Focusing Some Light on Two Specific Issues for Cost Effectiveness Testing

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ABSTRACT

As the energy efficiency industry moves farther into harder-to-reach segments and goes after increasingly smaller incremental improvements in efficiency, the accuracy of cost effectiveness testing becomes increasingly more important. Without diving exhaustively into which tests should or should not be used, what methods should or shouldn't be used to establish important program parameters such as free-ridership and spillover and market effects, or what discount rate is most appropriate, this paper focuses on two often overlooked issues that are important for accurate cost effectiveness testing. The paper focuses on: 1) an "apples-to-apples" calculation of incremental measure costs that explicitly accounts for differences in the lifetimes of baseline and efficient products and 2) the societal cost/benefit of incentives paid to free-riders.

These are two highly focused, but important issues regarding cost effectiveness that will be increasingly important over the next decade as the energy efficiency industry adjusts to changing market conditions and regulatory dynamics.

Introduction

In the last several years there has been considerable investigation within the energy efficiency community about cost effectiveness methods – especially, the pros and cons of individual cost effectiveness tests (for example, see: ACEEE 2012; Daykin et. al. 2012; Neme and Kushler 2010, Synapse 2012, Woolf et. al. 2014). The California Standard Practice Manual (CPUC 2001), now over ten years old, is still commonly cited within the industry as the "go to" source for information regarding cost effectiveness tests. However, it has been noted that the California Standard Practice Manual is out of date (Woolf et. al. 2014) and that the five tests covered by the manual are applied in a variety of ways in other jurisdictions (Haeri and Khawaja, 2013). Woolf, et. al. (2013) provide an excellent survey of issues related to cost effectiveness. It is beyond the scope of this paper to debate the inner workings or applications of various cost effectiveness tests. Instead, the focus of this paper is on two key issues for cost effectiveness testing that warrant more careful examination/consideration: 1) the calculation of incremental costs and 2) the societal cost/benefit of incentive payments to free-riders.

Incremental Costs

Incremental costs to consumers are often an important driver for cost effectiveness outcomes in popular tests that aim to capture the overall costs and benefits of market intervention (e.g. Total Resource Cost Test, Societal Cost Test). Incremental cost is commonly defined as (Sherman and Rouleau 2014):

> "… the difference between the cost of an energy efficient measure and the cost of a baseline measure that provides comparable service…"

This is simple enough. However, as demonstrated in research undertaken by the Northeast Energy Efficiency Partnership (NEEP) Regional EM&V Forum research, estimating incremental costs (especially across a wide geographic region) is complicated (Navigant 2011). At minimum, one must begin by considering whether costs should be measured against: a) the cost of a baseline product (as is appropriate for replace on burnout situations) or b) the full cost of the efficient measure (for many retrofit situations). Beyond that, there need to be considerations for differences in installation costs, characterizations of equipment, differences in market conditions, as well as analytical considerations about how to combine market data from various sources in a meaningful way. Sherman and Rouleau (2014) document the first two (of three) phases of research by the NEEP EM&V Forum to establish incremental costs for various, energy efficiency measures commonly promoted in programs throughout the Northeast and Mid-Atlantic Regions (see: Navigant 2011; Navigant 2013, and Navigant 2014a for detailed findings of the first three phases of this research).

In spite of efforts to account for this kind of complexity, an issue that is often overlooked is the simple fact that the product lifetimes for some efficient products differ substantially from their baseline counterparts (e.g. CFL and LED light bulbs compared to incandescent and halogen bulbs). In fairness, Navigant (2014a) (Phase 3 of the ICS) raises the issue of differences in lifetime for LED Refrigeration Case Lighting. However, in this retrofit measure case, the only adjustment was for the purchase of an additional ballast for the T8 baseline and resulted in only a 4% reduction in the overall incremental cost. In many cases with residential light bulb purchases, the difference will be far more substantial.

LED Lighting Example

Consider an example. If an omnidirectional LED bulb cost $6.92 in 2015 (year 0) and a spiral CFL cost $2.45 and an EISA compliant halogen bulb cost $1.25, the *first price* incremental cost differences between these would be as shown in Table 1. These incremental costs scaled out over a program where 200,000 LED bulbs are promoted in a year yield enormous participant incremental costs for the year (200,000 X $5.67 = $1.134M). This $1.134M dollar participant incremental cost makes a significant contribution to the overall program costs in a TRC or Societal test for this measure. Even with the long lifetime savings of LEDs, this is a substantial cost to offset with benefits to achieve a cost effective program.

Table 1. First Price Incremental Cost by Technology for Light Bulbs

	LED – CFL	LED – Halogen	CFL - Halogen
First Price Incremental Cost	**$4.47**	**$5.67**	**$1.20**

However, based on the differences in product lifetimes between efficient measures and baseline product, the critical question is:

Should this first price incremental cost be used in cost effectiveness tests for this measure?

Figure 1 illustrates the number of baseline halogen products (25 @ 1,000 hour rated lifetime) and spiral CFLs (2.5 @ 10,000 hour rated lifetime) required to provide the same service as a 25,000 hour LED bulb based on 2.3 hours/day of use. Obviously, there is a clear need to account for the cost of additional replacement bulbs in the incremental cost of the measures for a true “apples-to-apples” cost comparison.

Considering the actual purchase costs for these products, Table 2 shows the replacement schedule and costs for the products over a 29 year period. Based on the forecasted change in prices of the baseline halogen products (Mertz, 2015; see Figure 2, industry partners report that the price for this product will likely come down to approximately $1/bulb over the next few years as economies of scale are achieved) we find that the total cost of the baseline products required to meet the lifetime of the LED measure are considerably higher than the initial purchase cost of $1.25. Of course, for cost effectiveness testing, the net present value (NPV) of the future purchases is needed. The NPV (discount rate = 5%) of the total lifecycle cost is $12.67 for the baseline halogen bulbs.

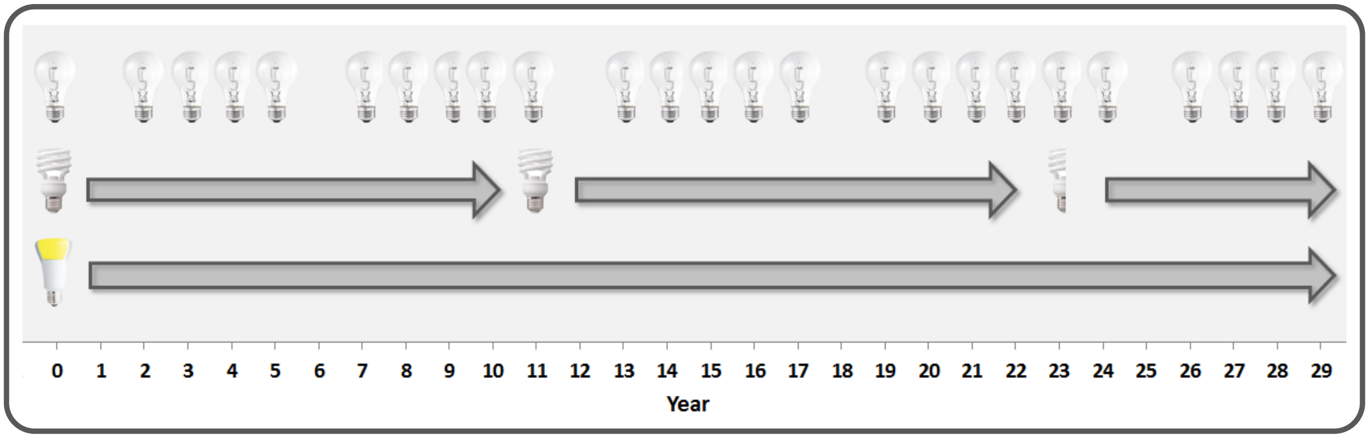

Figure 1. Purchases by Technology Type for Light Bulbs

Table 2. Lifecycle Cost Schedule (Including Replacements) by Technology

Year	LED	CFL	Halogen
0	$6.92	$2.45	$1.25
1			
2			$1.13
3			$1.07
4			$1.02
5			$0.97
6			
7			$0.97
8			$0.97
9			$0.97
10			$0.97
11		$2.45	$0.97
12			
13			$0.97
14			$0.97
15			$0.97
16			$0.97
17			$0.97
18			
19			$0.97
20			$0.97
21			$0.97
22			$0.97
23		$1.23	$0.97
24			$0.97
25			
26			$0.97
27			$0.97
28			$0.97
29			$0.97
TOTAL COST	**$6.92**	**$6.13**	**$24.78**
NPV (@ 5%)	**$6.59**	**$4.08**	**$12.67**

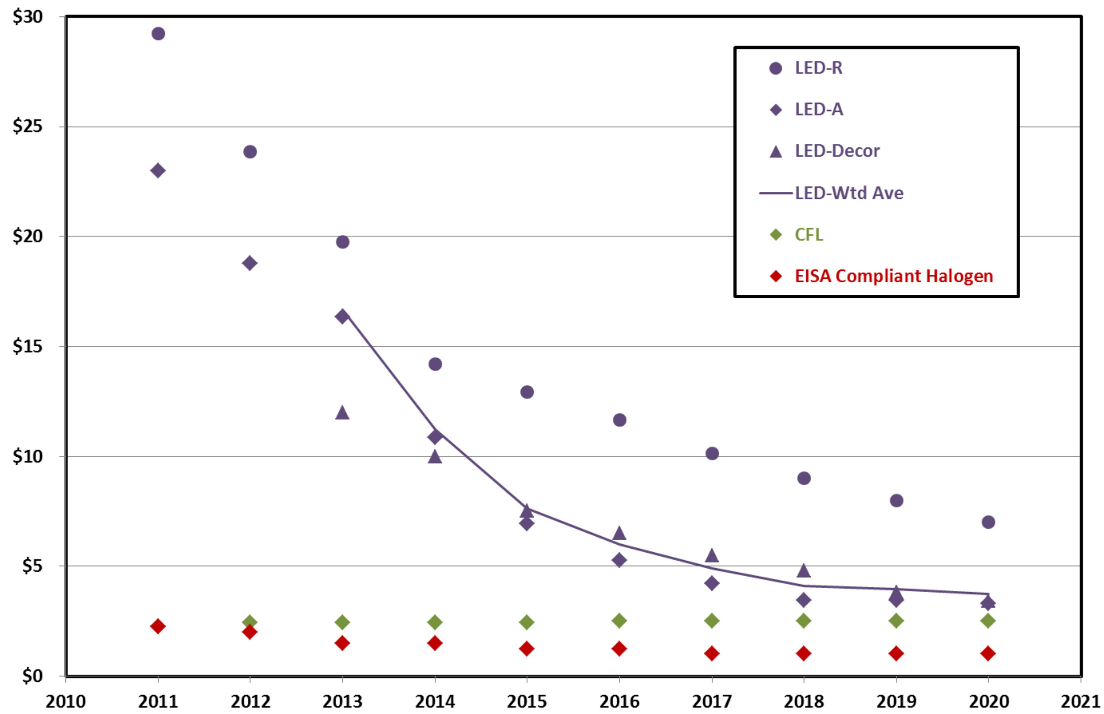

Figure 2. Retail Price Forecasts for Light Bulbs in the U.S. Market (Mertz, 2015)

The NPV of the lifecycle incremental cost between the LED product and the halogen baseline is $6.59 - $12.67 = -$6.08. The first CFL purchased in the example compared to the halogen baseline product also has a negative lifecycle incremental cost ($2.33 - $7.54 = -$5.21). These are direct benefits to customers over the lifetime of the LED/CFL. The lifecycle cost comparison between LED and baseline EISA compliant halogen products is something of an idealized case given that it assumes repeated purchases of baseline products rather than a transition, at some point in the 29 year period, to a more efficient technology (e.g. CFLs or LEDs). As such, this case represents an upper limit (highest cost for non-efficient) on the cost comparison with the baseline products.

To refine this cost comparison, the first consideration is a clear understanding of the market conditions for the baseline. The status of the DOE rulemaking for general service lamps in the U.S. market (see: http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx?ruleid=83 for additional information) indicates that the first tier EISA standard will be adequate to generate the required 45 lumens per watt efficacy requirement outlined in the EISA (2007) legislation by 2020. Based on the most recent market-wide U.S. shipment data for light bulbs (NEMA, 2015), the market is currently at 39.2 lumens per watt. As such, it seems likely that the 2020 backstop provision will **NOT** go into effect in the U.S. market. Accordingly, the EISA compliant halogen bulbs will continue to represent the least efficient, and therefore, baseline product in the U.S. market in 2020 and beyond.

The second consideration is what consumers are likely to purchase across the U.S. market. This is a very challenging question. On the one hand, LED costs are declining rapidly, the quality of LED products is generally high, and as the emerging technology in this product category, consumers are interested in LED products. On the other hand, light bulbs are a low interest, commodity item and there is a high degree of inertia in consumer preferences for light bulbs which, by definition, favors the baseline technology (Craigo-Snell, 2011). It is clear (NEMA, 2015) that customers are moving to LED technologies (many with the help of residential lighting programs), but as it relates to this topic of establishing accurate incremental costs, the question is: *How quickly*?

Knowing that market share for the various light bulb technologies varies from region to region, it is best to characterize the range in these incremental cost estimates. Having established the upper limit of the cost comparison – continued replacement with baseline halogen products – consider the other extreme. Given the rapidly decreasing prices for LED bulbs (see Figure 2), it would seem that the lower limit would be established in a comparison where a customer purchases a single halogen bulb or two and then purchased a single LED bulb in the very next year to match the remaining hours of the original LED purchase. For the case of the purchase of a single halogen bulb and then an LED for the remainder (@ 24,000 hrs./25,000 hrs. = 96% of $5.25 = $5.04), the NPV of those purchases would be $5.76 compared to the $6.59 in NPV of the original LED purchase which yields an incremental cost of $0.83. Table 3 details the incremental costs for initial baseline halogen bulbs then the prorated purchase of an LED to match the remainder of the lifetime of the initial LED bulb.

Table 3. Incremental Costs: LED and EISA Compliant Halogen to Prorated LED

Replacement Schedule	NPV of Initial LED Purchase	NPV of Replacements	Incremental Cost
Year 1:Halogen; Year 2: LED	$6.59	$5.76	$0.83
Years 1-2:Halogen; Year 3: LED	$6.59	$5.84	$0.75
Years 1-3:Halogen; Year 4: LED	$6.59	$4.78	$1.81 ←
Years 1-4:Halogen; Year 5: LED	$6.59	$5.43	$1.16
Years 1-5:Halogen; Year 6: LED	$6.59	$5.91	$0.68
Years 1-6:Halogen; Year 7: LED	$6.59	$6.44	$0.15
Years 1-7:Halogen; Year 8: LED	$6.59	$6.35	$0.24
Years 1-8:Halogen; Year 9: LED	$6.59	$6.84	-$0.25
Years 1-9:Halogen; Year 10: LED	$6.59	$7.30	-$0.71

As can be seen in Table 3, given the pricing dynamics and replacement schedules, the maximum incremental cost (lower limit of the replacement costs) is $1.81 when halogen bulbs are purchased during the first three years (2 bulbs) and an LED is purchased in the 4th year to match the lifetime of the initial LED purchase. The incremental cost switches from positive to negative when the LED is purchased in the 9th year.

Another approach to synchronize lifetimes for the incremental cost calculation between LED bulbs and the baseline halogen bulbs could be to prorate (4%) the cost of the initial LED bulb purchase to match the 1,000 hour lifetime of the baseline halogen bulb. The prorated incremental costs using this approach are found in Table 4 based on the forecasted retail price values in Figure 2.

Table 4. Prorated Incremental Costs: LED and EISA Compliant Halogen

Year	Prorated LED (4%)	Halogen	Prorated Incremental Cost
2014	$0.43	$1.50	-$1.07
2015	$0.28	$1.25	-$0.97
2016	$0.21	$1.25	-$1.04
2017	$0.17	$1.00	-$0.83
2018	$0.14	$1.00	-$0.86
2019	$0.14	$1.00	-$0.86
2020	$0.13	$1.00	-$0.87

All of these are negative incremental costs indicating a financial benefit to the consumer to purchase the LED over the baseline halogen bulb. Even if the life of the LED was only half as long (12,500 hours), all of these prorated incremental costs would still be negative (albeit smaller in absolute terms). Although this is a very simple calculation and side-steps the complications about exactly which products to assume for replacement purchases (and when), it is not clear that this approach could be reasonably used in cost effectiveness testing because all other values (e.g. program costs, energy savings, etc…) used in the testing are lifetime values. It is useful to notice that these prorated values are consistently negative, but beyond that, they are of relatively limited value.

In summary, the NPV of the incremental costs for the initial LED purchase ranges from -$6.04 to $1.81. This entire range of values is considerably smaller than the $5.67 first cost difference between an LED bulb and a baseline halogen bulb (Table 1).

Given that cost effectiveness testing for energy efficiency program efforts applies to the: product, program, or portfolio levels for a given jurisdiction and market conditions, it is important to consider how the values in Table 3 should be interpreted. For these incremental cost estimates to be useful in cost effectiveness testing, the replacement schedules need to reflect market conditions rather than simply what any given customer may decide to do. As such, the notion of when the switch from baseline halogen products to an LED product prorated to match the lifetime of the efficient measure purchase should be based on the market share position of LED products within the program jurisdiction. In light of this necessity, the replacement schedule involving an initial baseline halogen purchase in year 1 and then an LED purchase in year 2 is extremely aggressive given that LEDs currently represent such a small fraction (6.3%) of the U.S. market (and with considerably energy efficiency program promotional support over the last few years, at least). Navigant (2014b) forecasts that LEDs will have approximately 30% market share in 2020. Consistent with that, a replacement schedule where baseline halogen bulbs serve as the replacement product over the first five years and then a prorated LED (incremental cost of $0.68, see Table 3) better matches market conditions.

Dealing With Negative Incremental Costs

Negative incremental costs highlight the economically irrational behavior of light bulb purchasers. One might assume that with such substantial economic benefits for efficient light bulbs over baseline products (especially as the first cost for the baseline product has increased so radically from standard incandescent products to EISA compliant halogen bulbs), that customers would readily make the switch to efficient options. However, consumers are *extremely* sensitive to first cost and that there is a high degree of inertia in consumer purchase decisions for light bulbs (Craigo-Snell 2011). The recent market share information indicating the remarkable growth of EISA compliant halogen bulbs (39.9% market share) and the stagnant market position for CFLs (NEMA 2015) strongly support these consumer preferences.

Negative incremental costs present a challenge for cost effectiveness testing for two basic reasons:

a) in the purest sense, the negative incremental cost represents a benefit to the program participant rather than a cost, and
b) there are some cases where this benefit could exceed the program costs to promote the efficient measure.

For tests that utilize these participant costs (Haeri and Khawaja 2013), and in cases where the absolute value of this negative lifetime incremental cost does not exceed the other program costs, no specific handling of the costs (incremental or program) is required. In these cases the negative incremental cost can be simply treated as a program benefit off-setting a portion of the program costs (including incentives). However, the alternative – higher negative incremental cost in absolute terms than the other program costs – leads to negative overall program costs and a nonsense TRC ratio. In these cases, one must make a deliberate decision about how to handle the negative values. A couple of options would be:

1) One could allow the negative incremental costs to off-set all but the smallest amount of the program costs (computationally speaking, if one allows all of the program costs to be entirely off-set, the B/C ratio is undefined – division by 0). This method generates unnaturally high B/C ratios (by definition, regardless of the value of the benefit) and *very likely* overstates the true value of the program.
2) One could allow the negative incremental costs to off-set a portion (up to the entirety) of the program incentives used to promote the product.

Especially keeping in mind that negative incremental costs highlight economically irrational decisions made by consumers, it seems more reasonable to choose the second option. Beyond that, the program planner can choose how much of the incentive to be offset. Craigo-Snell (2013) chose to allow up to 50% of the incentive cost to be off-set.

A Final Note on Incremental Costs

Although the example in this paper highlights the importance of this issue around efficient lighting products, the same principles should be applied to other products where incremental costs play an important outcome in the determination of cost effectiveness. For example, manufacturer warranties for water heaters range from 6-12 years. Lower priced, standard electric resistance storage water heaters constitute the lower end of that range. There are also standard electric resistance storage water heaters at the upper end of the range, as well. Heat Pump Water Heaters are becoming an increasingly important non-lighting measure for energy efficiency programs, but have a high price premium as an emerging product in the market. It is critically important that incremental cost estimates for Heat Pump Water Heaters be calculated against baseline units that are more similar to the lifetime of the efficient measure.

It is not immediately clear that there are many (or perhaps any) other efficient measures that need this kind of lifetime synchronization in the incremental cost calculation, but it is important that it be considered and carefully dealt with for accurate cost effectiveness test results.

Free-Rider Incentives

Free-ridership reduces the net energy savings benefit from energy efficiency programs. Incentive payments (and other program efforts/costs) that are directed toward free-riders do not result in program benefits through program engagement (i.e. free-riders, by definition, would have achieved the program impact without the program cost/effort). It is challenging to identify free-riders and levels of free-ridership in programs, and there has been considerable debate and research into the topic over the past 10-20 years in the energy efficiency program evaluation community (for example, see: Ignelzi, et. al, 2012 and Mahone 2011).

The manner in which incentive payments to free-riders is handled in cost effectiveness testing varies by test (e.g. Program Administrator (PAC) vs. Total Resource Cost (TRC)) and jurisdiction. It is standard practice to include free-rider incentive payments as costs in PAC tests (e.g. Haeri and Khawaja, 2013 and CPUC, 2012). In TRC testing, however, the inclusion of incentive payments to free-riders varies. In jurisdictions such as: Illinois, Wisconsin, and Massachusetts, the cost side is the sum of the program administration costs and the participant portion of the incremental cost of the measures (incremental cost * Net-to-Gross Ratio) (see: IL SAG, 2012; Cadmus 2015; Commonwealth of Massachusetts, 2013). This formulation does NOT include incentive payments paid to free-riders as a cost element. In the state of California, however, and perhaps in other jurisdictions, incentive payments to free-riders are added into the cost side of the TRC test (CPUC, 2007).

To assess the appropriateness of this handling of free-rider incentive payments it is important to keep in mind that, despite the lack of program benefit derived from free-riders, incentive payments made to free-riders do, in fact, represent a direct monetary benefit to those individuals. This individual benefit has some (albeit, perhaps, small) societal benefit, as well, given that it has enabled the free-rider to save money and/or to make additional purchases. The magnitude of these payments to free-riders can be quite substantial in certain programs. Consider a typical upstream lighting program where 950,000 CFLs and 50,000 LEDs are promoted over the course of a year. Average incentives tend to be about: $1.15 /CFL and $3.00 /LED. If free-ridership rates were found to be 33% for CFLs and 20% for LED – which is typical for recent programs – the total incentive payments to free-riders would be: $360,525 + $30,000 = $390,525 out of a total incentive budget of: $1,242,500 (31% paid to free-riders). This is a sizeable fraction of the total program budget, and therefore, worth being careful to make certain that the program is not unduly harmed in cost effectiveness testing by treating these payments as costs.

So long as incentives are paid to qualified program participants (as opposed to leaking out of a program territory), the monetary value stays within the program territory. Even if these incentive payments to free-riders simply represent a transfer from ratepayers to individuals, they are, at minimum, neutral from the societal perspective. As such, these incentive payments should not represent a cost to the program in the TRC test.

Conclusions

This paper has explored two issues regarding cost effectiveness testing: 1) the calculation of incremental equipment costs where the lifetimes of efficient products vary substantially from baseline products, and 2) the value of incentive payments made to free-riders in energy efficiency programs. In both of these areas, the paper explores the nature of the issue and what could and should be done to properly account for the issue in cost effectiveness testing.

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