL, IEEE, NEC, and others where possible, and as a basis for updating, supplementing, or expanding the training materials.

Premises

- The training and certification of installers and of system designers are national issues that are impacted by local regulations and by the progress some companies have already made in this direction.

- This SPS Training and Certification program must allow for existing state, local and industry efforts while supporting a basic level of training and certification in areas where such training can have an impact on the acceleration of PV markets.

- Issues in this area are not appropriately addressed by Federal mandates; however, DOE can and should convene industry, states, and stakeholders to assess what issues exist with regard to installers and system designers, so that a process for industry and trades can move forward on the most important issues.

- SEIA and SEPA are the organizations best qualified to oversee development of standards. An effort under SEIA management with SEPA, DOE, and state agencies advising will produce effective and feasible standards, supporting the market for PV while enhancing safety.

- The program should build on efforts previously undertaken by DOE, including but not limited to:
    - Experiences from the TEAM-UP Program
    - Efforts undertaken by the Million Solar Roofs Program
    - Efforts undertaken as part the NREL and IREC programs

- Most other established "equipment" industries have adopted a training and certification program to give customers, the financial community, insurance carriers, and local officials confidence and assurance.

Program Features

- Minimum national standards, developed by a stakeholder group with the active participation of industry
- Targeted Federal support of local and state training programs, including recruiting of candidates and development of training materials where existing materials are inadequate or require supplementing. Close coordination with relevant Department of Labor programs
- Publication of contact information for qualified installers and system designers through the national information and education program, and through local initiatives.
- Cost $500,000 to develop basic standards and modules. Deployment costs to be borne by states and industry

- ***Program Management***
  - National accreditation standards to be developed by a broad stakeholder group with active participation by industry and the Institute for Sustainable Power.
  - Training programs should be conducted by qualified teams through local partnerships, either in support of a Community Solar Solutions project or separately funded as a training showcase project
  - This effort should be managed by SEIA with support from DOE, SEPA, and other key stakeholders. SEPA and its Board of Directors are prepared to fully participate in the development of certification standards.

XI. GENERAL RECOMMENDATIONS BY ACTING PARTY

DOE Actions

The Community Solar Solutions Project *(See Priority Recommendation #1)*

1. Provide targeted co-funding to community initiatives that build on successes in the market and emphasize participation by industry, government, energy providers, and financial institutions. Design a process for finding the best community solutions and successes to co-fund. DOE can model its programs on a later-stage venture capital approach, supporting the expansion of successful programs rather than trying to develop new ones from scratch.
2. Provide a forum concretely to share the results of the community projects. Identify the obstacles encountered and the steps taken to overcome them (interconnection, siting/permitting, distribution/installation, etc.). Highlight the partnerships formed and key actions taken. Offer information and insights on the various approaches.
3. Provide metrics to help states assess the performance of State incentive plans and policies. These metrics would to a large extent be used as criteria for selecting successful community projects to co-fund.

Information and Education *(See Priority Recommendation #2)*

1. Conduct public outreach and education on the merits, qualities, economics, and availability of PV electricity. While the public supports solar power, many are not aware of the benefits provided by the system or the current viability of the technology. Industry can play a primary role in developing this information with DOE providing support and dissemination.
2. Employ and integrate existing information resources such as NCPV and the *Consumer Guide* series. Some information should be national, some is region-specific.
3. Coordinate participation and support of various stakeholder groups (SEIA, SEPA, ASES, IREC, MSR partnerships, NREL, others) in this effort.

DOE/Industry Partnership Actions

Priority Actions

1. Quantify the total value proposition of solar electricity and develop a "benefit sharing" model to establish causal basis for the government role. This approach will illustrate the economic benefits to the community and nation of a PV installation, and return some of this benefit to the end user installing the system. A joint initiative involving DOE, EPA, utilities, industry, and others can quantify the benefits of solar electricity. *(See Priority Recommendation #3)*
2. Develop partnerships with other industries where valuable to address gaps in PV applications. Collaboration with the construction industry, including architects and builders, will capitalize on the vast potential for and advantages of building-integrated PV and Zero-Energy Buildings. Build on the extensive research conducted by DOE and programs such as PV:BONUS.

3. A working group should be convened to definitively resolve the issues associated with interconnection and net metering. This working group should include SEIA, SEPA, DOE, FERC, and representatives from state energy offices and utility commissions. A representative of potential consumers and end-users of PV systems would enhance the effectiveness of the dialogue; ASES is one possible organization to fill this role. This dialogue will also provide an opportunity to establish the role of energy providers in the development of the markets for PV.
4. Continue RD&D to realize the benefits of previous research efforts. Continue to develop next-generation technologies while maximizing the potential of today's technologies. Use customer data from the Community Solar Solutions project to create a formal source of customer feedback to RD&D efforts.

Other Important Actions

1. End users need quality information on the reliability and performance both of PV systems and of the PV service industry. Convene PV manufacturers, installers, and funders to address industry-wide adoption of standardization, including minimum product warrantees; standard purchaser disclosure on PV system performance and cost issues; and continued development and industry adoption of PV system measurement and verification practices, especially in coordination with energy efficiency upgrades.
2. Reach out to the investment community to encourage investment in the PV industry. DOE information and support can work to develop this relationship. Formally and systematically engage Wall Street firms, banks, insurance companies, and other funders in targeted dialogues about the industry, its issues, and its prospects.
3. Look at impediments to stable demand growth. Through procurement and community projects, develop long-term high-volume contracts, so that industry can increase manufacturing capacity and realize significant cost reductions through economies of scale.
4. Develop training workshops and education efforts to expand the PV service infrastructure to include traditional trades. *(See Priority Recommendation #5)*

<u>Industry Actions</u>

1. Build the infrastructure needed to support a market for PV, including sales, engineering, specification, installation, and service. *(See Priority Recommendation #5)*
2. Target emerging high-growth markets. Developed and growing markets, such as telecommunications and transportation, have provided a base demand for the industry and acted as a springboard from which to expand into new markets of larger potential. The principal target markets, for the purposes of public policy and market support initiatives, are residential rooftops, commercial and government buildings, and BIPV/ZEB.
3. Develop uniform standards and extended warranties for PV systems. This will lead to standardization of financing and reduction of transaction costs and loan risk, enabling financiers to offer simplified, low-cost, long-term PV loans.

4. Increase development of AC modules to achieve greater market penetration with the "plug and play" principle, enabling the consumer to develop a home power system through modular additions.

State and Local Actions

1. Continue to develop incentive plans and policies such as RPS and net metering; an RPS designed to encourage fuel diversity or distributed generation can support development of PV.
2. Develop sustainable financial instruments in addition to system benefit charges – such as bond referenda which engage citizens directly to choose to finance PV and other renewable energy.
3. Increase procurement of PV for State needs; employ long-term high-volume contracts; pool purchases with neighboring cities and states. *(See Priority Recommendation #4)*
4. Install PV in high-visibility applications on public facilities, especially schools. Aggressively install PV on schools and incorporate PV education into the curriculum, so that every school has at least a small system and PV is to the next generation as natural as computers.
5. Incorporate consideration of PV into environmental and energy planning and policy development; convene State and Federal energy and environmental regulators to maximize emissions credits and incentives.
6. Develop streamlined siting and permitting processes to facilitate the installation of PV systems. Clearly address the building standards, fire codes, and other technical and safety issues related to PV, based on DOE information and the experience of other communities.
7. Resolve institutional barriers on an expedited schedule.

Other Federal Agencies

Federal Procurement of PV *(See Priority Recommendation #4)*

1. Increase procurement of PV for Federal facilities, especially in high-priority community markets including defense and rural applications.
2. Build upon Secretary of Interior's initiative to support development of renewable energy on public lands. Capitalize on opportunities identified by Sandia for cost-effective applications of PV (including parks, forests, public lands, and defense).
3. Aggregate Federal purchases; revise GSA rules to allow long-term high-volume contracts, thereby providing greater economies for the manufacturing industry.
4. Increase Federal purchase of green power options, especially those including a PV component. Help facilitate states interested in pooling purchases.
5. Federal facilities with PV can include an education/outreach component as appropriate (e.g., Pentagon display) to increase the value of the application.

Other Federal Actions

1. Expand incentives for PV. Ensure that full benefit of the proposed PV tax credit is available for the installation of such systems as would be needed to attain the

ZEB goal, or about 4 kW for a typical residential system. The tax credit could be designed as 15%, up to a maximum of $1 per peak watt.

2. Integrate environmental and energy planning, coordinating EPA and DOE efforts with State counterparts. In designing new environmental compliance programs, incorporating the role of non-emitting sources (new and existing) in the cap & trade or offset programs is appropriate and will enable PV to obtain appropriate credits in meeting clean air goals.
3. Provide funding and programmatic support to Fannie Mae and Freddie Mac to rapidly expand their efforts to allow extension of home mortgage to cover PV financing. Fannie Mae has built a $600 million per year business of buying energy efficiency upgrade packages that are sources by third parties, such as utilities and that involve specific measures installed by pre-approved contractors. This program could be modified and extended with DOE support to allow home owners to use mortgage extensions to finance PV at low rates and for long terms.
4. Improve coordination of international development and AID programs with multilateral development banks and the industry to target renewable energy projects where they can add the most value and succeed.

Energy Providers

1. Take an active role in design and implementation of PV deployment initiatives, especially Community Solar Solutions projects.
2. Work with Federal and State agencies and other stakeholders in high-potential markets to systematically identify and address obstacles to system purchases.
3. Commit to efforts to establish the value of PV.
4. Participate actively in efforts to define the role of DG and PV in energy provider business plans. While there are business limits to how rapidly a portfolio can be expanded, energy providers need to overcome the perception that they are opposed to PV.
5. Maintain reasonable and practical interconnection standards. Existing efforts under the IEEE, FERC, and other groups need to be consolidated and focused as much as possible to achieve closure on these issues.
6. Develop a uniform, fair, and transparent net metering standard to allow PV systems to compete based on their total value proposition. For residential and small commercial installations (less than 30 kW), consistent net metering is appropriate. For larger installations, a time-of-use pricing strategy makes the most sense and is fair to energy providers.
7. Offer innovative pricing structures such as time-of-use pricing or tiered tariffs. Employ these pricing mechanisms to reduce peak load, mitigate strain on the transmission system, and encourage the use of PV.

Financial Industry

1. Develop financing mechanisms to annualize the capital cost of PV over the lifetime of the system to make it more cost-competitive. Alternative mortgage structures and leasing are two high-potential methods.
2. Develop an advisory guideline ("checklist") of PV system performance and costs for lenders, thus improving industry credibility, reducing risks, and facilitating financing.

3. Help overcome the primary financial barrier to green power purchases of new green power. The large majority of green power comes from existing rather than new green power sources. A principal reason for this is that green power marketers sell power in 1 to 2 year contracts but must buy new green power for long (typically 10 year) power purchase agreements. DOE can convene industry experts to explore development of private sector insurance to bridge this gap and can support the insurance industry in developing risk pooling and insurance type mechanisms to manage and mitigate the green premium risk.
4. Participate in public/private forum to identify challenges and solutions in the provision of capital and financing for renewable energy.