Issues with Evaluation of Early Replacement HVAC Projects Rebated through the Home Performance with Energy Star Program

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Abstract

Energy efficiency program administrators throughout the United States are seeking new program measures and designs that will help them offset rapidly declining savings from lighting programs and meet ambitious state energy efficiency savings goals.[2] Rebates for early replacement of central air conditioning and air source heat pumps repeatedly come up in this context.

As part of a major redesign of the Home Performance with Energy Star (HPwES) programs, EmPOWER Maryland program administrators are adding bonus incentives for HVAC replacements. HVAC rebates under HPwES would be much higher than incentives for the same equipment rebated through the Residential HVAC program. The objective is to stimulate participation in the program by HVAC contractors, encourage deeper and more comprehensive savings in HPwES participant homes, and help program administrators meet savings goals.

Initially, program administrators proposed to provide HPwES bonus incentives exclusively for early replacement (ER) of operating HVAC units. Higher HPwES incentives would potentially drive more ER of HVAC units and thus more portfolio savings. Pending a consensus definition of ER, the program administrators decided to, at least temporarily, offer the bonus HPwES incentives for all HVAC replacements, regardless of the age or condition of the replaced units or the reason for replacing them.

This paper discusses the numerous challenges and perspectives that emerged as Maryland stakeholders pursued a consensus ER definition and how the inability to agree on a definition is leaving potential savings on the table.

Introduction

The Maryland Public Service Commission (PSC) recently approved a request by the Home Performance with Energy Star (HPwES) program administrators to transition to performance-based incentives (PBI) (Maryland Public Service Commission 2017). As part of the new HPwES regime, the program administrators will offer bonus incentives for HVAC system replacements.[3] The HVAC incentives offered through HPwES will be far more generous than incentives for identical equipment rebated through the HVAC rebate programs, which have been operating since the launch of EmPOWER programs in 2009. To receive bonus incentives for HVAC replacements through the HPwES program, participants must take actions to meet HPwES minimum insulation and air sealing requirements or demonstrate that the requirements have already been met.

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[2] Federal minimum energy performance standards for the most commonly used and incentivized light bulbs are scheduled to increase significantly after December 31, 2019.

[3] The focus of this paper is on central air conditioning and air source heat pumps, but much, if not all, of the discussion would be applicable to furnaces, boilers and other types of HVAC system replacements.

Offering higher HVAC rebates in the HPwES program would encourage HVAC contractors to solicit their customers' participation in the HPwES program. They would also encourage HPwES contractors and participants to consider HVAC replacement opportunities in addition to shell and other measures.

Initially, the EMPOWER HPwES program implementers planned to provide bonus incentives only for Early Replacement (ER) projects – i.e., replacement of equipment that is still "operational." These ER projects, which compare the new unit consumption to the consumption of the unit that was replaced, would give much greater first year and life cycle savings than from Normal Replacement (NR) projects, which compare the new unit consumption to the consumption of a federal minimum standard unit. The threshold question for using bill analysis to evaluate savings from HVAC projects rebated by HPwES is whether an HVAC project should be counted as ER.[4]

However, evaluators, implementers, trade allies and other stakeholders have had difficulty agreeing on how ER would be defined and how claims, based on that definition, would be validated. Should a baseline central air conditioner or heat pump be considered ER if the fan turns on, but the compressor will not? What if the unit will turn on, but the maximum achievable temperature difference between return and supply air cannot adequately cool or heat the space? What if all the components will run, but there is no refrigerant in the system due to a leak? There are no clear right or wrong definitions; ER is ultimately an economic decision, since nearly all existing HVAC units, no matter their condition, could conceivably be repaired.

There is no industry-wide standard protocol for defining and validating early replacement projects. The Uniform Methods Project protocol for HVAC cooling equipment expressly avoids discussion of ER (Jacobson 2013). A set of studies for the Northeast Energy Efficiency Partnership provides a recent and nearly complete treatment of ER methods and challenges, but, while providing excellent discussion and recommendations pertaining to other aspects of ER evaluation, it ultimately provides little direction regarding the threshold question of how ER should be defined and validated (Evergreen Economics 2015, 2016).

Perhaps reflective of the lack of industry consensus on an ER definition, the EmPOWER stakeholders were unable to agree on a definition for ER, despite extensive stakeholder discussion and debate. In lieu of a consensus ER definition, the HPwES program implementers have decided, at least through the end of 2017, to offer the same bonus rebate levels for ER and NR HVAC projects. To ensure that excessive rebate amounts are not paid for the smaller savings associated with NR, the implementers will calculate rebates for all projects using a NR baseline.

The inability to arrive at an ER definition, which would have allowed the HPwES program to require HVAC projects to be ER, means that additional ER projects will not be incentivized. As the EmPOWER programs look for program measures and designs that can offset expected precipitous declines in lighting program saving, any lost savings opportunities become more and more meaningful. Moreover,

[4] Once an ER baseline is established, a variety of other savings and cost effectiveness parameters must either be deemed, estimated or observed. Required inputs to calculate life cycle energy and costs savings for early replacement HVAC, over and above the inputs required for an end-of-life replacement, include: the remaining useful life and efficiency of the replaced equipment and the initial project cost including labor. Development of these inputs present some interesting quandaries, but are beyond the scope of this paper. In simplified terms, the annual savings in the initial baseline period is equal to the difference between the energy consumption of the newly installed equipment and the *in situ* equipment that was replaced; the annual savings in the second baseline period is equal to the difference between consumption of the newly installed equipment and the equipment that would have been installed at the beginning of the second period; the incremental costs are equal to the total cost of the equipment at the project inception date minus the discounted cost of the standard equipment that would have been purchased at the start of the second baseline period. For further discussion of dual baseline methods used for early replacement savings calculations, see for example, Evergreen Economics, Michaels Energy and Phil Willems (2014, 2015).

offering higher incentives for both ER and NR HVAC projects implemented through the HPwES program adversely affects portfolio cost effectiveness.

The failure to distinguish between ER and NR HVAC projects in the HPwES program also presents significant evaluation challenges. Participant bill analyses, which are the primary method used for evaluation of the HPwES programs, can provide reasonably accurate estimates of HVAC first-year gross energy and demand savings for ER projects, but not for NR projects. Bill analyses will significantly overstate savings for NR projects.

EmPOWER stakeholders may continue to pursue consensus agreement on ER HVAC in time for development of the EmPOWER 2018-20 program plans. As EmPOWER stakeholders consider further the best ways to define ER in Maryland, it will be useful to consider definitions being used in other jurisdictions and to review the varied perspectives and challenges that arose as the EmPOWER stakeholders considered possible ER definitions and validation requirements over the last year.

The research conducted for this paper was intended to inform the Maryland EmPOWER discussions, but should be useful to any jurisdictions that is considering ER incentives for HVAC, whether as part of their HPwES programs or other programs. First, the paper summarizes ER definitions prescribed by programs and TRMs in other jurisdictions. Second, the paper discusses the pros and cons of ER definitions that have been considered by Maryland stakeholders to date. Finally, the paper closes with discussion of why a project-level definition of ER is important.

Early Replacement Definitions Used by Existing Programs and Technical Reference Manuals

At least eight utility energy efficiency programs offer incentives for ER HVAC. The ER-specific rebates, along with the ER definitions and criteria (if any) are summarized in Table 1 below. The criteria used to define ER vary, but the reigning criteria seems to be no criteria – i.e, four of the eight programs provide no meaningful guidance to contractors regarding how to determine whether an HVAC unit is functional. While the rebates are clearly provided on utility websites, along with terms like "working order" or "operating," detailed definitions of those terms were not on any of the program websites. Obtaining any level of detail required multiple calls to hot lines, program implementers and HVAC contractors. Given rebate levels as high as $1,200, the lack of a clear and transparent ER definition seems like a major omission.

Table 1. Confirmed HVAC Early Replacement Rebates and Eligibility Criteria

State - Jurisdiction [5]	ER Bonus Rebates [6]	Eligibility Criteria	ER Definition
Arizona -- Tucson Electric Power (2017)	$350	"Early retirement" and the rated or actual measured Energy Efficiency Rating (EER) [7] cannot exceed 8.5.	Certified contractors submit diagnostics data (~ ten measurements) through a call center – e.g., refrigerant charge must be within +-8% of manufacturer specification. Certified contractors must participate in training and have diagnostics

[5] See References for sources.

[6] These are incremental rebates for ER units. Where NR incentives are also offered, the ER incentives reported here are additional to the NR rebates. If there are no NR rebates, the ER rebates reported here are the total rebates.

[7] The EER is the ratio of BTU cooling capacity to kW power input.

			equipment, which is checked and calibrated as part of training. Quality control includes spot checks and software review of contractor data to identify any troubling patterns over time with contractor reporting.[8]
Colorado -- Xcel Energy (2017)	$500	"Functioning" or repairable at an estimated cost of $1,500 or less. The trade-in equipment cannot have a Seasonal Energy Efficiency Ratio (SEER) higher than 12.[9]	The unit must be able to cool the house. No other guidance is provided to the contractors.[10]
Illinois -- Ameren Illinois (2017)	$600-$1200	"Working" and nameplate SEER of 10 or less.	The only requirement is that the compressor must turn on.[11]
Kansas/Missouri -- Kansas City Power & Light (2017)	$125-$300	"Operating" and at least 5 years old and maximum nominal 10 SEER.	The only requirement is that the compressor must turn on.[12]
Massachusetts -- Mass Save (2017)	$500	"Functional" and at least 12 years old. Must be "verified" by a Mass Save Home Energy Service Provider or AC Check trained contractor prior to replacement.	The definition is left to the "discretion of the contractor." [13] The only requirement is that it must be "running." No further guidance is provided to contractors. [14]
Missouri -- Ameren Missouri (2017)	$50-200 (CAC only)	"Operating" and SEER 12 or lower.	Contractors must verify that there is a temperature drop across the coil to qualify for operating equipment rebates. This is corroborated with post installation customer surveys. Discrepancies are tracked and follow

[8] Phone conversation with Mike Simms, May 12, 2017.

[9] SEER is the cooling output during a typical cooling season divided by the total kWh electric input during the same period.

[10] Program hotline May 31, 2017.

[11] Based on responses from three of four randomly selected Ameren approved contractors May 2017. A fourth contractor said that Ameren Illinois looks at previous bills to see if there is a sudden reduction in consumption in cooling or heating season, which could indicate an existing unit failure and that the only other requirement is that it be connected to an air handler.

[12] Phone conversation with Terry Campo (ICFI) May 31, 2017.

[13] Program hotline May 19, 2017.

[14] Phone conversation with Sharon Carlino (CLEAResult) June 1, 2017. In the past, pretest measurements were required, but they were burdensome for contractors.

			up is conducted to determine accuracy of surveys.[15]
Nevada – NV Energy (2017)	$325-475	Existing system must be in "working order," at least 10 years old with rated EER < 8. New unit must be SEER 15 or higher.	Unit must have an operating condenser, fan motor, compressor, and enough refrigerant for a 15-minute test and still provide cool air. Implementer calls customers to verify unit was working.[16]
Ohio -- Dayton Power & Light (2017)	$100-200	"Working order," regardless of age, or less than or equal to 20 years old and repairable for less than $1,000.	Unit must "turn on."[17]

At least four state Technical Reference Manuals (TRMs) also prescribe criteria for determining ER baselines. The TRM criteria, which are summarized in Table 2 below, vary even more widely than the program eligibility requirements and are generally far more detailed. There seems to be little connection between program definitions and TRM definitions.

Table 2. Technical reference Manuals: Early Replacement Criteria

State	**Early Replacement Definition**
New York (New York Joint Utilities 2016, p. 466).	Equipment that is replaced before the end of its estimated useful life…Early replacement units are assumed to be no more than 10 years old, with no less than 5 years of remaining life.
Arkansas (Arkansas Public Service Commission 2016, p. 75)	The maximum lifetime age of an eligible piece of equipment is capped at the point at which it is expected that 75 percent of the equipment has failed.
Illinois (Illinois State Advisory Group 2016, p. 58).	"Operational" is not defined. If equipment is not operational, the existing unit should require repairs costing less than 20% of the new baseline replacement cost ($276 per ton for Heat Pumps and $190 per ton for central air conditioners). Note: There is no mention anywhere of repair estimates in lieu of being operational on the Ameren-Illinois website.
Texas (Public Utility Commission of Texas 2016, Vol 2.0, pp. A-3, 2-66 and Vol 5, p. 2-3).	The existing equipment should be "functional," "actively used," and have at least one year of remaining useful life. The age of the exiting unit should not exceed the 75th percentile of the measure estimated useful life; for residential central air conditioners, the age cannot exceed 24 years and for heat pumps the age cannot exceed 20 years. Each customer should respond to survey questions about the equipment condition and the customer's motivation for replacing the measure. The size of new unit should not exceed the size of the existing unit. A photograph should be provided of "temperature gauged by thermostat/thermometer before and after operating the unit to demonstrate functionality of the existing unit." Additional information should include a photograph of the unit nameplate;

[15] Email correspondence from Lou Brouk (ICF) June 20, 2017.
[16] Phone conversation with Debra Lohouse (CLEAResult) May 31, 2017.
[17] Phone conversation with Elizabeth Jacoby (CLEAResult) June 1, 2017.

	the manufacturer, serial number and model number; the age; and customer responses to survey questions about equipment condition and their motivation for replacement.

Pros and Cons of Early Replacement Definitions and Criteria

Various possible definitions and criteria for early replacement were considered in Maryland, including the ones highlighted above for existing programs and TRMs. Some pros and cons of each are summarized below.

Performance Measurement

The most common program definition of ER is whether certain system components will simply turn on. Four of the eight programs cited above only require the compressor to turn on. It is unclear how and under what circumstances this claim is verified by the programs. These are in a sense binary measures of performance, but give no further indication of the ability of a unit to cool the home and otherwise meet customer needs. None of the TRMs define ER in this way.

NV Energy requires that all the critical components turn on, including the condenser, fan motor, compressor, and that the refrigerant charge be sufficient to allow a 15-minute test and still provide cool air. Ameren Missouri requires a temperature drop as measured across the coil. Perhaps the gold standard for early replacement definition, validation and verification is Tucson Electric, which requires that HVAC contractors call in ten points of diagnostic test data to a program hot line during the actual test. Real time reporting of data by phone is intended to facilitate quality control and prevent contractors from submitting false efficiency values to the utility. Even with real time test data, the utility still conducts onsite verification.

Performance testing along the lines of Tucson Electric was considered in Maryland, with at least one HVAC contractor who has the required equipment and expertise supporting the idea. Other contractors and the program implementers were critical of using performance test citing the fact that, like the delta-temperature requirement, it would require a unit to be running. The evaluators were concerned about the reliability of self-reported test results from contractors, about the time required to verify the results, the possible intrusion on customers from additional and lengthy site visits by evaluators, and the need to purchase and learn how to operate test equipment for verifications.

At least two programs (Xcel Colorado and NV Energy) and one TRM (Texas) include at least vague reference to air temperature as an indicator of operability. The Maryland evaluators and implementers considered a minimum five-degree temperature difference between return and supply air measured at the unit for CAC and ASHP ER claims. A degree-minimum of ten degrees was also considered. Due to strong opposition from HVAC contractors, a delta-temperature requirement was rejected.

One possible problem with the delta temperature and other performance requirements is measuring air conditioner unit temperature changes in winter, since operating outdoor condensing units in cold or even cool temperatures (below 60 degree) can damage compressors.[18] This could preclude ER applications for air conditioning for as much as half the year. The question is how many ER units would be

[18] Some HVAC practitioners say that air conditioning systems can be tested during cold weather, but that it requires warming the house to 75°, connecting gauges and blocking air flow through the condenser. See, for example: http://www.hvactrainingsolutions.net/checking-refrigerant-charge-colder-months/. Other practitioners say cool weather testing of air conditioning should never be done. See, for example: http://www.webhvac.com/2012/01/will-running-an-air-conditioner-in-cold-weather-damage-it/

excluded due to testing requirement. If an HVAC contractor cannot turn a unit on for testing and diagnostics, what basis would the contractor have for recommending ER?

If the inability to conduct cold-weather testing is determined to be a significant problem, one way to address it would be to forego the performance testing requirement for ER applications submitted during the colder months of the year, say October through March. Applications for cooling that arrive in the colder months of the year are less likely to include failed air conditioning units than applications arriving in spring and summer.

Maximum Repair Estimates

Two programs (Xcel Colorado and Dayton Power & Light) and one TRM (Illinois) allows repair estimates to be used in lieu of a unit being operational. The intent is to avoid participants having to make hundreds of dollars of repairs to systems that they intend to discard and replace, just to demonstrate the system is operating. In worst case scenarios, participants might make repairs to then find out that the repairs did not make the unit operational, in which case they will have paid for the repairs and not received the larger ER rebate. While acknowledging that contractors could occasionally have to repair a unit just to turn it on and qualify for ER, there was some degree of skepticism about the extent to which this would be a major participation barrier for the EmPOWER HPwES program. As one person put it: "How often are 'early replacement qualifying' units inoperable? I'd hope not very often."

The Maryland HPwES implementers initially proposed that non-functional systems be eligible if they could be repaired for less than 50 percent of the cost of a new baseline (i.e., federal minimum standard) system. The Maryland proposal was more detailed than the author has seen presented in other jurisdictions. It would require that the repair estimate be presented to the customer alongside a high-efficiency replacement estimate. The customer would then have to expressly elect to forgo a repair for replacement with a new high efficiency system, thus demonstrating early retirement of an operating system.

The implementers acknowledged the risk of contractors gaming repair estimates, but argued that it would be self-policing. If a contractor underestimates the repair costs and the customer then decides to repair rather than replace the unit, the contractor would be obligated to make the repair based on the cost estimate, in the worst case even having to salvage a "dead" unit.

While the direction of the EmPOWER implementer's proposal was positively received by the evaluators, there are any number of ways that contractors could wiggle out of repair estimates and there would be no way for the program or utilities to force them to follow through with the estimates. And the group was unable to see how an implementer or evaluator would verify that repair estimates accurately reflect the condition of the ER unit. It is itself a counterfactual and verification would require detailed knowledge and an extensive inspection of the subject HVAC system. Even though implementers and evaluators were committed to conducting site visits, confirming or disputing whether repair estimates are realistic was not seen as tenable. A repair estimate definition of operational would ultimately have to rely on the integrity and competency of participating contractors.

Maximum Age

The Maryland HPwES program implementers also proposed age caps equal to the equipment EULs for ER HVAC projects. One program (Dayton Power & Light) and two TRMs (Arkansas, New York and Texas imposes age caps on ER central air conditioners and heat pumps. The Evergreen survey of HVAC contractors in the Northeast suggests general concurrence among surveyed contractors that major repairs are generally needed when typical units reach ages of 10 to 15 years. (Evergreen Economics 2015) This suggests that an age cap could provide a meaningful criterion for ER.

On the plus side, an age limit would restrict the number of ER claims; It would reduce the number of applications for failed units and the number of units that are near the end of their life. In doing so, an age cap would increase the average remaining useful life of the rebated units and thus, all else equal, increase the average lifecycle savings from the rebated units.

An age cap is easier to implement than some of the other ER criteria discussed in this paper, but that doesn't mean it would always be easy. Serial numbers for many HVAC units give manufacture date codes. For those units, a photograph with the nameplate information would provide the necessary detail to enable implementers and evaluators to establish the age of most units using look-up tables. Processes would be needed to ensure photos and other documentation associated with the units being replaced are available and contingencies would be needed for situations in which nameplates and other documentation are not available. [19]

The problem with an age cap is that it also restricts legitimate ER claims and disallows incentives for replacement of the oldest units.[20] Generally, the older the unit, the lower the rated efficiency of the unit was when it was new and the more time for performance to degrade.[21] The assumed EUL (i.e., median life) for central air conditioners and air source heat pumps in Maryland is 18 years, which means that half of units installed are assumed to still be operating after 18 years. As discussed elsewhere in this paper, an HVAC unit that is 18 years old (at the end of its EUL) has an expected remaining useful life of six years. The NEEP/Evergreen report was unequivocal in its conclusion regarding age caps: "[Program Administrators] should not implement maximum equipment age requirements — older units are likely to be the most cost effective to replace" (Evergreen Economics 2015, p. 70).

Minimum Age

Three programs (Mass Save, Kansas City Power & Light, and NV Energy) impose minimum age requirements on top of requirements that ER units be functional. An age floor would not stand by itself as a definition of functionality, but rather is intended to ensure the high ER incentives are paid for replacement of the oldest and least-efficient units. The implementation challenges associated with collection of accurate age information would be increased with minimum age requirements since, by design, the *in situ* units would be older.

Minimum age requirements were not discussed as a Maryland ER requirement, but perhaps should be if the programs bump against budget caps and need a relatively easy way to limit the number of program units.

Rated Efficiency

Six of the eight programs (the exceptions are Dayton Power & Light and Mass Save) impose caps on the rated efficiency (either SEER or EER) of the replaced HVAC equipment. None of the TRMs include efficiency caps.

Just the opposite of age caps, efficiency caps restrict incentives for replacement of higher efficiency units without discouraging replacement of older inefficient units. The objective is to avoid

[19] Obtaining age data for *in situ* units is not always feasible. Serial numbers on nameplates may not be readable because they have been worn off by the elements or are not viewable due to the position of the unit. Ensuring that serial numbers, which are lengthy, are recorded correctly is another challenge.

[20] A second concern expressed by at least one Maryland HVAC contractor is stakeholder meetings is the lag between when a unit is manufactured and when it is installed. Most contractors and HVAC experts the author has spoken with say the lag between manufacture and installation is generally less than one year and not a material concern.

[21] For discussion of central air conditioner and heat pump degradation and measurement methods see Cadmus (2014), p.77.

paying large ER incentives for small incremental savings. The NEEP/Evergreen study recommends efficiency caps be imposed on ER projects "to improve energy savings and cost effectiveness" (Evergreen Economics 2015, p. 70).

While a cap on rated efficiency can complement other ER criteria, it cannot stand alone as a definition of ER, since the rated efficiency when a unit was installed says nothing about the current operating condition of the unit. Another challenge with caps on rated efficiency is collection of data needed to establish efficiency levels, along with related documentation and verification. Efficiency ratings of the air conditioners and heat pumps are often not included on equipment nameplates so efficiency information would need to be obtained from lookup tables on manufacturer websites. And the system efficiency when the unit was installed may have been significantly less than the rated efficiency of the air conditioning or heat pump "out of the box" efficiency due to improper refrigerant charge and airflow settings.

Waiting Periods

Another option that was considered for establishing ER was to impose a significant waiting period between when applications are received and when the rebates are approved. The assumption behind the waiting period is that customers will be reluctant to do without heating or cooling for any significant period during the heating and cooling seasons – weeks and even months were discussed. A waiting period would seriously diminish the likelihood that system failures would be claimed as ER.

Waiting periods could eliminate the need to verify ER claims based on other criteria. The criterion for ER could simply be: "Is the customer willing to wait for replacement?" As one participant in the EmPOWER discussions put it: "If the ER program is truly working like it should be, then the "waiting" period is six-plus years, isn't it? So, what's a couple months in the grand scheme?" [22] If other criteria for ER are desired, the waiting period gives an opportunity for implementers and evaluators to verify at least claims for at least a sample of ER applications and, perhaps more importantly, let's the contractors know that verifications could occur.

Even if there are no formal waiting periods, if the HPwES program does not offer expedited reviews and approvals of HVAC ER project reservations, *de facto* waiting periods of at least a week or two will likely be imposed. Longer waiting periods were strongly opposed by program implementers and contractors citing disruptions to the sales cycle and that contractors would be less willing to recommend customers participate in the HPwES program if the requirements were too onerous.

Verifying Early Replacement Claims

For all options except waiting periods, offering meaningfully higher incentives for ER HVAC requires at least some level of third party verification to ensure the accuracy and veracity of ER claims. The challenge is to institute verification procedures that: 1) give the information needed to check the accuracy of contractor and/or customer ER claims, 2) do not create unnecessary delays or disruptions in the program and sales cycles, and 3) balance the added cost of evaluation with the benefits of increased accuracy.

It was difficult to discern, based on discussions with implementers and contractors, the level of formal verification that is conducted by the existing ER programs. In all cases, there seems to be at least some level of follow-up surveys to inquire about claims and/or systematic review of claims on applications.

[22] The deemed Remaining Useful Life for *in situ* HVAC equipment is 6 years – i.e., one-third of the 18-year estimated useful life.

To verify HPwES ER HVAC claims in Maryland, the evaluators proposed to conduct approximately 30 on-site visits annually. The site visits would occur after the application was submitted but before the project was implemented. The on-sites would be conducted in sets of ten over three week-long periods that would be unknown to implementers or contractors in advance. Implementers would be required to send weekly reports to evaluators with ER application approvals, rejections and scheduled inspections.

When the decided week arrived, evaluators would inform implementers that they would be conducting the inspections instead of the implementers. This would avoid multiple visits to the same home by evaluators and inspectors and thus minimize additional burden on customers. If material differences were observed, evaluator verification results would be compared to implementer inspection results and inspection sampling and onsite measurement methods would be revised to address those differences.

The verification burdens imposed on program participants and trade allies is an important consideration when deciding the ER definition. But, importantly, there also is a cost incurred if ER claims are not verified. While costs and benefits must be balanced, verification is a necessary cost of any meaningful bonus rebate for ER HVAC projects.

Why Project-Level Definition of ER is Important

EmPOWER Maryland savings goals are quickly ramping up to 2 percent of annual sales. Given rapidly declining savings from lighting and appliance measures expected in the next few years, the EmPOWER program administrators will need to achieve (and take credit for) every bit of first-year gross savings they can to meet their goals. Offering higher incentives for ER HVAC could increase first-year, as well as life-cycle, savings.[23] Giving higher incentives without distinction between ER and NR HVAC will reduce the potential increases in program and portfolio savings that could have come from more ER-only projects and may even reduce overall portfolio savings from current levels.

First, the HPwES bonus incentives for HVAC projects were intended to increase HVAC contractor interest in the HPwES program and thus increase HPwES program savings. However, the extent to which HVAC contractors' interest is heightened will depend on how much higher the HPwES HVAC rebates are than the existing HVAC program rebates. Basing HPwES HVAC incentives on NR baseline assumptions means lower incentive bonuses will be offered than would otherwise have been offered for ER HVAC. Thus, the failure to arrive at a consensus definition for project-level ER undermines the primary objective of offering HVAC bonus rebates through the HPwES program – to increase HPwES participation and savings.

Second, the implementers are at least temporarily passing up the opportunity to increase HPwES program savings by encouraging more customers to replace operating but inefficient HVAC systems. The existing Residential HVAC program incentives are, by most estimates, not large enough to drive ER. Although participant surveys suggest a large share of the existing HVAC systems that were replaced were "operating" and "not in poor condition," the rebates were not sufficient to induce replacement of their HVAC systems; rather, they just induced participants to purchase a higher efficiency system than they would have (i.e., NR). Inducing additional ER of HVAC with higher incentives for ER would increase overall

[23] First-year savings for CAC and ASHP units can be more than twice as high for an ER than an NR unit. For example, a 16 SEER program unit replacing an 11 SEER *in situ* unit (ER) would get 2 ½ times the savings of a 16 SEER unit replacing a federal minimum standard 14 SEER unit (NR). An 18 SEER program unit would get 75% more savings for ER than NR. The ER project life cycle savings will also be higher than an NR project, but by a smaller proportion, since the ER annual savings will revert to the NR annual savings at the end of the replaced units remaining useful life. For in depth discussion of ER and NR baselines, see Evergreen Economics (2016).

EMPOWER portfolio first year and life cycle gross and net savings. Higher incentives for ER HVAC cannot be offered without a clear project-level definition of ER.

Third, offering bonus incentives for NR HVAC projects through the HPwES programs may simply cannibalize projects that would have received smaller incentives through the HVAC program. While HPwES participants must meet certain air sealing and insulation requirements, and may be subject to blower door tests and other building performance diagnostics, the incremental effort associated with obtaining HVAC rebates through the HPwES program could be small for some customers, especially if they have already participated in the HPwES program. For those customers, the bonus HPwES HVAC incentives will not have driven HVAC or shell-efficiency savings over and above the savings that would have been realized without the bonus HPwES HVAC rebates; consequently, EmPOWER ratepayers will pay more rebates for the same savings. Meanwhile, given that program budgets are likely to remain flat for the foreseeable future, higher per unit incentives will mean that fewer HVAC projects can be rebated.

Finally, while the theory behind the changes to the HPwES programs have been discussed extensively in EmPOWER working group meetings, the redesigned EmPOWER HPwES program will in effect be a fully commissioned pilot program. Even before the HPwES makeover, relative incentive levels have been points of contention among various trade allies and stakeholders. Acknowledging these uncertainties, the PSC made very clear its concerns about the accuracy of modeled savings and the need for timely reporting of "actual" evaluated savings.[24]

Thus, it is no small concern that including both ER and NR HVAC in the HPwES program will complicate HPwES program evaluations. First-year, ex post gross savings from HPwES comprehensive whole-house projects (i.e., projects that include insulation, air sealing, and/or duct sealing) are evaluated by comparing one year of pre-project and one year of post-project bill data, with some adjustments for weather and other factors.[25]

Participant bill analyses can provide reasonably accurate estimates of HVAC first-year gross energy and demand savings only for ER projects. Participant bill analysis implicitly and unavoidably compares the post-treatment consumption to the consumption associated with the old *in situ* unit that was replaced. If the HVAC measures were replaced upon failure (i.e., NR), then bill analyses will significantly overstate savings.

Including both ER and NR projects means that evaluators will need to determine or deem the share of HVAC projects that are NR and for those projects will then need to subtract an engineering-based estimate of savings that would have been realized if the project was ER, then add back an engineering-based estimate of savings that would have been realized if the project was NR. This means that for all HPwES projects that include HVAC, the shell and other non-HVAC system savings will be a residual – i.e., the bill savings minus the estimated savings from the HVAC replacement.

Conclusion

Given the potential benefits of offering bonus rebates targeting HVAC ER, EmPOWER stakeholders will continue to pursue consensus definitions of ER. This paper and the struggle to arrive at a consensus definition of ER in Maryland underscores the need for a broader industry consensus on how to define and validate ER baseline claims.

[24] Maryland Public Service Commission, Order 88007, February 2, 2017, p6.

[25] This is common practice throughout the United States for HPwES evaluations, but means that ex post evaluation results are not available until at least 12-16 months after the end of the evaluated program year, which could mean more than a two-year lag for projects that were completed in the first few months of the evaluated program year.

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