What does the next generation of MEPS look like?

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Abstract

Minimum Efficiency Performance Standards (MEPS) have proven to be among the most effective and economically attractive national and regional policies for saving energy. In both the United States and European Union, the MEPS programs are mature with requirements covering products representing a significant portion of total energy consumption in the residential, commercial, and industrial sectors. In many cases, MEPS for individual products have been updated and strengthened multiple times leading some to observe that savings potential from future revisions are diminishing. However, significant sustained improvements in energy efficiency are needed to meet economy-wide energy saving and climate change mitigation goals. Technologies continue to evolve and converge. How can traditional MEPS evolve over the next decade to enable this policy approach to continue to deliver very large energy savings? This paper will report on the findings of two focus groups of experts convened in fall 2014. The focus groups, convened in the US, consisted of American experts, although many with international experience. This research was supplemented by individual interviews with experts based outside the US. This research generated and catalogued ideas for how MEPS can evolve to yield increased savings and identified pros and cons of applying various new approaches, some of which may have already been used on a limited basis in some economies. Topics included: strategies for maximizing energy savings through improvements to current processes; strategies for better capturing savings from controls, including applications of information and communication technologies; using MEPS to address systems opportunities; applying MEPS to new categories of products, including non-traditional types; wider application of horizontal MEPS; and improved integration with other energy efficiency and climate change mitigation strategies. The conclusion identifies future research directions for the most promising strategies. Although the paper is focused on the United States, many of the topics and conclusions have relevance for other economies as well.

Introduction

Appliance, equipment and lighting standards, also known as Minimum Energy Performance Standards[1], have been among the most successful policy instruments in reducing energy use in the United States and, in turn, saving money for consumers and businesses.[2] Cumulatively, all MEPS put in effect in the United States from 1987 to 2013, will reduce 6.8 billion tonnes of carbon dioxide (CO_2) emissions, equivalent to taking 1.4 billion automobiles off the road for a year, and will save consumers over $1.7 trillion (approximately €1.5 trillion) in energy costs, cumulative to 2030 (DOE 2015). The U.S. Department of Energy (DOE) implements MEPS for more than 60 categories of products used in the residential, commercial and industrial sectors.

1. In this paper we use "standards" interchangeably with the abbreviation MEPS.

2. We limit the discussion to MEPS that fall under the authority of the U.S. Department of Energy (DOE) Appliance and Equipment Standards Program (i.e., appliances, equipment, and lighting). In the US, building codes are adopted and implemented at the state level and vehicle standards are the authority of the Department of Transportation through the National Highway Traffic Safety Administration.

Existing national MEPS are expected to save 90 quadrillion British thermal units (quadrillion BTUs, or quads) which is equal to approximately 95 exajoules (EJ) of primary energy by 2020. The MEPS will continue to impact the market, amounting to more than 175 quads (185 EJ) through 2030. As a part of the President's Climate Action Plan announced in June 2013, the Obama administration set an aggressive goal of reducing CO_2 emissions by 3 billion tonnes by 2030 through energy efficiency standards enacted during the Administration's two terms. The 29 new or updated MEPS issued from 2009 through January 2015 will avoid an estimated 2.1 billion tonnes of CO_2 emissions through 2030, significant progress toward the administration's goal (ASAP 2015). Emissions reductions to date are equivalent to nearly one-half of the CO_2 emitted by the entire U.S. energy sector in 2013 (EIA 2014a).

While MEPS have proven to be an extremely effective mechanism for improving energy efficiency, a number of challenges and emerging trends suggest that the current approach[3] to standards may not adequately capture the energy savings available in the products sold today and in the future. As technologies and markets evolve, and as energy consumption patterns change, the conventional approach to standards must be examined with an eye to what is working and where new approaches could build on the success of the program and serve as a tool for future advances in energy efficiency. At the outset, the U.S. MEPS program was designed to lock in efficiency improvements in a set of well-defined product categories. This "widget" approach has captured enormous savings in many of the most widely used appliances, equipment and lighting products in the market.

At the same time that MEPS have driven down the per-unit energy use of many products, energy consumption patterns have shifted as an array of new products have entered the market and consumer habits have changed, both in our homes and in commercial spaces. Space heating and cooling, which for decades accounted for more than 50 % of residential energy consumption, now accounts for a declining share of 48 % (EIA 2014b). The share of electronics, appliances and miscellaneous end uses has increased; even by conservative estimates there are more than 3 billion plug-in devices in the US, a majority of which were non-existent even a decade ago (Kwatra et al 2013). As new end-uses account for a growing share of energy consumption, the existing scope of the standards program will cover a smaller portion of overall energy use.

The pace and scale of change in energy use patterns is increasing as the features and capabilities of energy using products evolves. For example, sensors and controls are now standard in many products, often with an objective of encouraging and complementing efficiency as well as providing convenience for users. As controls influence a larger portion of product energy use (e.g., on/off and dimming controls for lighting, automatic brightness control on televisions, etc.), effective MEPS and test standards will need to better account for the impact of controls on product energy use, including the energy use of the control systems.

Another major trend with implications for MEPS is the emergence of connectivity. As more devices not only incorporate controls, but also the capability for bidirectional communication with the electric grid, service providers, and other devices through the Internet, the potential to unlock further energy savings grows. While use of this capability by utilities in energy programs to date has been limited to certain products (largely air conditioners and water heaters in the residential sector and lighting in the commercial sector) and is more widespread in some parts of the country, it is expected to grow in the coming years. These developments have implications for product energy use while also potentially providing valuable data to inform better analysis and decision-making for MEPS.

This paper reports on a portion of the findings of a project designed to examine the current US approach to product and equipment regulations, including recent modifications to the regulatory process, and to explore potential new approaches to ensure continued success in providing significant, reliable and cost-effective efficiency gains.

METHODS

We organized two facilitated discussion panels, composed of about 30 representatives from a cross-section of industry, efficiency advocates, researchers, and government. All of the participants had experience with US MEPS and many had international experience. The panels engaged in a broad discussion that touched on a wide range of standards-related topics: product definitions and efficiency metrics; scope of MEPS coverage and possible expansion to new categories, including energy-related products, such as windows, that do not consume energy; improvements to the MEPS-setting process; and integration of standards with other efficiency policies such as voluntary labels, building energy codes, and utility demand-side management programs. The participants discussed various stages of the U.S. standards rulemaking process and posited suggestions for making it more responsive and adaptive to future products and equipment. The panels discussed features from other jurisdictions such as California and Europe that could inform future directions for the U.S. appliance standards program. We supplemented the insights from these panel discussions with personal interviews with subject-matter experts within the US and internationally. A summary of the expert panel discussions is included in the full project report expected to be published later in 2015[4]. From these discussions, we identified a set of promising new approaches or upgrades to the current standards process for further exploration and evaluation.

Next generation MEPS

While updating existing MEPS will continue to save large amounts of energy in the years ahead, expanding use of new approaches likely would increase savings even more. We identified seven topic areas which we broadly term "potential opportunities." They are (1) expanding the scope; (2) seizing systems opportunities; (3) capturing savings from controls; (4) capitalizing on smart devices; (5) improving test methods;

3. By "current approach" we mean updating standards using existing metrics, test methods and product scopes. We acknowledge that the "current approach" has evolved in recent years to incorporate some of the ideas that we describe later for some products.

4. The report, with the working title "Opportunities from Next Generation MEPS", will be published jointly by the American Council for an Energy-Efficient Economy (ACEEE) and the Appliance Standards Awareness Project (ASAP).

(6) improving the MEPS development process; and, (7) integrating with other efficiency policies. Some of these alternative approaches have already contributed significantly to existing MEPS. For example, the scope of the US standards program expanded from an initial group of thirteen products in 1987 to more than 60 today, primarily through Congressional action. In addition, test methods have been developed and refined for many products. Other approaches, such as those that rely on interconnectivity and controls, are less developed. In each of the sections below, we explore how broader or deeper adoption of each of these potential opportunities could increase the benefits delivered by MEPS in the years ahead.

EXPANDING SCOPE

The existing U.S. regulatory program covers end-use categories accounting for about 90 % of residential, 60 % of commercial, and 30 % of industrial primary energy (DOE 2015). However, significant subsets of these covered end-use categories are excluded from standards in one way or another (N.B. discussed in detail below). In the past, expansion of scope for MEPS was generally initiated with state level adoption of MEPS for new products. Since manufacturers prefer national standards to a patchwork of state-by-state rules, these state standards generally led to Congressional enactment of national standards. New national laws (i.e., Congressional Acts) in 1989, 1992, 2005 and 2007 each contributed to today's more than 60 covered products.

More recently, DOE has initiated processes to develop standards for products using its administrative authority. Processes are underway to develop MEPS for a range of previously unregulated products including pumps, fans, compressors, computers and battery backup systems, additional types of refrigerators, portable air conditioners and gas fireplaces. Concurrently, the state of California is considering expanding the scope of its state-level MEPS to a range of previously unregulated products focusing on consumer electronics, lighting products, and commercial clothes dryers (CEC 2014).

Despite the broad and expanding coverage of MEPS, more opportunities exist. These opportunities include: (1) covering additional products; (2) more completely covering existing categories; (3) horizontal standards; and (4) component standards.[5]

Covering additional products

A preliminary analysis for the European Commission identified roughly two dozen product categories not regulated in the EU or in the U.S. (European Commission 2014a). The analysis includes a diverse set of products including aquariums, kettles, athletic equipment, lawn and garden equipment, small network equipment, and patio heaters, among others. Other economies have established MEPS for products not yet addressed in the U.S., such as coffee machines (standby power) and rice cookers.

In the U.S., the most significant portion of residential and commercial consumption that largely remains uncovered by MEPS falls into the "other" category. This category includes a vast array of products such as transformers, medical imaging and other medical equipment, elevators, escalators, off-road electric vehicles, laboratory fume hoods, laundry equipment, coffee machines, water services, pumps and emergency generators. Although a few of these products are subject to existing MEPS, most are not. Identifying energy-using categories that are small today but may grow rapidly in the years ahead is an especially challenging aspect of identifying the most important next generation standards. It can be very hard to predict what small uses today will become commonplace tomorrow, particularly given the rapid evolution of technologies.

More complete coverage for products already regulated

More completely covering the energy use of a given category of products may entail addressing specific sub-categories exempted from standards or better characterizing the energy use of regulated products. For many product categories subject to existing MEPS, significant subsets of products have been excluded. For example, although refrigerators were among the first products with MEPS, DOE is currently developing new standards for categories of refrigerators used primarily for chilling beverages that had previously been unregulated (DOE 2014a). New electric motor standards completed in 2014 are among the biggest energy savers in DOE history and based almost entirely on expanding the scope of DOE standards to previously unregulated motor types (DOE 2014b). In the pending rulemaking for general service lamps, DOE is required to examine annually whether exemptions for certain lamp types should be continued. These exemptions are particularly important if the exemption either already represents a significant energy use or if it can easily be used as a substitute for the regulated product. As the regulatory requirements for products get stronger, the incentive to find and exploit these exclusions and exemptions will increase. The success of next generation standards will depend in part on ensuring such loopholes do not open up or, if they do, that policy-makers are able to quickly address them.

Equally important, existing MEPS may not fully or accurately characterize the usage of a given product. As a result, significant portions of product energy consumption may not be addressed. In general, this concern is best addressed by updating test methods to better or more fully reflect actual consumption, a topic we address later in this paper in the section titled "Improving test methods."

Horizontal standards

In some cases, horizontal standards that regulate a particular mode of operation across all or many products can be an effective approach to delivering very large savings, particularly in a market where product types are evolving. The EU network standby requirements are an excellent example. The EU estimates that this one set of requirements will be among the greatest energy savers among all the ecodesign requirements, saving 49 TWh in 2025, compared to a business-as-usual scenario (European Commission 2013). Similar standards in the US could be equally important.

Horizontal standards can be difficult to develop because of the breadth of products affected and the challenge of creating an effective approach for certifying and enforcing standards

5. While we are aware of efforts underway in the EU to expand the scope of ecodesign regulations with criteria related to waste and recyclability, those issues are outside the scope of this paper. Our research scope was limited to opportunities to expand the scope of regulations related to energy consumption during product use.

for such a broad range. Nevertheless, the anticipated impact of the EU network standby standards suggests other economies should explore similar approaches and track experience in Europe.

Component standards

Some of the largest energy-saving standards historically regulate products that are in turn components used in many products. For example, the US integral horsepower motor standards first enacted in 1992, updated and expanded in 2007 and again in 2014 cover motors used in a vast array of commercial and industrial equipment. By regulating just the motor, the standards address many devices that would be difficult to regulate individually (DOE 2014b). External power supply standards similarly affect the millions of devices that use external power supplies without regulating separately the products that use external power supplies. Other component level standards may make sense. For example, MEPS for internal power supplies could save energy in much the same way that those for external power supplies already have. Electronic displays are another component found in an increasing variety of products that could be addressed through component standards.

That said, MEPS for components can be challenging to enforce since it can be difficult to determine the energy consumption of the component once it is embedded into a product offered for sale. In addition, some manufacturers argue that they limit their flexibility to improve products as cost-effectively as they can. Others argue that small per-unit savings for some components like power supplies can add up to significant economy-wide savings, but may not be large enough to matter for meeting an integrated product's efficiency requirement.

CAPTURING SYSTEMS OPPORTUNITIES

A key characteristic of most products subject to MEPS is that they are manufactured or assembled by a company and offered for sale as a unit. Many of these products are enclosed systems. For example, a refrigerator consists of a compressor, fans, heat exchangers, insulation, controls, and other components. In order to meet a given efficiency requirement, the refrigerator manufacturer assembles components into a product that meets the minimum standard while achieving a combination of product performance, cost and amenity it judges will best serve its target market.

Many experts have identified the potential for large savings by addressing savings within systems that extend beyond a single device or product. For example, highly-efficient light sources waste energy if installed in inefficient fixtures or if they are left on when a space is perfectly well-lighted by daylight (Roisin 2008). Improving a pump's hydraulic efficiency may offer relatively little gain compared to applying the pump with a variable-speed drive in many applications (Pump Systems Matter and Hydraulic Institute 2008). Improvements in air compressor equipment efficiency can be dwarfed by the savings potential available by reducing system leakage or misuse of compressed air (Scales 2007). Each of these examples shows that aspects of the system within which a product is used have critical effects on the efficiency of the final service delivered.

In general, MEPS are ill-suited to address efficiency for systems in which the components are assembled at the location where the system is used. MEPS work best for products produced in volume in factories. Other policies such as building codes and incentive programs that establish site-specific requirements are better positioned to influence site-built systems. However, MEPS can make some inroads toward improving system efficiency. Approaches for capturing systems savings opportunities include: (1) include system efficiency effects in a product's efficiency rating; (2) regulate components based on their performance within a system; and (3) develop rating approaches that foster products that enable system savings.

The U.S. rating method for clothes washers provides an example of a rating system that captures system efficiencies. In this case, the system is the combination of a water heater, clothes washer and clothes dryer which together comprise a laundering system. The rating method for clothes washers includes the energy used by the water heater to heat water, the mechanical energy to drive the clothes washer and the energy used by the dryer. To meet a given performance requirement, a manufacturer can use less hot water in a wash cycle or use a higher spin-speed to extract more moisture from the laundry at the end of a wash, so less energy is required by the dryer. While the washer manufacturer cannot affect the efficiency of the other elements of the system, it can affect how much the other elements operate, improving the overall efficiency of the laundry system by improving the efficiency of the component the manufacturer controls.

Separately regulating components made by different manufacturers to achieve overall system efficiency is another, albeit counterintuitive approach for achieving system efficiency. A recent US standard for walk-in coolers illustrates this approach. Most walk-in coolers are assembled on site from components supplied by multiple manufacturers, including insulated walls and doors, unit coolers and condensing units. A walk-in cooler is essentially a site-built room, or, if large enough, an entire building (i.e., a system). MEPS are ill-equipped to regulate the overall system since most walk-ins are assembled one at a time by a contractor. DOE addressed this problem by requiring that the individual components meet performance requirements. For the refrigeration system components (unit coolers and condensing units), if they are sold separately, they must be rated based on default values for the missing component. These default values are set such that significant performance gains must be achieved by the product the manufacturer controls. Since manufacturers of all components must meet performance requirements designed to improve each component, the overall system efficiency improves. Manufacturers who can provide both refrigeration system components have more flexibility in how they comply since they can trade off efficiency between the major components. This approach may encourage manufacturers to collaborate in order to offer optimized refrigeration systems instead of selling the individual components. Similar use of default values for system components could be used for other systems.

Yet another way that MEPS can address system efficiency is with standards that credit features that make a product more likely to be used efficiently in the field. Pump systems (pumps, motors, and variable-speed drives taken together) offer savings opportunities beyond those available from simply increasing the efficiency of the pumps. DOE issued a rule in

March 2015 for test procedures for pumps that would encourage purchases of pumps with variable-speed drives. The proposed metric for pump efficiency would capture the energy-saving benefits of variable-speed drives such that a pump sold with a variable-speed drive would have a significantly better efficiency rating than a constant-speed pump. These pump efficiency ratings would both provide additional information to customers for their purchasing decisions and help facilitate efficiency programs to encourage the adoption of high-efficiency pump packages. This approach could be applied to other products as well. For example, fans sold with speed control could be rated as higher efficiency than fans sold without speed control. Light fixtures sold with controls or dimmable ballasts could be rated higher than those without controls or dimming capability. In each of these instances, the rating system used for the standard fosters the use the technologies that enable system efficiency, but does not require them. Conceivably, if a technology that enables better system efficiency enhances system efficiency frequently enough, a standard could require the technology either as a prescriptive requirements or because the performance level can only be met with a combination of improvements that includes the technology that enhances system efficiency.

CAPTURING SAVINGS FROM CONTROLS

The most common type of energy savings control strategy puts a product into a lower energy use state or turns it off when less service is required. Computers can go to sleep when not in use; vending machines can allow beverage temperatures to rise and turn off lights when no one is around; heating and cooling systems can adjust temperatures when rooms are unoccupied or residents are sleeping. In clothes dryers and dishwashers, controls can shut off the machine as soon as sensors indicate that clothes are dry or dishes are clean.

MEPS have taken three approaches to controls: (1) devise a test method that captures the benefit of the control; (2) provide credit toward meeting the standards for products with a given control; and, (3) require the control. Clothes dryers provide an example for the first and second approaches. DOE recently completed an update to the clothes dryer test method that measures energy consumption until the machine shuts itself off (if the clothes are not yet dry, the test run is invalid and a new run is conducted using the machine's highest dryness level setting). Controls that work well at sensing when clothes are just dry will yield better efficiency ratings than those that shut off too soon (leaving the clothes wet) or those that run too long (over-drying). This test method will replace a test method that gave an across the board energy allowance of about 12 % for clothes dryers that incorporated any sort of automatic termination control. Testing revealed that many clothes dryers with automatic termination controls significantly over-dried clothes, wasting energy, yet they still received the allowance (DOE 2013). Residential boiler standards provide an example of the third approach to controls (i.e., prescriptive requirements). In the US, residential boiler MEPS require that all boilers be sold with an outdoor reset control that adjusts boiler water temperature set points based on outdoor temperature.

MEPS that have relied on the credit approach have had mixed success. The dryer example is one where the savings achieved by a control did not match the credit. Thermal expansion valves in central air conditioners are another example. In this case, the savings from the device generally exceeded the credit provided by the test (DOE 2001). In cases where the credit was too generous, more reliable savings made to other aspects of the product may be forgone since the credit is used to demonstrate compliance. If the credit is not large as the benefit, the control may be underutilized. Prescriptive requirements like the boiler outdoor reset control can be appealing because they offer only upside potential for energy savings. However, if the controls are not properly installed (or not installed at all), or not used properly, the expected savings will not emerge.

Other products may benefit from MEPS that encourage or require controls use. For example, indoor and outdoor light fixtures that can be dimmed or turned off in high ambient light conditions or when no one is around can save considerable amounts of energy. Air conditioners that use outdoor air for "free-cooling" when ambient conditions allow can save enormous amount of energy (Brandemuehl and Braun 1999). As standards for these products are under development or revision, the energy-savings opportunities associated with controls should be considered along with any challenges presented by specific technical and market challenges (e.g., regional differences).

Some of the technology developments that enable two-way communication and monitoring may enable future approaches to controls to be more successful than some past experiences. Growing connectivity of devices may offer better information, helping product manufacturers and standards developers to better understand how controls are used and what savings they deliver. This kind of real world performance information can feed into test method revisions that allow the performance of controls to be reflected in product energy efficiency ratings. The following sections address more broadly the opportunity with smart devices and improved test methods.

CAPITALIZING ON SMART DEVICES AND SYSTEMS

The wide adoption of smart appliances, residential and commercial building energy management systems, smart grid, and a variety of interconnected and controlled systems requires some new thinking about opportunities for additional energy savings.

The term "smart" has been used to refer to a range of capabilities. For purposes of this paper, we use "smart" as shorthand for products capable of two-way communications. That is, a device that can tell another product or device something about itself or its environment, receive information, and change its operation. This communication may be within a home or over a wider area. The communication may be controlled by a home or building owner or occupant or by a third party, such as a utility, the device's original manufacturer or an energy or security management company.

To date, MEPS have not sought to take advantage of products' smart capabilities. The voluntary ENERGY STAR program has provided a credit for certain products that are controllable (e.g., refrigerators that defer a defrost cycle in response to an external signal), but this approach has not been adopted into the MEPS program. Furthermore, critics have argued that the ENERGY STAR credit undermines the energy saving goals of the program (CEE 2012) and utility research has shown very limited benefits (Mitchell et al 2014). One problem inhibiting more widespread adoption of appliances with smart features and the ability to take advantage of these features has been the lack of standardized interfaces or protocols to enable devices to easily communicate with one another. MEPS could play a role in fostering standardization.

Smart devices as defined here offer three general sets of advantages compared to devices and controls that are not connected. First, they have the potential capability to respond to remote commands. These remote commands could yield energy savings benefits. For example, a homeowner or building operator could save energy by controlling lights, thermostat settings, and other loads remotely.

Second, connected devices have the potential to be upgraded remotely. For example, cable companies upgraded millions of installed set top boxes in the U.S. in 2014 with a software upgrade that reduced the product's energy use by about 20 % (D&R 2014). Smart phones receive regular software updates as do computers, tablets and other devices. However, it should be noted that this capability can just as easily increase energy use as decrease it. Manufacturers certify products as compliant based on how they are sold. A product could receive an update from its manufacturer soon after installation that would adjust its operation, causing it to increase energy use. For example, a manufacturer of a connected dishwasher who received complaints about long cycle times might choose to increase water and energy use to decrease cycle times on installed dishwashers. As sold the product was MEPS compliant, but a subsequent product update, while perhaps perfectly legal, would undermine the intent and consumer benefits of the MEPS policy.

Third, the flow of information from devices creates the potential for vast new sources of data on product operation. This data could be used to better characterize duty cycles and product energy use, information that can be used to evaluate past standards and to inform future test methods and MEPS. Data gathered on energy use over the life of products can also be used to assess persistence of projected savings. For example, cabinet insulation in refrigerators may lose effectiveness over time causing energy use to increase. If data shows that some types of insulation degrade more than others, products using that insulation may need to be de-rated for purposes of standards compliance. A result might be to stimulate research into longer-lasting insulation types (e.g., improved vacuum insulated panels) or to foster use of other insulating materials that maintain their performance. This potential treasure trove of new data from smart devices has the potential to inform a round of test method revisions that could add significantly to future energy savings.

IMPROVING TEST PROCEDURES

Test procedures are intended to measure energy performance or efficiency utilizing a replicable method that is not unduly burdensome. Ideally, test methods should reflect energy consumption in the real world, although accounting for all the variability in applications represents a formidable challenge. These goals (being replicable, practical/affordable, representative) are in tension with one another. A truly representative test can be difficult and costly to perform; a simple test may not reflect the real world.

In several cases, improved test methods that better characterize actual consumption have enabled energy savings that would not have been possible with older less accurate test methods. For example, shifting to the modified energy factor (MEF) for clothes washers unleashed development of high spin speed clothes washers for the U.S. market. The development of a new test metric for rooftop air conditioners (Integrated Energy Efficiency Ratio, IEER) has enabled improved differentiation of products and provided the basis for significant savings that the previous test metric did not recognize (DOE 2014c). For many covered products, DOE has updated test methods to capture standby energy use in recent years, yielding energy savings previously ignored.

Field data gathered through smart devices or traditional methods would provide information about which products are most in need of test method revisions. For example, test results for products like clothes washers and dishwashers depend upon the cycles selected. Field data would help determine whether test cycles are representative of the real world. If they are not, they should be revised. The test methods for some of the largest end uses such as residential air conditioners and heat pumps and residential furnaces have not been significantly modified in nearly three decades. The test method for commercial air conditioners does not account for energy use in ventilation mode, which comprises a significant portion of annual operating hours. Data from field installations would help to identify other opportunities where test methods fail to fully or accurately capture consumption.

IMPROVING THE STANDARDS DEVELOPMENT PROCESS

Success in creating next generation standards depends upon implementation of a standards development process that is broadly accepted by affected stakeholders. Out of about forty standards established or upgraded by DOE since the early 1990s, only seven have been subject to litigation. In general, the DOE process for establishing test procedures and standards that has developed over the last 30 years has been accepted. In 2010, DOE adopted new procedures to improve the rulemaking process, including earlier proposed rules, shortening Federal Register notices, and negotiated rulemakings (DOE 2010). About one-third of new standards have been based on negotiated settlements between stakeholders (Nadel and deLaski 2011). More recently, DOE has turned to formal, government-sponsored negotiations to advance consensus recommendations while continuing to also encourage direct negotiations between stakeholders. Critically, DOE has also maintained its commitment to establish updated standards even if negotiated outcomes are not forthcoming.

Despite this general acceptance of the rulemaking development process, there remain opportunities to improve its effectiveness. Opportunities include shortening the rulemaking process and lead times, increased transparency, gathering additional data, improving predictability, and more complete quantification of impacts.

The time between initiation of a DOE process to update a standard and the revised standard taking effect is typically about 6 years, but can be longer for some products. DOE has sought to shorten the rulemaking process, but with limited success. For products with long development cycles and product lives, the duration of the DOE process delays savings. For products with short development cycles and lives, the current MEPS development timeline may hinder the effectiveness of federal regulations. For example, certain consumer electronics fall into this latter category and represent a large share of electricity in US residential buildings, about 12 % (Roth 2013). Research offers a proposed method for deciding whether to regulate electronics (Siderius 2014), as a function of the "policy action window." While faster regulatory processes could provide new savings opportunities, the existing timeline may still be effective for eliminating older generation, wasteful products.

Many of the stakeholders that participated in our expert panels commented on what they perceive as a lack of transparency in the DOE rulemaking process. In the current process, DOE typically provides information and an opportunity to comment to stakeholders and the public twice, at the preliminary analysis and proposed rule stages, and then provides full documentation upon release of the proposed and final rules. The information provided typically includes hundreds of pages of text (Technical Support Documents) and analytical tools (such as spreadsheets for the life cycle cost and payback analysis and the national impacts analysis). This process of batch release of large numbers of assumptions and calculations requires stakeholders to review and comment quickly. Public comment periods are typically 30–60 days, during which stakeholders need to absorb the batch release, with interaction with DOE limited to a one-day public meeting. One proposal is for DOE to be more open to review and comment earlier, by releasing information on their website (e.g., through Notice of Data Availability) at several phases of the analysis prior to the proposed rule, in order to provide a greater opportunity for review and input from stakeholders.

Improving information exchanges could help establish more consensus-building approaches. Regular meaningful exchanges with interested stakeholders representing a range of interests could increase stakeholder engagement earlier in the process and offer more opportunity for building consensus.

Multi-tier (or multi-phase) standards can enhance the effectiveness of MEPS without adding significantly more analysis; offering efficiency in the standards setting process by having one analysis that leads to two standard updates at different future dates. This approach has been used twice for clothes washers, simultaneously setting standards for 2004 and 2007, and then in the next round for 2015 and 2018. Multi-tier standards have been used successfully in the EU and California as well. This approach generally sets a relatively modest standard initially and then a more ambitious level that generates most of the savings at a later date. An advantage of the multi-tier approach is that it provides manufacturers with regulatory certainty over a longer period of time, enabling them to invest and plan for two rounds of standards.

Other potential opportunities for MEPS are more "outside the box" and would require a more fundamental re-thinking of US MEPS. For example, future mandatory levels could be directly tied to current voluntary levels. And developing a categorical label like that used in the EU could provide a clear trajectory for performance improvement over time. Alternatively, MEPS could be based on continuous improvement functions that set a percent-per-year improvement target over a period of many years. Manufacturers could decide when to make improvements provided they hit the target in every year. Much more analysis on the pros and cons of these approaches is needed before any changes are proposed.

INTEGRATION WITH OTHER EFFICIENCY AND SUSTAINABILITY ACTIVITIES

U.S. MEPS are part of larger research and policy ecosystems including public and private energy efficiency R&D, state building codes, voluntary labels (e.g., ENERGY STAR), mandatory labels (EnergyGuide), state and utility energy efficiency programs, regional and municipal climate action plans, and international efforts. Opportunities exist to learn from, benefit from, leverage, or contribute to energy and emissions savings by communication, coordination and integration.

The DOE Building Technologies Office (BTO) already supports both appliance and equipment standards and building codes, and is well positioned to support the transition from individual technologies to systems. BTO and its appliance and equipment standards program should continue to explore the opportunity for energy efficiency requirements to interact with building codes, building permits or licensing as other means of regulation.

Energy efficiency, distributed renewable energy, energy storage, and electric vehicles will interact with buildings. The program can explore how energy performance standards could contribute to achieving the best outcomes at the system (e.g., HVAC) and whole building level, and perhaps further, at the level of local neighbourhoods or electricity distribution networks.

Discussion and Way Forward

The U.S. DOE MEPS program has been instrumental in improving energy and economic efficiency through mandatory improvements in energy performance of consumer products. From 2009 through January 2015, DOE completed final rules for standards on 29 products (10 in 2014 alone), expected to reduce cumulative emissions of CO_2 by 2.1 billion tonnes by 2030. The program is expected to continue to have significant positive impacts through regular updates of the existing mandates. Possible changes to the program could further increase impacts in terms of reducing future energy demand and associated CO_2 emissions.

RECOMMENDATIONS

Significant energy savings remain available from on-going updates and enforcement of test methods and MEPS. Additional savings could be realised through some new approaches:

- Undertake a long-term roadmapping process for appliance and equipment standards to identify approaches for addressing long-term trends that substantially alter the portfolio or use of future energy-using consumer products. Such trends include: proliferation of consumer electronics and smart meters and changing utility practices regarding the control of appliances and equipment for demand response. The roadmap could also consider an evolving role for the standards program in its interactions with international standards bodies (on development of global test methods), other jurisdictions (setting other national or state standards or building codes), and broader environmental or sustainability activities (e.g., life cycle assessments and a broader set of environmental, health and social impacts).

- Continue recent efforts to consider new candidate products for standards and opportunities to expand coverage to previously exempted or excluded products within covered product categories, including consumer electronics, and, networking equipment, among others. Consider standards for the energy characteristics of energy-related (not energy-using) products, such as windows, skylights, doors, and insulation.
- During on-going updates of test methods and MEPS, consider new and emerging technologies; eliminate loopholes by broadening product definitions if substitution of exempted or excluded products might increase energy use compared to regulated products (e.g., some exempted types of general service lighting); and address cross-product ("horizontal") modes or functions, such as network modes.
- Gather field data (potentially through new smart appliances) on energy consumption as a basis for validating energy savings from existing standards and updating test procedures to stay current with changing energy use. Additional benefits from data collection could include a better understanding of the persistence of energy savings, and identification of opportunities for dynamic savings (or degradation) from firmware or software upgrades during the functional life of products.
- If products are not independent, but function in a system, consider ways that standards could foster system efficiency improvements. As devices become increasingly connected, exchanging information and feedback and acting in concert, the dependencies offer additional savings opportunities.

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