U.S. Aims for Zero-Energy:
Support for PV on New Homes

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Introduction

As a market segment for solar photovoltaic (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 – like common household appliances – creates 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 aimed at promoting zero-energy homes (ZEH) and, most recently, a proposal in California for a 10-year, $350 million program specifically for 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 fourteen 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 prepared by Lawrence Berkeley National Laboratory[3] for the Clean Energy States

[1] Due to their higher operating temperature, however, 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] Barbose, G., R. Wiser, and M. Bolinger. 2006. "Supporting Photovoltaics in Market-Rate Residential New Construction: A Summary of Programmatic Experience to Date and Lessons Learned." LBNL-59299. Berkeley, California, USA: http://eetd.lbl.gov/ea/emp/reports/59299.pdf.

Alliance,[4] describes the strategies to support PV in new, market-rate homes (as distinct from affordable housing) employed by clean energy funds and several other key organizations (see Text Box 1) in nine leading states, and discusses issues and lessons learned from these early efforts.[5]

Text Box 1. Organizations Reviewed in This Article

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

Broader Programs to Support PV in New Market-Rate Homes

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

[5] 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.

Table 1 summarizes the types of policy 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, having typically funded no more than 10-20 PV systems on new homes per year, the majority of which have been on 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 support 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. In Massachusetts, MTC has funded three market-rate or mixed-income multi-family residential construction projects with PV and other green building features. And in Pennsylvania, PEDA has funded two market-rate, zero-energy new home developments with 75 and 38 new zero-energy homes, respectively – both of which were part of an urban "redevelopment" strategy.

- General Research and Development (R&D) Funding for Clean Energy or Green Buildings. Several clean energy funds have provided financial support for R&D projects with particular relevance to PV in new homes, through a broader R&D program. For example, in California, 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 homes. Finally, in Wisconsin, WFE provided a grant for the development of a free software tool to aid architects and engineers in the design of zero-energy buildings.

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 have offered higher incentives for BIPV and/or for PV systems installed on high-efficiency homes (see

Table 3). 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 most likely to be new construction projects.

- 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 (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 in 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. In New York, 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 to support the installation of PV in new Energy Star residential developments (e.g., additional training and marketing materials). 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 deployment program, also called the *Zero-Energy Homes Program*. For their role in the 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. For their current *Zero-Energy Homes Program*, SMUD does not purchase equipment on behalf of builders, but the utility does offer informal assistance with module procurement to participating builders.

- 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.

Text Box 2. Other Types of Targeted Support for PV in New Homes

Various other strategies – not otherwise discussed in the body of this article – have been considered (but not employed) by state renewable energy funds for encouraging PV adoption in new, market-rate housing, or have been employed by other state or local organizations:

- **Builder Mandates.** States or local governments could require that builders install PV on new homes, that they offer it as an option, or that they construct new homes to be "PV-ready" (e.g., with proper roof orientation and pitch or with the required conduit and wiring for PV pre-installed).
- **Financing Strategies.** Reduced-interest rate mortgages could be offered to individuals who purchase new homes with PV, and low-interest construction loans or loan guarantees could be offered to developers who construct such homes.
- **Entitlements Granted by Local Planning/Permitting Agencies.** Local government agencies with planning and permitting authority for new residential construction projects can support PV on new homes by offering entitlements for new housing developments with PV, such as shorter wait times, higher density allowances, or reduced permitting and inspection fees.
- **Bulk Purchases by Groups of Builders.** Technical and logistical support could be provided to help homebuilders organize bulk purchases of PV equipment.

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 in 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 in growing this 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 ultimately may not be a profitable business model.[6] The most fundamental drawback of offering PV as an option is that PV adoption is contingent on each individual homebuyer making a separate decision about PV amidst all of the other decisions faced when buying a new home (most of which are much better understood). Comprehensive information has not been compiled on the adoption rate of PV in housing developments where it was 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. In comparison, the Scripps Highlands housing development in San Diego witnessed a notably greater (although still modest) uptake, with 15% of applicable homebuyers opting for PV.[7] 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 220 PV installations in 21 subdivisions where it was installed on model homes and offered as an option.[8] 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 new homes as a market for PV is the potential for lower up-front cost. Experiences in California provide some support for this premise. Wiser *et al*. (2006) 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 (see Figure 1).[9] Looking only at completed projects, PV systems installed in large new residential developments cost, on average, $1.70/W less than comparable retrofit systems installed on existing homes, while those 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 projects that have either been completed or approved (but not yet completed), cost differences are smaller in magnitude, but are consistent in direction with the comparison between just the completed systems.

[6] Farhar, B., T. Coburn, and M. Murphy. 2004. 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.
[7] Farhar, B., T. Coburn, and M. Murphy. 2004. 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.
[8] Keesee, M. 2005. Setting a New Standard – The Zero Energy Home Experience in California. Proceedings of the 2005 Solar World Conference. Orlando, FL.
[9] Wiser, R., M. Bolinger, P. Cappers, and R. Margolis. 2006. "Letting the Sun Shine on Solar Costs: An Empirical Investigation of Photovoltaic Cost Trends in California." LBNL-59282. Berkeley, California, USA: http://eetd.lbl.gov/ea/emp/reports/59282.pdf.

Lessons Learned and Recommendations

Our discussions with program staff and review of experience with this market segment 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.[10] 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

[10] 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

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 about PV to various types 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 overcoming 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.

Conclusion

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.

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Table 1. Support for PV in New, Market Rate Homes

	CA	MA	MN	NJ	NY	OR	PA	RI	WI
Broader Programs That Have Supported *Specific Projects* 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) solicitations	●	●							●
Targeted Support for PV on Market-Rate New Homes									
Higher buy-down incentives for BIPV and/or for PV on high-efficiency new homes		●		●	●				●
Buy-down program rules or administrative procedures that accommodate 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 Through Each Program Type†

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	-	359
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*	-	-

† Includes PV systems already installed and those that have been approved for funding but not yet installed.

* 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

Table 3. Incremental Buy-Down Incentives above the Standard Rebate Level

	BIPV	Energy Star Homes	LEED-Certified Homes
MTC Small Renewables Initiative	**+$1.00/W**	**+$0.50/W**	**+$1.50/W**
NJCEP Customer Onsite Renewables Program	–	**+$0.25/W**	–
NYSERDA Solar Electric PV Incentive Program	**+$0.50/W***	**+$0.50/W**	–
WFE Cash Back Rewards Program**	–	**+$1.00/kWh-yr**	–

* NYSERDA's bonus incentive for BIPV is currently available only for nonresidential projects, due to limited funding.

** WFE ceased offering this extra incentive in 2006.

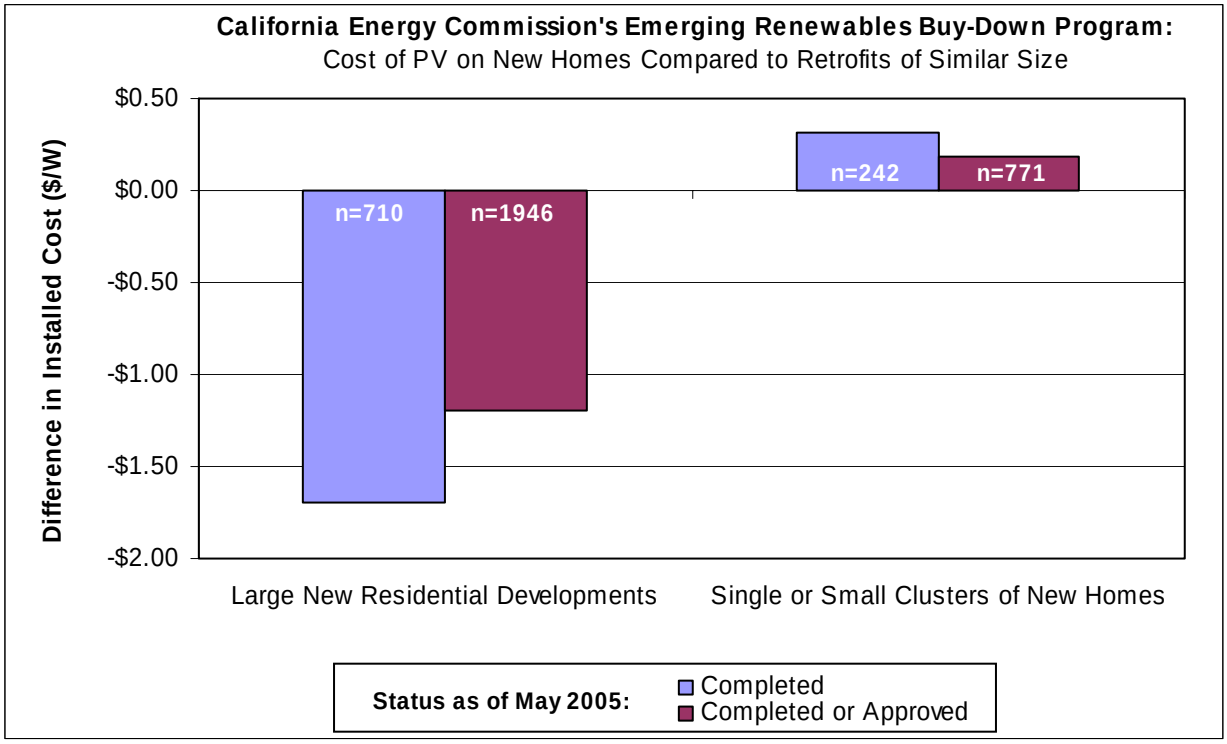

Figure 1. Relative Cost of PV on New, Market-Rate Homes Compared to Retrofits in the CEC's Emerging Renewables Program