Is It Time To Move Beyond the Whole House Approach?

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ABSTRACT

The home performance (HP) industry has made remarkable progress over the last decade, with help from the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA). Whereas 10 years ago building science based energy upgrades for middle and high-income homes were virtually unheard of, today HP upgrades are available in over 35 states and over 400,000 homes have received such upgrades to date. Following these early successes, DOE has set the following long term goals for improving the energy performance of existing homes nationwide: to demonstrate at significant scale the successful reduction of typical home energy use by an average of 20 percent by 2020, 25 percent by 2025, and 40 percent by 2030, while improving indoor air quality, durability and comfort of the improved homes. To achieve these aggressive goals, DOE must help achieve substantial growth in residential energy efficiency markets, beyond the apparent limitations of the whole house approach (WHA) to HP improvement. To this end, DOE seeks to answer the following questions:

- Do home improvement trades have significant unrealized potential for growth in residential energy efficiency?
- Can a trade-based approach (TBA) to HP improvements be developed that does not initially require the WHA?
- What strategies can DOE use to expand trade interest in offering energy efficiency?

This paper will discuss these questions in more depth and describe in limited detail the strategies DOE is currently considering to address these questions. In presenting this paper at the ACEEE Summer Study, the authors hope to stimulate constructive debate about the merits of the proposed approaches.

Background

Weatherization and Home Performance (HP) programs have made great strides introducing home energy performance to the housing industry, establishing new industry infrastructure, and developing a comprehensive approach to improving homes based on sound building science - i.e., the whole house approach (WHA) - and the economics of home energy improvements (EPA 2014, DOE 2008). Based on these early successes and lessons learned, DOE set the following long term goals for improving the energy performance of existing homes nationwide: *To demonstrate at significant scale[1] the successful reduction of typical home energy use by an average of 20 percent by 2020, 25 percent by 2025, and 40 percent by 2030, while improving indoor air quality, durability and comfort of the improved homes.* (Lee 2014)

[1] For this paper, DOE considers significant scale in HP improvement markets to be achievement of sustainable market growth independent of incentives, with target market penetration of 15% or more.

To achieve these aggressive goals, DOE must help achieve substantial growth in residential energy efficiency markets, beyond the apparent limitations of the WHA. DOE is considering trade-based approaches (TBA's) to engage home improvement trades to achieve energy efficiency in the broader home improvement and remodeling markets. DOE is not considering a TBA as a substitute for the WHA. Rather, DOE's hypothesis is that focusing on specific trades can incrementally improve the energy efficiency delivered by each trade, and gradually expose workers to building science and the WHA without requiring them to adopt significantly different business models, as is currently the case in the emerging HP contracting industry.

The Whole House Approach

For over a decade, DOE and EPA have encouraged the adoption of the WHA to improve the energy performance of homes (EPA 2014, DOE 2008). The WHA to home energy assessment and retrofits recognizes that a house is a system composed of interdependent subsystems (i.e., thermal enclosure, HVAC system, appliances, lighting, etc.), each of which affects the performance of other subsystems and which in turn are affected by the number and behaviors of the occupants, the home's site, and the local climate (DOE 2014). The WHA view of a home is thus quite distinct from traditional remodeling and renovation in which home improvements are separately considered by domestic function (kitchen, bathroom, bedroom, etc.), or by component (electrical, plumbing, roof, basement, siding, windows, heating and air conditioning).

One example of subsystem interactions is how lighting can impact home heating and cooling loads. Incandescent light bulbs produce much more heat than CFL and LED bulbs. Lighting upgrades can reduce cooling loads, increase heating loads, and thus significantly change HVAC system performance, depending on the loads and the amount of lighting affected (Sezgen and Huang 1994). Another example is the effect of home air-sealing on atmospherically vented furnaces and water heaters. Changing the air-tightness of the envelope changes house pressure dynamics, which can lead to furnace or water heater back-drafting in some cases. In this case, the subsystem interaction affects non-energy performance of the home (Rapp et al. 2012).

The WHA was developed by DOE's Low Income Weatherization Assistance Program (WAP), state and utility sponsored programs, and researchers at public and private institutions during the latter decades of the 20th century (DOE 2008). In 2002, Home Performance with ENERGY STAR® (HPwES) was launched to bring the approach to the private sector with the support of many leading-edge organizations including the EPA, New York State Energy Research and Development Authority (NYSERDA), Wisconsin Focus on Energy and Austin Energy (Krauss and Moriarta 2012).

HPwES promotes HP improvements in the private sector using the WHA, where a qualified contractor assesses the performance of the home, sometimes referred to as a comprehensive home energy audit, followed by the sale and implementation of energy efficiency, health & safety measures to improve the home's performance, and completed with verification that the installed measures deliver the promised performance improvements.

From the homeowner's perspective, the experience of going through HP improvements with the WHA is usually more involved than traditional home improvement contracts, in which improvements are installed individually and performance is not measured or verified or even considered. By contrast, HP improvement contracts begin and end with performance assessments, and the installed measures are the means to achieve a performance improvement

objective. For example, a homeowner may have a problem like high energy bills, a room that is too hot or cold, or the desire to reduce their environmental impact. Homeowners often learn about HP improvement opportunities through free or discounted home energy assessments offered by a local program. They schedule an assessment and are presented with a list of recommended upgrades, usually with incentives offered for each or combinations thereof. The assessor is either a qualified HP contractor or refers them to one or more qualified HP contractors to complete the recommended work. If the assessor is not a contractor the homeowner must decide which upgrades, if any to perform, contact contractors and obtain quotes on the cost of the work.

The Home Performance Industry has Made Impressive Progress

The HPwES Program, the Recovery Act-funded Better Buildings Neighborhood Program (BBNP), and the emerging HP industry have a shared primary goal of making energy upgrades with the WHA widely available to middle and upper income households. Significant progress towards this goal has been achieved and the industry has gained momentum in recent years. HPwES Sponsors and BBNP grantees, and their participating HP contractors are located in over 40 states. These programs and contractors have completed over 400,000 HP upgrade projects since 2002, and have demonstrated that the WHA works. According to reported data by HPwES Sponsors, homeowners realized an estimated weighted average savings on their annual energy bills of $506, 26% of EIA's estimated average U.S. home energy costs of $1,945 in 2012.

The HPwES Program is positioned for substantial growth in the near future. Keeping a focus on scaling the HP market, DOE released the *HPwES Sponsor Guide and Reference Manual v1.5* and is executing new initiatives focused on supporting industry growth, including: expanding delivery of HP by new market actors, development of new recognition and labeling schemes to improve awareness, using data to demonstrate value of HP to all market participants, and developing new quality assurance systems based on quality management principles utilized in other industries.

Remaining Home Performance Industry Challenges

While the HPwES and BBNP programs, and the HP industry, have made significant progress, the industry has not reached significant scale (i.e., >15%) in any major market to date. Thus, DOE is evaluating additional strategies to overcome challenges facing the industry and expand the growth of residential energy efficiency beyond the current approaches. DOE has identified the following programmatic challenges that HPwES and related programs must overcome to help the HP contracting industry reach scale:

- Perceived program value and market awareness
    - Market awareness of HP and HPwES is low
    - Few homeowners understand the value proposition for HP
    - Misconceptions exist regarding the cost vs. value of a HP project
    - Artificial barriers to participation are inhibiting market penetration
- Program consistency and effectiveness of delivery
    - Perceived program administrative burden and complexity inhibits broader program acceptance
    - Business case to appeal to broader range of trades is lacking

- Program cost efficiency
    - Lack of clarity on minimum program requirements to reduce local program production, data collection, and reporting costs
    - Costly approaches to conducting QA processes
    - Missed opportunities to apply the WHA during system specific projects

What if DOE Leveraged Routine Home Improvement Activity?

There are a number of trades that in the course of their work, could improve the energy efficiency of their client's homes without it being their main purpose. These include trades such as HVAC contractors, electricians, roofers, plumbers, exterminators, and remodelers. DOE is assessing these and other trades, to better understand where there are missed opportunities for energy efficiency improvements that could be relatively easily captured by encouraging trades to offer incremental energy efficiency services. To better understand these opportunities and explore policy options, DOE is considering the following questions:

1. Which home improvement trades have significant unrealized potential for growth in residential energy efficiency, and which HP improvements are feasible to add to their businesses?
2. Can a trade-based approach (TBA) to HP improvements be developed that results in home energy efficiency, avoids or mitigates related risk, and does not initially require the WHA? Can a TBA expand long term adoption of the WHA?
3. What strategies can DOE use to expand trade interest in offering energy efficiency, through either the WHA or a TBA, or both?

Which Home Improvement Trades Have Significant Unrealized Potential for Growth in Residential Energy Efficiency, and Which HP Improvements Are Feasible to Add to Their Businesses?

There is a tremendous amount of routine home improvement activity. In 2011, approximately 16 million U.S. households reported hiring professional contractors to complete approximately 30 million home improvement projects[2]. Of these, 89 percent[3] were projects which either offer a direct opportunity for significant energy savings through improved delivery of the core service, can create physical access to portions of the building envelope, or for which there is a natural sales link with a major energy efficiency improvement. (JCHS 2013). Which trades have the most opportunity for energy savings? Which trades will have the lowest hurdles to entry?

Table 1 paints a picture that begins to clarify the opportunities. Clearly, looking at volume directs us to evaluate the HVAC trade as an area of potential savings. However, strong arguments could be made for developing some initiative that would improve the roofing or flooring industries. Other arguments could be made to focus on remodelers who do bath and kitchen work to take advantage of potentially significant energy and water savings.

[2] Project estimate treats each household reported in each home improvement category as a separate project; exact total is 29,841,000.

[3] Estimate derived multiplying the total number of household reporting Professional projects from Table A-2 (JCHS 2013) (16,033,000) by the ratio of the sum of all categories of households reporting projects from Table A-1 (29,841,000) and the sum of all categories of households reporting projects in this table (26528000); ratio is 0.89.

In deciding which trade or trades to focus DOE's efforts, one of the criteria must be potential energy savings. One issue that needs to be included in the decision making process is breadth vs. depth. Should DOE focus an activity on a trade that has the potential to yield small savings on a substantial volume of homes, or should DOE focus on trades that could yield substantial savings from each project, even if there are not that many of them?

Table 1. Professional home improvements projects (2011) that might be leveraged to incorporate efficiency improvements

	Homeowners Reporting Projects (000s)	Average Expenditures ($)	Total Expenditures (Millions of $)
Kitchen Remodels (Major)	428	24,974	10,684
Bath Remodels (Major)	522	12,801	6,680
Room Additions and Alterations			
Kitchen	27	33,940	919
Bath	169	10,609	1,798
Bedroom	216	14,998	3,245
Other	531	14,434	7,668
Systems and Equipment Additions & Replacements			
HVAC	3,212	4,783	15,365
Appliances/Major Equipment	4,802	789	3,786
Exterior Additions & Replacements			
Roofing	3,018	6,540	19,742
Siding	720	6,101	4,392
Windows/Doors	2,825	3,554	10,039
Interior Additions & Replacements			
Insulation	1,059	1,502	1,590
Flooring/Paneling/Ceiling	4,308	2,974	12,809
Other Interior	467	3,692	1,725
Disaster Repairs	775	13,989	10,842
Other Property Additions & Replacements	3,449	5,835	20,127
Total (estimated)	14,253		131,411

Source: Table A-2 in Appendix to Harvard JCHS. 2013. The U.S. Housing Stock: Ready for Renewal.

Table 2 illustrates the efficiency improvements that might be incorporated or added as a new option for these categories of routine home improvement projects. This seems particularly apt given that most efficiency improvement in the housing stock since 1970 has occurred through incremental improvements that occur within the existing home improvement and remodeling markets.

Restricting consideration only to the subset of projects for which efficiency improvements are directly connected to the core service (i.e. HVAC, water heaters, siding,

windows and doors, and insulation) still captures 12 million professional projects contracted for by 6.8 million households, 33% of all professional home improvements (**Table 3**).[4]

Table 2. Opportunities for improved energy efficiency associated with routine home improvement activities

Category of Home Improvement	**Energy Efficiency Improvement**
Remodeling (additions)	Meet ENERGY STAR/DOE Zero Energy Ready Home requirements for addition; add air-sealing and insulation, high efficiency replacement products, or insulated, sealed, repaired, or improved ducts and duct systems
Remodeling (kitchen & bath)	Add insulation and air-sealing (e.g., finished basement)
Roofing	Add attic sealing and insulation; attic duct sealing and insulation
Siding	Install exterior wall insulation, where uninsulated
Windows	High efficiency windows; Add flashing; Add air-sealing; Add attic/basement insulation
HVAC Repair	High efficiency components; Add duct sealing
Insulation	Add duct sealing
Water Heating	Upgrade replacement to high efficiency water heater; hot recirculation pump; insulate pipes
Disaster Repairs	Add air-sealing and insulation, high efficiency replacement products, or insulated, sealed, repaired, or improved ducts and duct systems; equipment and system optimization.

For a subset of these categories of home improvement, the energy efficiency improvement opportunity is large and directly associated with the core service. For example, improper installation and poorly designed, leaky, uninsulated duct systems make most residential ducted HVAC systems inefficient. A program in Arkansas focused on tuning up existing HVAC systems and ducts, producing an average of over 1 kW of demand reduction per household. (Cadmus 2013)

Contractors selling vinyl siding already promote added insulation, but could offer exterior insulation finishing systems (EIFS) as a high end option. Half of all window replacement customers say their motivation is efficiency, and might readily choose an "energy performance plus" option that would give them even greater efficiency and other benefits. With the right sales support, and financing tools, plumbers could generate a competitive advantage and additional profit by upselling to high efficiency products such as a heat pump water heater, "I'm recommending the high efficiency unit even though it increases the cost of my bid, because in the long run it is a much better value for you".

[4] Values calculated using methodologies described in previous footnotes. Sum of households reporting projects for HVAC, water heaters, siding, windows and doors, and insulation is 9,979,255.

The high cost of many of the routine home improvements is likely to be an asset due to the power of the contrast principle (Cialdini, 2007). As car dealers have known for many years people judge cost in relative terms. People who would never pay $3500 for a leather couch, will happily agree to pay that much to add the leather seat option to $30,000 car they are purchasing. The reason for this is the contrast effect and it is why car dealers get customers to commit to purchasing the car at the base price and then offer you the options as add-ons one by one. Ironically, due in part to the contrast effect, window sales persons offering performance plus air-sealing and attic insulation for $1500 on top of a $10,000 window replacement job may achieve much better conversion rates than HP contractors trying to sell just air sealing.

There is another reason why a window sales person may have more success. When purchased with the window replacement, the attic insulation and air sealing are now part of a visible product which will give the homeowner frequent and repeated gratification and can be shown to and admired by friends, neighbors, and family.

Table 3. Restricted set of home improvement projects (2011) that might be leveraged to incorporate efficiency improvements

Professional Activity and Expenditures			
	Homeowners Reporting Projects (000s)	Average Expenditures ($)	Total Expenditures (Millions of $)
Systems and Equipment Additions & Replacements			
HVAC	3,212	4,783	15,365
Water heater*	2,163	774	2,702
Exterior Additions & Replacements			
Siding	720	6,101	4,392
Windows/Doors	2,825	3,554	10,039
Interior Additions & Replacements			
Insulation	1,059	1,502	1,590
Total (estimated)*	5,362		34,088

* JCHS does not disaggregate professional and DIY projects and expenditures for water heaters but does provide a disaggregation for all projects (combined DIY and Professional). Estimate for households reporting projects is derived by multiplying total households reporting water heater projects (Table A-1) by the ratio of Professional to DIY households reporting "Appliance/major equipment" projects (0.62) (Table A-2). Total expenditures are for all water heater projects.
Source: Tables A-1 and A-2 in Appendix (JCHS. 2013).

Can a Trade-Based Approach (TBA) to HP Improvements Be Developed That Results in Home Energy Efficiency, Avoids or Mitigates Related Risk, and Does Not Initially Require the WHA? Can a TBA Expand Long Term Adoption of the WHA?

One of the fundamental tenets of the WHA delivered by HP contractors is "Do No Harm". It is this principle that focuses HP contractors on fully understanding the home and all of its interacting subsystems before offering recommendations or beginning any work on a home.

By following this approach, the contractor can ensure that she is not causing any harmful health and safety issues or potential failures of systems as a result of their HP work. She can also focus on legitimately solving the most important issues for the homeowner whether they are energy, comfort, safety, or durability related.

In developing and executing a TBA, it is critical that DOE does not promote measures or methods that could potentially violate the "Do No Harm" principle. The options for possible measures completed by specific trades are narrowed when this filter is applied. DOE may only have two options: focus on technology based solutions that have no impact on health, safety, and durability; or focus on contractor-delivered measures that require limited training and possibly credentialing of the trade contractor. Through stakeholder engagement, DOE will explore reasonable options to deal with these risks.

What Strategies Can DOE Use to Expand Trade Interest in Offering Energy Efficiency, Through Either the WHA or a TBA, or Both?

This first order analysis described above (question #1) suggests that leveraging routine home improvement activities could provide DOE with the scale it needs to achieve its aggressive energy savings goals, even if only focused on those trades for which energy efficiency improvement is obviously linked to the core service. However, leveraging the larger home improvement industry and targeted trades will require new, expanded strategies. DOE is exploring three types of strategies for expanding markets to include home energy efficiency improvements, which are discussed in limited detail below.

DOE strategies to expand interest in the WHA through HPwES. Many HP contractors have difficulty selling HP because the homeowner isn't clear about the value of the recommended improvements. By associating the value of those improvements with a score, label, or benchmark that allows them to easily compare their home to others, the homeowner has a better idea of how to value the improvements related to HP. The NAHB Study, What Homebuyers Want, indicates that in 2012, 91 percent of homeowners would like an ENERGY STAR label on their home to convey its performance to others (NAHB 2014). There are several scoring systems available that evaluate the asset value of a home, including: DOE's Home Energy Score, Earth Advantage's Energy Performance Score, and RESNET's Home Energy Rating System (HERS). The national Green MLS Toolkit industry collaborative is working with stakeholders in the HP industry to facilitate the addition of these scoring and labeling systems into local MLS services around the country. The idea is that if more homebuyers see these scores and labels on homes, they will start associating them with higher value, thereby making energy efficient homes worth more than inefficient homes. (CNT Energy 2013)

While EPA ENERGY STAR for Homes and DOE Zero Energy Ready Home programs offer labeling schemes for new construction, there is no equivalent in the existing homes market. DOE, EPA, and many other stakeholders are investigating the value of labeling existing homes and how they may be implemented. For example, an existing home label could include information about how the home was improved and estimated energy savings. HPwES is also researching the value of certificates issued by Program Sponsors at the end of HPwES projects. These certificates are usually referred to as Certificates of Efficiency Improvements or Certificates of Energy Performance and can include the asset scores mentioned earlier.

HPwES is also evaluating opportunities to reduce the administrative burden placed on contractors and homeowners to participate in the Program. Through streamlined data exchange

protocols, improved quality assurance systems, and stronger integration with other EPA and DOE programs, it is hoped that the burden to participate in HPwES will be substantially reduced. Further, HPwES is looking for structures of partnerships that will enable contractors to offer HPwES services whether or not a local organization sponsors the program. In so doing, the contractor may be able to work under the auspices of HPwES through a company that does not have the type of cost-effectiveness or liability constraints of more traditional program administrators. This structure would encourage greater diversity of market actors in a local market thereby improving its health and sustainability.

To expand and increase the participation of different types of organizations and companies, DOE is exploring strategies to recruit HP contractors from the broader home improvement contractor trades. By educating contractors about HP contracting opportunities, home improvement contractors may learn to incrementally raise the level of performance of their client's homes while increasing revenues.

Figure 1 illustrates how HP can be incorporated into varying levels of home improvement. When combined with a home improvement plan, these types of improvements are referred to as staged retrofits.

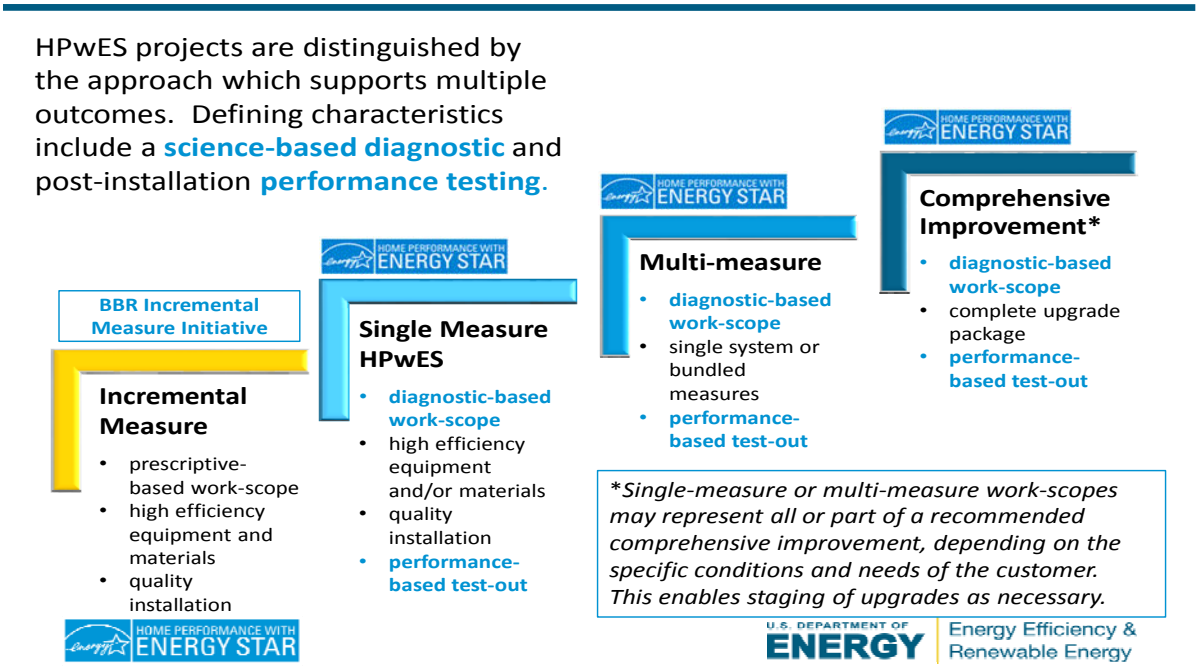

Figure 1. HPwES project staging options.

DOE strategies to explore TBA's with incremental measures. The second strategy DOE is exploring is currently called the Incremental Measures Initiative (IMI) and aims to add or enhance regularly occurring home improvement services to deliver greater energy efficiency. In contrast to HPwES, which focuses on applying the WHA to HP improvement, and targets 15-25 percent energy savings per project home, IMI is expected to focus on smaller market-ready individual (1-5 percent) or bundled (2-8 percent) energy saving measures as part of regularly occurring home improvement projects, making enhanced energy efficiency a secondary benefit rather than the primary objective of the home improvements. The IMI aims to capture the millions of currently missed opportunities, where homeowners upgrade an appliance, HVAC

component or other energy system but purchase less efficient systems or materials with higher lifetime cost. IMI will only achieve its objectives if specialized trade contractors learn to sell customers high efficiency options. The IMI is currently in the planning stage, but is anticipated to be piloted as one or more TBA initiatives. Development of the IMI is progressing along the following path:

1. Market research to identify and prioritize measures with the highest annual energy saving potential when considering savings per household and the frequency trigger events (such as HVAC failure) whose resolution could reasonably include implementation of the measure in TBA programs;
2. Research to identify programs in which existing single or bundled measures are successfully achieving high volume at a regional level;
3. Stakeholder outreach to target stakeholders, including manufacturers, distributors, trade contractors, and trade associations, to assess which candidate measures might increase profits and/or improve customer satisfaction, identify barriers to adoption, and evaluate stakeholder interest in testing the TBA;
4. Outreach to energy efficiency program sponsors and advocates for feedback on prioritized lists of measures, identification of successful programs which could be scaled nationally with DOE assistance, and indication of interest in participating in pilot TBA programs;
5. Facilitate pilot test TBA, incremental measure programs with industry and utility partners.

A key strategy question for DOE is where can it add value? For which measures would a DOE role unlock high sales volumes and new and/or lower cost energy savings? IMI plans to encourage existing program administrators and/or other energy efficiency market actors to do one or more of the following:

- Identify target trades and select trade-appropriate incremental measures to promote that offer [cost-effective] energy savings;
- Roll out new programs or improve existing individual measure delivery mechanisms to increase the sales/implementation volume of individual measure(s) and achieve greater energy savings;
- Claim more accurate savings from individual measures due to better data [5]
- Lower the implementation costs of energy efficiency measure deployment.

The TBA, if it proves viable, would be complementary to the WHA. DOE plans to pilot the TBA and implement the IMI so that measures are designed and installed consistent with building science principles, both to deliver expected savings and to avoid harm.

Should the IMI strategy achieve early success with single measures, DOE anticipates evolving the TBA towards staged or phased retrofit goals, consistent with DOE goals and the WHA. Each TBA project would replace or repair a major home systems or component, with added efficiency improvements, either by up-selling to higher efficiency or additional measures.

[5] More accurate savings are not an unalloyed good. Accuracy might lead to higher estimates, but could also lead to lower savings. Lower savings can have benefit by protecting the utility from a more unhappy surprise in the future, although this is not always the case and such data would not always be welcome.

For instance, when the furnace or HVAC is replaced, the ducts would be sealed and insulated, and ducts modified where necessary to ensure balanced air flow. The HVAC equipment would be properly charged and tuned, or perhaps ducting would be eliminated and replaced with a ductless system. When the customer's water heater failed the next year, the plumber would recommend the high efficiency product and pipe insulation. A few years later when the homeowner decides to replace old windows, the participating window salesman will offer the program package which would ensure the home receives DOE recommended insulation and air-sealing. By this point, the client may be ready for more advanced HP contracting services. By the end, the energy performance of this home and millions like it could be improved by 15 to 25 percent without the homeowner ever actively seeking energy efficiency upgrades. It will have occurred because IMI worked with the trade allies to identify approaches that would enable the efficiency to piggyback on the routine home improvement activity in ways that deliver increased profit to the installer and increased satisfaction to the customer.

DOE strategies to develop retrofit solutions & guidance for trades through Building America. DOE's Building America program conducts applied research, development and demonstration (RD&D) projects, led by expert building science teams, in partnership with leading industry partners – i.e., builders, major trade contractors, manufacturers and more recently HP contractors. Building America projects solve technical and market barriers to spur innovation and lead to high performance homes. DOE strategically selects Building America Teams and projects to leverage influential early adopters of energy saving technologies and practices that would normally be perceived by market actors as too risky or costly. Since 2011, several Building America projects focused on retrofit technologies and techniques that go beyond the WHA, including:

- Demonstrating Deep Energy Retrofits (DER) – from 30% to 70% savings [WHA]
- Developing and testing phased retrofit measure strategies [WHA and/or TBA]
- Assessing impacts of independent, incremental measures (i.e., sequencing), including technical risks and cost penalties for out-of-sequence measures [WHA and/or TBA]
- Developing and validating incremental retrofit best practice guidance and specs for energy saving measures (e.g., insulation, air-sealing, window repair, HVAC replacement, etc.) [WHA and/or TBA]
- Customizing best practice guidance for multiple trades [TBA]
- Demonstrating and proving the business case for best practice incremental measure approaches [TBA]

Each of these research efforts will help to shape and improve HPwES and IMI over the life of the programs and additional similar efforts will continue to be forthcoming.

Conclusion

DOE is exploring ways to significantly expand the scale of HP improvements to achieve up to 40 percent energy savings in existing U.S. homes by 2030. This paper raises a series of questions to help identify opportunities for expanding HP improvements, both within the emerging HP industry using the WHA, and through traditional home improvement trades using TBA's. This inquiry includes a preliminary assessment of the most promising trades and measures for consideration.

The authors then present three strategies DOE is pursuing in support of growing the HP industry more quickly and to have energy efficiency upgrades integrated into the large volumes of regular home repair and improvement activities. DOE plans to explore these new strategies through two deployment programs, HPwES using the WHA and the new IMI to explore TBA's. Both approaches will require successful engagement of repair, maintenance, and home improvement contractors, demonstrating that offering energy efficient options of their services or becoming HPwES providers is a path to higher profits. While neither strategy is a complete departure from the WHA, both are recognition that improvements to the vast majority of homes will occur stepwise and not necessarily in the optimal order.

The intent of the authors is not to dissuade contractors or programs from offering the WHA, rather, the authors acknowledge that creating a robust market for improving the energy performance of existing homes in the U.S. will require more than one approach. DOE's long term (20 years) goal is broad market adoption of home improvements to reduce building energy consumption by 40 percent by 2030, and for existing homes to demonstrate at scale the reduction of energy use of typical homes by an average of 20% by 2020 and 25%, by 2025. This cannot be achieved quickly without broad market transformation and more appreciation of HP within the home improvement & remodeling trades.

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