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# The NCPV: It's *Not* Business as Usual

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# The NCPV: It's *Not* Business as Usual

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**ABSTRACT**

The business of doing R&D has changed over the last year, involving new programs and some new priorities. We discuss insights concerning what the NCPV and PV Program are doing in light of the situations in our nation and world. A call is made for significantly accelerating our progress to reflect the National Energy Policy and respond to our nation's critical needs—ensuring the success and establishing the significance of solar electricity...even faster.

**Changing Times . . . Affecting How We Do Business**

In the 18 months since the last NCPV Program Review, we have experienced an interesting mix of the "best of times and the worst of times" for our technology. While we have continued to provide a healthy return on our R&D investments, world competition continues to cut into our leads—or widens the gap in some critical areas such as market share. World demand for photovoltaics grows [1]. So does the size of the offshore PV industry, with the help of investments, subsidies, and incentives from their own governments.

The energy dilemmas in California and the West have provided a focus and visibility on solar as a credible "energy of choice" here in the United States [2]. This "energy crisis of the new millennium" has created a growth atmosphere for our industry—and, more importantly, an incredible appreciation and authentic acceptance of solar electricity as a real contributor to energy supply by the *consumer*. The public awareness and understanding of "photovoltaics" has grown considerably.

On the other hand, our industry has not been able to adequately supply these new, expanding domestic markets. The industry has developed a roadmap [3] to address and further cultivate these U.S. electricity markets, but the joint industry and government roles are just starting to be defined. The change in federal administration has provided a good share of challenges for funding, proving significance, showing competitiveness, addressing technology myths, and showing how PV fits positively into current and future energy policy.

The change in the electrical utility structure in the United States has enhanced the position of photovoltaics as a distributed power resource [3]. The President's National Energy Policy (NEP) [4] cites this as a strength: "Photovoltaic solar distributed energy is a particularly valuable energy generation source during times of peak use of power." This is further reflected in that some 55% of the photovoltaic modules shipped in 2000 found their way into applications tied to the grid—a trend that has been developing over the past 3 years [5]. The old methods of getting PV into the markets are changing—with commercial home builders making PV "the roof," recreational and government installations touting PV as "practical" and the "logical thing to do" in supplying their electricity, and home improvement centers now selling PV "off the shelf" for watt-level garden lighting to kilowatt-roof installations.

The terrorist activities and the fear of dependence on foreign oil should only highlight and strengthen photovoltaics as a prime player in energy security. The decentralized aspects of photovoltaics in its distributed electricity delivery—providing power at the point of use and supplying the utility grid—are certainly valuable assets for a secure energy supply. The solar resource is not owned or controlled by a foreign interest. And the modularity of photovoltaics make it an energy of choice for uninterruptible power during natural disasters, power shortages, and other national or international calamities—like those we are now sadly experiencing. "Make no mistake" [6], photovoltaics supplies electricity for homeland security.

All these events have brought about new directions for our programs, and the need to reexamine our plans and strategies. We will cooperate with the NEP, which has not only challenged us—but has given us guidance to "increase America's use of renewable and alternative energy" and has recognized that "performance improvements of…photovoltaics systems would facilitate much wider use." [4]. We have the opportunity, as never before, to make solar electricity a real and significant part of our energy portfolio. *And it's not going to be "business as usual."*

**Building on Strengths**

As President Truman used to remark, "The only thing about the future you couldn't predict is the history you didn't know." Fortunately, we have a solid R&D history—and we continue to build on those fundamental and applied research strengths in programs that partner our universities and laboratories with our industry. These programs brought us "10% thin-film solar cells," which marks a performance level thought to be a stretch when our programs began 25 years ago. But they have also nearly doubled the performances of silicon devices through understanding how to absorb every photon, transfer their energies to create as many electron-hole pairs as possible, and collect the maximum number of these carriers for the electrical current. These programs have invented new paths—with multijunction cells, not even in existence 20 years ago, now converting about one-third the sun's energy into electricity.

In any successful program, one builds on one's strengths. These programs have developed the materials and designs for packaging. Module technology has gone from cells molded in rubber compounds to sleek packages warranted for 25 years. These programs have had to design and build the electronics that enable the PV system for its use. Our balance-of-systems (BOS) work was a hodgepodge of vacuum tubes, mechanical multivibrators, noisy electronics, and uncertain operation, with no guarantee of even working! BOS has evolved with electronics into the digital age, with "mean time to failure" soon expected to reach the 10-15-year timeframe. PV standards have gone from a question mark in the mid-1970s, to PV's acknowledged "poster child" role in the first interconnection standards for distributed generation [7]—several years in advance of the call for such activity by the NEP. At the start-up of the U.S. Department of Energy (DOE), larger systems were many times "dead on arrival." Now, we worry about delivering less than "6-nines" (99.9999%) power from them. Progress has marked the PV programs—build on R&D, understanding, and dedication of extremely competent, technical experts. Our university and fundamental science resource *must* continue to expand—both in support and in the extent of university involvement with our programs. *(This will* become *business as usual!)* These core science and engineering competencies will continue to be the foundation of what PV does in the next decades, and these competencies will have to grow and intensify to ensure the success that we expect.

**What's New**

The DOE PV Program and the NCPV have recommended and already implemented some new directions to foster and hasten the growth of our technologies. These new directions have been in the form of R&D initiatives—*recognizing* that our research programs are evolving along new paths and new levels, *recognizing* the progress of related technology and the guidance of the roadmap, and *recognizing* we have to close the gaps between laboratory development and use in manufacturing and introduction of technologies to first-time manufacturing.

Three initiatives are under way:

- Beyond the Horizon—Positioning us in "developing next generation technologies" [4] and realizing performances beyond the conventional
- High-Performance Photovoltaics—Building on current technologies and bringing them and near-term technologies to their attainable performance limits
- Manufacturing R&D—Developing new and PV-specific in-line monitoring, characterization methods, and smart controls to enhance yields and throughputs.

We are also proposing and starting a new R&D effort aimed at the reliability of PV components and systems. The purpose is to ensure that all the building blocks and systems themselves are the "best they can be" from the aspects of durability, reliability, and lifetime. This focus underpins our R&D programs by emphasizing the reliability of everything from the materials and PV devices, to the inverters and charge controllers, through the systems used by the consumers, as well as standards and certification for consumer protection. This technology prides itself on its ability to perform—and we must take these performances to the next levels to ensure more than customer satisfaction: PV will be *customer choice* for electricity generation because it is the *best* option.

We are also paying greater attention to building-integrated PV. The potential for PV is enormous in our built environment. So is the need for R&D to develop these technologies—building facades, shades, roofs, canopies, and windows. For example, marrying PV into architectural glass is not a simple transformation of a PV module. The glass is different; the processing is different; the sizes and geometries are different; the constraints for uniformity, aesthetics, reliability, and performance are greater; and the conformity with codes, standards, and interfaces are more stringent. *It is* not *business as usual.* The program has initiated workshops for and input from the community. It incorporates the best approaches in our past and recent building programs, but builds a new integrated approach in partnering research intimately with component development, manufacturing R&D, architectural design, buildings and trades, codes and standards, and users. It is imperative to accelerate the PV into the building and its envelope, and these new approaches and new emphasis will ensure this outcome.

**Accelerating Progress, Ensuring Success**

Why is this taking so long? There is impatience with the roadmap in time of delivery. Indeed, PV *is* important and *is* contributing now and over the near term. However, its greater impacts—the impacts that grab the attention of energy analysts and policy makers—come in the 2020 period. The roadmap was developed by the industry with a set of targets, a supportable growth scenario, and an assumption of a U.S. federal budget. How can these targets and plan be accelerated? How can the real impacts be brought closer? Consider the recent events—the electricity supply problems, the threats of terrorism and concern for homeland security, the focus on energy security [8,9]. Add to these the benefits brought by an environmentally clean, reliable technology with considerable economic benefit to the country. The clear conclusion is that a new investment and a new policy for U.S. solar electricity are not only warranted—they are *mandatory*.

We have the opportunity to respond to the call of the NEP [4], to bring energy security and significance even closer. *What if* . . . we had a response? What could be done, say, by *tripling* the current PV budget?

One path is a coordinated effort, assisting domestic growth through public-sector use of photovoltaics (education, energy security, premium power, system development, public awareness), integrally coupled with investment in manufacturing R&D, to more rapidly realize a "21$^{st}$ century PV industry." This would provide a mini-Manhattan project for solar electricity—toward ending the war over energy security. It would muster the science and engineering talent, support the arsenal of tools needed to complete the campaign, and provide a sustained, moderate-but-sustained market segment to warrant the growth and expansion of private capital. This could significantly accelerate the current goals and targets of the roadmap, as well as the impact of solar electricity in the President's National Energy Policy.

The plan would involve three coordinated areas, discussed below, with roughly one-half, one-third, and one-sixth of the investment allocated to each, respectively:

- *Technology Investment*: To accelerate the cornerstone of the roadmap—the private-sector-based commercialization plan (which highlights the importance of tax incentives, residential tax credits, and net metering)—an investment in the public sector would provide markets with substantial benefits. This would require building solid partnerships among government agencies, such as traditional connections among the DOE, Environmental Protection Agency, Department of the Interior, and Department of Commerce. And we need to foster essential new alliances with the Department of Defense, State Department, Treasury Department, National Institutes of Health, and the new Office of Homeland Security [8] on the federal side. The foundation is built on installing PV power resources on U.S. schools and on selected government building (sizeable users of U.S. electricity), in federally owned utilities (which currently produce about 8 GW annually [10] and in urban "brownfields" [4]). This technology investment would provide an authentic education base for the public and for consumers; assess progress in reliability and energy-delivery effectiveness; enhance energy security; and, "working with FEMA" [4], place premium power in critical sectors (government buildings and schools) that have power needs for computers, surveillance equipment, and facilities serving as emergency shelters. About 100,000 public and private schools, along with many hundreds of federal and state facilities, would be appropriate. Currently, the federally owned utilities are adding about 300 MW annually—a significant portion of which could be PV.
- *U.S. "21st Century PV Industry" Acceleration*: An investment in the PV manufacturing sector (cells through electronic components) beyond the current program is required for developing advanced, large-scale processes to build capacities, modernize industry infrastructure, enhance throughputs, increase yields, and enable first-time commercial introduction. The time needed to introduce new processes and products could be reduced substantially—by at least 50% from the current 8-12 years, with product lifetimes 50% improved over the current roadmap expectations.
- *Fundamental and Applied R&D Enhancement*: Realizing the manufacturing R&D targets would require an intensified investment in our university and research laboratory resources. This R&D encompasses process integration methodologies, special and new technique development, process research, nanotechnological approaches to process and materials understanding, materials development, device engineering, chemical engineering advances and applications, and engineering research to improve manufacturing and reliability of solar-electric components and systems. R&D is required in the physics and chemistry of solar cells through electronics for new BOS components.

In this approach, all three components are essential and are coordinated to ensure the success. They would not duplicate current programs, but substantially enhance and depart from current approaches and scales. The *outcome*, compared to the roadmap baseline, would include:

- 25%-30% annual growth in U.S. shipments from 2004 to 2007, and a 35%-40% annual growth from 2008 through 2014 (Fig. 1). Thereafter, at least a 25% growth would be maintained.
- Accelerating domestic markets, meeting *in 2015* the current roadmap's 2020 expectation of 3.2 GW, and approaching 10 GW by 2020, which is more than three times greater than the original target.
- Supplying about 20% of the new electricity-generation capacity in 2015 and lowering the U.S. carbon generation by about 20% in the same year.
- Enhancing the market leadership for the U.S.-based industry to 60% market share.
- Benefiting not only U.S. energy security, but also, the economy by generating about 150,000 new, high tech jobs in the United States by 2015.

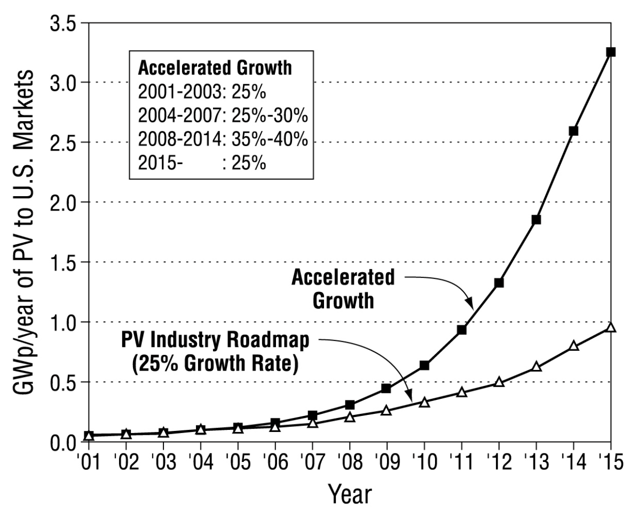


***Figure 1. Annual growth of PV shipments to U.S. markets from 2001 to 2015.***

Such an initiative would require a modest investment—merely one-quarter the level of Japan's 2002 PV budget [11]—for a potentially significant acceleration in the roadmap, addressing the directives of the NEP in "increasing America's use of renewable and alternative energy….to reduce costs and increase performance….promoting partnerships….[and again, recognizing that] performance improvements of… photovoltaic systems would facilitate much wider use." [4].

## Summary

Changing times—as especially seen within these past 18 months—call for action. We have a mandate from the President's National Energy Policy. We have programs that have implemented several new pathways in R&D for the now-, near-, and next-generation technologies. We have begun and revitalized programs in two priority areas: reliability and building-integrated PV. We can do more in bringing closer the time that PV will make a real impact. The acceleration calls for an investment—but one that is commensurate with the guidance of the National Energy Policy. It can be done because "it is easier to grasp the future if you know what it should look like" [12]. The investment in PV R&D and clean, solar electricity for our nation's future is good, sound business, *not* just business as usual.

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