U.S PHOTOVOLTAIC PROGRAM PLAN

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ABSTRACT

The U.S. Photovoltaic Program stands midway into its Five-Year Plan, 1991-1995. Compared to previous periods, the progress and momentum of the past year and a half has been unprecedented on all fronts - from record efficiencies in the laboratory, to advances in manufacturing, progress in PV industry scale-up, new applications, a more favorable regulatory environment, and growing market opportunities, both domestically and internationally. All of this activity is happening in the context of a new administration which supports accelerated development of environmental technologies. The DOE is committed to keeping this momentum alive to ensure U.S. leadership in the growing photovoltaic market. The purpose of this paper is to give an update of the exciting progress and discuss ways to build on this momentum.

U.S. PHOTOVOLTAIC PROGRAM MISSION & OBJECTIVES

The mission of the National Photovoltaics Program is to help the U.S. industry develop photovoltaic technology for large-scale generation of economically competitive electric power in the United States, making PV a significant part of our national energy mix. Our goal is to achieve a profitable and growing industry, reaching 1,000 MW of domestic market and a 500 MW overseas market by the year 2000. To meet this goal we are working to reduce the price of delivered electricity to 5 to 6c/kWh, raise lifetimes to 30 years, and increase module efficiencies to 15% for flat plate and 25% for concentrator technolgies.

Past efforts have emphasized material and cell research to achieve these goals. Today's Program follows a balanced plan, which gives equal attention to cost reduction through improved manufacturing, scale-up, expanded markets, and technology transfer to industry. The new approach, recognizing that PV technology is maturing, puts more emphasis on market conditioning and joint ventures to bring the present technologies into the marketplace, continuing R&D on the next generation of products, and using feedback from the marketplace to improve research.

Much of the success of these last two years can be attributed to the unprecedented cooperation between DOE, industry, the research community, state and federal agencies, utilities, and the financing community. This cooperative activity has emerged from a consultative process involving each of these groups. SOLAR 2000: A Collaborative Strategy articulates the results of this collaboration, and guides our efforts to bring these important stakeholders together to mitigate technical and market barriers to PV commercialization. Working together, these participants have made extraordinary progress in the laboratory, in manufacturing and industry, and in the marketplace, enhanced by positive changes in the federal environment.

IN THE LABORATORY

Collaborative work has resulted in important technical progress that is accelerating the development of a viable PV industry. Government and industry are cooperating to bring PV technology from the laboratory to prototype production. Through competitive procurements, the PV Program selects the most promising companies and development teams for support.

New record efficiencies have been set for several materials. The University of South Florida advanced the thin-film cadmium telluride (CdTe) cell efficiency record from 13.4% to 15.8%, illustrating that CdTe can meet ambitious efficiency goals and that low-cost goals are in reach. Equally important, Siemens Solar Industries demonstrated a near 10% efficiency in a copper indium diselenide module. Over 8% stabilized efficiencies in amorphous silicon prototype modules have been achieved -- nearly double the efficiency of modules from just a few years ago.

Concentrator technology has made dramatic progress as well, with more companies moving to prototype production. SunPower Corporation produced cells with an efficiency of 23% at 50 suns concentration and Applied Solar Energy Corporation achieved high-yield production of cells with greater than 21% efficiency.

The Federal research program has also made a major investment in building a foundation for future technical achievements by starting construction of a new state-of-the-art laboratory, the Solar Energy Research Facility, for the National Renewable Energy Laboratory.

IN MANUFACTURING AND INDUSTRY

Developing world-class manufacturing capabilities for photovoltaic products is the central goal of the PV Manufacturing Initiative (PV-MaT). The long-term objectives of PV-MaT are to ensure U.S. international competitiveness and to lay the necessary groundwork for substantial scale-up of U.S. production facilities. During the 5-year life of the program, more than $100 million will be invested--$55 million from the

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government and an equal amount from industry. Since the program’s inception in 1990 significant progress has been made to realize these objectives.

In 1991, PV-Mat provided 22 U.S. companies the opportunity and resources to identify manufacturing process barriers and approaches to overcome these barriers. In Phase II of PV-Mat, seven of those companies under cost-shared contracts are improving their manufacturing techniques. Other firms will join this group later in the year, in a second competition among US manufacturers.

These advancements are not merely staying in the laboratories. Rather, the private sector is investing in taking these recent developments into production. Recent announcements of manufacturing scale-up will more than double US capacity in the next two years.

For example, the United Solar Systems Corporation is building a 10 MW amorphous silicon triple-junction manufacturing plant in Virginia. This move can be attributed to the unique economic enhancement package offered by the state of Virginia ($0.75/watt for modules manufactured in Virginia from 1995 through 1999).

Golden Photon is building a 2 MW cadmium telluride facility in Colorado. This is a major investment by the Adolph Coors Company in a small Texas firm supported by DOE/NREL research contracts. Advanced Photovoltaic Systems has a new 10 MW facility in the final phases of construction in Fairfield, California. Siemens Solar installed a new automated manufacturing system in California that increases capacity and improves yield.

Several other companies are in prototype manufacturing of new module technologies and are expected to gear up production in the near term:

- Solar Cells, Inc. in Toledo, OH -- making 7% efficient prototypes of 8 sq ft cadmium telluride; now building their first 1 kW system
- Astropower in Newark, DE -- delivering their first 20 kW of silicon film modules to Virginia Power
- Mobil Solar announcing the sale of 2 kW and 4 kW ac power kits for residential use (the kit is factory-packaged for easy installation)
- ENTECH improving their concentrator module by fully automating their lens and cell assemblies
- Several foreign companies interested in building manufacturing plants in the US

**IN THE MARKETPLACE**

Eliminating market barriers has been a critical component of the DOE’s program to accelerate the entrance of photovoltaic technology into the marketplace. Over the last two years significant progress has been made in altering the regulatory and policy environment of energy production. Public utility commissions in many states are establishing or evaluating changes in traditional procedures so that utilities in their service area have a stronger incentive to include PV as an option. The Arizona Corporation Commission requires electric utilities to consider photovoltaic systems as an alternative to line extensions as part of their integrated resource plans. The Vermont Public Service Board is also considering amending its extension policy to encourage PV options by incorporating environmental costs into resource planning decisions or by giving some preference to renewable energy technologies in supply planning or bidding schemes.

Making the connection between laboratory and industrial advances to value added services for final customers has long been a major hurdle to PV’s expanded use. To address this barrier DOE has supported conferences, symposia, and targeted workshops to stimulate feedback and active involvement from the stakeholders that influence final purchases and applications. The objective of these efforts is to start a collaborative effort that will:

- provide feedback to research and development efforts to improve product design,
- improve the identification and marketing of high-value applications for end-users and manufacturers, and
- better inform potential users of PV capabilities and value.

The PV4U working groups and UPVG are two of the mechanisms DOE has supported to pursue these objectives.

**State Working Groups.** To date, 12 states have met to discuss the formation of state working groups with the primary goal of developing concrete plans for deploying cost-effective applications and near-term, value-added uses. These groups bring together stakeholders (utilities, regulators, consumer advocates, PV industry, state energy offices, environmental interests) to air their concerns, expectations and ideas for clearing obstacles to PV applications.

**Utility Photovoltaic Group.** Over 60 utilities are participating in this group to find practical and cost-effective ways to aggregate markets among utility members and integrate PV technology into their power-generating systems. They are active in technology transfer and disseminating new information on high-value applications of PV and new approaches utilities and

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their customers can take to profit from PV commercialization and use.

**PV:Bonus.** One of the high-value markets DOE is working to solidify is building applications of PV, where their DSM and distributed generation value is maximized. The building sector represents enormous opportunity for market expansion. Today, approximately 2/3 of the electricity generated in the U.S. is consumed in residential, commercial, and institutional buildings. In 1992 DOE began a new $40 million, cost-shared, five-year program, Building Opportunities in the United States for Photovoltaics (PV:Bonus) to develop a market for PV technology in the building sector. PV:Bonus supports the development of PV buildings concepts, the creation and testing of products, and the construction of demonstration buildings as an avenue to market penetration.

The U.S. Department of Defense (DoD) is another large untapped market. The DoD is the largest single energy user in the world. DOE is working jointly with DoD and the U.SPV industry to install up to 100 MW of PV by 1996.

**International Markets**

Internationally, development and financing agencies are beginning to recognize the benefits of renewable energy technologies and are implementing structural changes necessary for their entry. DOE has been actively forming partnerships to establish mechanisms for financing small-scale projects for rural electrification, and lending technical assistance to support aggressive developing country efforts to utilize these technologies in appropriate applications. Two ongoing programs include:

**FINESSE.** Project FINESSE (Financing Energy Services for Small-Scale Energy Users), is aimed at enhancing project opportunities for PV and other alternative energy technologies in the developing world by working closely with international financing institutions and host countries. For example, in January 1992, the World Bank, in conjunction with the DOE and the Government of the Netherlands, established the Asia Alternative Energy Unit (ASTAE) and approved the first World Bank loan for PV systems in December of 1992. This $55 million project is to encourage the development of a sustainable market for PV systems in India. To date, over $800 million in PV and other alternative opportunities have been identified and are being pursued in the Asian Region alone. Plans are underway to develop a similar office for the Latin American and Caribbean Region.

**Americas’ 21st Century Program.** This joint venture program is focused on the development of sustainable alternatives for meeting energy needs in Latin America and the Caribbean region using renewable energy and energy efficiency. Through this program DOE and the U.S Agency for International Development are working with the Government of Mexico on a multiyear program under which more than 10,000 PV systems have been installed since 1989. Early in 1992, DOE and the Committee on Renewable Energy Commerce and Trade (CORECT) sponsored a cooperative program with the Mexican government, called PROCER (Programa de Cooperacion en Energia Renovable), to provide technical resources and expertise.

Further exciting work has begun in Brazil stemming from meetings begun during the United Nation’s Conference on the Environment and Development, in Rio de Janeiro, Brazil. The U.S government and the Federal Republic of Brazil agreed to sponsor a project to install 2000 small residential PV systems in two rural Brazilian states. Ultimately, PV could serve more than 500,000 homes, schools, and health clinics throughout Brazil.

**IN A NEW FEDERAL ENVIRONMENT**

The current federal policy environment is much more supportive of accelerated expansion of PV in the mainstream energy market. First, the new administration has outlined a technology policy--Technology for America’s Economic Growth: A New Direction to Build Economic Strength—that puts priority on the accelerated development of environmental technologies. The Clinton administration is also stressing the relationship between the environment, economic development, and international competitiveness. Second, the Energy Policy Act of 1992 includes several new incentives for renewables and energy efficiency. These range from export promotion to increased emphasis on manufacturing.

We have the plans and programs in place (e.g., Solar 2000). Progress has been rapid on all fronts. But can we (DOE, labs, industry, the marketplace) keep up this pace?

**BUILDING ON THE MOMENTUM**

To achieve our long-term goals, the momentum of the last two years must be continued. Maintaining and building on this momentum requires that the market and industry develop together. To date the government helped make up the price deferential between what customers are willing to pay for power and what industry must charge to remain in business. The focus of the DOE program is now on creating an environment where the users value of PV and what industry charges will meet, and the demand for PV becomes self-sustaining.

Building on the momentum we have created requires more than just moving headlong down the same paths we have followed in the past. Our efforts have to be forward-looking and carefully crafted to meet new challenges and seize new opportunities. For instance, the UPVG is faced with a challenge of identifying and implementing 50 MW of near term applications that the PV industry has identified as the key to supporting their near-term...
production capacity expansion. Roughly 17 MW of these applications are to be targeted to already commercial applications of PV, aggregated into a single, large, purchase commitment. The remaining 33 MW is targeted for a purchase commitment for value-added markets such as DSM and distributed utility applications that are near commercial. This last category will be eligible for a 30% cost share from DOE.

The UPVG effort will be one of the first tests of our ability to keep our momentum going and direct it down the most productive development pathways. The challenge is to leverage the involvement of all the stakeholders -- DOE, the utilities, and the manufacturers -- to push the industry another step closer to sustainability. What criteria should we use to identify and structure joint ventures to meet our goals of stimulating large-volume purchases that will lead to the creation of a sustainable utility market for PV? How do we create an atmosphere in which both sides profit from interaction? How should our joint venture and commercialization strategy adjust to the new market situation emerging from PUHCA reform, and transmission access provisions of EPACT? What new opportunities might be seized with the passage of a BTU tax? How can we take advantage of the second phase of the Clean Air Act Amendments to highlight the environmental advantages of PV?

The answer is to keep our objectives and goals clearly in focus, and then shape the criteria for selecting joint venture opportunities and allocating resources to move the industry toward those objectives. Some of the key criteria for selecting the best opportunities and choosing the most productive challenges to take on should include:

- Is the effort ultimately commercial, and does it have a high probability of success? In the case of supporting a demonstration or pilot application program, this requirement would mean requiring a business plan that shows how this effort will ultimately lead to sales and profits from PV sales, and how those sales and profits will be achieved through sound technology, management and marketing.

- Does the effort further the acceptance of a new application or market segment that is valuable, replicable, and is not duplicative of other efforts? Our collaborative efforts should break new ground in broadening PV markets and applications and demonstrating to users the value of PV. Distributed utility applications of PV are a good example.

- Does the effort introduce a high-value application to a new set of potential customers? Information dissemination and overcoming the perception of PV as a technology for tomorrow but not today is a continuing problem that well-crafted joint venture efforts can overcome.

- Does the effort convince all the stakeholders that are involved in purchase decisions? Convincing a utility alone is not enough, because their resource decisions also depend on their commissions, on the intervention of consumer advocates, and on environmentalists. The more stakeholders that can be involved in a joint venture, the higher its value.

The following list of criteria goes even further in trying to pin down exactly what should be brought to the table when committing to collaborative efforts.

- Stimulates future volume purchases

- Illustrates a new cost-effective PV application that is profitable and replicable

- Institutionalizes use of PV for utility applications

- Phased PV purchase agreement with industry

- Clear cost reduction path

- Size of market potential

- The utilities planning process should accommodate PV applications
  - Will the screening process automatically exclude PV
  - Does the IRP incorporate DSM measures

- PV technology is a component of the utilities long-range plans
  - Mechanisms planned or in place to service, maintain, and evaluate the PV system
  - Support and commitment from stockholders, ratepayers and senior management has already been rallied
  - Intent to phase in larger volume purchases if demonstration proves profitable.

- PV industry must demonstrate ability to meet future product demand

- Needs to have the necessary regulatory and institutional approval
The general theme running throughout these criteria is a challenge to define the value-added the effort brings to the PV commercialization effort. In a broader context the same principles and types of criteria should be applied to all of our program efforts. We are all working to compete in a utility and energy sector that has a momentum, and direction of its own. It is being shaped by profound changes. Power producers are feeling the pressures of regulatory changes and tightening emission standards. The full effect of the Clean Air Act Amendments are just beginning to be felt in the industry. To meet these standards utilities will have a variety of options to choose from. The Public Utility Holding Company Act reforms in EPACT will create a much more competitive wholesale generating market, in which some utilities will play a much more aggressive role as developers of new generation and DSM projects. The growing influence of integrated resource planning, which EPACT encourages, will continue to bring DSM and supply options into more direct competition, and open an avenue for including externalities in valuing new technologies. EPACT’s provisions to increase transmission access will expand inter-utility sales and the geographic range of competition.

There are many who have a stake in our success. The accelerated entrance of PV and other renewable energy technologies into the marketplace will create environmental security and energy diversity while creating jobs and stimulating economic growth.

In this era of uncertainty, the PV community must become more responsive to the needs and concerns of its customers – we need to change our approach as the market changes. To not just maintain, but to grow, the renewable energy industry and DOE must anticipate the direction of the energy industry and adjust our course and our commercialization strategies accordingly.