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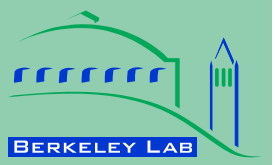

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Learning by Doing:
The Evolution of State Support for Photovoltaics

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Table of Contents

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Abstract

Fifteen states have established "clean energy funds" that will collect more than $3 billion in aggregate from ratepayers over the next decade. The general mission of these funds is to support the development of renewable energy technologies and markets; all of the funds target the installation of photovoltaics (PV) in one way or another.

So-called "buy-down" programs – i.e., programs that offset the high up-front costs of PV through capital grants or rebates – have been the most popular approach taken to date in supporting PV. At present, however, state clean energy funds appear to be evolving into a new phase of supporting PV – one that draws upon lessons learned from the past few years' experience with the first round of buy-down programs. This paper briefly discusses these lessons from the past and describes how various states are tweaking, rearranging, or crafting new programs to incorporate those lessons.

1. Introduction

Fifteen states have established "clean energy funds" that will collect more than $3 billion in aggregate over the next decade, most often through a small surcharge on retail electricity rates known as a system-benefits charge (SBC). The general mission of these funds is to support the development of renewable energy technologies and markets. The widespread popularity of photovoltaics (PV), along with its high up-front cost and resulting need for support, have made it a prime target of state clean energy funds – virtually all funds currently in operation provide some form of support for customer-sited PV (Bolinger and Wiser 2002a).

Many funds have implemented what are commonly known as "buy-down" programs, where funds are distributed as grants to subsidize or "buy down" the initial cost of the system. This approach was taken by California in 1998, and has since been widely replicated elsewhere. Table 1 provides a snapshot of buy-down incentives offered by state clean energy funds as of March 2003.[1]

As real-time programmatic experience accrues, however, lessons are being learned from the first round of buy-down (and other) programs, and states are beginning to revise their programs accordingly. For example, states have on occasion had difficulty setting the "correct" incentive level, inducing efficient system performance, warding off gaming of program rules, driving cost reductions, and supporting PV applications where the technology adds the most value.

Taking into account this experience from the past, this paper focuses on the innovative steps that state clean energy funds are now taking to try to remedy these perceived deficiencies and to ensure that their programs are as effective as possible in driving PV markets. These states have learned valuable lessons and, more importantly, are acting upon those lessons; the purpose of this paper is to share that progress with others.

We begin with a brief description of California's buy-down program as first implemented in 1998, with the intent of setting the baseline against which all subsequent programmatic evolution is measured. We then discuss the real-time challenges encountered by PV programs in California and elsewhere, and how programs have begun to evolve to overcome these challenges. Our focus is not on program results, but rather on what states are currently doing and how their programs have evolved over time.

[1] Table 1 does not include information on state loan programs, infrastructure-building activities, or other program types and is therefore not exhaustive with respect to state clean energy fund support for PV.

Table 1: Snapshot Of PV Buy-Down Programs (March 2003)

State	System Size Limit	Incentive Level	Maximum $/System	Notes
CA (CEC)	<30 kW	Contractor-Installed: $4/W Owner-installed: $4/W*85%	None	Incentive will decline by 20¢/W every 6 months. Developing performance-based incentive for systems ≥30 kW.
CA (CPUC))	30-1000 kW	$4.5/W up to 50%	None	Program implemented during energy crisis to supplement CEC program; currently funds all systems >30 kW
CT	None	≤$6/W up to 50%	None	Only non-residential eligible. 75% of incentive paid up-front, 25% paid after 1 year if system has achieved at least 70% of projected generation.
DE	≥0.3 kW	35% of installed costs (res.) 35% of installed costs (non-res.)	$10,500 $250,000	Only systems ≤$12/W are eligible, so maximum incentive is $4.2/W.
IL	≥0.5 kW	$6/W up to 60%	$300,000	This statewide program also partners with Chicago fund. A third program is open to publics and non-profits.
MA	No limit, but must be aggregated to at least 10 kW	Clustered: $3.5/W+38¢/kWh <10 kW: $3.5/W+38¢/kWh >10 kW: $2.8/W+30¢/kWh New Const.: $2.8/W+30¢/kWh	$5/W $5/W $4/W $4/W	The ¢/kWh incentive is paid quarterly over 3 years. Incentives represent two separate solicitations: "clustered" installations, and "open" installations.
MN	1-4 kW	$2/W	$8,000	Currently the lowest incentive out there, but 10 reservations since 7/02.
MT	None	$4/W (residential)	$8,000	Also completely funds 2 kW systems on schools and fire stations.
NJ	first 10 kW next 90 kW next 400 kW next 500 kW	$5.50/W up to 70% $4.00/W up to 60% $3.75/W up to 60% $0.30/W up to 60%	None	Incentives listed are for 1st of 4 blocks, with incentives declining in each block (at a set date).
NY (LIPA)	≤10 kW	$5/W	$50,000	Once 500 kW reached, incentive will drop to $4/W for next 1000 kW.
NY (NYSERDA)	≤15 kW >15 kW	$4-$5/W $5/W up to 70%	None $500,000	For systems ≤15 kW, $4/W for net-metered systems (≤10 kW), $4.5/W for systems installed on Energy Star homes, and $5/W for systems that can't be net metered (10-15 kW).
PA (PECO)	1-5 kW	$4/W (owner) up front +$1/kWh (owner) after 1 yr +10¢/kWh (installer) after 1 yr	$20,000 $5,000 $250	Combined payments to owner limited to 80% of installed costs. For a 2kW system, the production incentive approximates an additional $1/W.
RI	None	$5/W up to 50%	None	Originally $1.5/W, and then $3/W.
WI	None	$2/kWh (projected over 1 yr), up to 100%	$50,000	Annual kWh production is estimated with PV Watts, then de-rated by 20%. $2/kWh=$3/W at 17% cap. factor.

2. California's Original Buy-Down

As one of the first and largest states to implement an SBC-funded buy-down program (in 1998), California has set the standard for other states to follow, while also providing valuable real-time experience upon which other states have drawn in designing their own programs. California's original program design was elegantly simple, yet also sophisticated. Consistent with the idea

that system costs should decline as demand grows, the $54 million available to the program over its first 4 years was to be distributed more or less evenly over five funding blocks of decreasing incentive value. Once all the funds in the first block ($10.5 million at $3/W up to 50% of installed costs) were committed, the next block offering a lower buy-down ($2.5/W up to 40% of installed costs) would become available. By the fifth block, the incentive would drop to $1/W up to 20% of installed costs. In this way, California intended to gradually wean the PV industry off of public support.

California's program appeared to have many of the ingredients necessary to create immediate and tangible results. The program directly engaged the public, yet with minimal transaction costs (the reservation process was relatively simple). It pushed the industry towards maturity not only by encouraging cost reductions through the declining block structure, but also by requiring a comprehensive 5-year warranty on the entire system – heretofore unheard of in the U.S. PV industry (Starrs and Schwent 1998). The clear and steady progression through the funding blocks encouraged early adopters and allowed the PV industry to plan for the future with a long-term market view.

So promising was California's program that other states designing their own programs at the time closely mimicked it. New Jersey, for example, adopted a similar declining block structure (though at higher incentive levels), while Illinois and Rhode Island – states with both a lower level of funding *and* administrative support – kept the general buy-down notion, but pursued far simpler structures (e.g., a single incentive without blocks).

For all their promise, however, and in spite of the success that some of the early programs have had, it has become clear over time that buy-down programs first implemented in California and elsewhere were deficient in several limited, yet important respects. These challenges, and the innovation and evolution they have spurred, are discussed below.

3. Challenges And Innovative Responses

3.1 Setting the Correct Incentive Level

Economic theory states that the correct subsidy level for a given amount of funding is that which exhausts consumers' willingness to pay just as available funds are depleted. If instead the subsidy is too low, money is left on the table. If it is too high, the subsidy dollars will support fewer megawatts of PV than otherwise would be the case.

While the incentives currently offered by states range widely from $2-$6/W (see Table 1), in general, states have conservatively erred on the side of setting the incentive level "too low" and leaving money on the table. In fact, as shown in Figure 1, six of the seven states offering the lowest incentives at program inception have since increased their incentives, in one case (RI) more than once. Two of these states (CA and NY/LIPA) have subsequently reduced their buy-downs (in CA due to overwhelming response at $4.5/W), but to levels still exceeding their original offering. At the other end of the range, Montana has twice reduced its incentive level, while New Jersey recently nudged its relatively generous offering a bit higher.

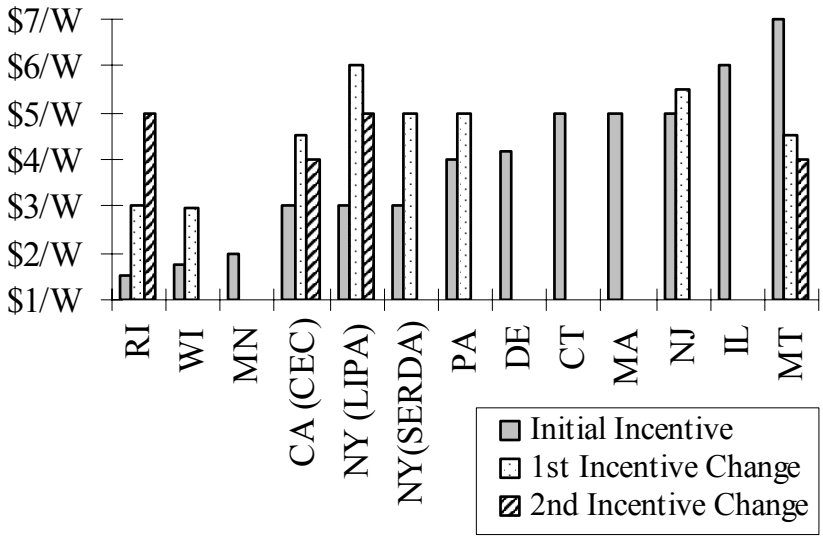

Figure 1. Changes in Incentive Levels

This ongoing "price discovery" appears to be converging on buy-down incentive levels of $4-$5/W as necessary (though perhaps not sufficient) to stimulate significant demand for grid-connected PV systems. This is particularly true for small residential systems.

Larger commercial systems, on the other hand, are typically more economical due to economies of scale,[2] federal tax incentives (the 10% investment tax credit and accelerated depreciation), and real-time or time-of-use tariffs coupled with demand charges that favor peak-shaving on-site generation. In recognition of this fact, New Jersey's tiered incentive structure progressively reduces the $/W incentive as systems grow larger (e.g., whereas a 10 kW system in the first block gets $5.5/W, a 200 kW system gets $3.95/W). Perhaps surprisingly, Massachusetts is currently the only other state to specifically pay lower incentives to larger non-residential systems. That said, it is important to recognize that percentage caps on funding may inherently reduce incentives for larger projects, to the extent that they cost less per Watt than smaller systems. As noted in section 3.3, however, percentage limits may create their own problems.

3.2 Encouraging PV System Performance

While a PV system has no moving parts and therefore might reasonably be expected to operate more or less as intended, monitoring of select residential PV systems funded under California's program revealed that AC output was frequently one-quarter to one-third below that expected based on certified module and inverter efficiencies at standard PVUSA Test Conditions; performance issues were relatively more serious for those systems with battery back-up and those that were owner-installed (RER 2000). It was also found that many program participants had no way of monitoring their systems' instantaneous or cumulative performance, and/or had

[2] The capacity-weighted average of installed costs for the first 40 PV systems installed under New Jersey's buy-down program (from 12/01-1/03) equaled $9.04/W for systems ≤10 kW (33 systems averaging 3.4 kW) and $6.48/W for systems >10 kW (7 systems averaging 75 kW). California data show similar cost reductions for systems >50 kW.

little understanding of what quantity of output to expect. New York has reportedly also experienced some performance problems, particularly with several early owner-installed systems.

States have taken several active steps to combat these performance problems (Wiser 2002, Bolinger and Wiser 2002b). New York and Pennsylvania now require the use of a certified installer that has passed minimum training standards (several other states have developed voluntary training programs, while awaiting the implementation of the nationwide NABCEP program to require installer certification). California still permits owner-installed systems, but discounts the incentive level for such systems by 15%.

California also now requires the use of "customer-friendly" meters that record instantaneous and cumulative performance, so that owners know how their system is performing. And so that owners know what to expect from their system, both California and New York require the installer to provide the customer with a written estimate of annual system performance.

In addition to these technical and human fixes, some states are also addressing performance issues through the incentive structure itself. One major drawback of a capacity-based incentive is that it encourages the installation of generation capacity, rather than the efficient operation of that capacity (i.e., it targets the means to an end rather than the end itself). Several states are now implementing or shifting towards per-kWh (rather than per-kW) performance incentives. Specifically, Massachusetts pays out 30% of the total incentive on a per-kWh basis over 3 years. Connecticut pays out 25% of the total incentive only after the system has achieved at least 70% of its projected generation during its first year. In addition to its up-front grant of $4/W, Pennsylvania also pays $1/kWh (capped at $5,000) to the owner and 10¢/kWh (capped at $250) to the installer – perhaps the person with the most direct control over system performance – after the first year of generation. Meanwhile, California is in the process of developing a performance-based pilot program for systems larger than 30kW.[3]

3.3 Gaming of Program

One of the primary advantages of a buy-down program relative to other approaches is its overall simplicity, for both the customer and administrator. Experience in California, however, has shown that simple program rules may also create opportunities for abuse if not carefully designed. For example, some California applicants have reportedly been quite liberal in interpreting what costs are eligible for the rebate, submitting re-roofing and other superfluous expenses in the hope that the state will pay for half (i.e., through the 50% cap on installed costs that was initially in place).

[3] While performance issues have been less serious for larger commercial systems, California is initially targeting this sector for logistical reasons: most of these systems already have sophisticated meters that will enable the use of performance-based incentives, and there are far fewer large commercial systems than small residential systems, thereby minimizing the administrative burden of such a program, which otherwise could be particularly high in California given the large number of systems installed. Furthermore, unlike capacity-based incentives, performance-based incentives likely *do not* reduce the value of the 10% federal investment tax credit and accelerated depreciation, making them relatively more valuable to commercial than residential system owners.

While this problem can be at least partially attributed to what could be interpreted as a relatively broad definition of eligible costs,[4] the problem also stems from the incentive structure itself. The presence of a percentage cap (initially 50% in California) on top of a $/W incentive means that in cases where the percentage cap is binding, the consumer and the installer have less of an incentive to limit or reduce system costs (because every $1 in cost reduction reduces the incentive by 50¢, meaning that the consumer only pockets half of any cost savings), and in fact may have incentives to pad costs (for the opposite reason – the program will pick up half of any incremental cost).

At least in part as recognition of this problem, several states – including California, Massachusetts, Minnesota, and New York (both LIPA and NYSERDA) – have eliminated (or in the case of newer programs, not included) percentage caps. Doing so, however, recreates the risk that the percentage caps were intended to mitigate in the first place – that in a declining cost environment, a $/W buy-down incentive may fund a substantial portion or even all (or more) of a PV system's cost. California plans to combat this possibility by reducing its incentive by 20¢/W every six months.

3.4 Encouraging System Cost Reductions

The declining incentive block structures originally implemented in California and New Jersey reflect a widely held belief that with increased manufacturing volume, PV system costs decline and therefore require progressively lower levels of public support. Despite the fact that over 40 MW of PV capacity has been reserved (with roughly half that amount installed) under state incentive programs to date, however, there has so far been little evidence of system price reductions, particularly among small systems.

For example, a preliminary evaluation of the first two years of California's buy-down program compared the installed costs of the first 300 small (< 10 kW) PV systems installed under the program against the costs of the last 100 small systems (in that period) and found virtually no reduction in installed costs over time (RER 2000). Later, during California's electricity crisis, anecdotal evidence suggested that installed costs were *increasing* rather than decreasing (though this was likely due to the demand spike in California and globally rather than poor program design). Elsewhere, a statistical analysis of the first 40 PV systems (representing 636 kW of capacity) installed under New Jersey's buy-down program from December 2001 to January 2003 reveals no discernible reductions in cost over time.

While both data samples are quite limited and should therefore be used only indicatively, the perception that installed costs have not declined is nevertheless impacting program design. Fearing that its declining block structure would prove disastrous in the face of stable or increasing system costs, California eliminated the blocks in the summer of 2001 and restructured the program to award a constant $4.50/W (up to 50% of total costs) to all new systems. Similarly, in the summer of 2002, New Jersey retroactively made an additional 3 MW of Block 1

[4] Previous versions of the CEC's *Emerging Renewables Program Guidebook* listed "the costs of installation" as eligible. The new *Guidebook* (February 2003) refines this to "the cost…to install the electricity generation system…" and specifically excludes the cost of "tree trimming, re-roofing, roof repairs or reinforcement, landscaping, relocating vent pipes, and moving HVAC or other equipment."

capacity available through the end of 2002 to large (>10 kW) PV systems, which had otherwise progressed to Block 3. When this temporary measure expired, New Jersey permanently altered its program by increasing its Tier 1 and 3 incentives (see Table 1), and restoring large systems to the same block as small systems. Both of these changes were in response to arguments from the PV industry that the reduced Block 3 incentives were not sufficient to attract commercial customers. In other words, installed costs had not declined in concert with incentives.

While the question of why installed costs have not declined (or declined more) for residential and/or commercial systems exceeds the scope of this paper, one possible factor is the percentage cost caps discussed in Section 3.3, which dampen incentives for cost reductions. To this end, California's abandonment of such caps, along with similar actions elsewhere, is encouraging.

Furthermore, with the electricity crisis now seemingly over, and with demand for PV incentives outstripping available funds, California has reduced its buy-down to $4/W and reinstated a declining incentive structure in an attempt to drive cost reductions. The incentive will decline by 20¢/W every six months, beginning in July 2003. At this rate, California's subsidy will completely disappear at the end of 2012.

3.5 Encouraging High-Value Installations

The indiscriminate nature of traditional PV buy-down programs – i.e., the same incentive is typically available to any system that meets minimum program requirements – may appeal to the American ideal of democracy, but may do little to specifically encourage high-value or niche applications for which the technology is particularly well-suited. Several states have been or are beginning to target such applications, either through targeted solicitations, the use of discretion in awarding incentives, or by explicitly setting different incentive levels for different applications.

3.5.1 Targeting the Non-Residential Sector

Because they are typically more economical (for reasons explained in Section 3.1), non-residential PV systems have been selling more quickly than residential systems in many states. States seeking to support larger amounts of capacity at lower costs have therefore focused on the non-residential sector. For example, Connecticut's new solicitation-based PV program is targeted exclusively at the commercial sector. New York (NYSERDA) has also long targeted the commercial sector through a separate solicitation process (Bolinger 2002). Massachusetts' "open installations grants" program, on the other hand, pays incrementally *lower* incentives to "commercial" (i.e., >10 kW) systems, in recognition of the fact that such applications should require less public support. New Jersey's buy-down program also accomplishes this through a tiered incentive structure.

3.5.2 Relieving Transmission Congestion

Connecticut's program will favor commercial projects located in transmission-constrained southwestern Connecticut. Massachusetts has also attempted to target transmission-constrained

areas, as well as capitalize on bulk purchase and installation opportunities, through a solicitation targeting geographically clustered installations.

3.5.3 Targeting Schools and Education

Several states, including Illinois (through the Chicago Solar Partnership), Massachusetts, Montana, and New York have provided elevated incentive levels to public schools for the installation of PV systems. Typically, recipient schools are required to also use the PV system as an educational tool by incorporating it into their curriculum. Montana has extended this concept to fire stations, which not only provide high demonstration value, but also benefit (as does the community served) from having an uninterruptible power supply (batteries are included as part of the system).

3.5.4 Targeting New Construction and Green Buildings

Recognizing that PV systems may be installed more economically if incorporated into the design of a new building rather than retrofitted onto an existing building, several states are differentially targeting new construction, and in particular energy efficient new construction or "green buildings." NYSERDA, for example, provides design and installation incentives for new commercial construction, and has also aggressively targeted PV on new energy efficient homes, whereby it pays the full cost of the first PV installation in a neighborhood of Energy-Star labeled homes, and 75% of the second (and 60% of the third) such installation (Bolinger 2002). Massachusetts also provides aggressive design and installation incentives to green buildings (Porter and Bolinger 2002), but at the same time, pays a *reduced* incentive (i.e., below that paid to systems installed on existing buildings) to installations on traditional or non-green new construction.

As is the case with respect to commercial applications, the differing approach of New York and Massachusetts to new construction highlights two different philosophies at play: a desire to target high-value applications because they are the most economical and therefore most likely to blossom into a self-sustaining market, versus an attempt to level the playing field for all applications by offering reduced incentives for those that should require less financial support. California takes a hybrid approach: its buy-down program does not differentiate between retrofits and new construction with respect to incentive level, but does attempt to reduce the administrative burden for new construction by allowing new home developers to fill out a single reservation for multiple homes within a new development, and by providing 18 months for project completion (instead of the usual 9). Minnesota has similarly modified its program to make it easier for new homebuilders to incorporate PV into "spec" houses.

4. Conclusion

On a scale that is unprecedented in the history of the United States, state clean energy funds have embarked on a path to support the widespread adoption and commercialization of PV. While considerable thought and foresight has gone into PV program design, actual program experience has nevertheless yielded a wealth of information about incentive levels, the need to induce

efficient system performance and safeguard against opportunities to game the rules, trends in system costs (and the need to drive costs lower), and opportunities to support high-value applications. Whether from their own programmatic experience or from that of others, states are "learning by doing," and more importantly are incorporating what they have learned back into their PV programs. In this way, state support of PV has evolved from "plain vanilla" buy-downs with a "come and get it" structure to more proactive and focused approaches that include modified and refined buy-down programs as well as targeted solicitations. This evolution has undoubtedly led to better programs that will maximize the impact of public dollars while continuing to help the PV industry towards maturity.

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