MAINSTREAMING RESIDENTIAL SOLAR PHOTOVOLTAIC ADOPTION IN THE UNITED STATES

Drivers, Timing and the Private Sector

by

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Abstract

A central question of this research report is whether households will lead a major change in the way electricity is generated and used in the United States. The residential sector is the largest consumer of electricity generated and accounts for 39% of consumption and 21% of CO_2 emissions. Unlike coal, solar does not deplete a fuel source nor contribute to emissions in the process of generating electricity. Scholars have shown the resource scale of solar is orders of magnitude greater than fossil fuels. Yet, solar photovoltaics (PV) have suffered from considerably less research and development and resultant higher costs relative to fossil fuel generation. This report analyzes the rapidly changing and emerging market of distributed, behind-the-meter generation of solar PV electricity for households with a focus on timing, drivers, and private sector strategies. Methods include a literature review, fieldwork, and a primary research survey instrument administered to 73 renewable energy professionals of varying backgrounds in the spring of 2012.

Industry trend data and survey opinion confirm that dropping residential PV costs, increasing PV efficiency and a wider array of financing options are the main drivers of adoption. Technological limitations or regional solar capacity in the U.S. are not limiting factors overall. Although installed costs vary greatly by location, residential PV installed costs have dropped exponentially from $9.7 per watt in 2000 to an average of $6.2 per watt in 2010 before any federal, state or local incentives. Some markets now show installed residential PV costs of $5 per watt. A critical tool for evaluating residential PV systems is the monthly cost of financing relative to monthly utility bill savings from the grid, rather than the often cited levelized-cost-of-energy (LCOE). Companies with expanded financing options such as PV lease and power purchase agreements (PPA) are currently leading installations by demonstrating immediate monthly cash flow savings and utilizing a turnkey service model.

Policy comparisons are made between California, New Jersey and Texas. California and New Jersey lead PV installations with commensurate policy support and financial incentives, while Texas by contrast has much less PV installation and relatively little policy support. Federal and state financial incentives are reviewed including tax credits and cash rebates; as well as the role of other incentives such as net metering, system benefit charges, and solar renewable energy credits. Though not widely used, a 0% interest financing option may produce immediate monthly utility savings and serve as another financing tool. Based on installation and cost trends, incentives are working by supporting growth, reducing payback times by nearly 50%, and closing the cost gap between PV and conventional power.

Diffusion models, growth trends and tipping points relative to residential PV growth are analyzed. Residential PV installed capacity shows 49% compounded annual growth (CAGR), growing from 27 megawatts (MW) installed in 2005 to 297 MW as of 2011. Based on approximately 250,000 known residential installations, market penetration is approximately 0.3% - a surprisingly low number. Seventy percent of survey professionals indicate residential PV will shift from innovator to early adopter stage and achieve at least 10% market penetration and reach retail grid parity in most markets within 10 years. To reach 10% of the estimated U.S. single family home market will require approximately 41% CAGR for 10 years or 19% CAGR for 20 years. When analyzing concepts of grid parity and levelized-cost-of-energy (LCOE), assumptions and definitions must be clearly stated while noting subsidies and externalities.

Leading policy, practice and opinion indicate the following are essential to mainstreaming: 1) fund federal and state financial incentives for 10 years, 2) support lease, PPA and other financing models 3) set installation goals like state Renewable Portfolio Standards (RPS), 4) continue government support for research and development, and 5) increase awareness and education of the benefits of residential PV.

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I. Introduction

Background

Onsite residential solar photovoltaic (PV) electricity generation, often classified as “behind the meter” or distributed generation, is increasing in sophistication, adoption and efficiency - all while costs are dropping. Although other residential solar technologies exist such as solar water heating, space heating and cooling; this report focuses on solar PV electricity generation for residences. Utility-side generation is not the focus of this report. The majority of discussion and research on solar PV has in the past focused overwhelmingly on utility-scale generation. Recently, this emphasis has begun to change. Could households lead a major change in the way energy is generated, delivered and used in the United States, and if so, when will this happen?

The residential sector is the largest main consumer of electricity generated in the United States, accounting for 39% of consumption in 2010, followed by the commercial and industrial sectors (EIA, 2011). Electricity generation for households[1] is also responsible for an estimated 21% of the CO_2 emissions of the United States (Duke Center for Sustainability & Commerce, 2011). Unlike coal, solar does not deplete a fuel source nor contribute to emissions in the process of generating electricity. Further, scholars have shown that the resource scale of solar is orders of magnitude greater than fossil fuels (Naam, 2011). Yet, solar PV has suffered from considerably less research and development and resultant higher costs relative to fossil fuel generation.

As many renewable energy advocates note, if the cost of conventional power reflected negative externalities such as air pollution, strip mining, and CO_2 emissions, then solar would be much more cost competitive. This report does not address Lifecycle Cost Analysis (LCA) of various conventional sources of power compared to solar. However, one such study concludes that greenhouse gas emissions resulting from electricity generation of a small solar PV system are less than one-fourth that from an oil-fired steam turbine plant and one-half that from a gas-fired, combined-cycle plant on a per kWh basis (Kannan et al., 2006).

The purpose of this research report is to analyze the emerging market of solar electricity generation for households. Particular attention will be paid to the drivers, private sector strategies, and timing for mainstreaming residential solar in the United States. A summary of state and federal policy incentives with best practices are included. Significant incentives include federal, state and municipal tax credits and rebates, net metering incentives, system benefit charges and more. Also included are a discussion of the financial metrics of

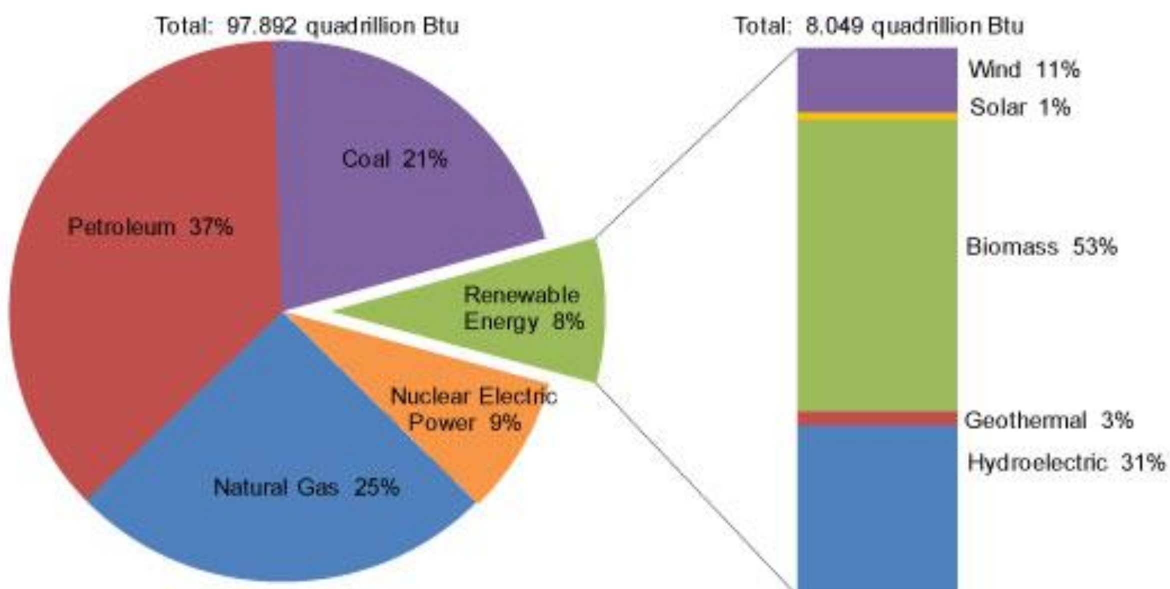
[1] The terms household, homeowner, residence, etc. are used interchangeably in this report, and not meant to imply any specific type of ownership or agency unless specified. All refer to residential PV systems, behind the meter, and not commercial, business, or utility scale projects.

residential PV, recent installation and growth trends, and potential tipping points. Since solar incentives and trends vary widely by state, specific examples using state-specific data from California, New Jersey and Texas are used in the Discussion section.

Drivers of residential solar include dropping PV module costs, increasing PV efficiency, and a variety of financing options. In addition, solar may appeal to a rather American sensitivity: the desire to be self-sufficient in terms of one's power generation. However, in spite of significant barriers such as high upfront costs and lack of homeowner awareness about residential PV benefits, solar is increasing in adoption precisely because it is becoming an increasingly marketable enterprise with more financially viable options for purchasers. Private sector deployment with PV lease and Power Purchase Agreements (PPA) are leading installations in many states, and these are supported by state and federal incentives.

Even as capital markets improve and popularity of renewables continues to grow, solar (all applications combined) still represents less than 1% of energy consumption in the United States, although renewables overall now claim a respectful 8% of the nation's total energy supply as shown in figure 1 (EIA, 2011). Yet, installed capacity has experienced 49% Compounded Annual Growth (CAGR) over the past six years, reaching 297 MW installed residential capacity as of 2011. Installed costs average near $6.2 per watt before incentives, and are near $5 per watt in some markets.

Figure 1. Renewable energy consumption in the nation's energy supply, 2010



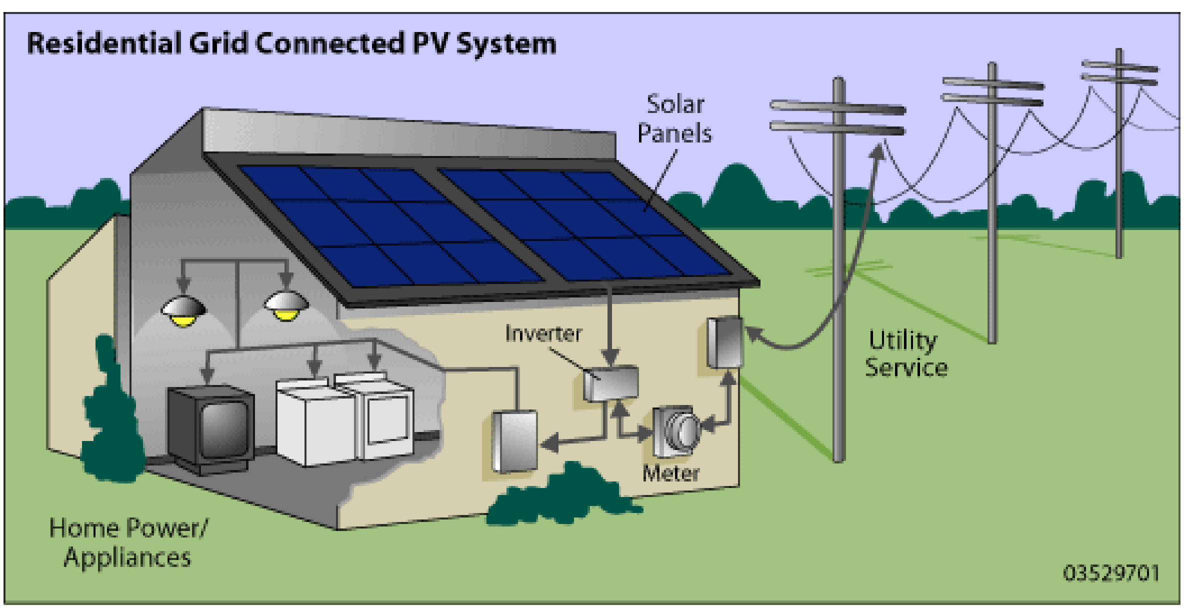
Source: U.S. Energy Information Administration

Analysis in this report reveals that incentives shorten simple payback times and reduce installed costs by nearly half, based on Lawrence Berkeley National Lab nationally-averaged and state-averaged 2010 installed cost data (shown in Tables 1 and 2 in Appendix A). Most studies do not consider the monthly cash flow of a household, which is likely to be the principle financial metric used to consider PV systems, and not Levelized Cost Of Electricity (LCOE). While the latter is useful for some analyses, it is not interchangeable with retail electricity prices for homeowners or the resulting monthly cost-of-ownership for a residential PV system. This report finds that incentives are crucial to closing the short-term cost gap between conventional generation electricity prices and solar PV. Also, a significant finding is the potential for a 0% APR, 100% financing policy option for PV over a longer period such as 25 years. This test case raises the possibility for a potentially new state or federal solar incentive program in partnership with the private sector.

In addition, a primary research survey instrument was administered in the spring of 2012. This survey of industry professionals (SIP) was sent to 73 renewable energy professionals from different backgrounds to assess ongoing trends in residential PV with a 47% response rate. Questions were included on residential PV trends, grid parity, tipping points, drivers and barriers. Industry trend data and survey opinion confirm that dropping residential PV costs, increasing PV efficiency, and a wider array of financing options are the main drivers of household adoption; these must continue for residential PV to reach a tipping point or grid parity and mainstream.

Overview of a Residential PV Solar-Electric System

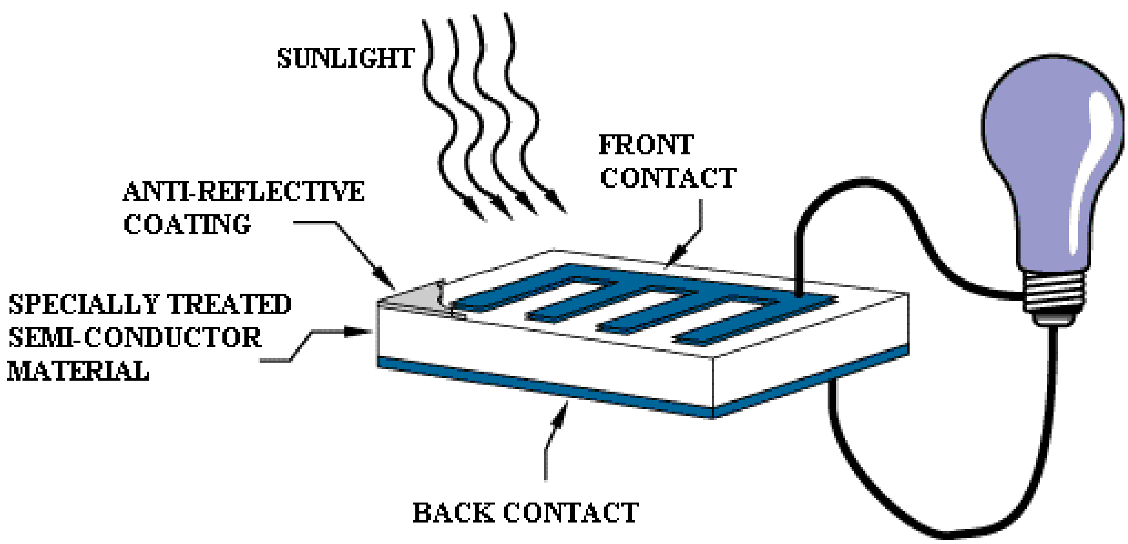
***Figure 2: A Residential Grid-Connected PV System**. (U.S. Department of Energy, 2011)*



Solar (PV) systems use semiconductor solar cells to convert sunlight directly into electricity. Crystalline silicon (si) PV modules represent about 80% to 90% of the PV market, and module efficiencies for converting sunlight into electricity currently range from 14% to 19% (Kroposki et. al., 2009; Merry, 2011). Silicon is laced with trace amounts of conductive elements such as phosphorous and boron which create an energy field potential.

Another type of PV, thin-film, can be made from amorphous silicon (a-Si), cadmium telluride (CdTe), or copper indium gallium diselenide (CIGS). The advantage of thin-film is that the material is layered over a substrate material such as siding or roofing material (as opposed to traditional racking or mounting of modules), but thin-film currently has lower efficiencies compared to silicon. When the device is illuminated by sunlight, electrons flow out of the PV cell and into the wires of the electric circuitry (Kroposki et. al., 2009; Merry, 2011). Figure 3 shows a basic schematic of a typical PV cell.

Figure 3: Basic schematic of a PV module. *(NASA, 2002)*



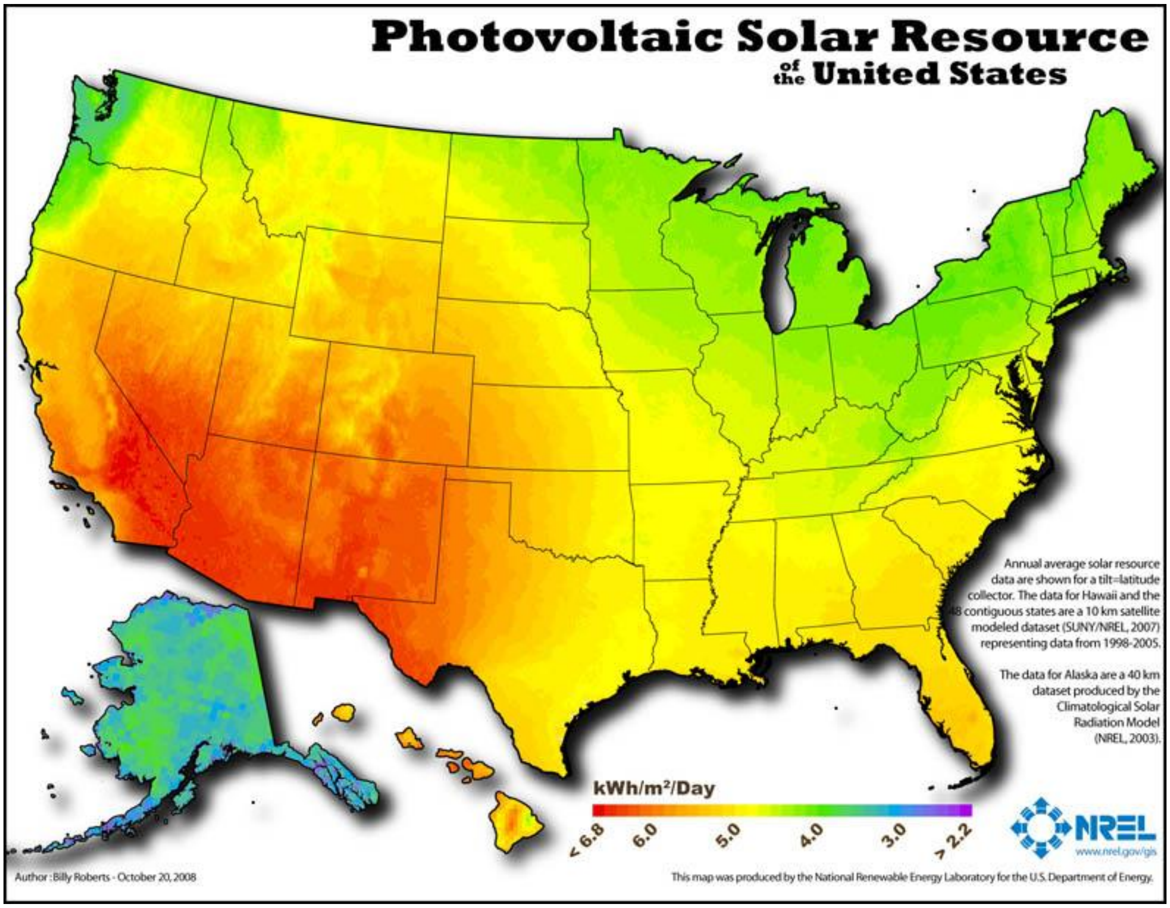
In addition to the PV cell, Balance-Of-System (BOS) components include an inverter which converts solar direct current (DC) into alternating current (AC) for use in homes. BOS components also include racking, modules (cells wired together), arrays (modules framed together), boxes, conduit, and wiring. Unlike conventional power generation, the PV module does not deplete any of the system materials nor a fuel source (such as coal) in the process of converting sunlight into electricity, although the system does slowly degrade in efficiency over a typical 25 year system lifetime. A typical degradation factor is 0.5% or less per year (Kroposki et. al., 2009; Merry, 2011).

A residential PV system is most productive when sunlight is perpendicular to the module, and most systems in the northern hemisphere face south for maximum production. Other system parameters include production, which is defined as kilowatt (kW) multiplied by the number of available sun-hours per day, which equals kilowatt-hours (kWh) per day. A typical U.S. home uses 958 kWh of electricity monthly, or 11,496 kWh per year (EIA, 2011). On average, 1 kWh of PV uses around 100 square feet of surface area for a PV system (Merry, 2011).

A fairly straightforward computation shows that most places in the United States can accommodate a typical 4 kW home PV system displacing at least 50% or more of grid-supplied power. A 4 kW residential PV system will produce at least 16 kWh daily production (averaged over a year), based on at least 4 sun hours per day being available in the continental United States and Hawaii, as shown in figure 4 (NREL, 2008). This equates to approximately 480 kWh of monthly solar power, which roughly displaces 50% of the average electricity grid consumption of a U.S. home (EIA, 2011). A typical U.S home needs only 400 square feet of roof space to accommodate such a 4 kW system. Informal interviews with installers indicate that most homes size a PV for at least 50% of their power needs; based on location, size and costs.

Many areas of the United States have 5 to 6 sun hours per day and can accommodate systems large enough to displace up to 100% of grid power. The vast majority of PV installations do not include storage batteries because of cost and complexity, but remain connected to the grid for power back-up and to take advantage of net metering benefits (discussed in Net Metering). The above example is based on U.S. averages, and each installation varies significantly depending on the size of the system, the efficiency of the modules, the region in the United States of installation, shade interference from trees and structures, and the energy consumption of the particular home (Merry, 2011).

Figure 4: ***Photovoltaic Resource of the United States.*** *(National Renewable Energy Laboratory, 2008)*



Given that almost half of grid-supplied electricity in the U.S. is generated from the mining and burning of coal (EIA, 2011), solar represents a significant potential for the overwhelming majority of US homes to "lock in" an electricity price for the next 25 years on at least half of their current consumption needs, using their own on-site generation, and at the same time significantly reduce air pollutants and greenhouse gas emissions from avoided conventional generation.

Financial Metrics

There are several different ways to assess residential PV financial value when considering home installations, and each has assumptions and challenges. First, simple payback may be calculated as depicted below (Paidipati et al., 2008):

$$\text{Simple payback} = \frac{[\text{installed cost - federal incentives - capacity based incentives - (tax rate x rebate amount)}]}{[\text{annual electric bill savings + performance based incentives - O\&M costs}]}$$

Certain questions arise with this metric: Where else is this metric used by households in appliance purchase criteria: air conditioners, hot water heaters, or pools? That is, is it fair to classify solar PV as a luxury, or as a necessity?

The second potential metric is Return On Investment (ROI). One definition of ROI is the sum of all returns over the system life divided by the net cost, after incentives (Solar Estimate.org, 2012). Some purchasers certainly may be interested in the basic ROI of a solar system. Third is the Internal Rate of Return (IRR), which can be defined as the annualized compounded rate of return for investing in a PV system over time (Merry, 2011). Some experts say that while this metric is the most accurate and perhaps best captures the benefits of a solar PV system, it is the least well understood by the typical purchaser (Merry, 2011).

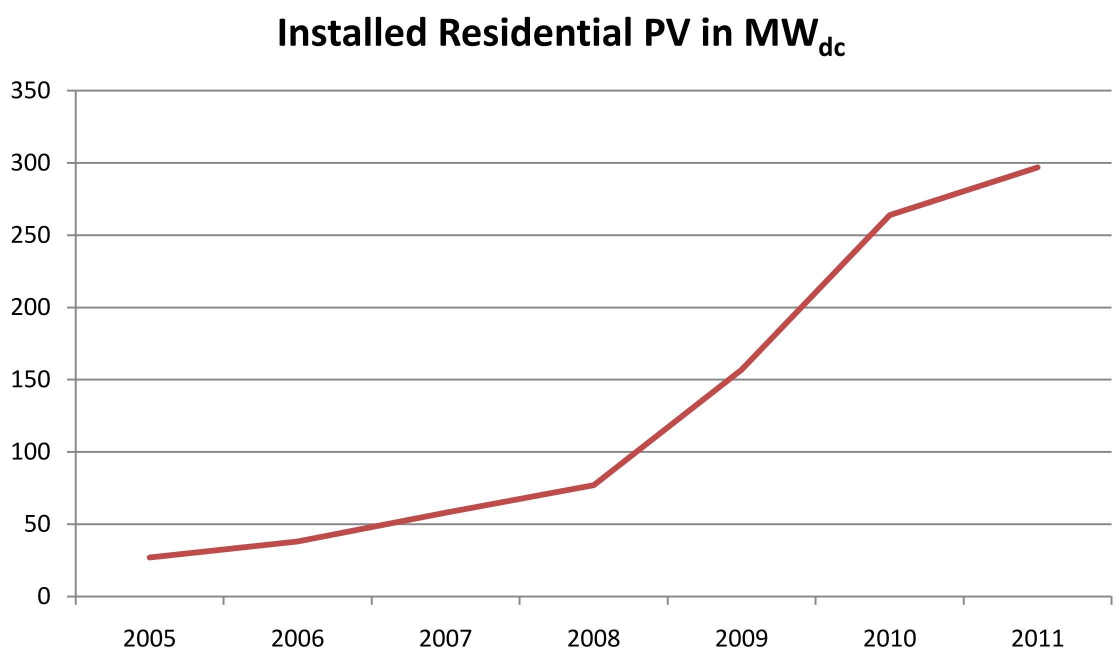
Finally is cash flow analysis, arguably the metric most understood and appreciated by households, precisely because it affects monthly electricity costs. Cash flow is straightforward. For example, assume an average U.S. household is interested in solar and wants to reduce energy costs over time, while also attracted to the environmental benefits. If the household pays $75 per month to finance a PV system and saves $100 per month on utility-supplied electricity for the next 10 years, then without knowing payback, IRR, or ROI, a homeowner can quickly realize the system will offer a net savings on electricity of $25 per month (after incentives).

The system is therefore affordable, and the environmental benefits are pleasing. The significant increase of PPA and lease agreements (discussed in Residential Market Drivers) confirms that cash flow analysis of monthly electricity costs is a key decision criterion used by households. The most recent assessment of residential PV growth indicates that in the fourth quarter of 2011, more third-party owned systems were installed than customer-owned systems for the first time under the California Solar Initiative (SEIA, 2012).

Recent Installation and Growth Trends

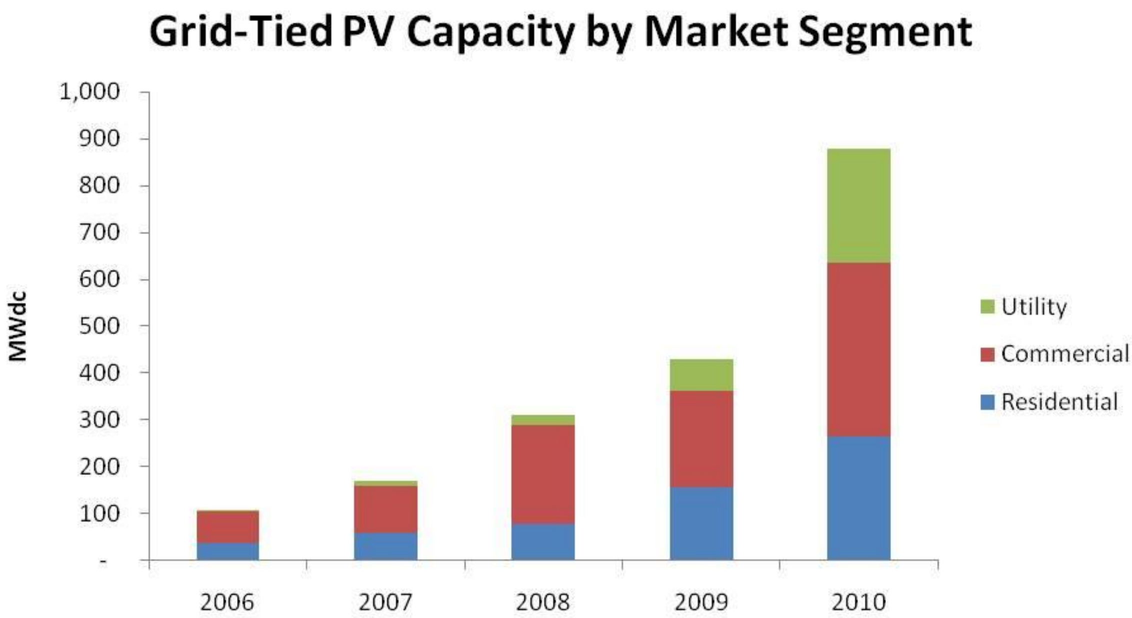
There were 51,176 residential PV installations in the U.S. in 2011, a growth rate of 11% in 2011 over 2010 (SEIA, 2012). Installed capacity of residential PV has grown approximately 49% per year from 27 MW_{dc} installed in 2005, to 297 MW_{dc} total installed capacity in 2011, as shown in figure 5 (SEIA, 2011; SEIA, 2012).

Figure 5: Installed Residential PV Capacity Trend. (Data from SEIA, 2012)



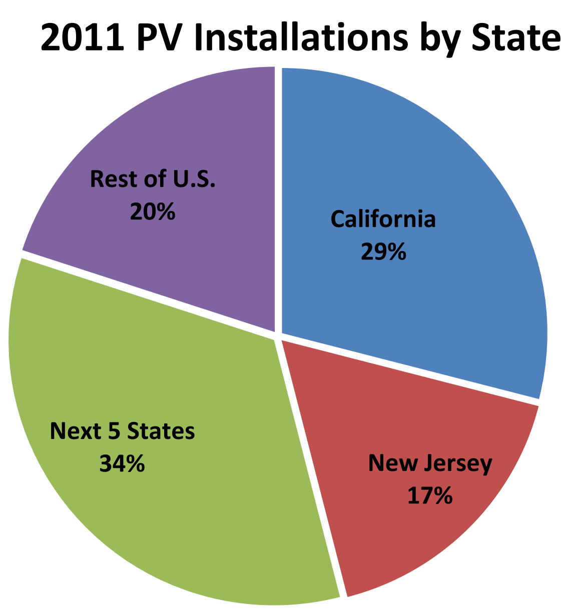
As shown in figure 6 below, cumulative grid-connected PV in 2010 in the U.S was ten times the size of solar capacity in 2005 (SEIA, 2011). Also in 2010, residential installations accounted for roughly one-third of the installed grid-connected solar capacity and more than 80% of total installations. Residential installations have grown dramatically over the past five years with annual growth rates ranging between 33% and 103% year-over-year. Similarly, the average size of a residential system grew from 2.9 kW in 2001 to 5.7 kW in 2010.

Figure 6: Segmented PV Capacity. (Data from SEIA, 2011)



As shown in figure 7 below, California and New Jersey led 2011 PV installations overall. Interestingly, when grid-connected PV is ranked per-capita by state, six states - Arizona, Colorado, Hawaii, Nevada, New Jersey, and New Mexico - had more installations than California in 2010, likely indicating that the market is diversifying and expanding across the country (Sherwood, 2011).

Figure 7: 2011 PV Installations by State. (Data from SEIA, 2012)



Electricity Prices

An important variable used to evaluate the cost of residential solar in many studies and industry publications is the expected future retail cost of grid supplied electricity. Obviously, with potentially rising electricity rates, the case for solar is more compelling as a hedge against future electricity prices. Most installers and industry analysts routinely assume escalating electricity costs of 5% per year or more. The Energy Information Administration's (EIA) 2012 short-term outlook projects an average drop in the U.S. residential average nominal electricity prices from 11.85 cents/kWh to 11.79 cents/kWh from 2012 to 2013, respectively. The agency cites short-term lower consumption of electricity based on moderate weather models as a key factor. Further, the agency projects over the long term that growth of energy use will slow due to extended economic recovery and increasing energy efficiency in end-use applications.

Although electricity sales are expected to grow by about 0.8% per year until 2035, end-use residential prices are expected to drop by 0.1% per year over the same period, from an average of 11.5 cents/kWh to 11.1 cents/kWh, in 2010 prices. As the outlook explains, electricity prices tend to reflect trends in fuel prices and particularly natural gas, because in much of the country natural gas-fired plants often set wholesale power prices. The recent rapid decline of natural gas prices with increased supply and exploration, the higher efficiency of gas fired power plants, and the increased regulation of air pollutants from coal plants are all factors affecting future electricity prices per the agency's reference case assumptions (EIA, 2012).

However, it is important to note that future projections of electricity prices must also account for inflation, or real prices. The agency does not calculate the effects of inflation, and relies on nominal prices instead. Given this assumption, real electricity prices should rise in 2010 dollars over the longer term, and by at least the future inflation rate.

II. Materials & Methods

This report draws upon the results of a literature review, a primary research survey of industry professionals, and informal interviews . The Survey of Industry Professionals (SIP) for this report was emailed to 73 industry professionals as a confidential survey in January of 2012. Appendix B includes the full survey instrument with collected responses. Thirty-four people completed and returned the survey, a 47% response rate. The survey was designed and administered using SurveyMonkey, commercial survey software delivered via a web-based platform. Professionals were selected based on the author's attendance at Solar Power International in Dallas, Texas in October, 2011, billed as the world's largest annual solar conference and exposition.

In addition, individuals were identified from a literature review of academic and industry-leading publications of energy or solar technologies. In addition, a few individuals known to the author or faculty advisor as having significant insight or expertise were included. The survey pool was not randomized nor was selection standardized, although every attempt was made to include a diverse set of professionals from different backgrounds, including:

- academia (energy and business)
- private sector companies with a leading market presence (installers, leasing companies, PV manufacturers, energy raters)
- recognized industry trade associations such as the Solar Energy Industries Association (SEIA)
- national laboratories and federal government such as the Department of Energy (DOE)
- media (business, technology, and investment rating services)
- policy groups such as the Nicholas Institute for Environmental Policy Solutions
- consulting firms

Eleven questions were formulated to assess market potential and future adoption trends of residential PV, including the role of drivers and barriers. The questions and protocol were reviewed by the Institutional Review Board at Duke University (IRB), then again by the Duke Initiative on Survey Methodology (DISM), and finally by Dr. Christopher Wedding, faculty advisor at Duke University. Based on the experience of IRB and DISM with similar types of surveys, it was determined that a minimum response rate of N=25 was necessary and sufficient to draw reasonably accurate conclusions about industry opinions.

After approximately six weeks the survey was closed. In order to ensure professional opinion was elicited of those in perhaps politically sensitive positions, respondents were promised confidentiality; therefore only aggregated results are shared with no mention of individuals or their responses. In addition, respondents were told they would receive a copy of the survey results and be eligible to win a $100 Amazon gift certificate by completing the survey, which was randomly drawn and awarded by SurveyMonkey.

Of the 11 questions, 3 questions were skipped by some respondents as these were optional questions. For reliability, similar questions were asked for both drivers and barriers of residential PV and then compared to see if the results were consistent. Fortunately, the results of these questions are consistent. For example, PV costs and module efficiency were assessed in two different questions, one ranking drivers and one ranking barriers. In both answers, PV cost and efficiency are cited as the number one driver and number one barrier to mainstreaming household adoption of PV.

Questions were scaled wherever possible to create quantifiable results, such as with ranking PV drivers on a scale of 1 to 5 with 1 being most important and 5 being least important. Also, for most questions, open responses were allowed to encourage comments and insights. For instance, in one question assessing whether "utilities, households, or neither" would lead the way in mainstreaming residential PV, one person commented the now-obvious, that "both" would lead the way. The majority of respondents indicate households will lead the way.

Ideally the SIP would include a systematic method for identifying participants from a large, diverse pool of energy professionals with less potential for selection bias. Also, the survey would collect demographic information for each respondent including occupation, experience, age, education, and income to note any systematic response bias. For instance, are solar-specific occupations more pro-solar than broader energy professions? Do younger professionals rate adoption trends more aggressively than older professionals?

The states of California, Texas and New Jersey are used to highlight state policy examples and provide more in-depth analysis, for the following reasons. California and Texas are the two largest state economies, respectively (Economist, 2011). According to a 2008 study, Texas and California have the most rooftop PV technical potential, using data on available square footage, solar radiation and efficiency factors, and independent of economic potential (Paidipati et al., 2008). Also, California and New Jersey have the most installed grid-connected PV nationally, while Texas ranks relatively low (Sherwood, 2011). Finally, California and New Jersey have robust state-level policy programs in place to support solar, while Texas generally does not, based on a review of state level policies in this report. Thus, Texas makes an interesting contrast case relative to California and New Jersey considering its market potential.

Residential PV 2010 installed cost data is included in Table 1 of Appendix A both before and after incentives, using data from Lawrence Berkeley National Lab (LBNL). Using state data for California, New Jersey, Texas, and a national average; the average upfront cost of a PV system is computed before and after incentives, along with a simple payback analysis, to note general trends cited in this report. A residential PV basic monthly cash-flow analysis is also included in Table 2 of Appendix A, and based upon the cost data from Table 1. In Table 2, an average representative installation after incentives for California, New Jersey, Texas, and a national average is computed for a PV retrofit financed with a 25 year home-equity/home-improvement loan at a 6% annual interest rate. From there, a monthly cash-flow gain or loss is calculated, relative to offsetting 50% of grid supplied electricity. Next, the same analysis is performed for monthly cash flow gain or loss for a new home purchase with a bundled PV system at 6% interest amortized over 30 years and 5% cash down. The purpose of this analysis is to note general cash flow trends using conventional financing options (not leases and power purchase agreements).

Finally, a test policy case of 0% interest with 100% financing over 25 years for a PV retrofit is offered for comparison using net installed costs. Scenario testing of loan variables indicates modest changes in cash-flow based on loan term and down payment. However, interest rate has the biggest impact on monthly cash flow, assuming no change to installed cost, and this finding is consistent with a recent study (Branker et al., 2011). The last column of Table 2 shows CO_2 emissions averted over 25 years for each scenario as well.

The Tables in Appendix A should only be used to note general trends, not specific outcomes. These tables do not calculate the net present value of cost-savings on utility bills, potential for rising utility rates over time, property taxes, the mortgage interest deduction, inflation rates, cost of maintenance to the PV system (industry publications often estimate 0.4% annually), nor a degradation factor (often estimated at 0.5% annually). LBNL installed cost data include state and federal incentives, tax credits and utility rebates, but do not include net metering incentives or future potential revenue from the sale of solar renewable energy credits. All data are historical and based on 2010 figures and thus might be different today. LBNL claims the sample size is small and represents aggregated data from different sources, thus specific installations and their costs, payback times, and cash flow will vary significantly.

III. Results

The SIP indicates that 76% of respondents think residential solar technologies are a "very realistic" energy option for U.S. households. Nearly half of respondents (16 of 34) think PV electricity will be adopted primarily by households versus delivered by utilities, although nearly 40% think utilities will lead the way. Notably, several respondents think both sides of the meter will drive adoption. The majority of industry professionals, 68%, do not think a "game changing" technology is on the way. Instead, dropping residential PV system costs and/or increasing PV efficiency rank as the number one cited driver (or impediment) to mainstream adoption over time, followed by financing options.

The majority of survey respondents, 70%, think residential PV will reach retail grid parity and/or 10% household adoption across most U.S. markets within 10 years. Another 20% claim between 10 and 20 years. Further, many respondents say California and New Jersey will reach grid parity first and within five years. Renewable portfolio standards are ranked as "very critical" for states to drive residential PV, while the case for a federal RPS is less compelling according to respondents. In terms of policy drivers such as federal and state rebates and tax incentives as well as net metering standards, the results of the survey are mixed with no clear trend or consensus on the importance of these. In fact, these tended to rank neutrally or generally low in importance relative to other drivers and barriers. Interestingly, both household "eco-green" desires and "restrictive neighborhood ordinances" both rank as least important for drivers and barriers, respectively.

Analysis and discussion of the literature review and informal interviews, along with SIP results, are discussed at length in Section IV of this report. Several important points may be distilled as follows. Given current residential PV technology and solar radiation available in the U.S., most homes today in the United States are able to generate 50% or more of their electricity consumption needs with solar. PV efficiency has been increasing year to year, while installed costs has been dropping, mostly due to drops in PV module and BOS costs (SEIA, 2011). Several companies are leading the recent growth in residential PV and are simplifying the process of acquisition for homeowners. These companies are offering power purchase agreement (PPA) or leases, delivering cash flow savings in month one (after incentives) for residential systems (Coughlin et al., 2009).

Federal and state tax credits and rebates, along with other financial incentives, play a crucial role in driving deployment of solar over the near term and until the cost gap between conventional generation and solar PV is closed. Although installed costs vary greatly by location, residential PV installed costs have dropped exponentially from $9.7 per watt in 2000 to an average of $6.2 per watt in 2010 before any federal, state or local incentives (Barbose et al., 201). Some markets now show installed residential PV costs of $5 per watt (before incentives; SEIA, 2012).

With incentives, payback times are nearly cut in half (Appendix A). The capacity-weighted U.S. average of net installed cost after federal, state and utility incentives or other credits was $3.6/W installed for residential PV in 2010, an historic low (Barbose et al., 2011). Nevertheless, at the current 10-year historical average interest rate of 6%, a 25-year home equity loan for a PV retrofit or a 30-year new home loan with PV bundled do not breakeven on monthly cash flow after incentives (Appendix A). Breakeven is defined as the monthly cost of owning the PV system which offsets at least the same amount of utility savings from the grid. Interestingly, if a 0% APR financing option is tested over a 25-year PV loan, all state scenarios breakeven and produce positive cash flow savings (Appendix A).

Section IV also enumerates the majority of the critical PV incentives shaping the U.S. industry. California and New Jersey lead PV installations with commensurate policy support and financial incentives, while Texas by contrast has much less PV installation and relatively little policy support. Incentives include net metering standards which allow households to receive credit for excess generation, system benefit charges to fund solar projects, and emerging feed-in-tariffs to support residential PV deployment. Further, lack of solar access and rights laws, interconnection standards, regulatory barriers for PPAs, and lack of household education and awareness are all adoption barriers.

Residential PV installed capacity shows 49% CAGR, growing from 27 megawatts (MW) installed in 2005 to 297 MW as of 2011 (SEIA, 2011; SEIA 2012). Based on approximately 250,000 known residential installations (Sherwood, 2011; SEIA, 2012), market penetration using single family home data is approximately 0.3%. Using this installation data, to reach 10% of the U.S. single family home market will require approximately 41% CAGR for 10 years or 19% CAGR for 20 years, based on 2000 housing census data adjusted upward by 10% for 2010 (about 77 million single family homes).

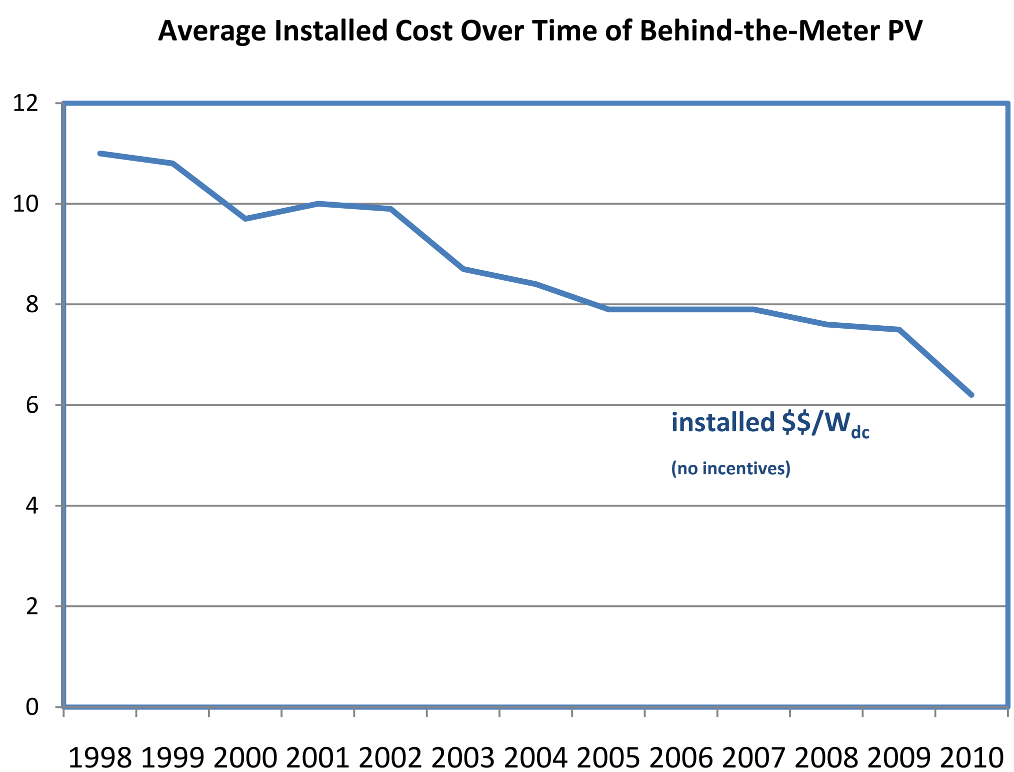
Results of leading policy, practice and professional opinion are summarized in Section IV, Best Practices and Section V, Conclusion.

IV. Analysis & Discussion

PV System Installed Costs Before and After Incentives

PV efficiency has been increasing year to year, while installed costs have been dropping, the latter mostly due to drops in PV module and BOS costs (SEIA, 2011). As shown in figure 8, the capacity-weighted average of up-front, installed cost of all behind the meter systems installed in 2010, and before any federal, state, or utility tax incentives or other credits was \$6.2/W; 17% lower than the rate of 2009 (Barbose et al., 2011). Most recent data show this figure is still very accurate at \$6.18/W installed before incentives at the close of 2011 (SEIA, 2012). System costs can vary by as much as 50% depending on the size and location of the system. Average installed costs range by state from \$6.3/W in New Hampshire to \$8.4/W in Utah. It is worth noting that the two states with the largest PV markets, California and New Jersey, were nearest the \$6.2/W national average for 2010 (Barbose et al., 2011).

Figure 8: Average Installed Cost over Time for Behind-the-Meter PV. (Data from Lawrence Berkeley National Laboratory, 2011).



The upfront cost of an average 4.3 kW_{DC} residential system in the U.S. is approximately$26,722 (4,310 W x $6.2), using above installed cost data for 2010. Working through a financial example, if the typical U.S. household consumes 11,496 kWh annually (DOE, 2011), and if the national average for utility supplied electricity is 11.6 cents per kWh (DOE, 2011), then the retail electricity bill for the national average example will be approximately $1,327 per year. A correctly sized and installed PV system, in this example a 4.3 kW_{DC} system, will offset approximately 50% of the grid-supplied electricity cost annually. Therefore, under a simple payback analysis dividing system cost by annual grid cost savings, the system will pay for itself in approximately 40 years before incentives, not counting inflation, system degradation or rising electricity price. If financed over 25 years with a home equity loan at 6% interest, the monthly household electricity cost is increased by approximately $44/month (Appendix A).

Assuming upfront costs can be addressed through incentives and financing options, however, yields a significantly different outcome. The same 4.3 kW_{DC} PV system noted above costs $15,516 net of incentives. The capacity-weighted net installed cost after federal, state and utility tax incentives or other credits is $3.6/W for residential PV in 2010, an historic low (Barbose et al., 2011). Payback times after incentives drop nearly 50% and demonstrate the crucial role that incentives, rebates and financing options offer in making solar affordable, along with falling module and installation costs. The impact to household monthly cash-flow is a significant driver for household adoption, and this assumption is confirmed by the SIP and other studies (Farhar & Coburn, 2000). In fact, third-party ownership models such as leases and PPAs which reduce monthly cost of ownership now dominate installations (SEIA, 2012).

Different payback times of residential systems inclusive of incentives have recently been calculated by the Global Solar Center (GSC) and range between 13.9 years on average to as long as 25 plus years, depending on state and municipality. California is estimated at 7 years, Texas 9.5 years, and New Jersey 1. 5 years according to the study (Global Solar Center, 2009). The difference between GSC payback times and this report's payback times in Appendix A are likely the result of this report not accounting for electricity price escalation, inflation, and a system degradation factor over time as has been mentioned. Also, the GSC study compares a 5 kW system across all markets whereas this report compares a system size necessary to achieve 50% grid-offset in each market. To further complicate comparisons, studies use widely varying estimates of installed costs and anticipated electricity price increases, and some studies count performance incentives such as net metering while others do not.

Scenario testing with various permutations of interest rate, loan term, and down payment reveal the importance of financing variables on monthly cash-flow for a PV system (Appendix A). A PV loan with 0% APR and 100% financing with up to a 25 year loan term, perhaps administered by a federal, state, or other loan-guarantee program, produces cash-flow positive results (using California, New Jersey, Texas and a national average as a test case). Considering recently strained federal and state budgets and a mood of fiscal austerity, this policy option should be explored.

The more energy efficient a home is the less power it consumes, allowing homeowners to install lower priced systems. Further, since monthly PV system maintenance costs are minimal, then once a PV system is paid off or prepaid early, then the household enjoys near-free electricity for the remaining life of the system, often 25 years or more per industry warranties.

Residential PV Market Drivers

As shown in table 3 below from the survey of industry professionals (SIP), dropping PV module costs and increases in module efficiency are cited as the number one driver for mainstreaming residential PV adoption. The majority of respondents (50%) rank this variable as foremost, followed by financing options and other drivers. For reliability, the same question was asked of most significant barriers, with the majority ranking PV cost or efficiency as the number one barrier (35%), also followed by financing options and other barriers. Module and balance of system (BOS) costs have been dropping consistently over the past several years (SEIA, 2011; LBNL, 2011).

Table 3: SIP Results of Ranked PV Drivers.

"Please rank these potential solar residential market DRIVERS when considering mainstream household adoption, by importance."

	Dropping PV cost &/or increasing PV efficiency	Financing options (lease/power purchase agreements/loans)	Net metering	Federal / state / local rebates & tax incentives	Household eco/green desire	Response Count
1 (most important / largest driver)	**50.0% (17)**	20.6% (7)	14.7% (5)	14.7% (5)	0.0% (0)	34
2	20.6% (7)	**35.3% (12)**	8.8% (3)	26.5% (9)	8.8% (3)	34
3	11.8% (4)	**35.3% (12)**	20.6% (7)	29.4% (10)	2.9% (1)	34
4	15.2% (5)	3.0% (1)	**33.3% (11)**	27.3% (9)	21.2% (7)	33
5 (smallest driver / least important)	2.9% (1)	5.9% (2)	20.6% (7)	2.9% (1)	**67.6% (23)**	34

Private Sector Innovations: Leases and Power Purchase Agreements

For residential solar to truly compete with conventional electricity, it must compare financially at some point in time with conventional sources of electricity generation. In the SIP, 76% responded that solar technologies for homes are “very realistic,” but 67% think there is no “game changing” technology on the horizon to significantly change the metrics. Given these considerations, financing options and incentives are critical to widespread solar adoption. As more solar is adopted, this will in turn lead to continuing increases in efficiency and lower costs, as has been the case with other technologies including computer chips.

The rise of third-party leasing arrangements and power purchase agreements (PPA) has taken the complexity of researching, sourcing, installing and maintaining a residential PV system out of the equation for prospective solar homeowners in key states. Coupled with a compelling claim that customers will save money on utility bills in the first month (positive cash flow), a private sector model is leading the way in residential PV installations (SEIA, 2012).

Sungevity, headquartered in Oakland, CA, offers lease agreements over a typical 20-year lease period with $0 down payment. The company is full-service in the sense that it contracts with the customer to evaluate, size, install, operate and maintain a PV system for a monthly service fee. The company currently partners with independent installers in eight states: California, Arizona, Colorado, Massachusetts, New York, Delaware, and New Jersey. Some customers opt to offset 100% of grid power, but most want to install systems that cover 50-70% of usage, especially in areas with tiered-rate structures where electricity rates go up with increased consumption (Sungevity, 2012).

The company customizes a quote based on the household’s location, utility service, state and local incentives, as well as the financial needs and interests of the homeowner. Clients may choose to make a down payment or to prepay the lease entirely. The latter option amounts to a discounted, net-of-incentives PV system. The majority of households take a $0 down payment approach according to the company. Sungevity claims that on average customers realize 10% to 15% savings on utility bills starting in month one, though field representatives note this figure is case specific and varies based on each installation. If a homeowner moves, one may buyout or transfer the lease. As with all leases, there are penalties if the lease is broken. At the end of the lease term, homeowners may start a new lease or buy the system at fair market value (Sungevity, 2012).

In an informal interview with Sungevity CEO Danny Kennedy, he notes that leases make sense to homeowners, and the company has a compelling offering whenever higher-than-average electricity prices, tax credits, and local rebates are present. However, he maintains the principle barrier is not financial; rather it is awareness and education. Much more solar would be installed if costs were lower, but trust, hassle and simple awareness are significant to expansion. Most Americans are probably unaware of the potential financial and environmental benefits of solar, or do not have the time to research such options.

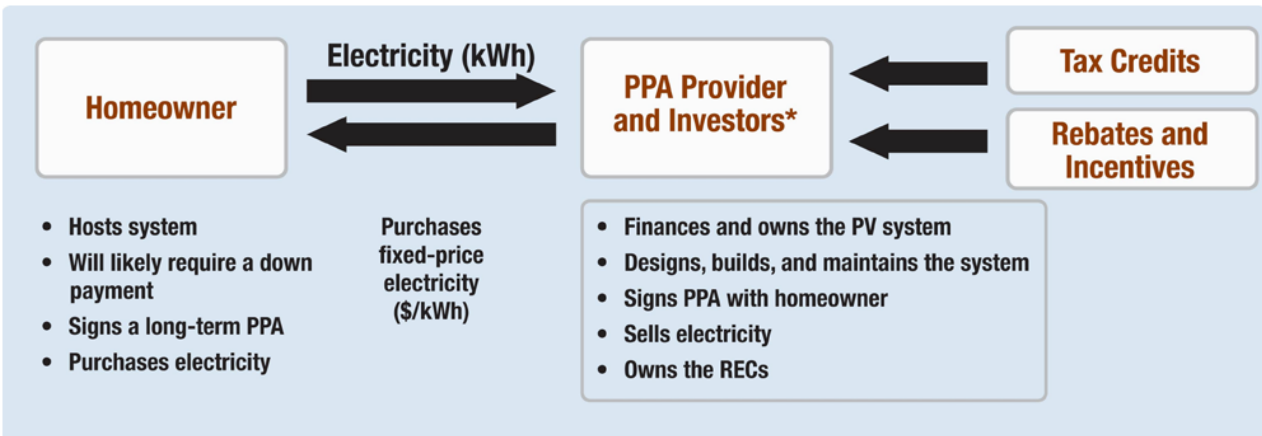
The SIP shows inconsistent responses by other industry professionals regarding the role of solar awareness and education. Responses are fairly evenly distributed on a scale of 1 to 5. Equal numbers rank this variable as the most important barrier and the least important barrier to mainstreaming relative to other barriers (with several responses in-between).

There are concerns with the lease model. Suppose the company creating the lease goes out of business and leaves a homeowner with equipment they do not own and which has 10 years remaining on the lease, especially if the consumer put money down? How many homeowners might be locked in to leases with very modest monthly savings, while PV efficiency continues to improve and costs drop? Will companies allow homeowners to upgrade and refinance? Within 10 years, many solar markets may reach grid parity without the need for tax credits or cash incentives in the future, making solar easy and affordable for many to purchase PV systems outright or finance at a low interest rate. What happens to prior PV lease owners who have long lease terms remaining? Although leases often contain an escalation factor over time (the rate goes up), do any leases contain a de-escalation factor as prices continue to go down? These concerns notwithstanding, leases likely serve an important role over the next five to ten years by allowing homeowners to simplify the procurement process and avoid high upfront costs.

Solar City, a company headquartered in San Mateo, California and founded in 2006, has regional offices in 15 states and claims to have more than 20,000 solar projects completed or underway which serve residential, commercial, education and nonprofit customers (Solar City, 2012). Solar City claims not to partner with installers in each state, but serves customers directly in each market where it operates. In addition to selling equipment and services in key states like Sungevity, the company also offers a full suite of energy efficiency products and services.

In addition to the lease model, Solar City has also pioneered the use of power purchase agreements (PPA) for residences. Solar PPAs have traditionally been used in commercial applications, and are increasingly used by residential customers. Under this model and like a lease, the company is full service and evaluates, installs, operates and maintains the solar PV equipment for the homeowner. Unlike a lease, however, a solar PPA is a contract to buy solar power based on a set rate that is usually less than current local utility rates. Typically over a 20-year period, this rate is “locked in” and thus purports to hedge the homeowner (like a lease) against future utility rate hikes (Solar City, 2012). As a solar PPA customer, homeowners pay only for solar power, not the solar equipment or installation as shown in figure 9.

Figure 9: The Residential Power Purchase Agreement*.(National Renewable Energy Laboratory, 2010)*



*This is a very simplified representation of the relationship between the developer and its investors.

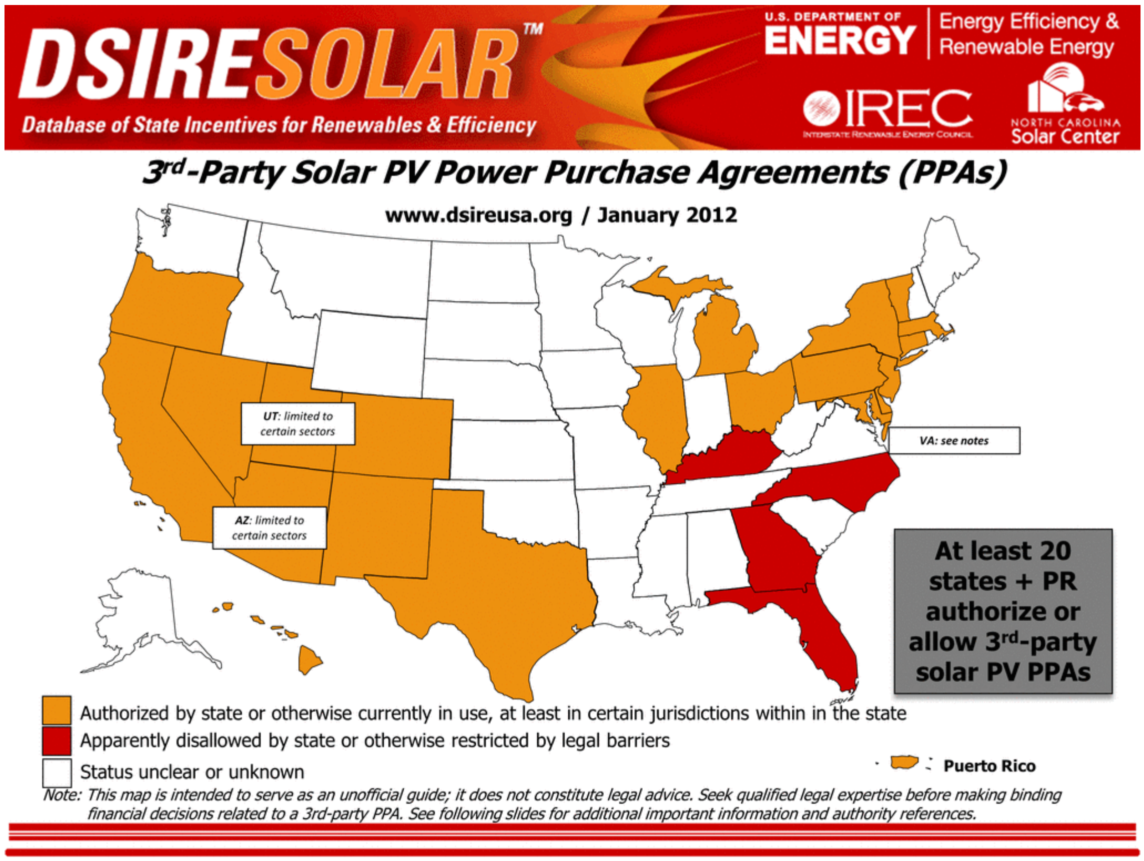
The company creates a custom profile for each customer based on local incentives and rebates. In addition, the company offers a performance guarantee on PV system production. Further, customers can pre-pay a PPA contract like a lease, often at a significant discount over what a typical system would cost outright (Solar City, 2012). Sun Run is yet another company with similar offerings, headquartered in San Francisco, California and which services customers in 10 states by partnering with solar installers.

Sungevity, Sun Run and Solar City are able to offer prepaid lease and PPA contracts as well as monthly leasing and PPA arrangements which are often lower than local utility bills or the cost of upfront purchase. The reason for this is because the companies delivering these services can take advantage of more incentives and tax credits than an individual homeowner, including depreciation and preferred pricing on PV modules, as well as economies of scale.

Both the Business Energy Investment Tax Credit (ITC), and Corporate Tax Depreciation (explained more in this section) allow these companies additional tax incentives that are not available to the homeowner. For financial reasons related to leasing regulations and IRS tax code, a "solar lease" offered by a third party provider is really a "solar service agreement" with the homeowner . The provider typically partners with a tax investor who is eligible to claim the federal tax and deprecation benefits (Coughlin & Cory, 2009). Recently, Solar City announced Google as an investor partner with Google investing $280 million into a tax equity fund to support Solar City's business model expansion (SEIA, 2012).

Companies may also take advantage of local incentives offered by states, utilities and municipalities, and homeowners may still be able to take advantage of certain incentives under a lease or PPA model such as net metering. Figure 10 below shows the prevalence of third-party solar PPAs in the United States.

***Figure 10: Third Party Solar PV Power Purchase Agreements**. (DSIRE, 2012)*



Federal Financial Incentives

There are three primary federal incentives impacting residential solar: the Residential Renewable Energy Tax Credit, the Business Energy Investment Tax Credit (ITC), and Corporate Tax Depreciation. Any taxpayer may claim a 30% tax credit for the costs to purchase and install a residential solar system. This policy was originally established by the Energy Policy Act of 2005. The Energy Improvement and Extension Act of 2008 and the American Recovery and Reinvestment Act of 2009 expanded the ITC and it is now in place until 2016 (DSIRE, 2011). The American Recovery and Reinvestment Act of 2009 allowed some companies eligible for the ITC to receive a cash grant from the U.S. Treasury Department instead of taking the tax deduction for new installations, but the grant expired December 31, 2011.

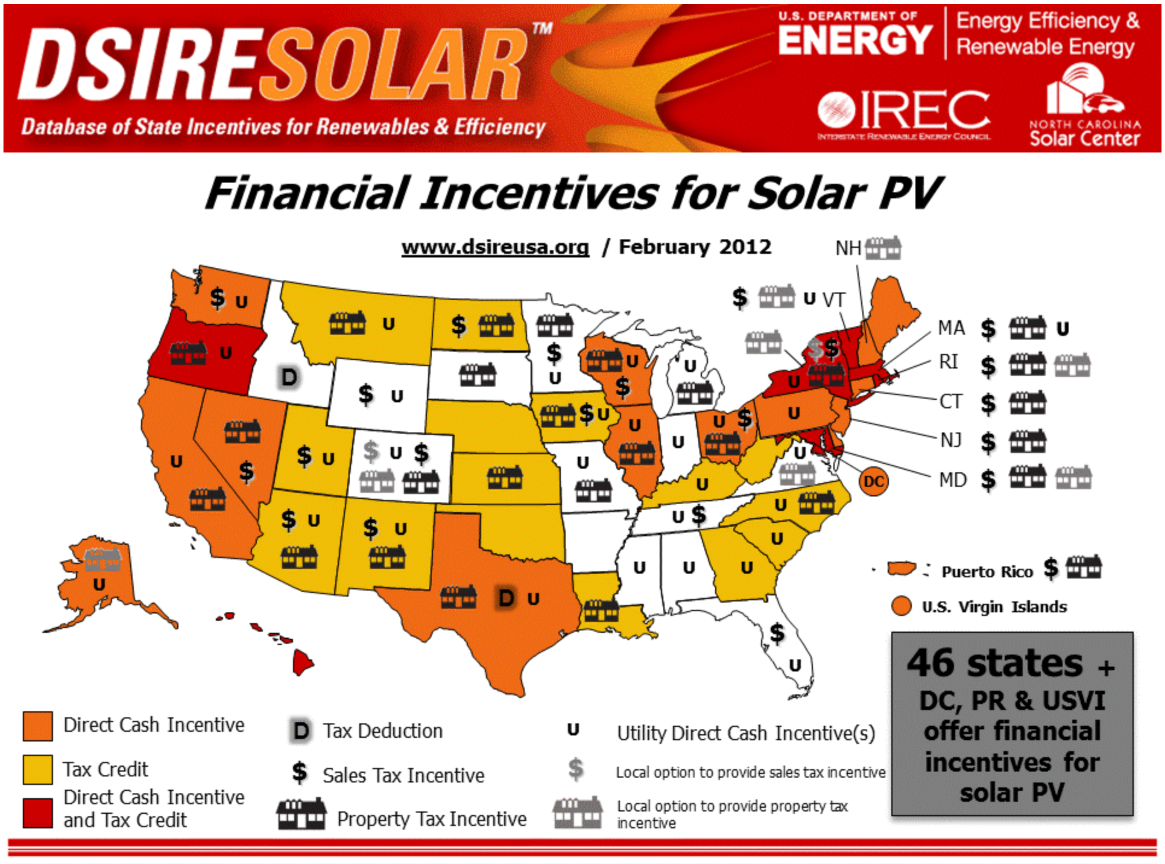
For residential lease and PPA service installations, the company providing the service may utilize standard Internal Revenue Service (IRS) equipment depreciation schedules. Under the Modified Accelerated Cost-Recovery System (MACRS) + Bonus Depreciation, eligible solar property installed between September 8, 2010 and January 1, 2012 qualifies for 100% first-year bonus depreciation. For 2012, the allowable deduction reverts from 100% to 50% of the eligible basis. Note that the often-mentioned Renewable Energy Production Tax Credit (PTC) does not apply to solar PV (DSIRE, 2011).

Companies offering lease and PPA services presumably take advantage of all available credits to make their service offerings competitive with local utility providers. Further, companies offering leasing and PPA product apply for those incentives for which they are eligible and may offer assistance to homeowners for others. Informal interviews with select solar installers and consultants indicate that research, complexity and paperwork are a daunting task for many prospective solar consumers. Installers may also offer assistance with applications and coordinate financial incentives, though this has not been systematically studied.

A few other federal programs such as the Residential Energy Efficiency Tax Credit for homeowners and the Energy Efficient New Homes Tax Credit for New Home Builders are also in place, but these are less often mentioned as critical incentives for residential PV adoption.

In the list below, note significant federal, state and local incentives. These incentives dramatically impact the near-term financial viability of residential PV, and significantly shorten simple payback times. Hence, significant detail is provided on incentives, since states such as California and New Jersey are leading the way in adoption and ranked #1 and #2 in installations respectively (DOE, 2011). Examples are included for Sacramento, California; Austin, Texas; and Trenton, New Jersey to show the significance of local incentives as well. Not all municipal level incentives are included except for the cities mentioned. Further, the list that follows suggests a trend: states which lead in policy lead also lead in PV installation. Figure 11 below shows the widespread use of financial incentives by state.

Figure 11: Financial Incentives for Solar PV. *(DSIRE, 2012)*



List of Federal Incentives (DSIRE, 2012):

Business Energy Investment Tax Credit (ITC): credits are available to companies installing solar for eligible systems placed in service on or before December 31, 2016. The credit is equal to 30% of expenditures, with no maximum credit. It is important to note that a tax credit reduces tax liability; it is not a tax deduction. The former is more impactful, although it may be affected by other incentives.

Residential Renewable Energy Tax Credit: An individual taxpayer may claim a credit of 30% of qualified expenditures for a system that serves a residence used by the taxpayer, until 2/31/2016.

Modified Accelerated Cost-Recovery System (MACRS) + Bonus Depreciation: Under the federal Modified Accelerated Cost-Recovery System (MACRS), companies installing solar may recover investments in certain property through depreciation deductions. 100% bonus depreciation expired 12/31/2011 and 50% expires 12/31/2012.

*U.S. Department of Treasury - Renewable Energy Grants***:** For companies installing solar, a renewable energy grant program has now expired. This cash grant could be taken in lieu of the federal business energy investment tax credit (ITC).

*Energy-Efficient Mortgages***:** Individual homeowners may take advantage of energy efficient mortgages to either finance energy efficiency improvements to existing homes, including renewable energy technologies, or to increase their home buying power with the purchase of a new energy efficient home. The U.S. federal government supports these loans by insuring them through the Federal Housing Authority (FHA) or Veterans Affairs (VA) programs. Informal interviews with select mortgage originators indicate these products are virtually unknown at the industry and consumer level.

State and Local Financial Incentives (DSIRE, 2012)

California:

California Solar Initiative - PV Incentives: This solar initiative is a widely heralded model of state rebate programs active since 2009 and is budgeted for 10 years. The program provides more than $3 billion in incentives for solar-energy projects with the objective of providing 3,000 MW of solar capacity by 2016.

California Feed-In Tariff: The California feed-in tariff is undergoing program changes and the status is uncertain. The program allows eligible customer-generators to enter into 10, 15 or 20-year standard contracts with their utilities to sell the electricity produced by small renewable energy systems, up to 3 MW, at time-differentiated market-based prices. The tariff is based on “CPUC market price referent (MPR) and is adjusted by time-of-use factors.” A higher rate is provided for solar energy between 8 a.m. and 6 p.m. All investor-owned utilities and publicly-owned utilities with 75,000 or more customers must make a standard feed-in tariff available to their customers, as the tariff is meant to help utilities meet California's renewable portfolio standard (RPS).

*Property Tax Exclusion for Solar Energy Systems***:** Section 73 of the California Revenue and Taxation Code allows property tax exclusion for certain types of solar energy systems.

*SMUD - Residential Solar Loan Program***:** The Sacramento Municipal Utility District's (SMUD) Residential Loan Program provides 100% financing to customers who install photovoltaic (PV) systems of up to $30,000. PV systems must be installed by a SMUD-approved PV contractor. Secured loan terms are available for up to 10 years with interest rates at 8.75% (SMUD, 2012).

SMUD - Non-Residential PV Incentive Program: A performance based incentive (PBI) is in place offering $0.10/kWh for 5 years or $0.06/kWh for 10 years. Under a third-party power purchase arrangement, companies are eligible for the 5-year or 10-year PBI option only regardless of system size.

SMUD - PV Residential Retrofit Buy-Down: Customers may choose between an upfront incentive or a production based incentive. The upfront incentive is $1.10/watt AC and is adjusted based on expected performance. The incentive can be paid directly to the customer or to the installer. The production based incentive is $0.17/kWh for the first 5 years of actual production.

Additional policies which drive residential solar in California are:

- Sales & Use Tax Exclusion for Advanced Transportation
- Alternative Energy Manufacturing Program for Industry Recruitment
- Green Building Incentives
- Building Energy Codes
- Contractor Licensing
- Energy Standards for Public Buildings
- Interconnection Standards
- Net Metering
- Public Benefits Fund
- Renewable Portfolio Standard (RPS)
- Solar Access Policy
- Solar Permitting Standards

New Jersey:

PSE&G - Solar Loan Program: Public Service Electric and Gas (PSE&G) of New Jersey offered loans for residential PV systems to all customer classes in its electric service territory (program is now expired). The program provided loans covering 40 to 60% of the cost of PV systems with the remainder to be financed separately by the customer. Residential customers were eligible for a loan term of 10 years at a 6.5% interest rate.

Utility Solar Financing Programs: Three of New Jersey's four investor-owned electric distribution companies offered 10 to 15 year SREC purchase contracts to solar system owners (program is now expired). The PSE&G Solar Loan program allowed solar system owners within its service territory to finance a portion of the system cost through the utility, and repay the loan with SRECs at a guaranteed minimum SREC price.

Property Tax Exemption for Renewable Energy Systems: New Jersey legislation exempts renewable energy systems used to meet on-site electricity, heating, cooling, or general energy needs from local property taxes for 100% of value added by renewable system.

Additional policies which drive residential solar in New Jersey are:

- The Edison Innovation Clean Energy Manufacturing Fund (CEMF) and The Edison Innovation Green Growth Fund (EIGGF) for Industry Recruitment.
- Building Energy Codes
- New Jersey Solar Energy Option Requirement for Residential Developments
- Energy Standards for Public Buildings
- High Performance Building Standards in New State Construction
- Interconnection Standards
- Net Metering
- Public Benefits Fund with a Societal Benefits Charge
- Renewable Portfolio Standard
- Solar Access Policy, Residential Solar Rights, and Solar Easements
- Solar Permitting Standards

Texas:

Solar & Wind Energy Business Franchise Tax Exemption: Also active since 1982, companies in Texas engaged solely in the business of manufacturing, selling, or installing solar energy devices are exempted from the franchise tax. There is no ceiling on this exemption, so it is a “substantial” incentive for solar manufacturers and installers.

Solar & Wind Energy Device Franchise Tax Deduction: Active since 1982, commercial entities may deduct 10% of the amortized cost of the system. The franchise tax is Texas’ equivalent to a corporate tax. Texas offers a franchise tax exemption for manufacturers, sellers, or installers of PV systems which also include wind energy as an eligible technology. Texas favored investment in the wind industry early.

Renewable Energy Systems Property Tax Exemption: Property tax code allows an exemption for the amount of the appraised property value of the installation of PV energy for on-site use.

Austin Energy - PV Incentive Program: Austin Energy, a municipal utility, offers a production incentive of approximately $0.14/kWh to commercial and multi-family residential customers for electricity generated by qualifying PV of up to 20 kW AC (expires 9/30/2012). It is not clear whether or not third-party ownership models qualify for this incentive.

Austin Energy - Residential Energy Efficiency Loan Program: Austin Energy offers solar PV loans up to $20,000 for solar PV, which may be combined with Austin Energy solar rebates.

Austin Energy - Residential Solar PV Rebate Program: Austin Energy's solar rebate program offers a $2.50 per watt incentive to eligible residential customers who install residential PV (expires 9/30/2012). Rebates are limited to $15,000 per home installation with a lifetime maximum of $50,000 per site, recognizing that some residential customers build out a home solar system in stages.

Additional policies which drive residential solar in Texas are:

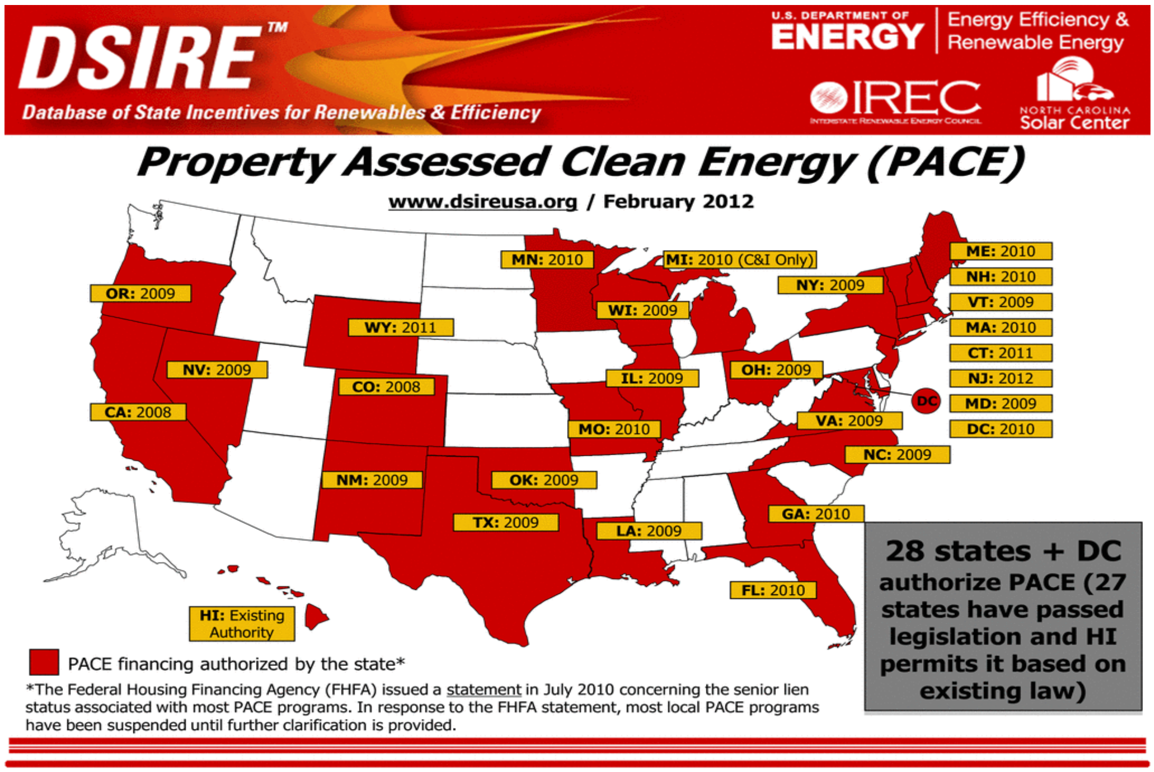
- Building Energy Codes
- Energy Efficiency Resource Standard
- Energy Standards for Public Buildings
- Fuel Mix and Emissions Disclosure for Utilities, Mandatory Renewable Energy Educational Materials for Customers
- Interconnection Standards
- Green Mountain Energy Company renewable energy buy-back program to Texas customers that produce renewable energy from distributed generation systems (voluntary net metering type)
- Renewable Portfolio Standard
- Solar Rights/Access Policy
- City of Austin Renewable Portfolio Standard
- City of Austin Solar Zoning Code
- City of Austin Green Power Purchasing
- City of Austin Net Metering

Property Assessed Clean Energy (PACE) Financing

PACE is another form of financing allowing customers to overcome the upfront costs or solar (as well as energy efficiency retrofits or other renewables). PACE is supported through investor-owned municipal bonds, and allows a residential owner to install a solar system and finance the project over time, similar to a loan. A special assessment on the property tax of the home is paid out over time and may be assessed on a utility bill within that jurisdiction. The program is pragmatic in approach and has many appealing features: the solar retrofit is attached to the property, both physically and financially, and not to the homeowner; the payment obligation transfers seamlessly with the property; projects have long-term, fixed cost financing which are advantageous to investors and to consumers; and part or all of the payment may be tax deductible at the state and/or federal level (DSIRE, 2012).

In most states, legislatures must authorize PACE special assessments, which homeowners may opt into. Five states are reported to have active PACE programs. Berkeley, California implemented the first PACE prototype, although the program is no longer active (City of Berkeley, 2012). In the last couple of years PACE has been essentially halted in some states because PACE policies gave senior lien status to PACE financing on a property, and this encountered a challenge by the Federal Housing Finance Agency for government insured mortgage loans issued by Fannie Mae and Freddie Mac. As is shown in figure 14, both California and Texas have authorized PACE financing at the state level, and New Jersey has authorized it as of 2012, although many programs across the U.S. remain in limbo (DSIRE, 2012).

***Figure 14: Property Assessed Clean Energy (PACE) Map**. (DSIRE, 2012)*



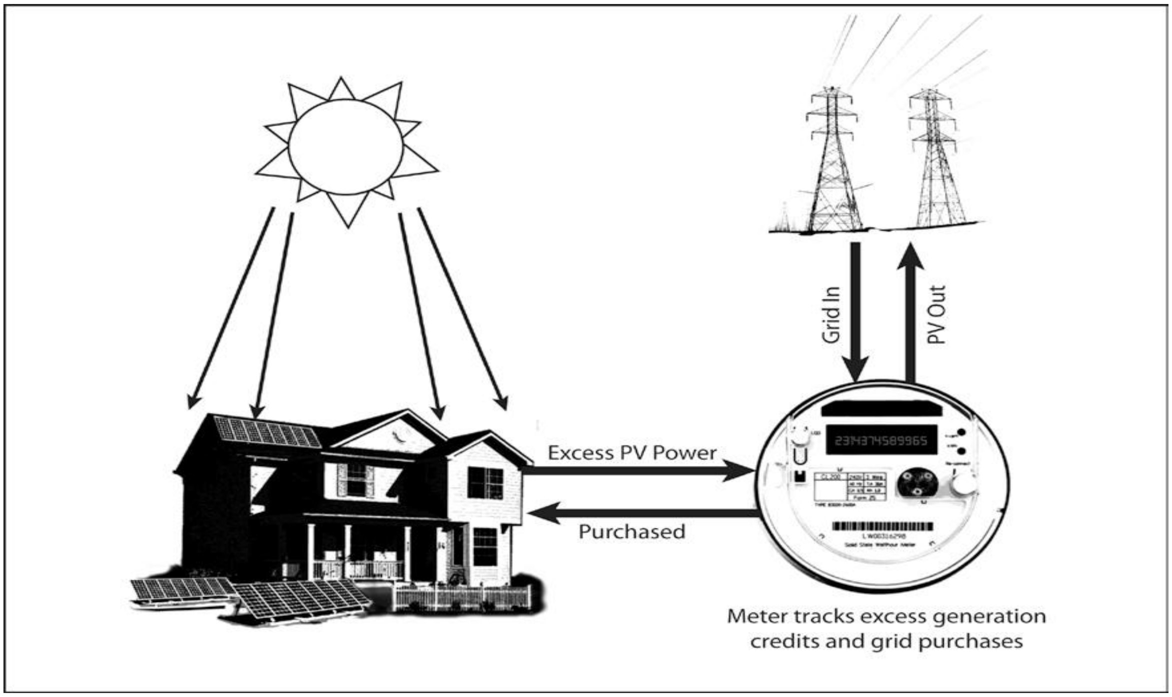
Although the SIP ideally should have included a question on PACE financing considering its potential suitability to solar financing, the survey did ask experts to rank all “financing options” including leases, PPAs, and loans relative to other market drivers. 70% of respondents ranked “financing options,” which might include programs such as PACE (although not specifically cited), as the number two or number three driver for market adoption after “dropping PV costs/increases in PV efficiency.”

A recent Forbes business article claims PACE is receiving a rebound as a bi-partisan bid is in the works to revise PACE for residential homeowners at the federal legislative level (Gerdes, 2012). Additionally, in January 2012 a federal district court in California ordered the Federal Housing Finance Agency (FHFA) to initiate a “full-blown” rulemaking process on PACE financing (Gerdes, 2012). PACE certainly deserves the attention considering its cost-effective and straightforward process, although it might threaten the competitive advantage of companies offering lease and PPA models such as Solar City. Installers and manufacturers would certainly benefit as would homeowners and communities.

Some might argue that a municipality is a credit-risk if it is involved with financing home retrofits and attaching them to property taxes, given the recent housing market. Yet, PACE programs typically do not impact state or local budgets, as the administrative costs are covered by bond issuance and interest paid by property owners that participate in the voluntary, opt-in program (DSIRE, 2012). Further, an analysis in 2011 studied the effects of residential PV systems on home sale prices in California, using an hedonic pricing model to assess the almost 90,000 residential PV installations. The authors found evidence that homes with PV systems have sold on average for a premium over comparable non-PV homes; however the authors recommended that further research is necessary to assess the impact on other real estate markets (Hoen et al., 2011).

Net Metering

Figure 12: Diagram of Net Metering. *(National Renewable Energy Laboratory, 2011)*

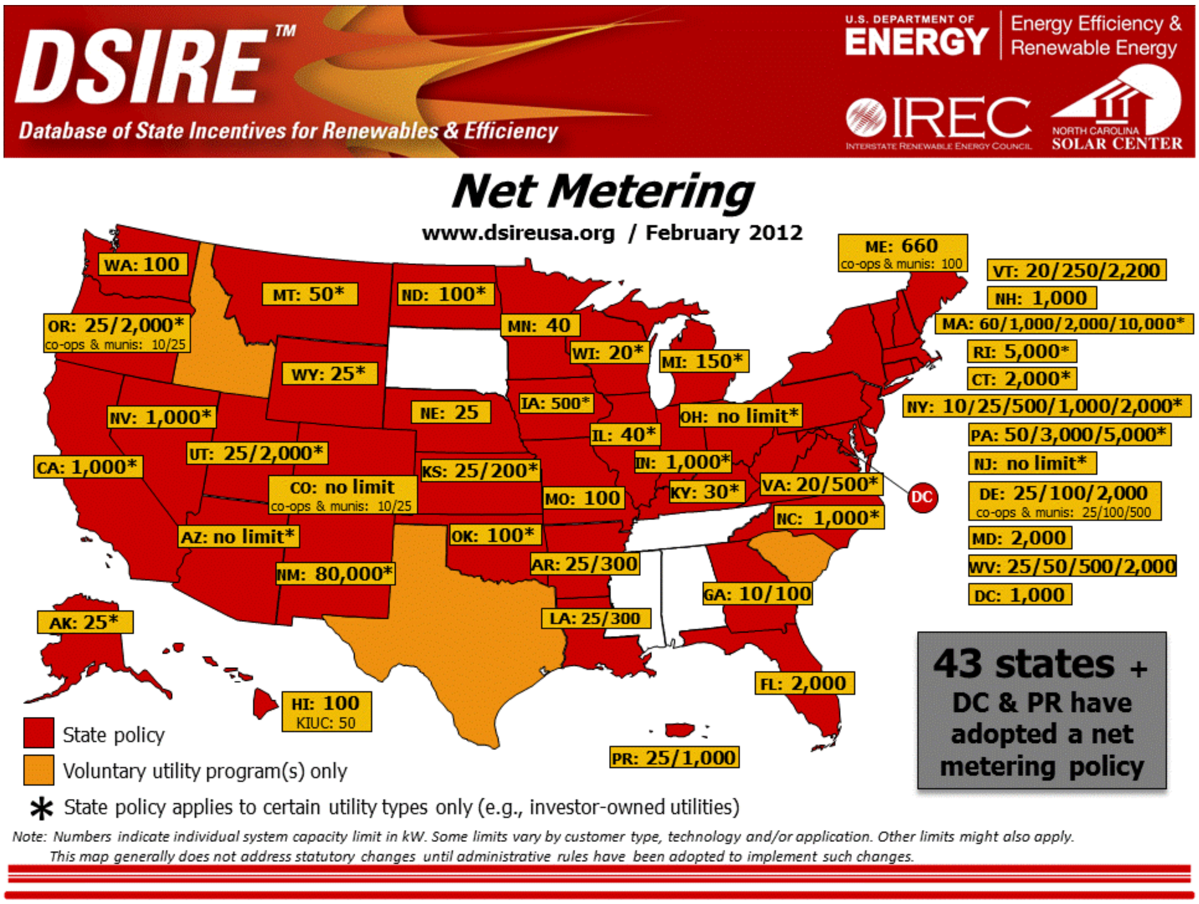


Net metering is a performance-based incentive, usually required by state policy, which allows electric customers who generate their own electricity using solar energy (or other forms of renewable energy) to bank excess electricity on the grid, usually as kilowatt-hour credits (DSIRE, 2012).These credits are used to offset electricity used during the same billing period, such as when the residential PV system is not generating enough electricity to meet the household's needs at night. The effect is to reduce grid-supplied electricity consumption and utility bill, as figure 12 shows.

Net metering is typically accomplished through the use of a single, conventional, bi-directional meter, but in some cases a special meter is required to be installed separately. Net metering has a variety of permutations such as utilities to which it applies, limits on PV system size, voluntary versus mandatory participation by utilities, and the definition of a credit. Not all states treat net metering the same, or fairly, as some argue in the solar industry (Merry, 2011).

For instance, ideal net metering to support solar is given at full retail credit. A household that delivers 1 kWh to the grid receives 1 kWh credit or payment in return (Coughlin & Cory, 2009). Some states value the credit at the highest rate structure, and this is more favorable for solar generation. Other states use a lower than retail rate known as an avoided-generation cost, or the wholesale rate. Depending on state requirements, at the end of the monthly billing cycle the utility can purchase the credits or reset credits to zero. It is important to note that this type of incentive takes place periodically over time, and does nothing to reduce the upfront cost of installing a residential PV system. Figure 13 shows net metering adoption across US states.

Figure 13: Net Metering Map of the United States*. (DSIRE, 2012)*



California has a state net metering policy which applies to all utilities except for those over 750,000 customers that also supply water (applies only to the Los Angeles Department of Water & Power which has its own net metering policy). The policy seems unnecessarily complicated. There is a 1 MW (1,000 kW) limit to residential systems, a significant limitation considering this PV system limit is roughly one-quarter the amount needed to power a typical California home (per Table 1). There is also an aggregate capacity limit of 5% of the utility's peak demand, another significant limitation which creates uncertainty of available net metering credits for residences (data from DSIRE, 2012).

Although the customer owns any renewable energy credits (RECs - discussed in next section), if a customer receives payment for net excess generation at the end of a 12-month cycle, the utility owns RECs associated with those electricity credits. Net excess generation is credited to the customer's next bill at retail rate. At the end of a 12-month cycle, the customer may roll over the credit indefinitely or receive payment for credit at a rate equal to the "12-month average spot market price for the hours of 7 am to 5 pm for the year in which the surplus power was generated" (DSIRE, 2012).

New Jersey has a more straightforward net metering policy which applies to all customers of investor-owned utilities and certain competitive municipal utilities and electric coops. There is no capacity limit, but the PV system must be sized so that energy production does not exceed the customer's annual on-site energy consumption. This latter requirement appears on the surface to be a pro-solar, reasonable policy limitation when compared to California's rather arbitrary 1 kW system limit. That is, customers can generate 100% of their own electricity, but not receive more than one year's consumption as a credit or payment. Although there is no aggregate capacity limit, the public utility board may limit net metering to 2.5% of peak demand. In general in New Jersey (there are variances), net excess generation is credited monthly to the customer's next bill at retail rate, and the remainder is reconciled annually at the lower, avoided-cost rate, and customers own all their renewable energy credits (data from DSIRE, 2012).

Texas does not have a state policy mandate for net metering, although retail electricity providers may voluntarily compensate customers. A retail provider in Texas, Green Mountain Energy Company, offers a credit/compensation scheme to their service customers for up to 500 kWh per month of net excess generation. Austin Energy, the municipal utility of Austin, offers net metering for solar systems up to 20 kW for all retail customers, with no specified aggregate capacity limit. Net excess generation is credited to the customer's next bill at the avoided-cost of generation rate (DSIRE, 2012). The latter rate is not the same level of incentive that the full retail credit is in California and New Jersey, and avoided-cost rates are often as low as 50% of retail electricity rates (Coughlin & Cory, 2009). However, given that credits under the Austin program are unlimited for systems up to sizes larger than most homes, this might not be a significant limitation. The SIP results show that net metering is not ranked highly as a driver or a barrier. Although a few did rank it highly, most ranked net metering neutral or low compared to other drivers and barriers. One possible explanation for the latter result is that professionals may place higher value on upfront cash incentives (as opposed to performance incentives) which go directly toward reducing upfront costs and system financing.

Solar Renewable Energy Credits (SRECs) and Renewable Portfolio Standards (RPS)

RECs are a performance-based, cash incentive designed to represent the environmental attributes of renewable generation (Coughlin & Cory, 2009). Typically, 1 REC equates to 1 MWh of renewable generation. In certain markets, solar RECs – SRECS - offer additional financial incentive to install residential PV, and homeowners may trade or bank the credits. To support SRECS, some states have specific solar carve-outs in renewable portfolio standards (RPS) which require a certain level of solar generation as part of an overall state-mandated goal for renewable generation. In some states homeowners can trade SRECs. These credits are often used to satisfy state-level RPS by utilities, which may install renewable generation and/or trade or bank credits to satisfy the state-mandated requirement.

New Jersey's RPS requires each electricity supplier/provider serving retail customers in the state to meet 22.5% of electricity with qualifying renewables by 2021. SRECs are traded through an online system of registered and verified trades (DSIRE, 2012). Further, New Jersey’s on-line marketplace for trading SRECs, launched in June 2004, is the first such operation in the world (DSIRE, 2012). New Jersey is often cited as the most ambitious solar market in the United States from a policy perspective.

The Texas RPS has a mandate of 5,880 MW by 2015, about 3% to 5% of the state's electricity demand, including a target of 500 MW of renewable-energy capacity from resources other than wind. RECs are traded by investor-owned utilities and retail providers, but not retail homeowners with PV systems, although it is unclear if providers of power purchase agreements for residential customers may take advantage of RECs (DSIRE, 2012). Similarly, California’s RPS of 20% renewables by 2013 and 33% by 2020 does not include a solar carve out but does include tradable RECs. However, residential PV systems may not participate (DSIRE, 2012).

Emerging Feed-In Tariffs

A feed-in tariff (FIT) is a performance-based incentive which requires energy suppliers to buy electricity produced from renewable resources at a fixed price per kWh, usually over a fixed time period such as 10 to 20 years (GTM Research, 2009). The program can be a state, municipal or utility level program, and is another means by which states support renewable energy targets (DSIRE, 2012). Feed-in-tariffs are widely seen, along with net metering, as two of the most effective policy measures for expanding solar, and are common in Europe and notably Germany – the world leader in solar installations. Gainesville Regional Utilities in Gainesville, Florida introduced the first FIT in the United States, offering 20 year fixed-rate contracts of $0.32/kWh with a program cap of 4 MW per year.

A key attribute of FIT design is the guaranteed rate paid. One less common pricing model incorporates environmental benefits and pollution offsets of conventional generation into the price. The other more common pricing model is based on the levelized-cost-of-energy (LCOE). LCOE can be defined as the net present value of the cost of electricity generated by different sources and includes initial capital, return on investment, as well as costs of continuous operation, fuel, and maintenance (NREL, 2011). Most renewable energy FITs are based on the LCOE or utility cost basis for solar and include a reasonable return on investment calculation for investors (GTM Research, 2009).

Recently, a number of states and municipalities have passed FIT legislation. California has the largest FIT in the U.S., which residential PV owners may participate in. The program has a cap of 750MW, and allows eligible customer-generators to enter into 10, 15, or 20-year standard contracts for up to 3 MW systems at time-differentiated, market-based prices. California is currently considering changing its FIT since the system is based on the avoided-cost of a gas turbine facility (GTM Research, 2009). New Jersey and Texas have no state-level feed-in-tariffs (DSIRE, 2012).

A 2009 study of North American and European private investment professionals in clean-energy technology firms ("clean-tech") assessed feed-in-tariffs as the most effective renewable energy policy for investors, although some were skeptical of government involvement of any sort in energy markets. Further, the study noted that a FIT by its nature lends investment consistency and stability, at least 10 years or more, thereby reducing investment risk and increasing deployment (Bürer & Wüstenhagen, 2008).

System Benefit Charges (SBC)

In several states, financial incentives for renewables are funded through a modest SBC assessed on the utility bill of each customer, and this can be voluntary or mandatory. In general, public benefit funds are setup to provide funds which are set aside to support renewables projects, as well as research and development and industry recruitment incentives. Eighteen states including Washington D.C. and Puerto Rico generate significant funds for renewable deployment (and other energy measures) from this method (DSIRE, 2012).

For instance, the California Solar Initiative, often seen as an ideal model for state policy support of solar, is funded by an SBC with a goal to deploy 1,940 MW of new solar by 2017 (California Solar Initiative, 2011), enough to power up to potentially 1.9 million homes annually. California raised $441 million in 2011 from this funding mechanism and New Jersey raised $22 million. Texas does not have such a fund (DSIRE, 2012). According to the North Caroline Solar Center, $6.8 billion in funds will have been raised between 1997 and 2017 via this mechanism across all states (NREL, 2009). Given that California and New Jersey are considered solar leaders and have deployed significantly more solar than Texas, one might conclude that system benefit charges play a critical role in bridging the funding gap. However, some states have allowed these funds to be pilfered for other measures including budget gaps, lessening credibility of such funds in those states (DSIRE, 2012).

Household Motivation

In a 2009 study of buyer motivations and demographics of residential solar, the majority of purchasers had a combined income of over $100,000 per year, though a significant amount were in the $50,000 to $100,000 per year category (Hossain et al., 2009). Further, the survey showed that the average PV consumer lived a in smaller than average household and was highly educated. However, another more recent study looking at southern California's market found that third-party ownership models (lease, PPA) which demonstrate immediate cash-flow savings are shifting the residential PV market toward younger, less affluent and less educated demographics. Further, mean population demographics are good predictors of residential PV adoption in the latter California study (Drury et al., 2011).

In comparing both studies, financial considerations alone seem not to be the primary motivator for innovators or early adopters. Further, environmental motivations, while named a primary driver in the first study, were not named a primary driver in the California study. The California study confirms that for residential PV to go mainstream, it must make financial sense to the average American household, regardless of environmental concerns or benefits. Further, the California study claims that approximately 30% of recent demand is for third-party ownership systems such as lease and PPA service offerings (Drury et al., 2011).

Lower upfront costs alone are not sufficient to entice new customers. The more recent California study also claims that lease and PPA service models are successful because they significantly lower household risk, uncertainty and complexity in the decision making process (Drury et al., 2011). Another 2005 study in the U.K. confirms this assessment by noting that as solar becomes more mainstream, if consumers cannot identify the relative advantage of solar power over conventional power which is supplied readily and cheaply, then it is unlikely that adoption will follow (Faiers & Neame, 2005).

Other incentives

A 2008 NREL study modeling rooftop PV penetration scenarios for 2007 until 2015 found that PV system pricing was the single biggest variable in determining market penetration (Paidipati et. al., 2008). The 30% renewable energy tax credit, the potential for improved interconnection standards, and net metering had the biggest policy impacts, although the impact of system financing options was not considered.

Other incentives for residential PV include state sales tax exemptions, local property tax exemptions, and other municipal and utility incentives. Also, twenty states including Puerto Rico have solar industry recruitment and support including tax, grant and loan incentives to encourage economic development. Some states have expediting permitting and fee waivers for solar, both of which are often cited as sources of frustration and bottleneck in the deployment process. Finally, energy efficiency and renewable standards for public buildings are one way that states and the federal government can lead by example and spur local growth of solar.

The DSIRE solar database of federal and state incentives for renewables and efficiency maintains a comprehensive database of incentives available to anyone at www.dsireusa.org. The database is a project of the North Carolina Solar Center and the Interstate Renewable Energy Council (IREC), funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, and administered by the National Renewable Energy Laboratory. Such sites are critical to the deployment of solar, helping to aggregate and organize complex, disparate sources of information for companies, consumers and policy makers. This further underscores the critical role that private, public and non-profit groups all play together in supporting the emergence of solar.

Residential PV Market Barriers

As shown in Table 4, SIP results indicate that current PV cost and the efficiency of modules, followed by financing options, are ranked the top two barriers to mainstreaming residential solar in the United States, by approximately 85% of professionals. Policy, incentives, and private sector innovation continue to play a vital role in the near-term deployment of residential solar. Again, a trend emerges indicating that states without strong solar policy support have lower levels of solar deployment relative to other states with such support in place.

Table 4: SIP Results of Ranked PV Barriers

"Please rank these potential solar residential market BARRIERS when considering mainstream household adoption, by importance: (issues with or lack of . . .)"

	Homeowner awareness &/or education	**PV cost &/or efficiency**	**Financing options**	**State/federal/ local rebates & tax incentives**	**Net metering standards**	**Neighborhood / ordinance PV restrictions**	**Response Count**
1 (most important / biggest barrier)	23.5% (8)	**35.3% (12)**	26.5% (9)	5.9% (2)	5.9% (2)	2.9% (1)	34
2	17.6% (6)	20.6% (7)	**32.4% (11)**	20.6% (7)	5.9% (2)	2.9% (1)	34
3	18.2% (6)	**24.2% (8)**	15.2% (5)	18.2% (6)	21.2% (7)	3.0% (1)	33
4	6.1% (2)	6.1% (2)	18.2% (6)	**30.3% (10)**	27.3% (9)	12.1% (4)	33
5	24.2% (8)	6.1% (2)	3.0% (1)	18.2% (6)	**30.3% (10)**	18.2% (6)	33
6 (smallest barrier / least important)	9.1% (3)	9.1% (3)	3.0% (1)	6.1% (2)	12.1% (4)	**60.6% (20)**	33

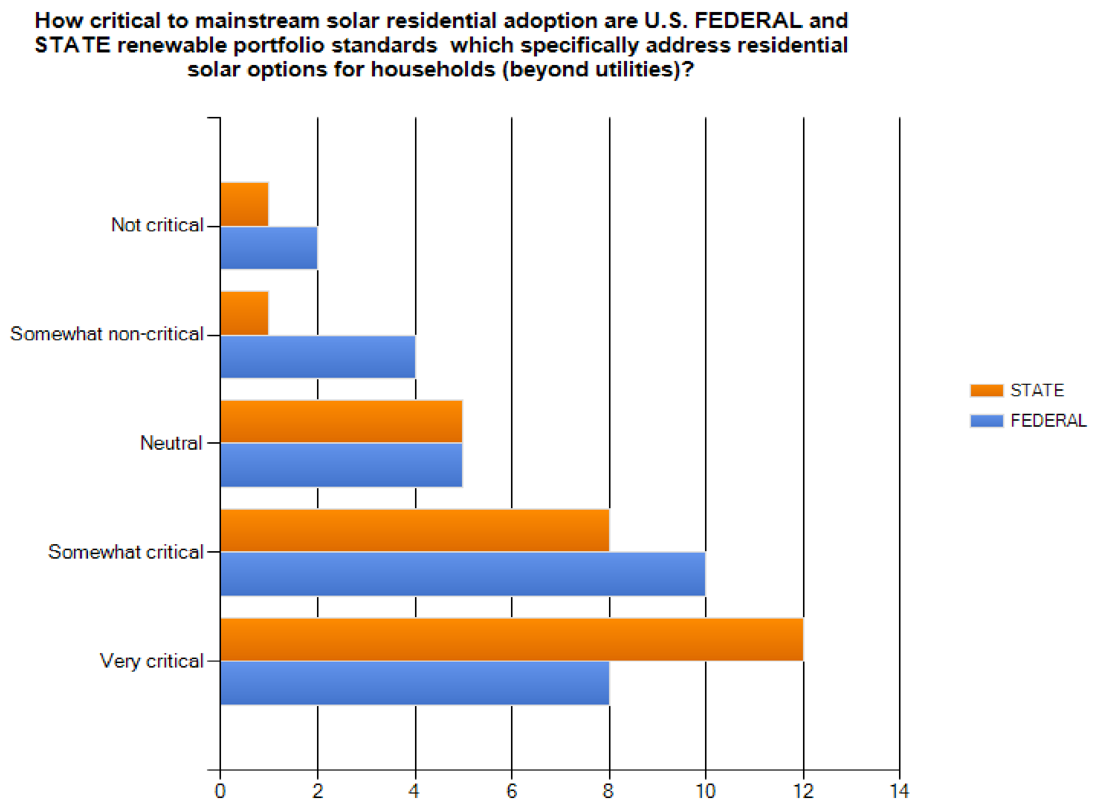
Module costs have experienced recent oversupply (SEIA, 2011), further stimulating residential installations. Recently, some in the industry have expressed concern about China "dumping" subsidized product and undercutting U.S. manufacturers (Whitaker, 2012). The U.S. Commerce Department has stated in 2012 that it would impose tariffs on solar panels imported from China after concluding that the Chinese government provided "illegal" export subsidies to manufacturers there (New York Times, 2012). As a side note, rather than seeing Chinese practices as unfair and responding with threat of import duties, the U.S. could respond with commensurate levels of support and subsidies for solar manufacturing as well. Households will demand the best product for the least price, and this combination is necessary for mainstreaming solar adoption.

Given prior discussion of the prominent role of financing options, financial incentives, and the trend toward declining PV module costs and increasing efficiency; then significant barriers will exist if these do not continue. Over the longer term, as long as prices of modules continue to trend downward and module efficiencies increase, this factor alone should supplant the role of financial, tax and other incentives. The SIP confirms this timeline assumption, given that 68% of respondents answered that residential PV will be cost-competitive is most states at the retail level without need for future subsidies in 5 to 10 years.

State renewable portfolio standards with a solar carve-out inclusive of residential PV are an example of such specific state policy goals. Consider that both California and New Jersey both have RPS requirements which specifically target solar distributed generation, and both are leaders in solar installations. One may reasonably conclude that lack of well formulated energy policy with specific solar goals is a barrier to residential PV. Further, a federal RPS or clean energy standard which sets a baseline commitment for the U.S., and which supports and builds upon state goals, may be a worthwhile policy goal.

The SIP figure 14 shows survey results of opinion on federal and/or state RPS requirements in driving residential solar. Interestingly, the survey results show strong support for state-level policies and less support for federal. Since states are the experiments for RPS standards in the U.S., then one might conclude that there is some cautious pessimism about the federal government's ability to deliver on energy policy. As one respondent in the SIP commented, the current legacy system of electrical interconnection puts states in control of retail transactions. Without a modernized grid for distributed generation, the federal government may have limited capacity to influence residential solar adoption through a federal RPS.

Figure 14: SIP Survey Results of State or Federal RPS Requirements.



Solar Access & Solar Rights

Interestingly, the 60% of respondents ranked potential neighborhood ordinance or deed restrictions restricting solar PV systems as the least critical barrier to adoption. Yet, fully 39 states and the U.S. Virgin Islands have enacted solar access and/or solar rights laws of some sort at the state level, which are designed to protect a residence's ability to access sunlight or install PV systems on a home. In general, the majority of solar easement statutes stipulate that any instrument creating such an agreement must contain certain elements, allow for compensation to secure those rights, and be recorded (DSIRE, 2012).

Solar easements are designed to secure access to sunlight from shading and adjacent buildings, and are the most common type of such legislation. It is important to note that a state law which authorizes an easement is not necessarily a protection to install PV or have access to sunlight; laws that allow for voluntary solar easements may have limited effectiveness since an owner has no guarantee of an agreement with a neighboring party who might interfere. Solar rights laws are designed to block or override any potential local private restrictions such as homeowner association rules or building codes which might interfere with the installation of residential PV (DSIRE, 2012).

Texas has a solar rights provision recently enacted in 2011. Property or homeowner associations (HOAs) in Texas are not allowed to include or enforce provisions which prohibit or restrict homeowners from installing solar PV. However, there are many caveats. Texas HOAs may still prohibit PV if a system violates public health and safety, is located on common or community property, and is taller than the fence if placed in the yard, or does not conform to the HOA rules on “proper” roof placement or color. A homeowner may counter the roof placement requirement if the owner can show the rule negatively impacts performance more than 10%. Further, the HOA may prohibit PV if permission is not sought first, or if the system interferes with the “use and enjoyment” of the land for other people. Of course, these caveats and especially the latter exception create potential for legal challenges, and certainly carry risk and uncertainty for Texas households seeking to install PV systems subject to an HOA (data from DSIRE, 2012).

Both California and New Jersey have enacted solar access and solar rights laws. Municipalities within those states may also have zoning codes or city ordinances designed to protect residential PV (DSIRE, 2012; Coughlin & Cory, 2009). New Jersey seems to have carefully contemplated a solar rights law that is more protective of homeowners. In 2007, the state enacted legislation which prevents HOAs from prohibiting PV systems. Like Texas, New Jersey has some caveats such as exemptions for community property regulations on size and placement. However, an overriding feature of the New Jersey statute is a provision which states that any regulation which would increase system costs more than 10% or prevent the system from operating at “maximum efficiency” is not enforceable (DSIRE, 2012).

California has several solar provisions for access and rights. The civil code allows for voluntary solar easements and subdivision level easements to ensure access to sunlight. California further stipulates that vegetation planted after a solar device is installed may not obscure more than 10% of PV collection between 10a.m. and 2p.m. (does not apply to prior plantings). Further, the Solar Rights Act of California bars any HOA from restricting PV systems, and bars any public entity receiving solar funding from placing unreasonable restrictions in place. Aesthetic restrictions must cost less than $2,000. Building inspectors are limited to health and safety requirements when reviewing solar installations. To further empower residents, any suit brought over solar results in the prevailing party being awarded reasonable attorney fees. Finally, all PV applications to a governing authority must be answered in 60 days or the project is deemed approved, and the Act provides penalties for any HOA which willfully violates this rule (DSIRE, 2012).

PPA Regulatory Barriers

Considering the private sector has taken a leadership role in creating financing options for residential PV installations, a number of potential regulatory and legislative challenges exist for power purchase agreements (PPA) which are taking time for states to work through, according to a recent study co-authored by Duke University and the NREL (Kollins et al., 2010). For example, if a state defines an electric utility as a seller of electricity or includes power generation equipment in the definition of an electric utility, then a third-party provider may be subject to public utility commission (PUC) regulation.

In addition, some municipal electric monopolies may prohibit the sale of power by other providers. To address this situation, California has determined that third-party owned systems and non-traditional power generators are not utilities. Further, municipal utilities and rural cooperatives are concerned that by allowing a third-party to sell electricity in their territory, they may be forced into deregulation by the PUC, as is the concern in Texas (Kollins et al., 2010). No limitations within New Jersey are noted. There are two potential alternatives to these PPA challenges. One alternative is the third-party leasing model discussed in this report, whereby the leasing company is not technically “selling” power. The other is for utilities themselves to act as installers and providers of residential PV. Interestingly, considering the market opportunities presented throughout this report, not many utilities appear to be seriously considering solar lease or PPA offerings to their current, captive client base.

Interconnection Standards

Interconnection standards refer to the technical and legal requirements for connecting distributed generation systems to the regional utility grid. A myriad of concerns are involved including engineering standards, safety provisions, maintenance issues, and political and economic interests (Kollins et al., 2010). Although the federal government, through the Federal Energy Regulatory Commission (FERC), sets standards and regulations for connecting to the grid, states and their public utility commissions can and do also regulate distributed generation including residential PV systems, and these regulations vary widely by state.

Forty-three states plus D.C. and Puerto Rico have interconnection standards or guidelines, and some of these only apply to net metering (if authorized or mandated). Given the adoption of RPS by states to include renewable generation, states have generally trended toward establishing comprehensive standards. IREC, the Interstate Renewable Energy Council, has established best practices for states to limit barriers to distributed renewable energy deployment. Notable recommendations include (DSIRE, 2012):

- a provision that all utilities should be subject to the state interconnection policy

- no system capacity limit
- standardized forms
- timely turnaround
- minimum application costs

The Texas Public Utility Regulatory Act (PURA) of 1999 included a provision that "a customer is entitled to have access to on-site distributed generation," which applies to investor-owned utilities with a size limitation of 10 MW. California's "Rule 21" specifies standard interconnection, operating and metering requirements for systems up to 10 MW with separate simplified rules for small renewables. New Jersey standards apply statewide to all electric distribution utilities, but not to municipal utilities and electric cooperatives. All states specifically address residential interconnection standards, and California and New Jersey also specify net metering, but not Texas (DSIRE, 2012).

A recent study concerned with the future landscape of electricity generation argues that efficient integration of multiple sites of generation will require network innovations such as "active distribution network management." Such a system will ideally be less centralized and more of a distributed system (Rujula, 2008), reflective of the current IT trend in distributed computing with nodes and interconnected networks. This type of configuration should increase system security, redundancy and efficiency and is often termed a "smart grid."

Lack of Net Metering

Although policy papers and industry publications make considerable mention of net metering standards as a significant barrier if not in place, the SIP results do not consider net metering to be a significant driver nor a significant barrier. Professionals ranked net metering 4 or 5, where 5 is the least important barrier. This discrepancy is a bit puzzling since net metering, besides being a performance based financial incentive, is also a technological way to virtually "store" solar production. Batteries are expensive, and the grid acts as a reliable and cost-effective back-up. Given that net metering is prevalent in the two top installation states of California and New Jersey and is not mandated in Texas, a state with much lower relative PV installations, then one may reasonably conclude that net metering is a critical deployment variable in residential PV.

Permitting, Paperwork & Fees

A study in 2007 by the Solar Electric Power Association of several hundred customers in various states found that the majority of customers cited the permitting and installation process of residential PV as "easy" (Hossain, 2009). Informal interviews for this report with industry professionals cast doubt on this finding. Since we do not know the experience of the PV installers during the installation, then a drawback of the study is that it did not interview other key stakeholders in the PV installation process such as installers. Installers might very well have rated the permitting and paperwork process differently from customers. Further, permitting incentives have presumably been put in place in key solar markets to reduce burdensome permit fees and review times.

Expedited permitting may be an incentive for installers and consumers, and if significant impediments are in place then the latter may serve as a barrier. For instance, permitting fees across the U.S. range from $0 to more than $1,000 (DSIRE, 2012). Informal interviews of certain industry professionals indicate that some markets do have excessive permitting fees and other bureaucratic obstacles. Further, there is some suspicion of utilities using interference tactics to delay permitting and impose excessive paperwork burdens in certain markets. A Sierra Club initiative publicized fees as high as $1,074 in certain California markets in 2005 which led to permit fee changes in those markets, and a follow up study in 2008 found that those fees had dropped significantly (DSIRE, 2012).

Household Awareness and Education

Informal interviews of industry professionals cite homeowner awareness and education as a critical factor in residential PV deployment. Although 23% of SIP respondents ranked "homeowner awareness or education" as the number one barrier, the survey did not show a consensus among respondents as to the importance of this potential barrier. Nevertheless, individual consumers must research and apply for each applicable incentive unless assisted by an installer or other service provider, and this certainly adds complexity to making a PV purchase decision.

Most residences are likely unaware of the PV options, benefits or financial alternatives for residential PV. A number of initiatives have been launched to address this information gap. Twelve states have solar licensing requirements for installers including California, but not Texas or New Jersey (although these states may require certifications to participate in certain funding programs administered by the state) (DSIRE, 2012). Also, a number of online tools have emerged, some sponsored by solar companies, which help homeowners and installers correctly estimate the size of a PV system, estimate costs and monthly payments, research incentives, as well as locate a local installer.

Such websites offer information about residential PV, system parameters, benefits and costs, and other considerations and include:

- PVWatts developed and hosted by the National Renewable Energy Labs (a DOE project) at www.nrel.gov/rredc/pvwatts
- Solar Estimate.Org at www.solar-estimate.org, an industry sponsored site
- The Clean Power Estimator at www.consumerenergycenter.org/renewables/estimator/ from the California Energy Commission.

All these are available free to consumers. To assist potential residential solar installers, the System Advisor Model (SAM) is performance and financial software created by NREL and available for download. SAM claims to make performance, cost and energy estimates for solar power (and other renewables) based on installation, operating costs, and system design parameters that the user specifies.

Best Policy Practices

A consensus of best practice recommendations are set forth below. These have been articulated in various forms by the DOE's Million Solar Roofs Initiative, the National Renewable Energy Laboratory (NREL) the Solar Energy Industries Association (SEIA), the Interstate Renewable Energy Council (IREC), and the Clean Energy Group, a coalition of electric generating and electric distribution companies committed to environmental stewardship.

- Create consistent, long term federal and state financial incentives over at least a 10 year period to ensure stable project investment and returns, and to bridge the near-term cost gap between solar and conventional power. This should be coupled with step-down support over time to signal to the market a clear timeline and to reduce near-term uncertainty and boom/bust cycles.
- Establish state-level installed capacity or a grid parity price goal with carve-outs for residential solar in RPS.
- Adopt state-wide, standardized, low-cost interconnection standards for residences and net metering requirements for all utilities, with credits earned at full retail rate, and no unreasonable size limitations or aggregate generation caps.
- Support use of third-party owned systems including PPA and lease service models.
- Consider local sales tax and property tax incentives such as PV exemptions from both.
- Remove solar barriers in permitting, ordinances, and deed restrictions at the state level.
- Lead-by-example and "seed" solar projects at the state and municipal level for public housing, education, and mix-use developments which make use of public money.
- Support installation training and reasonable licensing standards at the state level.

- Support grass-roots campaigns to educate and raise awareness about the options for residential PV, costs and benefits. Lack of knowledge and resources for adopting solar is perhaps one of the most significant yet under-recognized barriers to adoption.

Research & Development (R&D) and Public/Private Investment

The goal of the U.S. Department of Energy's Million Solar Roofs Initiative (now concluded) was to transform markets for distributed solar technologies by facilitating the installation of solar systems (DOE Million Solar Roofs, 2006). DOE's newer Solar America Communities program is now working to remove market barriers and encourages the adoption of solar energy by residents and businesses in local communities. The program objective is to develop comprehensive approaches that lay the foundation for a viable solar market and provide a model for communities throughout the United States (DOE Solar America Communities, 2011). The current Sun Shot Initiative of the DOE is a collaboration amongst academia, the private sector, and government national labs which aims to dramatically decrease the total costs of solar energy systems by 75% before the end of this decade. The program funds select research and loan guarantees for high risk, high payoff concepts and technologies that show transformation potential (DOE Sun Shot, 2011).

One such high-risk and now notable failure of the program is California-based Solyndra, a PV module manufacturer. One market analyst claims that the DOE loss, while important, represents about 1% of the $38 billion loan guarantee portfolio that DOE manages (Plumer, 2011). Further, a new report from the American Energy Innovation Council claims that the utility sector spends just 0.1% of revenues on R&D while the average for other U.S. industries is 3.5%. This is attributed to capital-intensive, long-term time horizons for electricity generation (and likely entrenched business practices and regulatory frameworks). Further, the federal government spent about $3.9 billion in funding energy projects, compared to $36 billion for the National Institutes of Health and $77 billion for defense research (Plumer, 2011).

Considering energy is the building block of our economy, this point argues in favor of a comprehensive national energy policy which clearly increases set-aside funding for emerging energy technologies and seeks to match public and private money. Daniel Yergin, chairman of HS Cambridge Energy Research Associates and Pulitzer Prize winning authority on the political economy of energy, notes that total annual energy R&D spending in 2008 was equivalent to two weeks' spending on the Iraq War. He further makes the case that "with the decline in corporate research, the basic science and R&D endeavor has increasingly been driven by what has over the last 70 years been the largest engine of scientific advance, and the biggest funder – the U.S. government (Yergin, 2011)."

Private and public collaboration toward economic and industry goals have always proven critical in making large scale technology and innovation leaps in the United States. NASA and the aerospace industry, the former DOD Arpanet and the commercialization of the Internet are two major examples.

Recent federal legislation such as the Emergency Economic Stabilization Act of 2008 and the American Recovery and Reinvestment Act of 2009 are providing increased levels of support for the U.S. solar industry, and global venture capital and private equity investment in solar totaled $2.3 billion in 2010, representing a 58% compounded annual growth rate from 2004 to 2010 (SEIA, 2011).

LCOE and Grid Parity

Levelized cost of electricity (LCOE) is a useful tool for comparing different sources of electricity generation, and is often defined as the present value of the total cost of building and operating a PV system over an assumed financial life and duty cycle, converted to equal annual payments and expressed in terms of real dollars to remove the impact of inflation (DOE, 2011). LCOE is often the tool used in industry publications or policy reports to compare different utility generation projects, and as such, some argue it is not as useful for residential applications.

$$\text{LCOE} = \frac{\text{Total Life Cycle Cost}}{\text{Total Lifetime Energy Production}}$$

For one, an LCOE calculation of $25,000 to install and operate a PV system over 25 years which yields 150,000 kWH over the lifetime of the PV system would result in an LCOE of $0.17/kWh for such a PV system. This calculation might be more useful for comparing a utility-scale PV project with a coal plant, but perhaps not a residential PV project with a typical municipal utility. For one, retail electricity rates reflect LCOE but are not synonymous. Second, if we assume most customers focus on cash-flow analysis or simple payback based on avoided cost of retail electricity rates, then LCOE is not very useful. Also, most homeowners move on average every 5 to 7 years (About.Com, as quoted in New York Times, 2012) and will not realize the LCOE over the full life-cycle.

LCOE is useful for companies where large capital outlays are considered for projects. As such it is a utility-scale perspective and an important tool for a company capable of realizing future cash-flows from a project. It is worth noting that LCOE calculations do not take into account the externalized environmental costs of traditional generation such as air pollution, resource extraction and CO_2 emissions. Though in fairness, calculations for solar PV systems do not consider these either; that is, solar PV may in fact avoid significant environmental costs *relative to* a coal-fired power plant, but the LCOE cost of solar does not take into account the environmental footprint of manufacturing PV, transporting modules, nor installation. LCOE has also been criticized as a utility-driven perspective with a least-cost power mandate, with no accounting for the potential effects of peak shaving or future potential to balance demand when a smarter, distributed grid is implemented (Merry, 2012).

A study in Energy Policy notes that the cost effectiveness of distributed generation PV may be further away from grid parity than industry enthusiasts hope (Yang, 2009). Another recent study in Renewable and Sustainable Energy Reviews finds that due to technology trends and favorable financing terms, PV is already obtained grid parity in specific locations as installed costs continue to decline, grid electricity prices continue to escalate, and industry experience increases (Branker et al., 2011). More importantly, the latter study looks at a number of LCOE calculations from different studies across North America, including Yang's. The authors find a "lack of clarity of reporting assumptions, justifications, and degree of completeness, which produces widely varying and contradictory results." As a benchmarking tool for solar, LCOE is highly sensitive to the assumptions made, especially when making forecasts such as predicting grid parity (Branker et al., 2011).

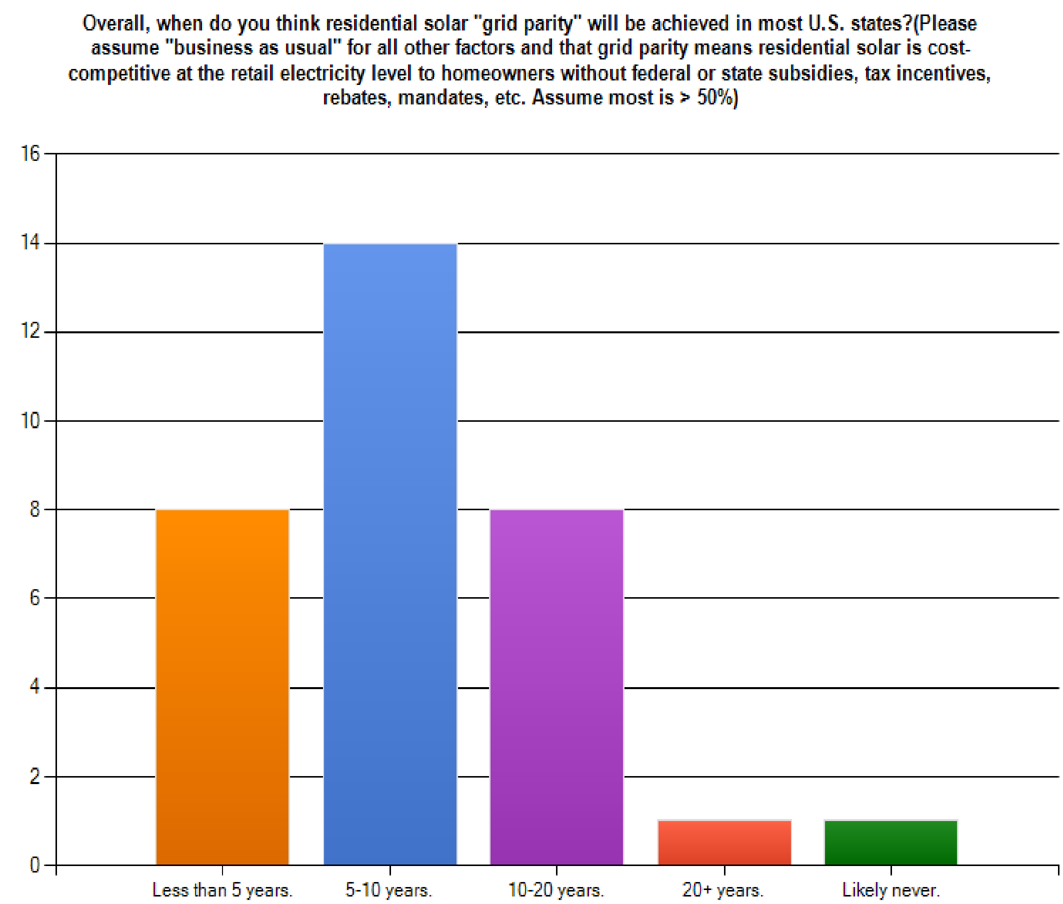
The study notes the importance of explicitly defining the variables below and stating all the assumptions for a proper LCOE calculation (Branker e al., 2011):

- Discount rate used (role of inflation)
- Financing method
- Average system lifetime (20, 25, 30 years)
- Degradation of energy over system lifetime: 0.5% annually is common but may be too high
- Average system price. Note that PV modules are around 50% of costs while BOS are also around 50% of costs.

The authors of the latter LCOE study find that upfront cost and cost of financing are primary, and thus LCOE is highly dependent on financing method and PV cost reductions. A compelling observation from their study is that a 0% interest loan for residential PV over a long period can result in the lowest LCOE values. To test this assumption, the data from this report's Table 1 were calculated again, yet using a potential alternative test policy with 0% APR for solar PV loans over 25 years and found that under each scenario, monthly cash flow is positive.

Grid parity can be defined as break-even costs for PV systems where cost of PV-generated electricity equals the cost of electricity purchased from the grid (over a 20 year period, for instance), and may be shown in $/W for an installed system (Merry, 2012). A 2009 NREL study of the largest 1000 utility markets assessed grid parity for residential PV and found, not surprisingly, that break-even cost of PV varies by a factor of more than 10, despite a much smaller variation in solar resource. Achieving PV breakeven is a function of several variables, including the solar resource, local electricity prices, and federal and state incentives; this leads to considerable variation in break-even cost across the U.S. The authors simulated deployment until 2015 and found that key drivers of grid parity are the availability of system financing, the cost of electricity, and the rate structure; as opposed to often-assumed technical factors such as solar resource and orientation (Denholm et al., 2009). Figure 15 below shows SIP results of professional opinion assessing when grid parity might be reached for most (>50%) of U.S. markets.

Figure 15: **SIP Results of Grid Parity.**



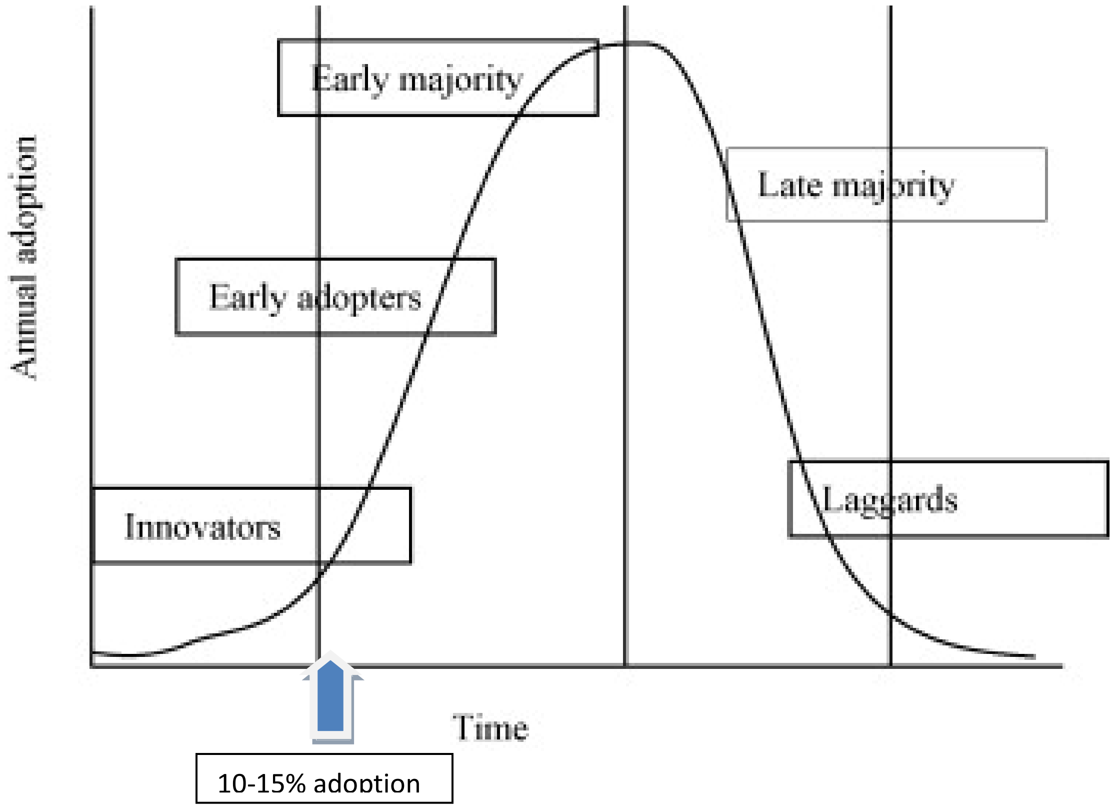
When considering LCOE and grid parity, the latter often being considered a tipping point for mainstreaming solar adoption, it is important to consider that LCOE is not the same as retail electricity prices, although it often used as a proxy. This has important implications for speculation of grid parity: is it cost parity, wholesale generation parity, or retail electricity parity? Additionally, a very important consideration in LCOE and grid parity debates is the role of cash and tax incentives such as FITs and net metering, which affect the net installed costs of residential PV. Are these incentives coupled or decoupled from the installed cost assumptions?

Some might argue incentives distort the "true market cost" or market grid parity of solar PV, and argue against subsidies of any sort on the grounds of favoritism or market distortion. However, aside from the fact that all markets share distortions and inefficiencies of one sort or another, it should be noted that many recent studies have emerged highlighting long-standing subsidies and tax incentives available to conventional generation. Environmental Law Institute's 2009 comprehensive study found subsidies to fossil fuels, a mature industry, totaled approximately $72 billion over the study period 2002 to 2008. This represents a direct cost to taxpayers since most of the largest subsidies to fossil fuels were written into the U.S. Tax Code as permanent provisions. In contrast, subsidies for renewable fuels, a developing industry, totaled $29 billion over the same period. Further, many subsidies for renewables are initiatives implemented through energy bills, with short timelines and significant budget risk for investors, installers, and consumers (Environmental Law Institute, 2008).

PV Tipping Points and Technology Diffusion

Tipping points can be thought of as critical thresholds beyond which ideas go from the minority to the majority. A modeling study at Rennselaer Polytechnic Institute, using computer models of social networks, found that when "committed opinion holders" of a new idea reach 10% of a population, it quickly goes mainstream (Rensselaer, 2012). In a similar vein, multiple diffusion models exist which attempt to model and predict market penetration of consumer electronics, automobiles, and other products, as shown in the product diffusion curve in figure 16. Often, the barrier between innovators and early adopters is delimited at about 2.5% of a given population. Given that residential PV is less than 1% of installations and solar overall is less than 1% of generation, residential PV is undoubtedly still in the "innovator" phase. Will residential PV follow this diffusion model?

Figure 16: A Typical Product Diffusion Curve. (Sustainable Energy Reviews, 2009)

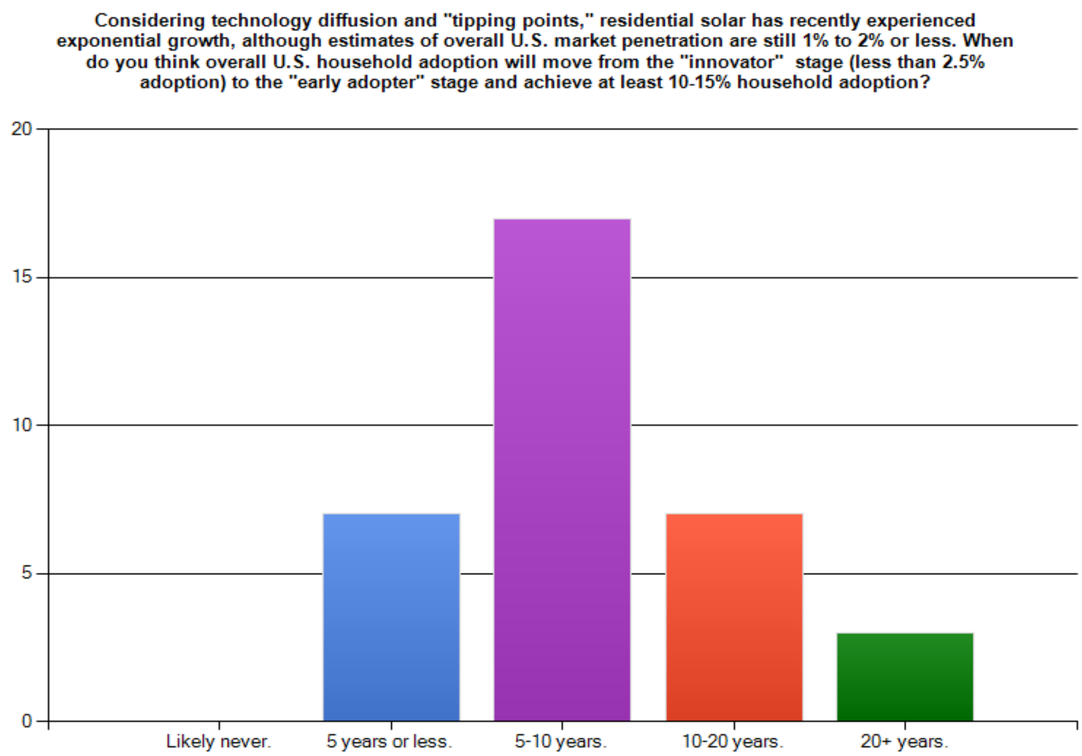


California has approximately 90,000 residential PV installations (Hoen et al., 2011) out of 6.9 million single family homes (2000 census), which represents less than 0.1% adoption . This is decidedly "innovator" under a typical product diffusion model. To reach 10% of single family homes in California would require 23% CAGR per year. California must add some 60,000 solar equipped homes to the grid every year for the next 10 years to reach 10% penetration in the market based on 2000 housing data and not counting new housing.

Similarly, there are approximately 77 million single family homes in the U.S., based on 2000 census data plus an estimated 10% growth factor. Assuming approximately 250,000 current installations (Sherwood, 2011; SEIA, 2012) yields 0.3% single family home PV market penetration as of 2010. To reach 10% of single family homes nationwide would require 41% CAGR of residential PV installations over 10 years, or 19% CAGR over 20 years. Growth may be measured by number of installations, installed capacity, or installed capacity per capita. Since 2005, installed capacity of residential PV has grown approximately 49% per year from 27 MW_{dc} installed in 2005 to 297 MW_{dc} total installed capacity in 2011 (SEIA, 2011; SEIA 2012) as shown in figure 5. According to LBNL, 1MW of electricity has conventionally been reported to power approximately 1,000 U.S. homes, yet 600 to 750 homes is probably more accurate with some estimates as low as 200 homes. LBNL cautions the old “rule of thumb” can be misleading.

Growth figures needed above are within the range of recent industry growth, and are also consistent with SIP survey results as noted below. Growth trends may increase if installed costs continue to drop, electricity prices continue to rise, and more financing innovations continue to drive the market. An analysis by Ramez Naam in Scientific American reviewing NREL data claims that PV costs are in fact dropping exponentially, and efficiency is increasing exponentially for every dollar spent, when calculated over the last 30 years. In fact, the author claims that at the current rate, PV will cross grid parity and be half the cost of conventional electricity by 2030 (Naam, 2011).

Figure 16: SIP Results of Tipping Points.



Considering tipping points, figure 16 shows that about 70% of SIP respondents think that adoption will cross a tipping point to early adopters and achieve at least 10% to 15% household adoption within 10 years. About 20% of respondents think 10 to 20 years, and 10% claim longer than 20 years. According to a technology diffusion study, diffusion of technologies does not follow a single, uniform pattern and is a complex phenomenon with many exceptions (consider that nuclear power has had over 40 years to achieve less than 20% of generation capacity). Rather than necessarily predicting a trend in a given time frame, flipping the model as a test rather than a prediction might be more useful. Since policies may help or hinder diffusion, then diffusion models for renewables such as solar, rather than predicting outcomes or timing in the future, might rather be a good gauge by which to measure and evaluate policy outcomes (Rao & Kishore, 2009).

V. Conclusion

Industry trend data and survey opinion confirm that dropping costs, increasing PV efficiency, and more financing options are the significant current drivers of residential PV and account for the recent surge in installations. Although installed costs vary greatly by state and municipality, PV residential costs over the last 10 years have dropped exponentially. A critical perspective for financing residential PV systems is the monthly cost of financing relative to monthly utility bill savings from the grid. Companies with expanded financing options such as PV lease and power purchase agreements (PPA) are currently leading installations by demonstrating immediate monthly cash-flow savings and turn-key service.

California and New Jersey lead PV installations with commensurate policy support and financial incentives, while Texas by contrast has much less PV installation and relatively little policy support. Federal and state financial incentives include tax credits and cash rebates. Performance incentives include net metering, system benefit charges, and solar renewable energy credits. Though not widely used, a more robust 0% APR policy with 100% financing over a longer term may produce immediate monthly utility savings and serve as another policy or private sector financing tool. Based on installations and cost trends, incentives are working by reducing the short-term cost gap between solar and conventional power and thus making lease, PPA and other financing options cash-flow viable.

Seventy percent of survey professionals indicate residential PV will shift from innovator to early adopter stage and achieve at least 10% penetration within 10 years. Survey results also indicate most professionals think over 50% of U.S. electric markets will reach grid parity in 10 years or less. Analysis in the report suggests that solar retail grid parity is at least 5 to 10 years out for most markets in the United States, 10 to 20 years for others. Assuming cost and adoption trends continue to improve, reaching a critical adoption threshold or tipping point of 10% of U.S. households is likely in 10 years for many markets and up to 20 years for others. Incentives are critical in the short-term as the cost gap between solar and conventional generation closes, and according to this report's analysis have cut simple payback times in half for residential PV systems.

Federal, state and local financial incentives are critical to adoption and should be maintained ideally for 10 year periods to ensure financing and investment stability. States and municipalities should minimize any local roadblocks to adopting solar including excessive permitting fees and paperwork, and should support third-party ownership of PV systems such as leases, PPA's, and other financing options. Specific installation goals are critical for accountability as with state renewable portfolio standards (RPS) as is government support for research and development. Subsidies for solar (and for all renewables) might be linked not just to installation goals in a state

RPS, but could also be tied to retail price parity with conventional generation. As solar reaches grid parity, subsidies could be scaled down over time.

Finally, awareness and education of the options and benefits of adopting residential solar are important and necessary if we are to reduce emissions, increase domestic energy supply, and diversify the nation's supply mix away from current overreliance on fossil fuels. Household solar stands to make a significant and enduring contribution in the near future.

We are like tenant farmers, chopping down the fence around our house for fuel, when we should be using Nature's inexhaustible sources of energy — sun, wind and tide. I'd put my money on the sun and solar energy. What a source of power! I hope we don't wait till oil and coal run out before we tackle that.

-- Thomas Edison in conversation with Henry Ford and Harvey Firestone (1931)[2]

[2] as quoted in *Uncommon Friends: Life with Thomas Edison, Henry Ford, Harvey Firestone, Alexis Carrel & Charles Lindbergh* (1987) by James Newton, p. 31.

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VII. Appendix A Installed Cost Tables

Table 1: Residential PV installed costs with simple payback analysis, before & after incentives

(based on 2010 data, inflation & electricity cost escalator not included)

State	Avg. retail price of grid electricity in ¢/kWh	Avg. monthly consumption in kWh	Avg. monthly bill in $	Avg. upfront cost PV installed, *no incentive* $/$W_{DC}$	Years to payback system	**Avg. upfront cost of PV installed *after* state + federal incentives in $/$W_{DC}$**	**Years to payback system *after incentives***
CA 2.37 KW_{dc}	14.75¢	562	$82.85	$7.3	35	$4.0 **$ 9,480 total**	**19**
NJ 3.46 kW_{dc}	16.57¢	731	$121.13	$7.1	34	$4.0 **$13,840 total**	**19**
TX 5.29 kW_{dc}	11.6¢	1199	$138.99	$6.4	40.5	$2.7 **$14,283 total**	**17**
Natl Avg 4.31 kWd_{c}	11.54¢	958	$110.55	$6.2	40	$3.6 **$15,516 total**	**23**

Table 2: Residential PV basic monthly cash-flow analysis, after incentives

(based on 2010 data, inflation & electricity cost escalator not included)

State	Monthly cash-flow gain/loss to homeowner 25 yr. home-equity loan @ 6% interest (PV retrofit)	Monthly cash-flow gain/loss to homeowner 30 yr. new home loan @ 6% interest (PV bundled)	**Test policy case: 0% APR (25 yr)**	CO_2 emissions averted over 25 years
CA	**$19/mo**	**$12/mo**	**$10/mo**	69 tons
NJ	**$28/mo**	**$18/mo**	**$14/mo**	90 tons
TX	**$22/mo**[7]	**$11/mo**	**$22/mo**	147 tons
National Average	**$44/mo**	**$33/mo**	**$4/mo**	118 tons

Tables 1 & 2 Footnotes:

Cost data from Lawrence Berkeley National Labs, *Tracking the Sun IV*, 2010. Total system cost and size is based on PV system for 50% grid-offset.

For a given geographical location in Table 1, a solar PV system computation using solar-estimate.org for each state's capital city is computed, based upon some standard assumptions of a solar calculator:

- solar orientation and solar insolation (sun-hours available as per PV Watts)
- unsoiled PV panels
- 25 degrees Celsius with calm wind
- no backup batteries / grid-connected
- no shading
- 95% energy delivered as a per-cent of manufacturer's rating
- 9% wiring and power point tracking losses
- 90% inverter efficiency
- total energy delivered is approximately 78%.

This calculation is based on correctly sizing and installing a system to offset approximately 50% of grid-supplied electricity, using 2010 state-averaged energy consumption and retail electricity rates published by the Department of Energy (DOE), and based on the annual avoided-cost savings of grid supplied electricity.

Installed cost data is taken from *Tracking the Sun IV, An History of the Installed Cost of Photovoltaics in the United States from 1998 to 2010*, a Lawrence Berkeley National Laboratory (LBNL) ongoing study revised every few years (Barbose et. al., 2010).

Location-specific data for states was computed based on Austin (TX), Sacramento (CA), and Trenton (NJ), except for the national average scenario, where an average system size of 4.31kWH was used.

For calculating the pre-installed costs and net installed costs of solar PV bundled with a new home purchase, new home data for each state and a national average as of 2010 was taken from Yahoo-Zillow Real Estate Network.

Figures from CO_2 emissions were calculated using solar-estimate.org, which calculates emissions averted using data from The Cadmus Group, and is based on an estimated average emissions factor of 1.64 pounds CO2 per kWh, with annual CO2 emissions estimated at 20,000 lbs per household at 1,000kWh use per month.

VIII. Appendix B Survey Instrument

Solar Residential Poll of Industry Experts SurveyMonkey

Over the long term, how realistic do you think residential solar technologies such as photovoltaic panels for electricity, solar heating, etc., are as an energy option for U.S. households?

	Response Percent	Response Count
Very unrealistic	0.0%	0
Somewhat unrealistic	2.9%	1
Neutral	0.0%	0
Somewhat realistic	20.6%	7
Very realistic	76.5%	26
answered question		34
skipped question		1

Solar Residential Poll of Industry Experts SurveyMonkey

In the next few years, do you think there is a "game changing" technology on the way that will be available "off the shelf" for households, and which will dramatically expand the use of residential solar technology?

	Response Percent	Response Count
No.	67.6%	23
Yes.	32.4%	11
Optional comments:		18
answered question		34
skipped question		1

Solar Residential Poll of Industry Experts SurveyMonkey

At some point in the future for U.S. household electricity consumption, do you think solar photovoltaic electricity will be delivered primarily by utilities ("in front of the meter"), or adopted primarily by households on-site ("behind the meter")? In other words, which side of the meter will "lead the way" if and when solar goes mainstream for U.S. households?

	Response Percent	Response Count
Delivered primarily by utilities.	41.2%	14
Adopted primarily by households on-site.	**47.1%**	**16**
Neither (please explain briefly below).	11.8%	4
Optional comments:		16
answered question		**34**
skipped question		**1**

1 of 1

Solar Residential Poll of Industry Experts SurveyMonkey

Considering technology diffusion and "tipping points," residential solar has recently experienced exponential growth, although estimates of overall U.S. market penetration are still 1% to 2% or less. When do you think overall U.S. household adoption will move from the "innovator" stage (less than 2.5% adoption) to the "early adopter" stage and achieve at least 10-15% household adoption?

	Response Percent	Response Count
Likely never.	0.0%	0
5 years or less.	20.6%	7
5-10 years.	**50.0%**	**17**
10-20 years.	20.6%	7
20+ years.	8.8%	3
answered question		**34**
skipped question		**1**

1 of 1

Solar Residential Poll of Industry Experts SurveyMonkey

Overall, when do you think residential solar "grid parity" will be achieved in most U.S. states? (Please assume "business as usual" for all other factors and that grid parity means residential solar is cost-competitive at the retail electricity level to homeowners without federal or state subsidies, tax incentives, rebates, mandates, etc. Assume most is > 50%)

	Response Percent	Response Count
Less than 5 years.	25.0%	8
5-10 years.	**43.8%**	**14**
10-20 years.	25.0%	8
20+ years.	3.1%	1
Likely never.	3.1%	1
	answered question	**32**
	skipped question	**3**

1 of 1

Solar Residential Poll of Industry Experts SurveyMonkey

Consider the last 25-50 years of technological developments in the U.S. and indicate whether you agree or disagree with the following statement. If domestic solar technologies had been given the same attention and R&D budgets by the federal government as were given to the space industry, or by the computing industry as were given to the software development business; then the majority of U.S. homes would currently be powered by solar technologies.

	Response Percent	Response Count
Firmly disagree	2.9%	1
Somewhat disagree	14.7%	5
Neutral	8.8%	3
Somewhat agree	**55.9%**	**19**
Firmly agree	17.6%	6
	answered question	**34**
	skipped question	**1**

1 of 1

Solar Residential Poll of Industry Experts SurveyMonkey

Please rank these potential solar residential market DRIVERS when considering mainstream household adoption, by importance:

	Dropping PV cost &/or increasing PV efficiency	Financing options (lease/power purchase agreements/loans)	Net metering	Federal / state / local rebates & tax incentives	Household eco/green desire	Response Count
1 (most important / largest driver)	**50.0% (17)**	20.6% (7)	14.7% (5)	14.7% (5)	0.0% (0)	34
2	20.6% (7)	**35.3% (12)**	8.8% (3)	26.5% (9)	8.8% (3)	34
3	11.8% (4)	**35.3% (12)**	20.6% (7)	29.4% (10)	2.9% (1)	34
4	15.2% (5)	3.0% (1)	**33.3% (11)**	27.3% (9)	21.2% (7)	33
5 (smallest driver / least important)	2.9% (1)	5.9% (2)	20.6% (7)	2.9% (1)	**67.6% (23)**	34
			Is there another important DRIVER, and if so where should it rank?			11
					answered question	**34**
					skipped question	**1**

1 of 1

Solar Residential Poll of Industry Experts SurveyMonkey

Please rank these potential solar residential market BARRIERS when considering mainstream household adoption, by importance: (issues with or lack of . . .)

	Homeowner awareness &/or education	PV cost &/or efficiency	Financing options	State/federal/local rebates & tax incentives	Net metering standards	Neighborhood / ordinance PV restrictions	Response Count
1 (most important / biggest barrier)	23.5% (8)	**35.3% (12)**	26.5% (9)	5.9% (2)	5.9% (2)	2.9% (1)	34
2	17.6% (6)	20.6% (7)	**32.4% (11)**	20.6% (7)	5.9% (2)	2.9% (1)	34
3	18.2% (6)	**24.2% (8)**	15.2% (5)	18.2% (6)	21.2% (7)	3.0% (1)	33
4	6.1% (2)	6.1% (2)	18.2% (6)	**30.3% (10)**	27.3% (9)	12.1% (4)	33
5	24.2% (8)	6.1% (2)	3.0% (1)	18.2% (6)	**30.3% (10)**	18.2% (6)	33
6 (smallest barrier / least important)	9.1% (3)	9.1% (3)	3.0% (1)	6.1% (2)	12.1% (4)	**60.6% (20)**	33
				Is there another important BARRIER, and if so where should it rank?			8
						answered question	**34**
						skipped question	**1**

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Solar Residential Poll of Industry Experts

SurveyMonkey

How critical to mainstream solar residential adoption are U.S. FEDERAL and STATE renewable portfolio standards which specifically address residential solar options for households (beyond utilities)?

	STATE	FEDERAL	Response Count
Not critical	33.3% (1)	**66.7% (2)**	3
Somewhat non-critical	20.0% (1)	**80.0% (4)**	5
Neutral	**50.0% (5)**	**50.0% (5)**	10
Somewhat critical	44.4% (8)	**55.6% (10)**	18
Very critical	**60.0% (12)**	40.0% (8)	20
		Optional comment	12
		answered question	**34**
		skipped question	**1**

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Solar Residential Poll of Industry Experts

SurveyMonkey

Considering the top 5 solar residential states below by installed capacity, where do you think each lies on the road to mainstreaming residential solar at the state level (in terms of grid parity and/or achieving a 10% household adoption threshold)? (note you may skip this question if not familiar with solar trends in states below)

	At grid parity	Will achieve grid parity and/or 10% household adoption in 5 years	Will achieve grid parity and/or 10% household adoption in 10 years	Will not achieve grid parity nor 10% adoption in 10 years or less	Response Count
California	20.0% (4)	**60.0% (12)**	20.0% (4)	0.0% (0)	20
New Jersey	5.3% (1)	**47.4% (9)**	31.6% (6)	15.8% (3)	19
Pennsylvania	0.0% (0)	10.5% (2)	**52.6% (10)**	36.8% (7)	19
Arizona	0.0% (0)	26.3% (5)	**57.9% (11)**	15.8% (3)	19
Colorado	0.0% (0)	27.8% (5)	**50.0% (9)**	22.2% (4)	18
				Optional comment	6
				answered question	**20**
				skipped question	**15**

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Survey last question: ***Is there a question you would like to ask other solar or energy industry experts? If so please note it here.***

Note that in previous question you asked when solar grid parity will happen with unsubsidized solar. This is a loaded question as all energy is subsidized. If you are taking the subsidy out of solar, you need to compare LCOE of unsubsidized energy for all energy options.

1/30/2012 8:58 AMs

The big shift in the last 12 months is the now forecasted decline in electricity prices because of falling natural gas prices. This is the real hinge on our medium term goals in my mind. Does fracking really provide us cheap gas for 100 years? Will we put a price on the potential environmental costs? Will our leadership look past this windfall at our really longer term challenges? Will a shift to EV bump electricity prices in 10 years? Hard decisions and complex questions for sure. Renewables are still in a spot where the next 10 years view of growth is not solid, but on a 50 year cycle they are clear leaders. The prices of solar will continue to fall and performance will continue to improve. No question about this really Talking about levalized cost of energy(LCOE) is the smart metric in my mind. Thanks for the opportunity to participate.

1/21/2012 1:51Pm

What is the environmental footprint of the various types of panels?

1/19/2012 9:45 PM

Many states have enacted solar set-asides in the portfolio standards. As costs drop, these set-asides may not be needed. Therefore, how do you anticipate solar competing against other renewable energy technologies?

1/19/2012 6:44 PM

What is the appropriate IRR for using as a benchmark for residential solar? Are customers demanding a higher return than is warranted by the level of risk in making a solar investment?

1/19/2012 5:14 PM

When talking about the future, I think a pertinent question is the availability and ease of interconnection from the local IOUs. The closer we get to parity on the cost front, I believe the utilities will start imposing additional fees or roadblocks on connecting to their system.

1/17/2012 1:33 PM

What is the importance of a trained and certified workforce in developing a sustainable PV industry?

1/11/2012 12:28 AM

What about the sterling engine?

1/10/2012 8:41 PM

How will the forcasted price of natural gas influence the uptake of solar PV in the next 10 years? Great questions, Erik. Good luck with your research. I would be interested in receiving a copy of your paper.

1/10/2012 7:57 PM

Do you think it likely that the fossil fuel industry will own and operate most PV manufacturing and project development by 2015? And if so, will it be because they are transitioning to a clean fuel model or because they want to cap/retard the competition coming from clean fuels?

1/10/2012 11:20 AM

How long can coal last?

1/10/2012 12:06 AM

Do you think that the rapid development of shale gas resulting in significant long term suppliers and low prices will dampen the implementation of solar?

1/9/2012 7:38 PM

What is the biggest policy threat to the solar industry in the next 3-5 years. What is the biggest threat to the solar industry in the next 3-5 years.

1/6/2012 3:57 PM

Notable comments from open-ended responses to several SIP questions shown below:

- The fact that companies are offering cost-saving financing options with turnkey service is itself a “game changing” technology. In addition, the DOE has a request-for-information circulating seeking promising “plug and play” residential technologies.
- Utilities may eventually realize the potential of residential PV and start offering leases and power purchase agreements themselves.
- Ease, awareness and accessibility are very important to widespread adoption.
- California has already reached retail grid parity under certain rate structures.
- What is the importance of a trained or certified workforce to PV deployment?
- How will the recent forecasts for increased natural gas generation impact solar adoption?
- Might the major energy players (including utilities) gain market share of PV in order to shape adoption or even retard growth, as happened with the electric car in the 1980’s?
- What is the biggest threat to the solar industry over the next three to five years?