REPP

SPECIAL REPORT

Renewable Energy Policy Project

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EXPANDING MARKETS FOR PHOTOVOLTAICS:

What To Do Next

Research Coordinated by Adam Serchuk and Virinder Singh of the Renewable Energy Policy Project

Notwithstanding years of steady technical and economic progress, markets for photovoltaics (PV) remain small and scattered. Based on extensive research and professional review, we endorse the "product path" to expand PV markets, as described in our ten-point package of recommendations.

The "Product Path" to Expanded Markets for Photovoltaics: Summary Recommendations from the Renewable Energy Policy Project

We endorse the "product path" to expand PV markets. The following recommendations are inspired by — but are not confined to — a multi-part research program described in this report. The package reflects our close consultation with an Advisory Committee assembled for this project, as well as an extensive professional review process. The recommendations appear here in random order; the sequence does not indicate their relative importance.

A. Increasing Consumer Choice:

A coordinated array of state "buy-down" programs for residential and other small users, with funds from a federal system-benefit charge matching state contributions;

An industry-funded analysis of near-term product markets, aimed at developing existing technology to serve existing markets, and building the strategic partnerships necessary to sell into those markets;

Aggressive, coordinated government procurement of PV, requiring suppliers to decrease price, increase quality, and provide long-term service contracts, and aiming to train PV firms for the consumer markets on which they ultimately will have to depend;

A multi-year PV communication plan linking public-interest campaigns and product marketing;

Elimination of barriers to capital formation, and the provision of financial products appropriate for specific PV products.

B. Setting Market Rules:

Legislative packages facilitating the deployment of distributed PV systems, for instance by requiring standardized interconnection protocols, net metering, no-hassle power purchase contacts appropriate for very small systems, prohibition of restrictive homeowner covenants, etc.;

A strategic discussion of whether and how PV interests should collaborate with other distributed energy technologies on a common legislative and regulatory agenda, and what role, if any, regulated electric utilities can play in the further deployment of PVs;

A solar "rapid response" team of legislative and regulatory experts able to assist states in coordinating their solar efforts, for example in setting rules for distribution utilities;

An integrated professional training program targeted at all professions whose members interact with a PV system during its life, for example builders, realtors, property appraisers, inspectors, etc.;

Integration of PVs into the overall development strategies of developing countries, rather than segregating it as a boutique environmental technology or merely a niche luxury product.

For a more complete explanation of these recommendations, please turn to Pages 4-6.

EXPANDING MARKETS FOR PHOTOVOLTAICS: What To Do Next[1]

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PART I: Context

Photovoltaic (PV) technology has enormous potential to reduce pollution, diminish energy-related emissions of greenhouse gases, expand access to electricity for rural populations, supply reliable power to urban centers, and accelerate the global transition to a clean, distributed energy system by providing high-value products. Unfortunately, despite two decades of steady technical progress and price reductions, markets for photovoltaics remain small and scattered.

In part, the predicament of PV power reflects astonishing declines in the price of fossil fuels. The past two decades witnessed increasing mechanization of the U.S. coal industry, deregulation of the natural gas industry, and an inability by the Organization of Petroleum-Exporting Countries to maintain its cartel intact after the mid-1980s. In fact, in March 1998 the real price of oil neared its all-time low, to some extent lowering the ceiling on all energy prices.

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Photovoltaic power, while ever cheaper, has been unable to catch the moving targets set by competing resources, which in any case began the price race from a point far in front. In addition, consumers wishing to install PV systems face substantial non-price barriers. These include, for example, lack of appropriate credit and jumbled protocols for connecting systems to the grid, which vary not only among states but even within them. Finally, of course, photovoltaic power will seem less attractive than its competitors as long as the price of conventional energy sources ignores the environmental and geopolitical cost of using energy, as well as the non-energy advantages of PV systems.

Numerous past research projects have explored barriers to the expansion of markets for photovoltaics. Today, a confluence of political, environmental, and regulatory factors persuades us that the time is right to ask the next, more challenging question: how can we best apply available resources to increase the size and stability of such markets?

To address this question, in early 1998 the Renewable Energy Policy Project (REPP) initiated a broad inquiry into the issues surrounding PVs. As described in *Action Recommendations for a Project on Expanding PV Markets*, a separate scoping document posted on our Web site (<http://www.repp.org>), we interviewed some 40 professionals from inside and outside the PV industry. These included representatives of module manufacturers, system assemblers, financial firms, multilateral development institutions, trade associations, and energy companies, as well as architects, financiers, environmental advocates, tax analysts, and numerous others.

Taken as a whole, our scoping process indicated that several interrelated areas merited further research: public policies to increase volume — and thereby lower manufacturing costs — through subsidized purchases; measures to develop high-value PV products for existing markets without subsidies; policies to encourage distributed energy generation; capital formation; public education; professional training; markets in developing countries; and government procurement. In addition, the experts helped us identify researchers capable of undertaking a deeper analysis of these areas. After hiring our team (see Section IV) in early summer of 1998, we laid before them the challenge: "*who* has to do *what* to expand PV markets?" We stress here that we explicitly avoided the narrower question

The challenge: "Who has to do what to expand PV markets?"

[1] The research described here enjoyed the participation of a sizable team of researchers, an Advisory Committee composed of members of the REPP Board of Directors and other experts (named within), and reviewers too numerous to thank individually. Part III contains an integrated package of proposals for expanding PV markets endorsed by our Advisory Committee. Readers should note, however, that the Executive Summaries in Section IV reflect our research team's analysis, and do not necessarily represent positions of REPP, the REPP Board of Directors, the Advisory Committee assembled for this project, or other reviewers. REPP Research Director Adam Serchuk and Research Associate Virinder Singh coordinated this project; Dr. Serchuk wrote the final report, including the Executive Summaries. We warmly thank those who reviewed drafts of this work, the Energy Foundation for its generous support, and Kerry Kemp for her diligence in editing the compendium of final papers. Readers may view the compendium document on the REPP website, or contact REPP to request a paper version.

of what public policy tools could best establish PV markets; we assumed from the beginning that public policy would constitute only one avenue — and governments only one set of actors — for the expansion we seek.

Although the authors collaborated and interacted through frequent telephone conferences, each team concentrated on one piece of the puzzle. To help us bring the "big picture" into focus, we assembled several members of our Board of Directors and other experts into an Advisory Committee:

- Michael Jansa, GE Capital
- Renz Jennings, Arizona Corporation Commission
- Alan Miller, Global Environment Facility
- Karl Rábago, CH2M Hill
- Scott Sklar, Solar Energy Industries Association
- Joel Stronberg, The JBS Group
- Carl Weinberg, Weinberg Associates
- Jane Weissman, Interstate Renewable Energy Council

This group helped us extract the most promising insights and recommendations from the various reports and form them into an integrated PV strategy.

We also instituted a professional review process, inviting well over 100 experts from academia, multilateral development institutions, federal and local governments, environmental groups, federal laboratories, the solar industry, and other sectors to inspect our drafts, which we posted on a confidential section of our Web site. (Several of these reviewers distributed the address within their organizations, to their students, and so on, increasing the scope of the process.) In Part IV of this report, we present our executive summaries of the final papers.

PART II: The "Product Pathway" to PV Development

Before presenting our package of recommendations, we offer here a broader view of how we expect PV technology to develop, and what general approach we believe will allow that development.

First devised at Bell Labs in the mid-1950s, photovoltaic technology has become commonplace for some comparatively narrow industrial applications (e.g., providing reliable power for some remote telecommunications facilities). Yet, much of the industry remains immature, and experts disagree on how best to develop it. On the one hand, the existing electric system may prove able to absorb PVs as a conservative innovation, allowing the technology to exist in comparative harmony with current institutions, technologies, and measures of value (such as the cost of energy). Indeed, PVs may help sustain and preserve the existing system. On the other hand, PVs may represent a radical, disruptive innovation, able to thrive only in a very different environment and possessing attributes not generally incorporated in established measures of value (such as adaptability to customer-located installation). On the basis of our investigation, we incline to the latter view: that *PVs challenge the technological status quo*, and can best be exploited by new institutions providing new kinds of value. To appreciate this point, consider the divergent ways in which conventional generating technologies and PV achieve cost reductions.

Nuclear and fossil-fueled power plants represent a *constructed* technology: unique, centralized projects connected to users through complex transmission and distribution networks, requiring several years and massive amounts of capital to complete. These technologies benefit from *economies of scale*. That is, up to capacities of roughly a gigawatt, bigger plants produce cheaper power. For most of this century, electric utilities delivered ever-cheaper electricity by building larger and larger facilities.

Are Some Innovations More Innovative?

Historian Thomas Hughes, who has written extensively on the electric power sector, distinguishes between *conservative* innovations, which tend to preserve large technological systems, and *radical* ones, which spark the construction of new systems. In a similar vein, business analyst Clayton Christensen describes *sustaining* innovations, which improve product performance according to traditional measures of value, and *disruptive* ones, which perform poorly according to conventional measures — but outperform established technology in ways valued by emerging markets.

See Thomas Hughes, "The Evolution of Large Technological Systems," in Wiebe Bijker et al., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, England: Cambridge University Press, 1987), and Clayton Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (Boston, MA: Harvard Business School Press, 1997).

Might renewable energy technologies qualify as radical or disruptive technologies? See Richard Hirsh and Adam Serchuk, "Momentum Shifts in the American Electric System: Catastrophic Change or No Change at All?" *Technology and Culture* 37 (April 1996), pp. 280-311, and Adam Serchuk and Richard Hirsh, "Condemned to Repeat? IOUs, History and Green Markets," *The Electricity Journal* 11 (March 1998), pp. 76-86.

Photovoltaic technology is more like consumer electronics than a conventional power plant. Along with other renewable energy technologies such as wind turbines and solar water heaters, as well as non-renewable energy technologies such as gas microturbines and fuel cells, and even energy efficiency and energy storage devices, PVs are not constructed but *manufactured*. Rather than scale economies, PVs offer economies of *mass production*: the more units manufactured, the less each one costs. Historically, the cost of PVs has dropped 18% for each doubling of cumulative production.[2]

Viewed this way, PVs seem to face a typical chicken-and egg problem: higher production will *drive* lower costs, but selling enough PVs may also *require* lower costs. Yet the problem is neither so straightforward nor so intractable. PV technology is not simply a manufactured substitute for constructed power plants; it offers a different set of values that canny retailers can exploit. Unlike, say, a nuclear reactor, PV technology lends itself to small, distributed uses, close to where people consume electricity. Under the right conditions, customer-located PV units can forestall the need to upgrade an overburdened power line; more often, a PV facility in a remote location makes unnecessary any power line at all. PV systems can provide high-quality, reliable power for users who cannot afford an outage — say, to run a computer network. And, of course, "green" customers may appreciate freedom from a well-known list of environmental impacts associated with conventional energy sources: toxic air emissions, land and water degradation from mining, production of radioactive waste, and the release of greenhouse gases, among others.

Thus the secret to expanding markets for PVs seems to include both the exploitation of high-value markets and subsequent volume-driven cost reductions. To highlight the distinctions, consider the two roughly defined pathways historically put forward for PV development:

- The *power plant path* relies on large, grid-connected photovoltaic power plants as a conservative innovation within the existing electric system. Besides megawatt-scale facilities, this path integrates PVs into utility operations as substation and end-of-line upgrades. Such facilities may capture economies of scale, although much more modest ones than conventional generating technologies; they appeal chiefly because of the stimulus they deliver to manufacturing capacity. Yet since early PV power plants will be unable at first to compete economically in the wholesale power market with conventional technologies, this path probably requires large amounts of public funding. On the other hand, it requires less business and technical infrastructure, since it does not rely on retail sales and since utility professionals would probably construct the installations. The "power plant path" also requires little consumer education, except where necessary to endorse government support.

- The *product path*, an alternative approach, builds production volume through developing affordable, value-based products and expanding markets. In this scenario, PVs compete at the retail level, and take advantage of characteristics other than the cost of the electricity generated. These include the reliability of PV systems, the technology's adaptability to grid-independent deployment, the possibility of avoiding upgrades for transmission and distribution lines, consumers' interest in environmental products, and so on. This path limits government involvement to increasing the diffusion rate of consumer products through setting market rules, making strategic purchases, and other innovative support. However, it requires the emergence of a sophisticated retail infrastructure, as well as the availability of consumer finance mechanisms and education. Above all, it requires that PVs be integrated into existing business systems, such as the home-building sector.

We endorse the "product path."

We endorse the "product path." It will take longer than the "power plant path," and it will require arduous coordination of numerous groups. Yet we find that it makes better use of PVs' nature as a manufactured technology and does not try to force PVs into an inappropriate technological framework. We also find that the product path resonates with accelerating regulatory and market shifts in the electric system. Most utilities, constrained by lower profit margins, have retreated from research and development. In contrast, restructuring has refocused the marketplace on applications over kilowatt-hours, on value over price, and on customers over technocracy — an ideal setting for the development of PV products. The product path has become an increasingly accepted theme at recent conferences on the state of the PV industry.[3] In sum, it strives ultimately for the volumes that could conceivably allow PVs to compete at the wholesale level on *price*, but it does so through painstakingly building markets for retail products in which PVs can compete on the basis of *value*.

[2] Electric Power Research Institute and U.S. Department of Energy, *Renewable Energy Technology Characterizations*, EPRI-TR-109496 (Palo Alto, CA: EPRI, 1997), p. 4-2.

[3] See, for example, *Proceedings of the 1995 International Executive Conference on Strategic Photovoltaic Business Opportunities for Utilities* in Sun Valley, ID (17-20 September 1995).

In sum, several key points emerge from the research described here:

- An important element of market expansion will be the progressive lowering of prices through *economies of mass production*.
- PV manufacturers can best achieve these economies through establishing *self-sufficient markets* for high-value products that exploit PVs' characteristics, and that people want to buy.
- Effective market expansion requires *coordinated movement by a variety of actors*, including the federal and local and state governments, the PV industry and its trade association, the financial sector, non-profit environmental advocates, foundations, and others.
- *Public policy must seek to enable consumer markets* for PVs, for example by establishing fair market rules, rather than merely by subsidizing purchases.

One significant aspect of this investigation is notable in its absence. Analysts in the early 1990s looked hopefully toward the nation's electric utilities to bring PV technology into common use. Through organizations such as the Utility Photovoltaic Group, government programs allowed some American electric companies to install notable numbers of PV systems. And although we decline to endorse the "power plant path" in this study, there might nevertheless conceivably be a role for electric utilities in the "product path." On the contrary, our research team manifests decreasing faith in traditional electric utilities' ability — or willingness — to adapt to the technological and market changes represented by PV power, particularly in light of the utility sector's cautious response to restructuring. Indeed, today's utilities too often hinder PV development, just as they did a decade ago. For this reason, our authors look largely to new institutions to deliver PVs to future consumers. Whether the utilities' unregulated subsidiaries can fulfill this function as effectively as completely unaffiliated entities remains an open question, as does the issue of whether regulated utilities may necessarily play a larger role in marketing PVs in developing countries with immature consumer infrastructures. And, indeed, the utility companies of the next decade may be much more innovative institutions. On the whole, however, our team manifests appreciable skepticism toward the utility sector.

PART III: An Integrated, 10-Point Plan to Expand PV Markets

Not surprisingly, the seven papers summarized in Part IV contain potential conflicts. Expanding PV markets is, after all, a complex and challenging task. For this reason, we have extracted from the final reports what we consider the most important and complementary points, and assembled them into a cohesive package of recommendations. The package reflects our close consultation with the Advisory Committee assembled for this project, as well as our extensive professional review process. We stress that the package represents our best judgment of which elements recommended by our authors can function together as a coherent whole; we do not, however, include all the suggestions contained in the papers.

We intend here merely to sketch the dimensions of an effective PV strategy. Implementation will require further refinement. For more explanation of each point and an initial discussion of how each might be implemented, consult the executive summaries that follow and the papers themselves. Note that these recommendations appear here in *random order*; the sequence does not indicate their relative importance. Note also that although for each recommendation we identify the most directly relevant paper in the series, some recommendations actually reflect the combined insights of several papers.

The recommendations fall into two rough categories: expanding consumer choice and setting market rules.

A. Expanding Consumer Choice

1. A federal and state buy-down program: States should coordinate a set of "buy-down" efforts, perhaps modeled after the California "Emerging Technology" program. This initiative will offer progressively smaller rebates to purchasers of small PV systems. A federal system benefit charge on electricity purchases should match the funds provided by the states. (See *Government Buy-Downs for the Residential Market* by Thomas J. Starrs and Vincent Schwent.)
2. Analysis of product markets: The PV trade association should coordinate an industry-funded analysis of near-term product markets (such as those for PV-driven pumps and portable generators), aimed at developing existing technology to serve existing markets, and building the strategic partnerships necessary to sell into those markets (for instance, with irrigation associations). Where possible, these studies should consider the domestic market for these products as a springboard for the much larger

international market. Similar product analyses of developing-country markets will also be necessary. (See *Industry Development Strategy for the Photovoltaics Industry* by Eric Ingersoll, Daniel C. Gallagher, and Romana A. Vysatova.)

3. Aggressive, coordinated government procurement: A variety of actors must come together to provide leadership and detailed support for minimum federal and state government purchases of PV and green power; these purchases should require suppliers to decrease price, increase quality, and provide long-term service contracts. This initiative will require at least an Executive Order from the President and complementary legislation; a resolution of existing regulatory and legislative conflicts; and changes in the way governments finance their purchases. (See *Government Procurement to Expand PV Markets* by Joel B. Stronberg and Virinder Singh.)
4. A multi-year PV public communication plan: Lead environmental foundations should convene PV advocates and private-sector players to establish a multi-year communication plan linking public-interest campaigns and product marketing. (See *Public Education and Professional Training* by Larry Shirley, Shawn Fitzpatrick, and Chris Larsen.)
5. Elimination of barriers to capital formation: Foundations, policymakers, and the financial community must open pathways for capital specifically targeted to different PV products. Foundations should consider whether they can jump start a self-sustaining source of private capital for the PV manufacturing industry. Policymakers must make existing public lending, grant, and bonding authority friendlier to PVs. The financial community needs to work with the PV industry to make consumer-friendly financial products available. These sectors should work together to research, set priorities within, and implement a list of needs. The list may include extending the permissible term of public capital to 15–25 years and commissioning feasibility studies on using project finance to support PV manufacturing additions. (See *Financing PV Production Capacity Through Risk Management* by Eric Ingersoll, Robert DiMatteo, and Romana Vysatova.)

B. Setting Market Rules

6. Legislative packages supporting distributed energy: Environmental advocates with funding from foundation and industry sources must develop and lobby in support of "solar statutes" at the state and federal level. These statutes should facilitate the deployment of distributed PV systems. Key elements include net metering; a requirement that the utility industry adopt a fair, safe, uniform interconnection protocol devised by a third party, or else submit to a federal protocol; a requirement that utilities offer standardized, no-hassle power-purchase contracts appropriate for very small systems; prohibitions against unwarranted fees levied by utilities on distributed energy generation; the prohibition of restrictive homeowners' covenants; and a requirement that localities adopt solar zoning standards. (See *Policies to Support a Distributed Energy System* by Thomas J. Starrs and Howard J. Wenger.)
7. Strategic discussion: Moderated by an appropriate objective entity, the PV community must seek consensus on at least two issues: whether and how PV interests should collaborate with other distributed energy technologies on a common legislative and regulatory agenda, and what role, if any, regulated electric utilities can play in the further deployment of PVs. (See *Policies to Support a Distributed Energy System* by Starrs and Wenger, and *Government Buy-Downs for the Residential Market* by Starrs and Schwent.)
8. Formation of a solar "rapid response" team: With federal and foundation support, an appropriate nonprofit entity should organize a team of legislative and regulatory experts able to assist states in coordinating their solar efforts. The team must especially participate in state and regional forums organized to set distribution and transmission rules. It might also coordinate communication between policymakers, environmental advocates and the solar industry, to ensure that policies send the desired market signals to manufacturing and distribution firms. (See *Policies to Support a Distributed Energy System* by Starrs and Schwent.)
9. An integrated professional training program: Federal and state agencies, convened by the U.S. Department of Energy and working in coordination with labor unions, professional societies, rural extension offices, and other entities, must institute a program to ensure that all the professionals that come into contact with a PV product during its lifetime receive adequate training. These professions include architects, builders, and developers; building inspectors and realtors; loan officers and real estate appraisers; utility engineers; and PV retailers, system installers, and service personnel. In particular, the PV industry and state governments should insist on training and certification for system installers. (See *Public Education and Professional Training* by Shirley, Fitzpatrick, and Larsen.)

10. Integration of PVs into the overall development strategies of developing countries: Our limited analysis of developing-country markets indicates the value for those nations of the same "product path" that we prescribe for the United States, with significant differences due to the comparatively greater role that PVs can play there in improving the quality of life. Aid agencies and other donors must refine ways to build PV product markets, often with the assistance of local non-governmental organizations, while de-emphasizing demonstration programs and subsidized purchases. Human capacity-building activities include vocational training for technicians, business training for entrepreneurs, and education of potential customers. Financial mechanisms include loan guarantees, funding local development banks, funding private equity and venture capital funds, and assisting microcredit organizations. Most important, the U.S. government and donor agencies must work with developing-country governments to integrate PVs (and perhaps other clean, distributed resources) into their overall development strategy, rather than segregating it as a boutique environmental technology or merely a niche luxury product. (See *Accelerating PV Markets in Developing Countries* by Michael Philips and Brooks Browne.)

PART IV: Executive Summaries

Unlike the integrated package presented in Part III, the following executive summaries do not necessarily reflect the positions of REPP, the REPP Board of Directors, or the Advisory Committee assembled for this project.

CHAPTER ONE: Government Buy-Downs for the Residential Market

Thomas J. Starrs of Kelso Starrs and Assoc., Vashon, WA
Vincent Schwent of the California Energy Commission, Sacramento, CA

Executive Summary

Government-funded buy-down programs consist of rebates or other cash subsidies to consumers or retailers that reduce the cost of a new technology. In recent years, policymakers in various regions have used buy-downs to create markets for photovoltaic systems, and several more such programs are under development.[4] In this paper, we recommend a coordinated array of state-run buy-down programs, the state funding of which would be matched by federal funds collected through a national system benefit charge. To expand markets for PV successfully, however, such a program must be accompanied by the removal of diverse barriers to PV market formation: we recommend formation and support of a core group of professionals able to assist states in this market transformation work.

State-funded buy-down programs for the residential PV market, matched by a federal system benefit charge on electricity sales.

Most notable among American efforts, California initiated its Emerging Renewables Buydown Program in March 1998. (PV buy-down programs in Japan and Germany have been under way somewhat longer.) Receiving $54 million over four years from the state's system benefits charge (set to expire in 2002), this endeavor will disburse rebates to purchasers of small wind, fuel cell, solar-thermal electric, and PV systems. Over time, the program will offer progressively smaller rebates on a per-watt basis. At this very early date in the program's history, it seems successful at encouraging sales of medium and large PV systems, but has attracted only a few dozen purchasers of small systems. This indicates, we believe, the need for simultaneous market transformation activities of the type described elsewhere in this collection of reports. (See, for example, *Policies to Support a Distributed Energy System* by Thomas J. Starrs and Howard Wenger, and *Public Education and Professional Training* by Larry Shirley, Shawn Fitzpatrick, and Chris Larsen.)

Supporters of buy-downs refer to two major rationales for their use. First, short-term subsidies such as buy-downs stimulate technology purchases at early (high) prices, thereby encouraging manufacturers and distributors to accelerate their investment. This raises production levels, which in turn decreases prices and expands markets. Second, the early sales stimulated by buy-downs help develop the necessary infrastructure to support larger, non-subsidized markets in the future and force the early resolution of institutional barriers. These include, among other problems, utility interconnection requirements, lack of financing for purchasers, and building code officials ignorant of the technology.

[4] A requirement that a small but rising percentage of state electricity usage be generated from central-station or customer-located solar technology would provide an alternative way to expand PV manufacturing volume. The Arizona Corporation Commission (ACC) recently instituted such a "solar portfolio standard." In the compendium version of this report, we include an appendix by Ray Williamson of the ACC describing how a national solar portfolio standard might function.

Analysts skeptical of buy-down programs raise three concerns: that the marketplace may perceive buy-downs as transitory, and resist the investment necessary to achieve the expected economies of scale; that governments should not attempt to select technology winners and losers by their eligibility for buy-downs; and that subsidies such as buy-downs can skew the market for PVs in various ways. Based on the experience to date, we offer six recommendations to address these concerns.

i. Lower non-price barriers: Buy-downs are a central element to a commercialization strategy, but they will not succeed if institutional barriers remain in place, or if policymakers and PV firms neglect consumer protection and education.

ii. Allow flexibility: For a buy-down to succeed, its managers require the flexibility to adapt the program to the market's response. Consequently, enabling legislation or regulations should avoid specifying program details and instead should allow the implementing agency to determine them.

iii. Guarantee reliability: Program features critical to success include a multi-year term, certainty of funding during the program term, avoidance of arbitrary time limits for expenditure of program funds, and the ramping up of demand and ramping down of the level of incentive over the term of the program.

iv. Don't pick winners: On the basis of policy goals and physical resources, program designers may appropriately determine which broad technologies (such as PVs or wind) to include in their buy-downs. However, government should avoid favoritism at the sub-technology or company level.

v. Use auxiliary financial tools: Other financial incentives that can complement and apply leverage to buy-downs include net metering, property and sales tax exemptions, income tax credits and a low interest rate, and financing with long terms and low interest rates for purchasers.

vi. Coordinate programs: States and the federal government must coordinate their activities to maximize the number, size, and effectiveness of buy-down programs for PVs and other renewables. A state-federal matching program may make it easier to secure protection for PVs and other renewables in any state restructuring proceedings. However, federal participation should not be a requirement for state programs to go forward.

Action Recommendations

We recommend buy-downs as a major building block to expand domestic markets for PV. Nevertheless, we prefer to place incentives for PVs within the context of a broader renewable energy program. In addition, we believe that a buy-down can only succeed if numerous other market-enabling conditions are met, which will require a large, coordinated effort by a core group of professionals. We propose the following two-part action plan:

A National Systems Benefit Charge for PVs and Renewables

Federal legislation should create a nationwide system benefits charge of 1 mill (0.1 cents) per kWh on all electricity sold in the United States, perhaps as part of a broader charge to guarantee a variety of public-interest programs. Such a charge could generate approximately $1 billion per year, and should be reviewed after 10 years. The money collected should be held in a trust fund and invested until spent. They should not be subject to any short-term time restrictions for their expenditure.

The fund would be used solely to provide matching grants to states that maintain their own programs to provide incentives for purchases of PVs or other renewables. No matching funds would be granted for R&D expenditures, nor could matching funds be allocated to programs that only mandate purchases of renewables, such as portfolio standards or set-asides. The Department of Energy would determine the level of matching, which would depend on the number of participating states and the level of their commitment. Presumably, the federal commitment would be substantial and on the same order as the amount of funds directly committed by the states.

Individual states would determine the details of their buy-down programs, including the identification of appropriate recipient renewable technologies and the level of buy-down payment. Depending on the states' decisions, the matching program we describe might stimulate more than 1,000 megawatts of new photovoltaic purchases over its lifetime, as well as thousands of megawatts of other renewables. Thus its impact on the commercialization of renewables would be significant.

A Solar "Rapid Response Team" to Coordinate State Efforts

Every effort should be made to maximize the number, size, and effectiveness of state buy-downs and other programs for renewables, especially in states currently restructuring their electric sectors. To accomplish this, we recommend the formation of a small group of experienced, knowledgeable individuals who can devote their full efforts to coordinating national renewable energy efforts at the state level. This effort is needed immediately, as at least six states currently have programs in varying degrees of implementation and operation.

Such an effort would have three broad components:

i. Identify states potentially interested in establishing new PV and renewables programs. Work with state legislatures, regulators, and local non-governmental organizations as appropriate to assist in the creation of state-level incentive programs. Provide information, model legislation, communication with counterparts in other states, and expert witnesses as needed.

ii. Coordinate and establish on-going communications between states that have enacted programs. Provide information, analysis, and expertise to the program designers and implementers in each state to ensure that programs enjoy maximum success and provide a coherent and ordered program of market incentives.

iii. Research the effects and impacts of these programs on the market prices of PVs and renewables and the development of the necessary long-term infrastructure. Provide this information to the states in a timely fashion so that state policymakers can adjust their programs (for example, with respect to buy-down level, program size, and duration) as necessary, to ensure continuous, increasing sales of renewable energy.

CHAPTER TWO: Industry Development Strategy for the Photovoltaics Industry

Eric Ingersoll of Lucid, Inc., Cambridge, MA
Daniel C. Gallagher of Lucid, Inc., Cambridge, MA
Romana A. Vysatova of the J. F. Kennedy School of Government, Cambridge, MA

Executive Summary

PVs will not compete broadly with conventional electricity-generating technologies in the United States unless PV prices fall substantially. These drops will most likely occur as manufacturers increase cumulative volume and capture associated economies of mass production, and as the business operations at other links in the value chain mature and expand. In the interim, PV firms will sell some of their relatively expensive wares to customers who value characteristics of PV other than the cost of electricity, such as independence from the grid, reliability, portability, or benign environmental impact. While conceivably lucrative, these markets are too small to produce appreciable, volume-driven price reductions.

Relying on subsidies to supply the difference by producing "apparent" cost reductions for consumers in the United States and other developed (that is, wired) countries would be expensive, perhaps costing billions of dollars. Yet there may exist a more economically efficient alternative: tapping markets in the developing world in which PVs can already compete. In the developing world, where some 2 billion people still lack electricity, PVs do not have to contend with an established distribution infrastructure and can enjoy a *price advantage* over conventional alternatives. PVs can also compete in these markets on the basis of value rather than price. For instance, the technology's modularity is an asset in the developing world, because PV power investments are scaleable — that is, affordable — to an extent that large-scale conventional technologies are not. Most important, markets for PV in the developing world may prove large enough to spur cost-reducing investments in PV production and distribution facilities.

That photovoltaics are not yet widely deployed in markets in the developing world suggests that barriers such as distance, geographic size, fragmentation, and cultural and regulatory diversity inhibit deployment. To the extent that individual PV companies, constrained by small size and meager resources, cannot overcome these barriers, effective and responsive marketing infrastructures will fail to develop. The end result will be high costs, poor presence, and a lack of optimal (or perhaps even appropriate) products.

However, domestic markets exist for which firms could develop PV-based products and the associated business infrastructure. Although too small to produce the full economies of mass production sought by the industry, or perhaps even be profitable on their own, these domestic markets could serve as testing grounds for new products and market development strategies, thus providing experience that could spark rapid penetration of international markets. With effective development of the necessary distribution infrastructure — including appropriate financing mechanisms — these larger markets could then help to accelerate demand for PVs dramatically.

Domestic markets exist in which firms could test PV-based products appropriate for the developing world — the only market capable of driving economies of scale.

To identify PV market barriers and development opportunities we recommend *value-chain analysis*. This technique entails explicit consideration of each step in a product's distribution chain — product design, manufacturing, sales, and service — thus identifying the weak or absent elements in a potential product's journey from raw material to no-hassle use by the customer. For example, the value-chain approach could be used to develop a strategy for PV penetration of the remote pump market. At more than 10,400 megawatts a year, the remote pump market alone is some 70 times larger than total world output of PV. Given PVs' performance characteristics relative to the dominant pump power technology (i.e., the diesel engine), this should be a major opportunity — yet the industry has achieved little in this area so far.

Action Recommendation

We recommend that an appropriate analytic organization apply value-chain techniques to identify the best market opportunities for PV, identify domestic analogs for these markets (where possible), and devise strategies for their coordinated development.

We suggest convening a meeting of potential funding organizations in order to secure joint support of this program. Invitees might include donor organizations such as the Rockefeller Brothers Fund, Rockefeller Foundation, and MacArthur Foundation; governmental agencies specific to a region, such as the Massachusetts Technology Collaborative and the Massachusetts Department of Economic Development; or federal agencies. It might also be appropriate to require cost-sharing by the PV industry.

Once funded, the program would develop PV market "industry scripts," specifying individual roles and activities. Steps might include:

- analysis of PV industry structure;
- analysis of submarkets by geographic region and application;
- identification of PV opportunities in the submarkets;
- mapping of existing value chains;
- identification of product development issues and opportunities;
- identification of relevant market barriers;
- identification of ways to address these barriers; and
- identification of specific stakeholder roles in development of the market.

Depending on particular circumstances, PV market development activities could include the following:

Apply value-chain analysis to identify promising PV products.

- Foundations or other entities might arrange a joint cash prize for the best proposal to develop or refine products and marketing strategies to meet key market segments;
- The Overseas Private Investment Corporation or the Export-Import Bank might develop a competitive financing program tailored to the needs of small PV equipment exporters; and
- Foundations or the World Bank might develop a fund to provide "money-back guarantees" to early distributors and customers, thus encouraging them to try PV products, linked to the collection and dissemination of key information about customer and distributor satisfaction or lack thereof.

CHAPTER THREE: Policies to Support a Distributed Energy System

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Executive Summary

The established model for generating electricity sites large nuclear, fossil fuel, or hydropower facilities in central locations and delivers energy to scattered customers via a high-voltage transmission grid and, subsequently, a low-voltage distribution network. Recently, several analysts have explored and, in some cases, begun to implement an alternative model, in which very small generating units produce power close to where customers actually need it.

This model of distributed generation, which also accommodates small energy storage and energy efficiency technologies, can provide technical and economic benefits to utilities and customers that are unavailable from traditional central-station generation. These include relief of congested transmission facilities and slower, modular capacity increases more in line with today's competitive, capital-constrained energy market. Furthermore, distributed generation can remove customers' dependence on external suppliers for their electricity needs.

There remain substantial institutional barriers to distributed generation.

PV technology represents the quintessential distributed generating technology. It can provide high-quality, reliable power anywhere the sun shines, and it can generate power on any scale from milliwatts to megawatts. Recognition of the benefits of distributed generation by utilities, utility regulators, energy users, and other stakeholders in the electricity industry is likely to contribute to the expansion of PV markets.

Despite the technical and economic attractiveness of distributed generation, there remain substantial institutional barriers to its adoption. These obstacles reflect a century of central-station generation, with its associated laws, regulations, attitudes, and habits. In most cases, the appropriate response to these barriers consists of modest policy action. Removing the barriers will not guarantee the success of PVs, but it is a necessary precondition to that success.

Action Recommendations

To promote the development of PVs and other distributed energy systems, policymakers must take the following actions:

i. Offer net metering: Adopt pricing policies that recognize the value of distributed generation. Net metering, the simplest of these policies, allows owners of distributed PV systems to sell their excess electricity to offset retail power purchases from their local electric company, while buying any required shortfall for the same price, thus paying only for the "net" electricity consumed.

ii. Institute standardized interconnection requirements: Although organizations such as Underwriter's Laboratories and the Institute of Electrical and Electronics Engineers have developed standards for the safe interconnection of PV systems to the electric grid, utilities have the discretion to accept or modify such standards, resulting in a melange of requirements that differ from state to state and even within states. This prevents PV manufacturers from developing products for a national market. Electric companies should be encouraged to agree on an industry standard as an alternative to a standard mandated by the federal government and enforced by the states.

iii. Offer standardized power purchase agreements: To attach a PV system to the grid, system owners must sign a power purchase agreement (PPA) with their local utility. Unfortunately, most utilities developed their PPAs for facilities with capacities up to hundreds of megawatts, rather than PV systems of perhaps a few kilowatts. Understanding these documents requires specialized — and expensive — legal expertise, presenting a substantial and unnecessary obstacle to PV market development. State policymakers must require that utilities offer simple, straightforward contracts to customers installing their own PV systems.

iv. Minimize additional fees: Utilities frequently impose various fees, for example for engineering design reviews, metering, permitting, and utility insurance. These charges are arguably discriminatory and, at least, often incongruously onerous for small PV systems. Policymakers wishing to promote PV development must minimize these "hidden" costs or eliminate them by instituting standards. Otherwise such barriers will thwart even the best designed PV program.

v. Prohibit restrictive homeowners' covenants: In many cases, developers of residential real estate institute covenants to restrict property modifications or other behavior perceived to lessen a community's aesthetic appeal and thereby its commercial value. Often, homeowner associations retain these restrictions after a development is completed. According to solar professionals, these regulations constitute a large and unaddressed barrier to PV market development. Removing this barrier will require a combination of state legislation and education for associations of home builders and owners, along with coordinated legal intervention by state solar trade associations (or the "solar rapid response team" proposed above in *Government Buy-downs for the Residential Market* by Starrs and Schwent) when the presence of the state proves an insufficient safeguard.

vi. Enact and enforce solar zoning laws: U.S. law generally accepts the right of property owners to build as they please over the right of adjoining property owners to air, wind, light or sunshine. Although a majority of states now recognize the validity of solar easements — voluntary agreements, negotiated individually — land use planning and zoning laws may prove a better vehicle for protecting solar access because of their broader application, simpler implementation, and more effective enforcement.

vii. Ensure the fairness of future distribution utility rules: Today's integrated utilities (firms that generate, transmit, and distribute power) may sense an incentive to discourage distributed, customer-owned generation such as PVs, in that regulators calculate the utilities' allowed profits on the basis of the capital equipment they themselves purchase and install. Restructuring of the electric system will pare the regulated portion of many of today's integrated electric companies into residual distribution utilities. Regulators will retain control over these firms, probably pegging their allowed rates to the amount of electricity they deliver. Thus, although disinterested in generation per se, the distribution firms will retain a financial incentive to discourage self-generation. Federal and state regulators must devise performance-based regulations that give distribution utilities an incentive to encourage PV and other distributed technologies — or that at least remove the incentives to discourage these technologies.

Finally, on a broader level, the PV community must reach consensus on at least two strategic questions. *First*, in the short term, they must consider whether and how to ally themselves with other distributed resource interests. Models for this collaboration include the California Alliance for Distributed Energy Resources and the Distributed Power Coalition of America. We acknowledge the controversial nature of such alliances: chief among scenarios to consider is the possibility that other, better funded technologies — for example, gas-fired microturbines or fuel cells — could use the political appeal of PVs to advance the cause of distributed energy, and subsequently squeeze PVs out of the market. Nevertheless, opening the market for distributed energy helps PVs. We believe that the very weak financial and political position of the PV community makes such alliances necessary: PV technology is in a tough spot, and must make tough choices.

Two challenges: Should the PV community find allies among other distributed energy interests? And what role can utilities play in delivering distributed PVs?

Second, in the long term, supporters of PVs must address their relationship with established electric utilities and consider what kind of entity can best bring PVs to market: Electric utilities are well established, highly experienced, well capitalized, technologically savvy, and, from many customers' point of view, trustworthy and likely to remain in business indefinitely. They control access to distribution networks, and are likely to pursue market opportunities that can be smoothly integrated into their existing networks. On the other hand, companies developing PV and other distributed generating technologies are likely to be more innovative, entrepreneurial, and creative, and they have no complicating commitment to central station technology. Distributed generation in general, by virtue of its real technical and economic advantages, poses a genuine threat to the established business of how electricity is made and delivered. Established energy firms can become potent enemies if policymakers freeze them out of the market for distributed generation. For this reason, we believe it wisest to provide opportunities for all potential market participants, while ensuring through policy safeguards that utilities cannot use their control over distribution networks to unfair competitive advantage.

CHAPTER FOUR: Government Procurement to Expand PV Markets

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Executive Summary

Federal, state, and local governments can play a crucial role in expanding the market for PVs in the near term — not only through their policy decisions, but by means of their own purchasing power. Concerted government purchases could have an enormous positive impact on the PV industry. In 1995, the federal government alone constituted the nation's largest electricity consumer, buying $3.5 billion worth of power. It also owns extensive property: countless office complexes, remote buildings and parks, vast stocks of residential housing, and other installations. If the federal government installed enough PVs at its facilities to generate just 1% of the electricity it consumes, it would require 334 megawatts of new PV capacity — more than six times as much as the U.S. PV industry shipped in 1997.

The renewable energy industries generally, and the PV industry in particular, would benefit from government purchasing in two main ways:

- Government purchases can address the chicken-and-egg dilemma of technology commercialization. Large government purchases will lower the net cost of the technology, leading to private market demand and a virtuous circle of increasing sales, swelling production, and falling prices.
- Governments, as important "early adopters," can help overcome the many institutional barriers to pervasive PV markets. Early adoption paves the way for technologies whose commercialization requires integration within complex technical or regulatory systems.

Unfortunately, purchasing officers rarely consider PVs, often due to the technology's high first-cost compared with various alternatives, as well as to rules that often require purchasing officers to consider cost rather than value in their decisions. Purchasing agents also often lack a means by which they can consider the environmental costs to society in their buying decisions. Finally, professionally cautious purchasing agents may doubt that renewable energy technologies will perform adequately, or that the firms that sell them can provide dependable service and future supply.

A carelessly designed procurement program might have little positive impact on the PV market. In fact, it could have a negative impact if it distracted PV firms into a line of business with little resemblance to private-sector markets. A program that encouraged firms to acquire marketing and administrative skills, cost structure, and an organizational form that facilitated only the unique process of government contracting would leave them less able to compete in non-government markets. Most dangerous of all, without lasting political support and long-term incentives for risk-averse purchasing agents, government demand for PVs could dissipate, leaving firms with excess capacity, burdensome debt, and the threat of bankruptcy.

Government purchases must train PV firms for the consumer markets on which they ultimately will have to depend.

An effective program for the government purchase of PVs and other renewably generated energy would account for the high first cost of PVs and would convince purchasing agents that political leaders were willing to accept the cost; it would also pursue innovative financing options to limit the cost. It would educate the general public and government officials on the rationale for such purchases. It would remove confusing and conflicting regulations, and give purchasing agents the analytic tools to consider environmental costs in their decisions. Likewise, the program would include mechanisms to assure procurement officers that PVs are reliable, effective, and safe — and will be adequately serviced by the seller. The program would nudge the PV sector in the correct direction, by matching, as far as possible, the demands of government purchasers to the demands of the private market on whom renewable energy firms will ultimately depend. And by aggregating municipal, state, and federal government facilities in a given area and building on existing energy efficiency programs, the program would use tax dollars efficiently and advance local economic development.

Action Recommendations

Our specific recommendations fall into four broad categories. Some recommendations concern more than the narrow topic of PV procurement. We include them here to demonstrate just how much must be done to create the context in which a PV procurement program could succeed.

i. Resolving existing regulatory and legislative conflicts:
   - Grant federal agencies the authority to choose their energy suppliers.
   - Require life-cycle costing procedures by removing 10-year payback requirements.
   - Exempt renewable energy projects from the 10-year contract-term limit.

ii. Creating an integrated procurement framework:
   - Streamline the existing procurement process.
   - Permit agencies to purchase renewable energy technology and green power.
   - Aggregate purchases among federal, state, municipal and other government entities.
   - Create an effective implementation structure.
   - Set quantitative goals.

iii. Building the confidence of purchasing agents:
   - Demand long-term warranty protections for the entire system, not just the PV modules.
   - Develop standards and performance measures.
   - Train facilities managers and service personnel.

iv. Financing:
   - Increase agency budgets to cover the higher first-cost of renewable energy systems.
   - Extend authority to sign Energy Service Performance Contracts for a minimum of 15 years.
   - Expand agency authority to use funds from separate accounts for related purpose.
   - Change the federal tax code to permit the issuance of tax-exempt bonds in support of renewable energy projects.
   - Enact a national Renewable Portfolio Standard and/or Systems Benefits Charge.

It will be difficult to change governmental energy practices. Legislation and executive action can accomplish a great deal in the short term (that is, within a year), but full implementation at the federal level will require several years of persistent work. Elected policymakers and professional purchasing officers will only undertake and carry forward this tough task if they perceive strong public support. For this reason, we believe that implementation of an effective government purchasing program will require a strong public education effort, a targeted advocacy campaign, and a convincing demonstration by the renewable energy industries that the goal is worthwhile.

CHAPTER FIVE: Financing PV Production Capacity Through Risk Management

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Executive Summary

In order for the use of PVs to reduce carbon emissions dramatically and to expand the grid-connected market, manufacturers must reduce product costs, perhaps to a level where PV-generated power can compete with alternative energy sources. In addition to subsidizing R&D, conventional PV policy strategies focus on "leveling the playing field," either by increasing the cost of conventional power (through carbon taxes or tradable permits, for example) or by lowering the apparent cost of PVs (through rebates, perhaps, or tax credits). In contrast, this paper proposes a market-based strategy for lowering the cost of PVs by linking investment in larger, more efficient PV production facilities with new demand created by the lower-priced product. We propose the introduction of "project finance" to the PV sector; this tool would allow PV firms to obtain investment on the basis of expected future revenue, secured by aggregated contracts to purchase PV products.

Photovoltaic firms and their backers can use project finance to manage many of the risk factors that hinder large-scale investment in PV production capacity. In general, project finance uses a project's expected future revenue stream to obtain initial investment capital, and allocates the risks and rewards among a variety of stakeholders. Project financing proves especially apt where strong demand for a project's output encourages purchasers to contract to buy that output at a specified price at some specified time in the future. Project finance is currently more typical of traditional "constructed" energy technologies such as gas-fired power plants than it is of new, "manufactured" energy technologies such as PVs. But project finance is becoming more common generally in the manufacturing sector, and could bring important benefits to PV firms.

To attract capital to the PV industry, manufacturers must convince sources of finance that the unsatisfied demand for PV systems on the part of scattered families and businesses constitutes a reliable market. To overcome this market/sales

risk, we suggest the formation of "intermediary" agents, who would pool final consumer demand by entering into forward contracts (that is, bilateral contracts for future purchase at a set price and time) with PV producers, possibly on a secured basis or with third-party guarantees.

The existence of intermediaries would tie demand directly to investments in new plants. By pooling and guaranteeing future demand, forward contracts would provide security for the financing of new PV production facilities. Entities able to play the role of intermediary include power marketers, municipal utilities, energy service companies, purchasing cooperatives, real estate developers, and retail financial institutions.

Fostering dramatic production scale-up through the financial means described here may stimulate the PV industry at a lower cost than traditional policies such as direct subsidies of output or loans for plant and equipment. (It may also be used in conjunction with these policies.) However, the initial costs involved in educating the financial community, as well as developing the necessary contracts and documents, constitute a hurdle to achieving financing efficiency by this method. It would be appropriate to spend public — government, non-profit, or charitable — funds to help create this infrastructure, including the creation of educated financial services companies for subsequent transactions.

Action Recommendations: The *"What"*

By using standard approaches to risk management, the key obstacles to financing large-scale manufacturing facilities on a project basis can be overcome. Although these approaches are already available, they will need to be adapted for use by the PV industry. Some of the key tasks to accomplish this adaptation are outlined here.

i. Steps required to demonstrate economic feasibility:
   - Develop project *pro formas* necessary for bond issuers.
   - Model all financing costs and risk management costs.
   - Determine optimal capital structure for the project.

   Outcome: Determine production costs at which projects will be viable, and produce a detailed economic feasibility model.

ii. Steps required to access the bond market:
   - Work with bond issuers/investment banks to determine possible deal structures and a standardized methodology for analyzing the risk of PV projects.
   - Identify other necessary players (such as those who can provide a letter of credit or guarantee).

   Outcome: Develop relationships with capital providers and reach consensus on how to structure deals and address risk.

iii. Steps required to create performance insurance:
   - Determine the requirements for obtaining performance guarantees from insurers.
   - Work with manufacturing equipment suppliers and national laboratories to produce data on reliability and cost.
   - Compare with performance guarantees for existing products.

   Outcome: Develop prototype performance guarantee.

iv. Steps required to create forward purchase contracts:
   - Explore alternative structures for the forward contract and evaluate them based on marketability and the level of security required by lenders and other stakeholders.
   - Work with mortgage issuers and insurers, including Fannie Mae and banks, to develop prototype contract.

   Outcome: Develop prototype forward purchase contract

v. Steps required to create Structured Demand Contracts (SDCs)
   - Explore security issues and solutions such as mortgage-backed SDC for distributed consumers, SDC guaranteed by back-up buyer, and large-buyer SDC.
   - Test market offers to customers and incorporate feedback into offer.

   Outcome: Develop prototype offer for consumers.

Action Recommendations: The "*Who*"

We describe the steps above as imperatives without subjects; we do not specify *who* should do these things. This reflects the basic nature of our proposal, as an instrument of voluntary corporate policy, rather than one of mandated government policy. To go forward, it will be necessary for a variety of private-sector players to undertake distinct but interrelated activities of their own volition because they believe that the financial tool we propose makes business sense.

Nevertheless, it will be necessary for the public sector or nonprofits to convene and enroll the diverse players able to develop the tool. Our immediate action recommendation, therefore, is that a national laboratory or other government entity, or, alternatively, a nonprofit organization or foundation, commission initial feasibility studies to investigate the concept further. The express purpose of this work would be to identify the relevant actors able to implement the steps detailed above, and to develop the means to convince them that consideration of this model is in their business interest.

Based on the work described above, discussions should be held with representatives of PV and green power marketers, manufacturers, and manufacturing equipment suppliers; bond issuers; investment and other banks; performance insurers; national laboratories and other technical analysts; mortgage issuers and insurers; and other relevant parties. The purpose of these discussions will be to secure agreement from the different parties that the concept we describe bears consideration, and to assume group responsibility for undertaking the various steps. We believe that once this coordinated investigation acquires momentum, its inherent logic will propel it forward as a purely private-sector endeavor.

CHAPTER SIX: Public Education and Professional Training

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Executive Summary

A dramatic increase in the deployment of PV systems in homes, businesses, schools, and other venues across the United States will require a daunting increase in the sophistication of the nation's legislative, regulatory, technical, and market infrastructure. The papers in this "Expanding Markets for Photovoltaics" series each address mechanisms for achieving this increase. Yet each proposal has an element in common: expansion of PV markets will depend on educating the public and training the professional community — and efforts in both areas must go hand in hand.

Events in California in 1998 highlight the import of public awareness. (See *Government Buy-downs for the Residential Market* by Starrs and Schwent.) Although an ambitious and well-designed state buy-down program offers rebates of $3 per watt toward the cost of PV systems, as of this writing homeowners have claimed less than 7% of the funds allotted for the residential sector. The sluggishness of the residential program (admittedly in its infancy) perhaps reflects the absence of a planned public education program, compounded by PV manufacturers' and retailers' modest marketing efforts. By and large, consumers do not know about the program, do not know about the costs and benefits of PV, do not know how to contact a PV business, and do not know how to evaluate the qualifications of an installer.

Consumers do not know about the program, do not know about the costs and benefits of PV, do not know how to contact a PV business, and do not know how to evaluate the qualifications of an installer.

Programs to train the professions that make up the solar infrastructure are equally important. Such programs must target *each* of several professions and trades. Among others, these include: architects, builders, and developers; building inspectors and realtors; loan officers and real estate appraisers; utility engineers; and PV retailers, system installers, and service personnel. (Educating policymakers is a separate concern.) While some of these actors play a more central role than others during the life of a PV system, ignorance at just one link in the chain can stymie the best-designed PV policy program or the most determined potential customer.

Ignorance at just one link in the professional chain can stymie the best-designed PV policy program or the most determined potential customer.

Successful public education and professional training requires a combination of tested tools and new alliances. Much of the basic information that a potential customer must receive before opting to buy a PV system falls within the "public interest" and may appropriately be funded and delivered by governmental, charitable, and nonprofit entities. Examples include the information that electricity generation has an environmental impact,

that alternative energy sources exist, that public programs or funds can facilitate the purchase of a system, and so on. Although fresh ideas and approaches can greatly advance educational and training efforts, the industry and its advocates do not start from scratch.

Effective public and professional education are hindered not by lack of skills or tools but by limited funding and poor coordination. Many of the most successful programs, such as the National Solar Home Tour, survive on a shoestring budget and have not tapped even a small percentage of their potential. No vehicle exists for the development and execution of a comprehensive education program for either professionals or the public. There is no strategic vision that integrates local, state, and national needs and resources.

Despite the barriers, we can make appreciable progress. This report makes numerous detailed recommendations for a *coordinated* campaign of public and professional education. It will be necessary for an appropriate nonprofit or charitable organization to convene the principal organizations identified in this report. Using this document as a starting point, such a group should revise the recommendations, assign roles and responsibilities, develop budgets, and target potential funders for the purpose of implementing a comprehensive national plan.

It will be necessary to coordinate public-interest campaigns with the targeted marketing undertaken by individual PV firms.

We note here one final challenge. To establish self-sufficient markets for PV technology, it will be necessary to coordinate the public-interest campaigns of the governmental, charitable, and nonprofit sectors with the targeted marketing undertaken by individual firms. This new alliance may be awkward at first, but it is absolutely necessary. Our attempts to develop public and professional education must include consultation with the industry whose growth we hope to stimulate.

Action Recommendations

This paper proposes a comprehensive, although not exhaustive, set of action recommendations for PV education activities. The list is long, as there is much to do.

i. PV Education for the General Public:

- The PV community must develop a comprehensive national media plan, including national spokespeople and targeted events, to promote public awareness of PV.
- Environmental advocates planning events such as Earth Day 2000 and the twenty-fifth anniversary of Sun Day should ensure a central role for PVs, and coordinate their efforts with the PV industry.
- Public-interest PV education should complement the PV industry's efforts to identify specific market segments that can act as early adopters.

ii. PV Education for Professionals:

- The PV industry and states should require certification of PV installers through accredited training institutions.
- The PV community should develop PV education programs for real estate and finance-related fields who advise and provide financing for home buyers.
- The PV industry and advocates should work with labor unions, professional societies, and other groups to provide PV education programs for technical and building-related professionals who are essential to the deployment of PV.

iii. Financing for PV Educational Activities:

- PV advocates should continue to seek resources for PV educational activities from a variety of sources: the PV industry, utilities, state and federal government, and foundations.
- The PV industry must support an increasing number of education activities, including paid national advertising campaigns.
- PV advocates and sympathetic policymakers should pay special attention to including PV and broad renewable energy education in the state funds established under state utility restructuring legislation.

CHAPTER SEVEN: Accelerating PV Markets in Developing Countries

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Executive Summary

The developing world represents a very large potential market for PV technology. Especially promising opportunities for expanding PV markets are found in countries with inadequate electricity systems, accessible rural populations, and a robust enough cash economy to allow families to pay minimum installments on household PV systems. Our accumulating experience from numerous projects and policies promoting PVs makes clear that no "silver bullet" exists to expand PV markets. Rather, past experience shows the need for a varied basket of measures, carried out by a diverse set of actors, if PV is to fulfill its rich potential in the developing world.

There is no "single magical policy" to expand PV markets in developing countries.

The PV community should focus its efforts in developing countries on the off-grid market, where PVs can currently compete best. In particular, the most promising use is in solar home systems (SHS) in rural areas; these range from 30 to 50 peak watts, cost around $300–500, and are installed in individual homes. Other off-grid PV applications, including water pumping, battery charging, and village micro-grids, show promise but have not yet rivaled SHS as the favored approach for off-grid PV project developers, international donors, and the PV industry.

Other, cheaper energy sources currently make it difficult for PVs to gain market share for on-grid applications. However, if PV modules fall below $3 per watt, then grid-connected PVs could compete with conventional fuels on select utility systems. This would be a promising development, since the grid-connected market will dwarf the off-grid market. At present, however, it makes little sense to stimulate the grid-connected market with subsidies: there will never be enough subsidies to allow PVs to outcompete other energy sources.

Even in the competitive off-grid market, past PV projects yield lessons with many more "don'ts" than "do's". Problems include excessive focus on limited cash (rather than credit) markets for direct sales, lack of working capital, slim profit margins for dealers, poor financial management, excessively low consumer lending rates, and inadequate maintenance due to insufficient staff training. Further, many projects are actually weakened by subsidies that stimulate PV markets in the short term but then work against the market in the long term. Currently, most PV projects rely on grants or concessional financing from multilateral and bilateral agencies. The PV community has not tapped the much larger private financial market, which tends to shy away from small, capital-intensive projects in nascent industries.

Sustainable expansion of PV markets in developing countries can only take place by means of a healthy PV industry. This will require that every step in the value chain from raw materials to end user (such as assembly, distribution, and retail sales) be profitable. In addition, the industry must have adequate working equity and human capital. Finally, the industry must successfully bridge the gap between direct sales and sales to middle-market consumers, by providing appropriate finance vehicles, including micro-credit. The PV community should take special care with micro-credit programs, as established models tend to lend less money with shorter maturities than consumers require for PV systems. They also rely on credit philosophies that do not fit easily within the collateral-based approach likely to be followed for PV lending programs.

Action Recommendations

Bilateral and multilateral institutions, host governments, nongovernmental organizations, project developers, and project sponsors all will play important roles in expanding PV markets. Each actor should assist in developing a fair policy environment, sufficient human capital (particularly local dealers, developers, and technicians), and adequate investment capital to nurture a healthy private PV industry. Ultimately, the PV industry must be freed from subsidies that artificially distort markets and doom the industry's long-term commercial development.

i. Multilateral and bilateral institutions should limit their efforts to finance and training: They should discontinue, or at least sharply scale down, their traditional role as grantmakers and subsidizers of PV procurement programs administered by host governments. This does not mean that such institutions should abandon PVs. To the contrary, since conventional energy projects can increasingly attract capital from the private sector, multilateral and bilateral institutions should focus their energy-related actions on PVs and other nonconventional energy projects.

Multilateral and bilateral institutions should support market-building activities, and scale down their traditional role as grantmakers and subsidizers.

Key actions by multilateral and bilateral institutions should support market-building efforts such as technical education and financing. Technical education should include vocational training for installers and support personnel; background education for potential users of PVs; and PV-oriented business training for potential entrepreneurs, for example through assessments of promising financial models and business plans. Financing should include partial loan guarantees to multilateral development banks and to private lenders, so as to buy down the risks of lending to PV projects and PV loan pools. Multilateral and bilateral institutions should also fund local development banks and private equity/venture capital funds so they can provide working capital at close to market rates.

ii. Host governments must create a non-discriminatory policy environment: Ideally, governments should reduce subsidies for fossil fuels. If that proves politically impossible, they must even the playing field for PVs by injecting one-time subsidies to technical and managerial training, initial program administration, and limited equipment purchases. Host governments should also reduce import tariffs for PV equipment, since a healthy local PV market can nurture local manufacturing and service industries. Governments can also consider granting rural concessions to solar providers, who can then install PV systems on homes, take care of all maintenance, and charge the households a monthly fee in the same way that conventional electric utilities charge for electric service. Finally, host governments, along with foreign donors, should ensure that PV projects include consumer financing that will wean firms away from the limited cash market.

iii. PV project developers and sponsors must prepare themselves to compete in an open market: They must have access to capital and to strong local partners who can insulate a project from political risk. They should wield financial and project development skills specific to developing nations, technical and managerial know-how, and the ability to transfer their knowledge to a working project. Project developers should not necessarily look to funding from the Clean Development Mechanism (CDM) since PV will have to compete with other potentially cheaper activities such as energy efficiency and forest preservation.

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Expanding Wind Power: Can Americans Afford it?, by Jamie Chapman and Steve Wiese, with Edgar DeMeo and Adam Serchuk, November 1998.

Expanding Markets for Photovoltaics: What To Do Next - Special Report, by Adam Serchuk and Virinder Singh, December 1998.

Upcoming REPP Research*

Research Reports

Project Siting: Comparative Case Studies and Lessons Learned, by Robert Kahn and John Grattan. This paper examines case studies of renewable energy project siting, and provides lessons for project planners, renewables advocates, local environmental advocates, and local planners who need to balance access to good renewable resources with local environmental and aesthetic concerns.

Lessons Learned from the Colorado Green Marketing Experience, by Eric Blank and Blair Swezey. The authors describe a community-based approach for aggregating demand for renewable energy that was developed in Colorado by The Law and Water Fund of the Rockies and Public Service Company of Colorado. The authors also investigate the potential for transferring the model to other regions.

Past Price Projections: Renewables as a Success Story, by Dallas Burtraw. Skeptics often argue that renewable energy has failed, since it has received two decades of public support without reaching cost competitiveness. This paper examines whether renewables have met policymakers' cost goals. It also examines whether renewables' smaller-than-expected market share is largely due to price declines in competing energy technologies, rather than technological problems with renewables themselves.

Making Technology Happen: Case Studies of the Government's Role in Innovation, by Adam Serchuk and Bernard Moore. This paper explores the role of the Federal government in promoting diverse consumer technologies, including the fax machine and recycled paper, to supply background for a discussion of an appropriate Federal role in developing renewable energy technologies.

Issue Briefs

International Policy Support for Renewable Energy, by Curtis Moore. This paper surveys policy mechanisms used by Japan and selected European countries to promote renewable energy technology, both domestically and as an export product.

Clean Government: How Government Procurement Can Support Renewable Energy, by Virinder Singh. The author explores the power of government purchasing to open markets for renewable energy technology, offering lessons learned from current renewable energy procurement efforts throughout the U.S.

* Provisional Titles

The Renewable Energy Policy Project (REPP) supports the advancement of renewable energy technology through policy research. We seek to define growth strategies for renewables that respond to competitive energy markets and environmental needs. Since its inception in 1995, REPP has investigated the relationship among policy, markets and public demand in accelerating the deployment of renewable energy technologies, which include biomass, hydropower, geothermal, photovoltaic, solar thermal, wind and renewable hydrogen. The organization offers a platform from which experts in the field can examine issues of medium- to long-term importance to policymakers, green-energy entrepreneurs, and environmental advocates.

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