The Challenges of Comparing PV's Success to Efficiency

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ABSTRACT

With increasing frequency, broad statements are being made that highlight the success of the solar photovoltaic (PV) market— often followed by questions on why the energy efficiency market hasn't seen similar meteoric growth. Some commenters conclude that efficiency needs to move away from programs and rebates and stand on its own two feet, like PV. But such statements are simply too broad to be supportable. Many energy efficiency submarkets have seen significant success - some greater than PV in terms of volume or market share. This is especially true for technologies involving one-for-one replacements, including lighting and appliances. And the PV market *has* received incentives and market interventions to drive growth, including tax credits that far exceed those available for efficiency projects both in size and usefulness. This paper illustrates the many differences between PV and a specific type of efficiency work that can be done within similar cost parameters (the whole-home retrofit) in hopes that future dialogue comparing these options will be more specific and grounded.

"Wow! Look at PV! What's Wrong With Efficiency?"

In recent years a growing number of voices in public policy discussions have raised questions as to why efficiency has not seen the same level of success as PV. States with leading PV deployment and a strong commitment to advancing energy policy such as Connecticut, New York and California have all seen significant growth in the PV market even as state incentives are reduced. All three of these states have also seen commentary suggesting that efficiency should become more self-sufficient, ultimately moving away from programs and rebates – "just like PV".

For example, in December of 2015, the Connecticut Green Bank stated support for an increase in a customer co-pay for energy efficiency work because "it is important to signal to the market that there is a transition to lower subsidies in order to provide it with an opportunity to grow. Given our experiences reducing incentives by over 70% and increasing demand for rooftop PV by over 2000 percent, the Green Bank stands ready to assist the Department of Energy and Environmental Protection, the Energy Efficiency Board, and the utilities to help with program design to scale-up the Home Energy Solutions program to deliver more savings with less subsidies." (Farnen 2015).

In New York, the Chair of Energy and Finance, who is also the Chair of the New York State Energy Research and Development Authority (NYSERDA) Board has commented on the success of the PV industry in transitioning away from rebates, while highlighting the goal for NYSERDA and utilities to become "market enablers", rather than the "market" itself: "When you're in the resource acquisition business, you become the market, and the market organizes itself around trying to get grants. We're restructuring programs at NYSERDA and at the utilities to do things so they are enablers of markets, rather than becoming the market…NY Sun is a good example. The industry will be off of all public support well within 10 years." (Kaufmann 2015).

This is further characterized in the New York State Public Service Commission's 2015 Order Adopting Regulatory Policy Framework and Implementation Plan: "There are, however, distinct disadvantages to an approach that relies solely on rebates. A rebate program can have the unintended effect of displacing markets and inhibiting market transformation. Where a program that subsidizes well-established technologies and practices is maintained indefinitely, market activity outside of the program is at a disadvantage…In contrast, a successful market transformation program can leverage far more customer investment than a direct rebate program can. The end goal of a market transformation program for any particular measure is to eliminate further need for customer-funded subsidies of that measure." (Zibelman, Acampora and Sayre 2015)

In California there has also been rhetoric describing the successful weaning of the PV industry off of rebates – and how efficiency programs have done poorly in comparison: "The recent success and rapid growth of PV energy provides an instructive example of such innovation. It's a real-time example of the power of market forces to reward business models that work for customers and industry while being held accountable to results. As the California PV Initiative rebate program trended from a subsidy of nearly 50 percent to zero, a strong industry, driven by billions in private capital, has emerged in its wake. Costs have plummeted as financial and technology innovations have delivered solutions to meet customer demand, resulting in a huge influx of private investment and innovation in technology, finance and business models. By contrast, the energy efficiency industry has been conducting a grand experiment for the past 40 years to prove the theory that top-down programs can "transform markets". At this point, we have proven rather conclusively that the program-centric approach to energy efficiency does not appear to benefit from economies of scale found in competitive markets." (Golden 2014)

Certainly, the goal of achieving market transformation for efficiency is one we can all agree upon, and many of the points raised by the commenters above are valid. The level of activity that would be required to make a significant dent in installing comprehensive home retrofits is not occurring, and the available funding resources are not near the required cost to upgrade and retrofit well over 100 million existing buildings in the United States (Granade et al. 2009; Goldman et al. 2011). And we *have* seen a considerable reduction in some areas of PV incentives and the market has continued to grow.

For example, between 2012 and 2015, Connecticut saw a reduction of their PV incentive from $2.45 per Watt (up to the first 5 kiloWatt) and $1.25/W (for the next additional 5 kW), to a 2015 offering of $0.064/kWh up to 10 kW in size (Shaw, Drake-McLaughlin, and Khawaja 2016). Meanwhile, in New York, the NY-Sun Incentive Program establishes incentives based on a Megawatt (MW) Block design that assigns MW targets to specific regions of the State. Incentives are established for each MW block and are awarded to applications based on the block in effect at the time of submission. When a MW Block is fully subscribed, the next block, with decreased incentives, goes into effect (NYSERDA 2016). California also utilizes an incentive structure where the rebates automatically decline in "steps" based on the volume of PV MWs with confirmed project reservations (California PV Initiative 2016). It's clear that state incentives for PV have been decreasing. Is it also accurate that PV is seeing greater success than efficiency? Not necessarily.

Is PV Actually More Successful than Efficiency?

When we talk about PV in a residential context we are talking about a single technology whose application is generally well-understood. We install panels on the roof or in the yard that turn sunlight into electricity. In contrast "efficiency" can mean many different things, from the installation of specific measures (such as an efficient appliance) to a comprehensive whole-home retrofit. And some measures may be installed individually or within a comprehensive approach that combines multiple technologies. Trying to answer questions about the relative success of PV compared with efficiency requires more precise definitions— are we talking about single technologies with one-for-one replacements, such as lighting and appliances, or are we talking about complex, multi-faceted projects that address multiple technologies and end-uses?

We *have* seen program-centric models for discrete, singular efficiency measures result in a transformed marketplace. For example, witness the change in market penetration according to shipping data provided by the National Electrical Manufacturer's Association in Figure 1. In 2011, incandescent products were nearly 70% of shipped a-line lighting, but by 2015 these products represented less than 10% of shipments:

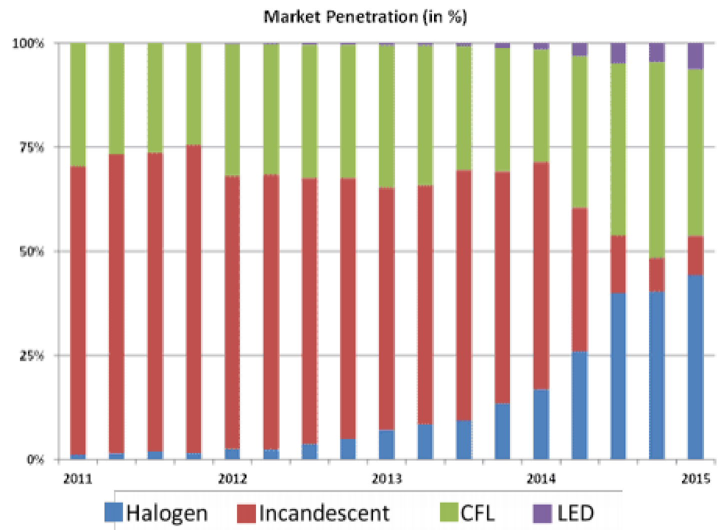

Figure 1. Shipping data for lamp indices, a-line.
Source: NEMA 2-15.

Comparing the PV and the lighting markets shows that both have seen similar trends in cost curves, opening the door for both more profit and more market interest (EIA 2014).

Clothes washers, furnaces and air conditioners have seen considerable support through efficiency programs and are achieving significant market transformation. The ENERGY STAR® Unit Shipment and Market Penetration Report Calendar Year 2014 Summary reports the following market penetration rates for these technologies: 69% for clothes washers; 24% for residential gas furnaces; 15% for residential oil furnaces; and 50% for room air conditioners

(Environmental Protection Agency, 2014). Further, the 2014 national market share for ENERGY STAR® Certified New Homes was reported to be 11.8% (EPA 2014).

However, if we take "efficiency" to mean a comprehensive, "whole-home" energy upgrade project that addresses multiple fuels— such as would be promoted through Home Performance with ENERGY STAR®— then the kind of growth that has been praised in the PV market has indeed been elusive to date. However, there are important reasons why this is the case, and simply reducing market support to this type of effort is unlikely to lead to the same kind of market changes that have been seen with PV.

So How Does the Whole-Home Retrofit Market Compare to the PV Market?

So how does the whole-home retrofit market compare to the PV market? While PV has seen growth, do the data really show that PV has seen greater market penetration than whole-home retrofits? And, is it accurate to portray PV as not receiving market interventions such as incentives and rebates? Let's try to find out.

First, it is critical to recognize the difference between market growth and market penetration. Assessing the PV market penetration based on estimated numbers of residential installations, the Solar Energy Industry Association recently found that 135,000 homes and businesses had PV installed during the first half of 2015 (SEIA/GTM 2015). Compare this to the finding that in 2009, 861,000 homes had insulation[1] professionally installed (DOE 2012 Table 2.6.3). Extrapolating the 135,000 PV installations over the entire 2015 calendar year would result in 270,000 PV installations for 2015. It is likely that the actual number is larger, but even a comparison of 270,000 PV installations (homes and businesses) to 861,000 homes (excluding businesses) shows that insulation is seeing greater market penetration if based upon number of installs. Additionally, with PV we are "measuring" an entire market that started very small just a few years ago, whereas with whole-home retrofits we are trying to increase a market that has been seeing growth for several decades.

Regarding market growth from the perspective of revenue, AEE finds that solar revenue in 2015 in the United States is estimated to reach $22.6 billion, while the efficiency lighting market (for an "apples-to-apples" comparison of a single measure to another single measure) is estimated to reach $24.6 billion (AEE 2016). The closest comparison to a "whole home retrofit" is the building envelope market which is estimated to reach $14.1 billion. Clearly, we are seeing significant market growth in PV, but that does not necessarily equate to market penetration, nor to the tag-along assumption that the efficiency market is not succeeding, and therefore that this market should be weaned off program support.

This leads to another important clarification. The statements quoted earlier infer that PV has grown predominantly through financing and hasn't seen the same sort of market interventions as efficiency. This is simply untrue. Certainly, as shown above, we have seen various states reduce state rebates for PV, but it must be recognized that Renewable Portfolio Standards, a transferrable 30% federal investment tax credit, and net-metering policies are all forms of market interventions that have supported and continue to support the PV market.

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[1] We have chosen to reference insulation installations as the closest proxy to a "whole-home retrofit" available as compared to other efficiency measures based on the previous explanation of the definition of "efficiency" for this paper.

How Do the Technologies and Markets Differ?

Efficiency can never the less learn from the development of the PV market. Yet, to adequately identify what those lessons may be, we must first identify where the two technology options differ to ensure that lessons across the sectors are actually transferable. Table 1 shows a number of significant differences ranging from economics to human behavior to technology.

Table 1. Comparison of PV to efficiency

Category	PV	"Efficiency"	Outcome
Economics: Overall Project Cost	~$20,000-$25,000	~$8,000-15,000[1]	PV businesses have a greater margin to work with than efficiency businesses to meet opportunity costs and make profit, which increases investor interest
Economics: Federal Tax Credit	Up to 30% ($6,000 - $8,000)	Tax credits (typically in the range of ~$300-$500) available per individual efficiency unit but not comprehensive retrofits	Transferability has led to PV attracting significant interest by tax equity investors
Economics: Soft Cost Reductions	Over 5 years: PV industry has seen multiple soft cost improvements: tax certainty, moving from permitting to "registration" processes, simplified meter installs, etc.	Over 40 years: efficiency industry has decreased labor time by streamlining software requirements (e.g. reducing inputs); Hardware has improved (blower door, duct blaster); Cost reductions have occurred (infrared cameras), etc.	Both technologies have made multiple software and hardware cost reductions. As PV is a newer industry, it may be likely that there are more soft cost reduction opportunities remaining for PV as compared to efficiency
Economics: Bill Visibility	PV is an easy relationship to electricity – one technology shown on one bill	Efficiency savings may occur across multiple bills: electricity, heating, water	More difficult to see the immediate financial value of efficiency
Economics: Financing	PV has seen considerable Third-Party-Ownership (TPO) financing models	Federal tax credits for efficiency are not transferable, and financing mechanisms such as PACE have not yet appeared to result in the same market response as TPO	Some cite TPO as a primary driver to PV growth (Bollinger and Holt 2015). If this is accurate, then efficiency faces large hurdles to obtain the same level of growth without TPO
Human Behavior: Metering	PV can show it is producing energy and making money	Efficiency benefits are counter-factual: generally, they do not prove that it is saving money and energy[2]	Customers feel more confident in investing in a product that shows its output in an easy, numerical way

[1] This range of comprehensive retrofit costs comes from Vermont.
[2] The authors recognize that there are now some connected smart devices and controls capable of offering more "real-time" visible proof of energy savings. However, this is not yet mainstream and therefore the potential impact to the market and customer experience is not yet understood or comparable to the visibility of PV production metering.

Category	PV	"Efficiency"	Outcome
Human Behavior: Visibility	PV is visible	Efficiency is invisible	For customers who choose PV because it may be interpreted as a status symbol, visibility matters. For EE, building labeling (which is not yet common) could help but is not the same as a shiny piece of silicon and metal
Technology: Plug and Play	PV is relatively easy to install and complete and in many instances can be relatively "cookie cutter"	Efficiency requires diagnostic analyses for each project, incorporating multiple steps with a variety of technological and financial decision-points required by the customer throughout the project process[1]	Customer may find PV more understandable and may be more easily confused and deterred by efficiency's complications. Additionally, the various tasks involved in a whole-home retrofit (e.g. air sealing, insulation, appliance replacements) frequently requires different contractors to do different parts of the work, thereby increasing overall project complexity
Technology: Intrusiveness	PV is relatively unobtrusive with installers climbing on a roof or installing a stand-alone system in a backyard	Whole home retrofits require workers to be in and out of ones' home for multiple days	Many customers find having contractors and on-going construction in their homes while they live in them to be, at the very least, inconvenient. The alternative of moving out during the retrofit work is also, at minimum, an inconvenience
Technology: Work Required	PV requires very little effort from the customer	Efficiency can require customer labor to empty out the attic and basement	Customer may not want to undertake the effort needed to prepare in advance for efficiency[2]

Customer Perspective

It appears that there are relatively few similarities between a whole-home retrofit (which is only one of many different types of "efficiency programs") and the installation of PV. Ultimately, as the Lawrence Berkeley National Laboratory's human behavioral research has pointed out (Fuller et al. 2010), programs must sell something that people want. Of the two most often cited reasons why customers choose to do energy upgrades (save money and "do the right thing"), PV has distinct advantages over efficiency.

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[1] While some programs have sought to streamline and therefore simplify this experience, this does not appear to be the "norm" for whole-home retrofits throughout the United States.

[2] Comparing whole-home retrofit work to basement waterproofing provides additional insight regarding the "work required" category. Basement waterproofing does not see support from federal and state programs and yet has seen the growth of successful, mature waterproofing businesses that provide a "one and done" experience offering financing during the first customer interaction and closing the deal within a few hours. Like efficiency, basement waterproofing often requires the homeowner to empty storage areas so it could be assumed that this would act as a deterrent. However, while emptying out a basement may be a hassle, having all basement items be routinely flooded is even more of a hassle. Ultimately, one level of inconvenience may outweigh another. While basement waterproofing may be similar to whole-home retrofits in the level of "work required" by the homeowner, there is an additional motivation for the homeowner to undergo the hassle of emptying out the basement due to the vivid customer experience of having to regularly deal with a flooded basement. Another point in waterproofing's favor? A flooded basement is far more visible than air leakages and drafts.

PV in a Nutshell

From a customer perspective, PV provides homeowners with the ability to watch the meter go backwards and also realize the financial investment on their utility bill. PV is highly visible and easy-to-install with a clear, single call-to-action that, once done, is completed for 20-25 years. PV requires little physical labor for the customer, and does not ask the customer to make any decisions between "this energy upgrade or that". For customers to whom it matters, a PV panel shows everyone that they made this "green" investment.

Efficiency in a Nutshell

From a customer perspective, efficiency is invisible, with savings spread across multiple energy bills and requiring numerous decisions from the homeowner as to which efficiency measures to undertake. Compared to PV, efficiency is an on-going continuum like many building maintenance projects, and often the benefits are less measureable (for example, improved comfort) than those associated with PV installations. Measuring the effectiveness of the efficiency upgrades requires compiling the savings across several utility bills and perhaps an unregulated source such as cord wood or pellets, thereby making the savings less direct and clear for the customer as compared to PV production on one electric bill. Granted, over the last few years more cities and realty groups are including HERs ratings in housing information at point of sale, but this is relatively new and not as visible as a new PV array perched on a roof. Perhaps most importantly, whole-home retrofits can require significant labor on behalf of the homeowner to empty out one's attic and basement or to move out entirely. Case in point: a trial in Great Britain found that customers were three times more likely to do insulation projects when the work was offered with attic-clearing services as part of the scope (Gray and Ross 2012).

Financing and Third Party Ownership (TPO)

Often when the argument is made that energy efficiency should seek to emulate PV market trends, a key focus is on the central role that financing, and in particular TPO has played within the PV industry. Just as there are key differences in these technologies and markets, however, there are also important distinctions that should be recognized in terms of the role of financing within each industry.

One consideration regards the basic purpose of financing. Typically, customers will choose to take out financing only if they have either a need or a strong desire to complete a project that they cannot otherwise afford. Where their motivation is less strong, customers often will choose to forgo a project rather than take out debt to enable it moving forward.

In the residential PV market, recent trends indicate a strong desire among some segments of the population to acquire PV panels (Clover 2015). For these customers, financing may offer a solution to allow them to take on a project that they already are very interested in doing. By contrast, there is less clarity within the energy efficiency market as to whether there is a growing demand for comprehensive residential retrofits, and in particular for less visible measures such as air sealing and insulation. If customer motivation is not independently growing increasingly strong in this market, then it is much less likely that offering financing will facilitate rapid growth on its own.

As previously noted, growth rates and market penetration are vastly different metrics. As such, it may be worth noting that even if financing has facilitated *growth* within the PV market among those customers who are independently motivated to complete PV projects, it is much less clear whether that growth will be limited by the size of the sub-segment that is independently motivated in this way. If this turns out to be the case, then just as in the energy efficiency market, the impact of financing in the PV market may be limited by whether external drivers can further increase demand.

One additional way in which financing is sometimes used to encourage energy projects is by spreading repayments out sufficiently to be fully covered or exceeded by energy savings. It is worth noting, however, that this type of arrangement may be more attractive in the PV realm than the efficiency industry, given that PV output can be metered, giving customers more confidence that energy savings projections will be realized.

Indeed, in the energy efficiency industry, realization rates are often well below 100 percent (West Hill Energy and Computing 2013; Reeves et al. 2014) which customers may intuitively sense given the challenges in measuring savings directly. While some pilot efforts are being made to address this issue in the efficiency space via savings guarantees over a portfolio of homes (which may be less risky collectively than banking on savings projections for a single home) results of these efforts thus far have not gone to scale. Unless and until the confidence barrier can be overcome in the energy efficiency sector, cash-flow-positive financing arrangements may remain much less powerful in this market than in the PV field.

Finally, it should be pointed out that the growth of financing models within the PV industry has largely been spurred by the interaction of financing and federal tax credits via TPO models (Bollinger and Holt 2015). Both leasing arrangements and power purchase agreements allow third-party investors to take advantage of these tax credits in the PV market, which has provided an attractive business model that has brought in significant investment to grow the PV industry to scale. No comparable tax credits currently exist in the energy efficiency space, nor is it clear whether the nature of certain key energy efficiency measures such as air sealing and insulation would allow for a TPO model that could facilitate the transfer of tax credits even were they to become available.

For all of these reasons, while financing is likely to continue to play an important role in the energy efficiency industry, it is oversimplified to suggest that the key to growing the industry to scale is to rapidly ramp up financing models and ramp down programs.

Additionally, according to Lawrence Berkeley National Laboratories' Mark Bollinger, from a policy design perspective, "be careful what you wish for". While PV hard and soft costs have greatly reduced, it is not all that clear that these reductions have reached the end-customer (M. Bollinger, research scientist, Lawrence Berkeley National Laboratory, pers. comm., March 4, 2016).

Limitations and Qualifications

Various reviewers of this paper have asked the authors why the data comparisons are not a clear, simple "one-to-one" analysis. For example, using the same reference years when comparing solar PV installations to whole-home retrofits; or comparing market revenue for PV installations to whole-home retrofits (as compared to just building envelope work – which may not include appliances and heating, ventilation and air conditioning (HVAC) efficiency improvements). The authors recognize that this type of comparison would be preferable to what is provided here, and will continue to work towards that. However, at the time of the writing of this paper, the data sets referenced are the resources available to the authors with permission. One data challenge results from the fact that much of the available efficiency analyses focus on a discrete, singular measure rather than the more comprehensive, “whole-home retrofit” measure. For the purposes of this paper, our points remain valid: broad sweeping statements that question the success of efficiency as compared to PV are not only inaccurate but also limit the potential for helpful “lessons learned” across the PV and efficiency markets due to their lack of specificity.

Conclusion: Where To From Here?

It is clear that overarching statements that highlight the success of the PV industry to the efficiency industry and then question the success of the efficiency industry and efficiency programs in a broad sweeping approach, is problematic. First, it’s inaccurate: energy efficiency submarkets have seen significant success – many greater than PV. Second, even the most difficult energy efficiency submarket, the whole home retrofit as defined in this paper, sees success. Third, the PV market *has* received incentives and market interventions to drive growth.

Are there potentially “lessons to be transferred” from the PV market to the market serving whole-home retrofits? It is likely. But in order for those lessons to be truly illustrative and transferable, we must first identify the many differences between these markets. Only then can we rightly compare markets and identify transferable lessons from PV to efficiency. For example, identifying how to bring the “cache” of efficiency closer to that of PV, and making flexible tax credits available for efficiency could potentially make a large difference for the whole-home retrofit market.

Many energy experts would like to see a vast increase in the number of whole-home retrofits across the United States. Certainly, forty years of programs have not yet achieved market transformation for this category of efficiency work. However, overarching statements that look to the success of the PV industry to identify what efficiency can do differently to achieve market transformation are only helpful to the degree that the comparison recognizes the economic, human behavior and technological differences between these two customer-facing energy opportunities.

As PV policies, particularly net-metering, continue to evolve, and as whole-home retrofits, hopefully, become more visible and quantifiable from a customer perspective through mechanisms such as HERs and bill guarantees, we may see a shifting of the challenges and opportunities for PV as compared to whole-home retrofits. In the meantime, opportunities to reduce some of the hurdles the whole-home retrofit market faces may be identified by comparing the differences between PV and comprehensive retrofits, as provided in Table One.

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