



[Lawrence Berkeley National Laboratory](#)
[Lawrence Berkeley National Laboratory](#)

Title:

Encouraging PV Adoption in New Market-Rate Residential Construction: A Critical Review of Program Experiences to Date

Author:

[Barbose, Galen](#)

[Wiser, Ryan](#)

[Bolinger, Mark](#)

Publication Date:

04-24-2006

Publication Info:

Lawrence Berkeley National Laboratory

Permalink:

<http://escholarship.org/uc/item/3r04x1sg>



eScholarship
University of California

eScholarship provides open access, scholarly publishing services to the University of California and delivers a dynamic research platform to scholars worldwide.

ENCOURAGING PV ADOPTION IN NEW MARKET-RATE RESIDENTIAL CONSTRUCTION: A CRITICAL REVIEW OF PROGRAM EXPERIENCES TO DATE

Galen Barbose
Lawrence Berkeley National Laboratory
1 Cyclotron Rd., MS 90R4000
Berkeley, CA 94720
glbarbose@lbl.gov

Ryan Wisler
Lawrence Berkeley National Laboratory
1 Cyclotron Rd., MS 90R4000
Berkeley, CA 94720
rhwiser@lbl.gov

Mark Bolinger
Lawrence Berkeley National Laboratory
105 North Thetford Road
Lyme, NH 03768
mabolinger@lbl.gov

ABSTRACT

In this paper, we review experiences with programs to support the deployment of photovoltaics (PV) in new, market-rate homes, drawing upon interviews with program managers around the country, project data, and publicly-available documentation on program design, impacts, and experiences. We focus on state clean energy funds, which have been established in 14 U.S. states to build markets for clean energy resources, as well as a select number of other state or local organizations whose activities are particularly noteworthy. We describe the types of programs implemented and their impacts to date, and discuss key issues and lessons learned for initiatives aimed at growing the new home market for PV.

1. INTRODUCTION

As a market segment for PV adoption, new homes have a number of attractive attributes. Homebuyers can easily roll the cost of the PV system into their mortgage and, with rebates or other financial incentives, potentially realize an immediate net positive cash flow from the investment. PV system performance can be optimized by taking roof orientation, shading, and other structural factors into account in the design of new homes. Building-integrated photovoltaics (BIPV), which are subject to fewer aesthetic concerns than traditional, rack-mounted systems, are well-suited to new construction applications.¹ In large new residential developments, costs can be reduced through bulk purchases and scale economies in system design and installation. Finally, the ability to install PV as a *standard*

feature in new developments offers an opportunity to circumvent the high transaction costs and other barriers typically confronted when each individual homeowner must make a distinct PV purchase decision.

Along with its unique advantages, the market for PV on new homes also faces significant challenges. Most fundamentally, perhaps, is the general aversion to technology risk within the building industry, particularly in “hot” housing markets. Builders also have specific reservations about PV related to its impact on home prices and profits, potential project delays, and a perceived lack of homebuyer interest. Furthermore, many builders may not recognize or fully value the potential benefits that PV offers for their business, including greater market differentiation, enhanced media exposure, and less community or political opposition to development projects.

Recognizing its potential, various initiatives have been launched in the U.S. to support the growth of the new home market for PV, including programs to promote zero-energy homes (ZEH) and, most recently, a proposal in California for a 10-year, \$350 million program aimed specifically at PV in new homes. In addition to these high-profile initiatives, various organizations throughout the U.S. – at the local, state, and federal levels – have undertaken important efforts to encourage PV in new homes. In particular, clean energy funds, currently established in 14 U.S. states and with more than \$5 billion to invest in renewable energy over the next decade, have emerged as leaders in these efforts.²

This article, based on a longer report [1] prepared for the Clean Energy States Alliance,³ describes the types of strategies to support PV in new, market-rate homes (as distinct from affordable housing) employed by clean energy funds and several other key organizations in nine leading states, and discusses issues and lessons learned from these early efforts.⁴

These organizations include the California Energy Commission (CEC), Energy Trust of Oregon (ETO), Long Island Power Authority (LIPA), Minnesota State Energy Office (MSEO), Massachusetts Technology Collaborative (MTC), New Jersey Clean Energy Program (NJCEP), New York State Energy Research and Development Authority (NYSERDA), Pennsylvania Energy Development Authority (PEDA), Rhode Island Renewable Energy Fund (RIREF), Sustainable Development Fund (SDF) of Pennsylvania, Sacramento Municipal Utility District (SMUD), and Wisconsin Focus on Energy (WFE).

2. BROADER PROGRAMS TO SUPPORT PV IN NEW MARKET-RATE HOMES

Table 1 summarizes the types of programmatic support for PV in new, market-rate homes provided in the nine states in our review. Given that it is a relatively narrow market segment, much of the support for PV in new, market-rate homes has been provided through broader programs aimed at more general classes of projects. These include the following:

Standard Buy-Down Programs. A common program type in the U.S., buy-down programs offer standard consumer rebates, usually on a first-come first-served basis, for PV and other types of customer-sited renewable energy technologies. In many regions, these programs are the primary, if not the sole, source of direct financial support for PV on new homes. To date, the CEC's *Emerging Renewables Program* has funded by far the largest number of PV installations on new homes of any buy-down program nationally (see Table 2). Through May 2005, more than 2,700 PV systems on new homes had been installed or received a funding commitment through the CEC's program – about 15% of all PV systems supported through the program at that time. Of particular note is that most of the systems on new homes are in large new residential developments where multiple homes were outfitted with PV. Outside of California, PV buy-down programs have had a more limited impact in the residential new construction market. Most of these programs have funded no more than 10-20 PV systems on new homes per year, the

majority of which have been individual, custom new homes, rather than large residential developments.

General Solicitations for Clean Energy or Green Building Projects. Competitive solicitations are another common funding mechanism used to encourage the deployment of customer-sited renewable energy technologies, particularly for larger and more complex projects. Two organizations within the nine states in our review have provided funding for PV on market-rate, new homes through general solicitations for clean energy or green building projects. MTC has funded three market-rate or mixed-income multi-family residential construction projects with PV and other green building features. PEDA has funded two market-rate, zero-energy new home developments with 75 and 38 new zero-energy homes, respectively, both of which also served as urban “redevelopment” projects.

General Research and Development (R&D) Funding for Clean Energy or Green Buildings. Through broader R&D programs, several clean energy funds have provided financial support for R&D projects with particular relevance to PV in new homes. For example, the CEC has funded several projects involving the development of new BIPV products. MTC awarded funding to a manufacturer of modular homes to conduct a feasibility study to determine the potential for integrating PV and advanced energy efficiency measures into their manufactured homes. Finally, WFE provided a grant for the development of a free software tool to aid architects and engineers in the design of zero-energy buildings.

3. TARGETED EFFORTS TO SUPPORT PV IN NEW MARKET-RATE HOMES

In addition to the broader programmatic activities described above, state clean energy funds and others have also initiated various *targeted* efforts aimed more narrowly at PV in residential new construction or other closely-related market segments. These forms of targeted support include the following:

Higher Buy-Down Incentives for BIPV or for PV on High-Efficiency Homes. Four state clean energy funds with buy-down programs (MTC, NJCEP, NYSERA, and WFE) have offered higher incentives for BIPV and/or for PV systems installed on high-efficiency homes. Though not strictly limited to new homes, these higher incentives in effect constitute a targeted form of support for PV in new homes, given that BIPV installations and high-efficiency (e.g., Energy Star-rated) homes are quite likely to be new construction projects.

TABLE 1: SUPPORT FOR PV IN NEW MARKET-RATE HOMES

	CA	MA	MN	NJ	NY	OR	PA	RI	WI
Broader Programs That Have Supported <i>Specific Projects</i> Involving PV on Market-Rate New Homes									
Buy-down programs for customer-sited PV	•	•	•	•	•	•	•	•	•
Green building or clean energy solicitations		•					•		
Research and development (R&D) programs	•	•							•
Targeted Support for PV on Market-Rate New Homes									
Higher buy-down incentives for BIPV and/or for PV on high-efficiency new homes		•		•	•				•
Accommodations within buy-down programs for PV on new homes	E	E	I	I	I	I	I		I
Demonstration or deployment programs specifically for high-efficiency new homes with PV	•				•				
Bulk purchase of modules for builders or technical assistance with bulk module procurement	•								
Outreach and training for residential building industry professionals	•				•	•			•

E = buy-down program has provisions that *explicitly* accommodate residential new construction; I = buy-down program has provisions that *implicitly* accommodate residential new construction, or the program administrator has the flexibility to grant variances to normal program rules to accommodate new construction, if warranted.

TABLE 2. NUMBER OF PV SYSTEMS ON NEW MARKET-RATE HOMES FUNDED[†]

State	Organization	Standard PV Buy-Down Programs	General Solicitation for Clean Energy or Green Buildings Projects	Targeted Demonstration or Deployment Programs for PV on New Homes
CA	CEC	2717	-	150
	SMUD	Few	-	252
MA	MTC	13*	3**	-
MN	MSEO	8	-	-
NJ	NJCEP	Unknown	-	-
NY	LIPA	Few	-	-
	NYSERDA	20*	Unknown	15
OR	ETO	Few	-	-
PA	SDF	30	-	-
	PEDA	-	113	-
WI	WFE	8*	-	-

[†] The table summarizes PV systems installed or approved for funding but not yet installed, through the various programs offered by organizations reviewed in this article.

* The only PV systems on new homes that could be identified were those that received a higher incentive for BIPV or Energy Star homes, thus the value shown here is a lower bound.

** All are large PV installations on new multi-family buildings

Accommodations within Buy-Down Programs for PV on New Homes. Buy-down programs often have provisions that could potentially pose barriers for PV on new homes, albeit unintentionally. To alleviate potential obstacles, many buy-down program administrators make (or are willing to make) special accommodations for residential new construction projects. For example, in order to

accommodate the longer project lead-times typically associated with new construction, the CEC and MTC both offer longer rebate reservation periods (the window of time between reservation of the rebate and when PV installation must be verified) for all new construction projects. For groups of PV installations in new residential developments, the CEC also offers simplified documentation requirements

(e.g., related to building permits, application forms, and interconnection agreements) and allows developers planning to offer PV as an option to reserve rebates for 10% of the lots in advance, without specifying the particular sites. Other buy-down program administrators are often able to make accommodations for projects involving PV on new homes on a case-by-case basis, even if not formally specified in the program rules.

Demonstration or Deployment Programs for High-Efficiency New Homes with PV. Organizations in several states have offered a diverse set of stand-alone programs aimed specifically at funding the demonstration or deployment of PV on high-efficiency new homes. The CEC issued a competitive solicitation for projects that (among other things) include the construction of a new residential development with at least 75 zero-energy new homes meeting specified cost and performance standards and that demonstrate an innovative business model to reduce up-front costs to the homebuyer. NYSERDA also issued a competitive solicitation for demonstration projects involving PV on high-efficiency new homes. Their program offered elevated buy-down incentives (i.e., at a higher rate than the standard PV buy-down program) and additional grant funding for various activities (e.g., additional training and marketing materials) to encourage PV installations in new Energy Star residential developments. At the federal level, the U.S. Department of Energy (DOE) has offered targeted funding for the deployment of PV in new homes through its *Zero-Energy Homes Program*, which has funded six teams to develop ZEH designs and recruit large production homebuilders around the country to build ZEHs. SMUD, a California municipal utility with a long history of support for PV in new homes, recently partnered with one of DOE's ZEH teams to offer a targeted PV deployment program, also called the *Zero-Energy Homes Program*, for new home builders in their service territory. Through this partnership, SMUD offers large production homebuilders various forms of financial support, including PV buy-down incentives, funding for builder marketing materials, and financial incentives for energy efficiency measures.

Bulk Purchases. SMUD previously offered a different deployment program for PV in new homes, dubbed the *Solar Advantage Homes Program*, through which SMUD purchased BIPV systems and inverters in bulk quantities directly from the manufacturer, and resold the systems at a discount (using buy-down incentives from the state) to large production homebuilders. SMUD did not incorporate this element into their current *Zero-Energy Homes Program*, although the utility does offer participating builders informal assistance with module procurement.

Education, Outreach, and Training for Residential Building Industry Professionals. A number of state clean energy

funds and others have sponsored or directly conducted various types of education, outreach, and training activities for professionals in the residential building industry. For example, NYSERDA funded educational seminars for realtors, lenders, and building code officials, in conjunction with its PV on new homes demonstration program. SMUD incorporated PV installation training for builders into its earlier *Solar Advantage Homes Program*. And, several buy-down program administrators have held educational seminars for builders at industry conferences or other trade events, to share information about PV technology and available financial incentives.

4. MARKET IMPACTS TO DATE

Outside of California, where thousands of PV installations on new homes have been funded through the CEC's and SMUD's programs, most states have seen a relatively small number of installations on new, market-rate homes (see Table 2). In large part, this difference is simply a manifestation of California's larger overall PV market, and is indicative of the substantial and long-running support that the state has provided for PV deployment. Efforts to encourage PV on new homes in other states are generally in their early stages, and as such, their market impacts may not yet be fully revealed.

One critical step to growing the new home market is to generate interest in PV among large production homebuilders. Several developers (in California and elsewhere) have recently built large new residential subdivisions with PV installed as a standard feature on some or all homes. More commonly, though, builders have offered PV only as an optional upgrade. Although more appealing to builders who are uncertain about homebuyer interest in PV, the optional sales strategy has several inherent disadvantages from the perspective of PV deployment, and it ultimately may not be a profitable business model [2]. The most fundamental drawback of offering PV as an option is that PV adoption then becomes contingent on each individual homebuyer making a separate decision about PV, amidst all of the other decisions faced when buying a new home.

Comprehensive information has not been compiled on the adoption rate of PV in housing developments where offered as an option, but experiences with several developments have been documented and reveal rather mixed results. In several cases, very few (or no) homebuyers opted for PV. For example, throughout the twelve subdivisions supported through NYSERDA's *Photovoltaic System and New York Energy Star-Labeled Home Demonstration Project*, only three homebuyers opted for PV. The Scripps Highlands housing development in San Diego witnessed a notably

greater (although still modest) uptake, with 15% of applicable homebuyers opting for PV [2]. SMUD's experience with its previous *Solar Advantage Homes Program* suggests that, at an aggregate level at least, the optional approach can achieve a fairly significant impact. Over its two-plus years of operation, the program resulted in approximately 113 PV installations in 21 subdivisions within the utility's service territory, where PV was installed on model homes and offered as an option [3]. Clearly, more work is needed to understand where optional sales strategies have and have not worked, and why.

One of the key factors driving interest in the new home market for PV is its potentially lower up-front cost. Experiences in California provide some support for this premise. Wiser *et al.* analyzed project cost data for PV systems funded through the CEC's *Emerging Renewables Program*, controlling for a variety of factors, such as system size and time of project approval [4]. Looking only at completed projects, the 710 PV systems installed in large new residential developments cost, on average, \$1.70/W less than comparable retrofit systems installed on existing homes, while the 242 systems installed on individual or small clusters of new homes were slightly more expensive (+\$0.32/W) than comparable retrofits. The higher cost of PV on individual or small clusters of new homes may reflect the combination of a potentially higher incidence of BIPV systems and the absence of scale economies realized in larger housing developments. Among the larger number of projects that have received funding commitments (either completed or approved but not yet completed), the cost differences relative to retrofit projects are smaller in magnitude but consistent in direction, compared to just the completed systems.

5. LESSONS LEARNED AND RECOMMENDATIONS

Our discussions with program staff and review of program experience highlight a number of basic lessons and recommendations for how to successfully tap the residential new construction market for PV.

Do no harm. As is evident from our review, much of the support currently offered for PV in new homes in the U.S. is provided through broader programs aimed at more general classes of clean energy projects. It is therefore important that these broader programs do not inadvertently disadvantage the new construction market, especially those projects involving PV installed as a standard feature in new housing developments. Buy-down programs, in particular, often have provisions or features that could pose barriers for PV in new homes (e.g., short reservation periods, limits on the number of rebates per project site, restrictions on the types of entities eligible to apply for a rebate). Program

administrators should consider making explicit accommodations for new construction projects, as the CEC has done [5]. If accommodations are instead made on an *ad hoc* basis without any formal changes to the program rules, it is important that builders are made aware of that flexibility.

Track key information about PV installations on new homes. Incorporating basic information about residential new construction projects into standard application forms and program databases (e.g., whether the system was installed "on spec" or offered as an option, and whether it was an individual installation or part of a larger cluster) may be useful for future program design and market assessment. Other, more-involved data collection efforts (e.g., performance data for PV installations in new construction, and survey data on builder and homebuyer experiences) would also be valuable.

Ensure sufficient funding. The amount and duration of program funding is particularly important to the development of the new home market for PV. Given the long project lead times and the start-up costs associated with training construction and sales staff, large production homebuilders may be reluctant to make major changes to their business strategy if the program budget is small or the funding cycle is short. A threshold level and consistency of funding may therefore be required in order to "jump-start" the market.

Consider a higher incentive level. Higher incentives or other forms of differential financial support for PV installed in residential new construction may be appropriate. However, because PV systems installed on new homes are expected to be less costly than residential retrofits, policymakers may want to focus differential support on "high-value" projects. For example, higher incentives might only be provided for BIPV systems, PV on high-efficiency homes, innovative new business models, or PV systems installed as a standard feature (as opposed to selling PV as an option).

Coordinate PV and energy efficiency programs for residential new construction. Policymakers can capitalize on natural synergies between energy efficiency and PV in new homes by integrating or coordinating PV and energy efficiency initiatives for residential new construction. At a minimum, creating the appearance of a single program to the builder ("one-stop shopping") can help to simplify participation and reduce transaction costs.

Cultivate the installer infrastructure. Efforts to develop the installer network are particularly important for the residential new construction market and should consider any specific needs of large production homebuilders. For

example, some large production homebuilders prefer to use their own roofing or electrical sub-contractors for PV installation, rather than specialized PV installers. Those that are willing to use specialized installers are likely to require a level of professionalism above and beyond what is acceptable in other market segments, and may need installers that provide a comprehensive suite of services (e.g., obtaining utility interconnection agreements, applying for rebates).

Educate and train key professionals in the residential building industry. Staff at several clean energy funds echoed similar sentiments about the importance of conducting outreach and education across the range of residential building industry professionals (builders, realtors, lenders, appraisers, inspectors, etc.). Such efforts are critical not only to creating interest in and support for PV, but also for addressing specific barriers, such as project delays associated with obtaining permit approval or building inspection sign-off.

Engage the building community. Given the conservative nature of the residential construction industry as a whole, it is important to enlist leaders and champions within the building community to demonstrate the technical viability and market acceptance of new homes with PV. Engaging builders early on in program development can also help to forestall potential program design issues and create a sense of buy-in from the building community.

6. CONCLUSIONS

Although most regions in the U.S. have yet to see an appreciable number of PV installations on new, market-rate homes, interest in this market segment continues to grow. Clean energy funds and other organizations throughout the U.S. have demonstrated a variety of potential strategies for targeting this market, and these early experiences provide an important benchmark for ongoing efforts to develop this market. Though growing the market for PV in new homes may take time and effort, the rewards for doing so may be significant.

7. ACKNOWLEDGMENTS

The work described in this article was funded by the Clean Energy States Alliance, and by the Assistant Secretary of Energy Efficiency and Renewable Energy and the Office of Electricity Delivery and Energy Reliability of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

8. REFERENCES

1. G. Barbose, R. Wiser and M. Bolinger, "Supporting Photovoltaics in Market-Rate Residential New Construction: A Summary of Programmatic Experience to Date and Lessons Learned," LBNL-59299, Berkeley, California, USA, February 2006.
<http://eetd.lbl.gov/ea/emp/reports/59299.pdf>.
2. B. Farhar, T. Coburn, and M. Murphy, "Large-Production Home Builder Experience with Zero Energy Homes," Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA: American Council for an Energy Efficient Economy, August 2004.
3. M. Keesee, "Setting a New Standard – The Zero Energy Home Experience in California," Proceedings of the 2005 Solar World Conference, Orlando, FL, 2005.
4. R. Wiser, M. Bolinger, P. Cappers, and R. Margolis, "Letting the Sun Shine on Solar Costs: An Empirical Investigation of Photovoltaic Cost Trends in California," LBNL-59282. Berkeley, California, USA, January 2006.
<http://eetd.lbl.gov/ea/emp/reports/59282.pdf>.
5. See Appendix 5 in the CEC's program guidebook, <http://www.energy.ca.gov/2006publications/CEC-300-2006-001/CEC-300-2006-001-ED6F.PDF>

ENDNOTES

¹ Due to their higher operating temperature, BIPV systems may not perform as well as rack-mounted systems.

² For an overview of state clean energy funds and their activities, see www.cleanenergystates.org.

³ The Clean Energy States Alliance is a non-profit, membership-based, multi-state coalition consisting of most of the state clean energy funds.

⁴ The nine states included in our review were selected because they have a clean energy fund that has directly funded and/or offered some form of targeted support for PV on new, market-rate homes. Our review is not meant to be entirely comprehensive, however, and other states and organizations not included in this article have also provided some support for PV on new homes.