Next-Generation Standards: Opportunities to Broaden the Impacts of Federal Appliance Standards[1]

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ABSTRACT

Appliance, equipment, and lighting standards have been among the most effective energy efficiency policies, yielding increased savings over multiple rounds of standards for many products. This paper explores the potential for additional savings from future standards, specifically for the next presidential administration, beginning in 2017. The first section of the paper provides an analysis of the savings that could result from implementing updates to existing standards. Our research finds that very large additional savings are possible by updating existing national standards: 76 quadrillion Btus (quads) of energy, 3.8 billion metric tons of carbon dioxide (CO_2), and $1.2 trillion cumulatively by 2050. The second section of the paper develops five strategic recommendations for further increasing savings. These recommendations are (1) investment in test-method improvements, (2) systematic scope expansion, (3) improvements in analysis methods and data sources, (4) more-consistent incorporation of systems opportunities, and (5) a strategic approach to addressing connected products.

Introduction

Appliance, equipment, and lighting efficiency standards, also known as minimum energy performance standards (MEPS), have been among the most successful policies for reducing energy use in the United States and in turn saving money for consumers and businesses. National standards now apply to about 55 categories of residential, commercial, and industrial products. The US Department of Energy (DOE) estimates that existing efficiency standards completed to date will save 132 quadrillion Btus (quads) of energy; save residential, commercial, and industrial energy consumers nearly $2 trillion on their utility bills; and reduce carbon dioxide (CO_2) emissions by more than 7 billion metric tons cumulatively through 2030 (DOE 2016).

A combination of congressional and administrative action over the last few decades has built this impressive record of savings. For most products covered by national standards Congress enacted initial standards through energy bills (in 1987, 1988, and 1992). Further Congress charged DOE with updating those standards to increase energy and economic savings as technology improves. However by 2006 DOE had missed the legal deadlines for updating 22 standards, some by more than a decade. In addition, energy laws passed in 2005 and 2007 created new deadlines for additional DOE updates. As a result, upon taking office in 2009, the Obama administration faced the legally required task of updating or establishing many standards.

Within days of his inauguration the president issued a memorandum for the secretary of energy directing the DOE to meet or exceed all of the deadlines for new standards (EOP 2009). Additionally, the administration directed substantially increased resources to the program to keep

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up with the increased workload. Perhaps most importantly, the administration integrated standards into its overall energy and climate policy strategies, placing a new emphasis on the importance of standards. The president's Climate Action Plan, announced in June 2013, set an aggressive goal of reducing CO_2 emissions by 3 billion metric tons by 2030 through efficiency standards set in President Obama's first and second terms (EOP 2013).

In summary a combination of executive attention, adequate resources, and integration with overall climate and energy policy and goal setting has served to propel enormous energy efficiency improvements through standards completed during the Obama administration. Taking into account MEPS enacted by law and those set by DOE, this administration has completed 16 more standards than any prior administration. Accounting only for MEPS set administratively, the Obama administration has completed seven times more standards than any previous administration. More important than the number of standards are the energy savings and economic and environmental benefits. DOE estimates that MEPS already completed during the current administration will save 44 quads of energy and save consumers and businesses $540 billion on their utility bills through 2030. These savings far exceed the savings from MEPS adopted administratively under any prior president.

Given the enormous progress achieved by DOE during the Obama presidency, the Appliance Standards Awareness Project (ASAP) and the American Council for an Energy-Efficient Economy (ACEEE) launched this project to explore the future potential for national efficiency standards. With a new administration taking office in January 2017 we sought to answer two key research questions:

- With so much progress to date, especially over the past eight years, what is the potential for realizing future savings associated with updates to existing standards during the next administration?
- What strategies could be employed to enhance the savings potentially available from efficiency standards during the next administration?

In order to answer the first question we developed product-by-product estimates of the potential future savings from the next updates due after January 2017 (i.e., the next standard that could be completed after the inauguration of the next president). This analysis followed a similar bottom-up approach used in prior ASAP/ACEEE assessments of savings potential from future standards (Neubauer et al. 2009; Lowenberger et al. 2012). We were able to develop estimates for most but not all of the products covered by existing or pending national standards. The analysis assessed energy-savings potential based on currently available technology, using existing metrics, test procedures, and product scopes. Through this analysis, we found very large savings potential available from updating standards. Part 1 of this paper contains our findings.

While there is huge savings potential from updates to current standards, Part 2 of this paper explores the opportunities to further increase the savings potential from future DOE standards updates through MEPS program-wide strategies. Based on two expert panels, individual expert interviews, and our own knowledge, we considered a wide range of ideas. We used two criteria—(1) the actions that are indisputably within DOE's control (i.e., that do not require new legislation) and (2) the actions that would potentially have very large savings benefits—to distill these ideas into five actionable recommendations. DOE has used many of these strategies in the past, but they could be more formally or systematically implemented going forward. We discuss the following strategies further in Part 2 of this paper:

- Invest in improved test methods, including expedited updates for top priorities
- Systematically assess opportunities to expand scope and conduct rulemakings for the biggest opportunities
- Continue to improve analysis methods and data sources
- Consider how DOE test methods, ratings, and standards can achieve or facilitate systems savings opportunities
- Develop a strategic approach for addressing connected products

Savings from Updates to Existing Standards

DOE is required to review each standard at least once every eight years, so within the span of the next two presidential terms all federal standards should undergo at least one review for potential updates. For this paper we initially considered all products currently covered by standards or expected to be covered by the end of the Obama administration (about 55 products). We excluded some products (e.g., unit heaters) from the analysis due to lack of sufficient information to estimate potential savings. We developed potential-savings estimates for 45 products, representing the vast majority of the energy-savings opportunity.

We estimated final rule dates and compliance dates for post-2016 standards based on DOE's statutory requirement for when the next revised standard is due and on statutory lead times between publication of final rules and compliance dates. These are typically three to five years. The estimated compliance dates for the post-2016 standards range from 2022 to 2029.

For the baseline efficiency (i.e., absent standards updates) for most products we used either the current standards or standard levels that have been finalized or proposed in recent rulemakings. In a few cases we assumed a baseline efficiency equivalent to levels recommended as part of recent negotiated rulemakings (e.g., for central air conditioners). For almost all of the products we analyzed efficiency levels for post-2016 standards equivalent to the maximum technologically feasible (max-tech) level in DOE's most recent standards analysis. For plumbing products (faucets, showerheads, toilets, and urinals) we analyzed efficiency levels equivalent to recent standards adopted in California.

Max-tech from the most recent rulemaking analysis is a reasonable level for estimating the potential efficiency level from the next standard. DOE usually constrains its estimate of max-tech levels to levels found in commercially available products, ignoring available technologies that have not yet been deployed in marketed products or prototypes. The implementation of a new standard will often unleash a new round of innovation and deployment of efficiency improvements, as manufacturers invest not only to comply with the new standard but also to develop products that are differentiated by their even better efficiency performance. Therefore levels that were max-tech a few years ago are serious candidates for minimum standards implemented in the 2022–2029 time frame.

Each new DOE standard must meet statutory criteria: it must achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified (GPO 2014). Economic justification takes into account consumer and manufacturer impacts. We are not necessarily endorsing the precise levels evaluated in this paper for the next revision to each of these standards. In some cases higher standards will make sense; in others lower. In still other cases strategies other than strengthening the current standard using the existing metric and test method (including some discussed in Part 2 of this paper) could yield better results. Nevertheless, given the historical record of rapid technological progress for most products covered by standards, in part spurred by the standards themselves, the last round of max-tech levels provide a good basis for estimating savings potential from updating existing standards.

For a few products, such as fluorescent-lamp ballasts and general-service fluorescent lamps, DOE adopted the max-tech levels (or very close to max-tech levels) in the most recent rulemaking. While new technologies could allow for efficiency levels beyond what DOE's recent analysis shows to be max-tech, we have not attempted to estimate potential energy savings for levels beyond DOE's most recent determination of max-tech levels. Therefore these products are among those excluded from this analysis.

Our general methodology for estimating savings is based on sales of the affected products. We estimated savings through 2050 and used estimates of annual shipments, per-unit energy and/or water savings, and average product lifetimes based on the best available data. In most cases we used information from recent DOE rulemakings. For annual shipments we used estimates of shipments in the year the standard is assumed to take effect. We took into account the fact that some portion of sales will likely meet the assumed standard level even in the absence of a new standard. For products that do not have an ENERGY STAR® specification (or WaterSense specification for water-using products) we assumed that 10% of the shipments will meet the assumed standard level in the base case. For products that do have an ENERGY STAR or WaterSense specification we assumed that 25% of shipments will meet the next standard level in the base case, as the ENERGY STAR and WaterSense labels have proved very effective in increasing the market penetration of efficient products. To simplify the analysis we assumed that both annual shipments and the percentage of shipments already meeting the standard level will remain constant over the analysis period.

Our estimates for products that save hot water (clothes washers, faucets, and showerheads) assumed current water-heater efficiency levels. If water-heater standards are updated to the levels evaluated for this report, the energy savings from reduced hot water use by these products would be lower than what we show in our results, perhaps by about one-third.

A full-length version of this paper, scheduled for publication in late summer 2016, will include more-detailed assumptions and updates to this analysis.

Findings

We estimated that updates for the evaluated products have the potential to annually save 4.3 quads of energy and reduce CO_2 emissions by 220 million metric tons (MMT) by 2050, as figure 1 shows. The annual energy savings are equivalent to about 6% of the total energy consumed in the residential, commercial, and industrial sectors in the United States in 2015 (EIA 2016).

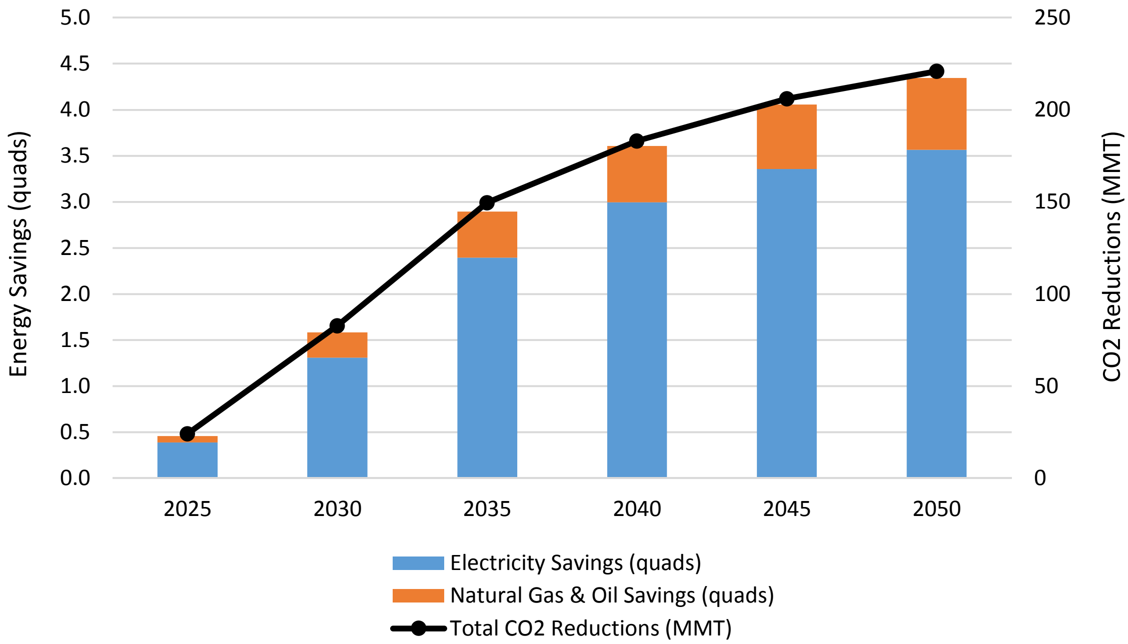

Figure 1. Potential annual energy savings and CO_2 reductions from post-2016 standards

Potential annual water savings in 2050 are 885 billion gallons, which is more than the annual water used by all the homes in Texas in 2010 (Maupin et al. 2014).

Tables 1 and 2 below show the cumulative savings estimates for energy, water, CO_2, and utility bills, for specific residential and commercial/industrial products, respectively. Table 3 shows the total savings estimates.

Table 1. Potential cumulative energy and water savings, CO_2 reductions, and utility-bill savings from post-2016 standards for residential products

Product	Cumulative savings through 2050			
	Energy (quads)	Water (billion gallons)	CO_2 (MMT)	Utility bills (billion 2013$)
Battery chargers	0.7	--	38.1	10.6
Boilers	0.7	--	38.7	11.8
Ceiling fans	0.7	--	34.3	9.7
Central air conditioners and heat pumps	6.6	--	333.5	95.4
Clothes dryers	4.8	--	244.4	68.3
Clothes washers	1.2	3,109	60.8	56.5
Dehumidifiers	0.3	--	12.9	3.7
Direct-heating equipment	0.1	--	7.4	2.0
External power supplies	0.4	--	21.5	5.9
Faucets	3.5	6,191	181.2	128.2
Furnaces	1.6	--	84.5	24.0
Furnace fans	0.8	--	39.0	11.1
General-service lamps	0.1	--	7.6	2.1
Incandescent reflector lamps	1.6	--	84.5	23.0
Microwave ovens	0.3	--	12.8	3.6
Pool heaters	0.2	--	12.2	3.3
Portable air conditioners	0.5	--	25.9	7.3
Ranges and ovens	0.3	--	16.6	4.7
Refrigerators and freezers	4.3	--	216.8	60.6
Room air conditioners	0.5	--	27.8	7.7
Showerheads	5.6	6,820	291.8	166.8
Toilets	--	1,476	--	19.0
Water heaters	16.1	--	824.8	230.1
Wine chillers	0.3	--	15.3	4.3
Residential total	**51**	**17,596**	**2,632**	**960**

Table 2. Potential cumulative energy and water savings, CO_2 reductions, and utility-bill savings from post-2016 standards for commercial and industrial products

Product	Cumulative savings through 2050			
	Energy (quads)	Water (billion gallons)	CO_2 (MMT)	Utility bills (billion 2013$)
Automatic ice makers	0.1	--	4.9	1.1
Beverage vending machines	0.1	--	4.9	1.1
Commercial boilers	0.8	--	41.4	9.8
Commercial clothes washers	0.04	105	1.8	1.8
Commercial furnaces	0.9	--	48.2	11.3
Commercial packaged ACs and heat pumps	2.7	--	135.6	31.6
Commercial refrigeration equipment	0.8	--	42.3	9.6
Commercial three-phase ACs and heat pumps	0.3	--	15.5	3.6
Commercial water heaters	0.2	--	8.3	1.9
Compressors	3.3	--	169.4	27.7
Computer-room ACs	0.6	--	28.9	6.6
Distribution transformers	3.4	--	174.0	40.1
Electric motors	4.3	--	216.5	35.3
Fans	4.3	--	216.1	50.3
Metal-halide lamp fixtures	0.3	--	13.6	3.1
Packaged-terminal ACs and heat pumps	0.1	--	6.0	1.4
Pumps	0.7	--	35.5	8.2
Single-package vertical ACs and heat pumps	0.1	--	3.8	0.9
Small motors	0.4	--	18.7	4.2
Urinals	--	555	--	7.0
Water-source heat pumps	1.0	--	51.8	12.0
Commercial and industrial total	**24**	**659**	**1,237**	**269**

As table 3 shows updating existing standards has the potential to save 76 quads of energy, reduce CO_2 emissions by 3.8 billion metric tons, and cut consumer and business utility bills by $1.2 trillion cumulatively by 2050. The cumulative CO_2 emissions reductions are equivalent to taking offline for 2 years all 454 coal-fired power plants that were operating in the United States in 2010 (EPA 2015).

Table 3. Potential cumulative energy and water savings, CO_2 reductions, and utility-bill savings from post-2016 standards

	Cumulative savings through 2050			
	Energy (quads)	Water (billion gallons)	CO_2 (MMT)	Utility bills (billion 2013$)
Residential	51	17,596	2,632	960
Commercial and industrial	24	659	1,237	269
Total	**76**	**18,255**	**3,869**	**1,229**

A disproportionate share of the potential savings derive from the top 10 standards; these account for about 75% of energy and utility-bill savings potential. Figure 2 shows the cumulative energy savings and bill savings from the top 10 standards. For products that save both electricity and natural gas or oil we show the share of savings for each energy source.

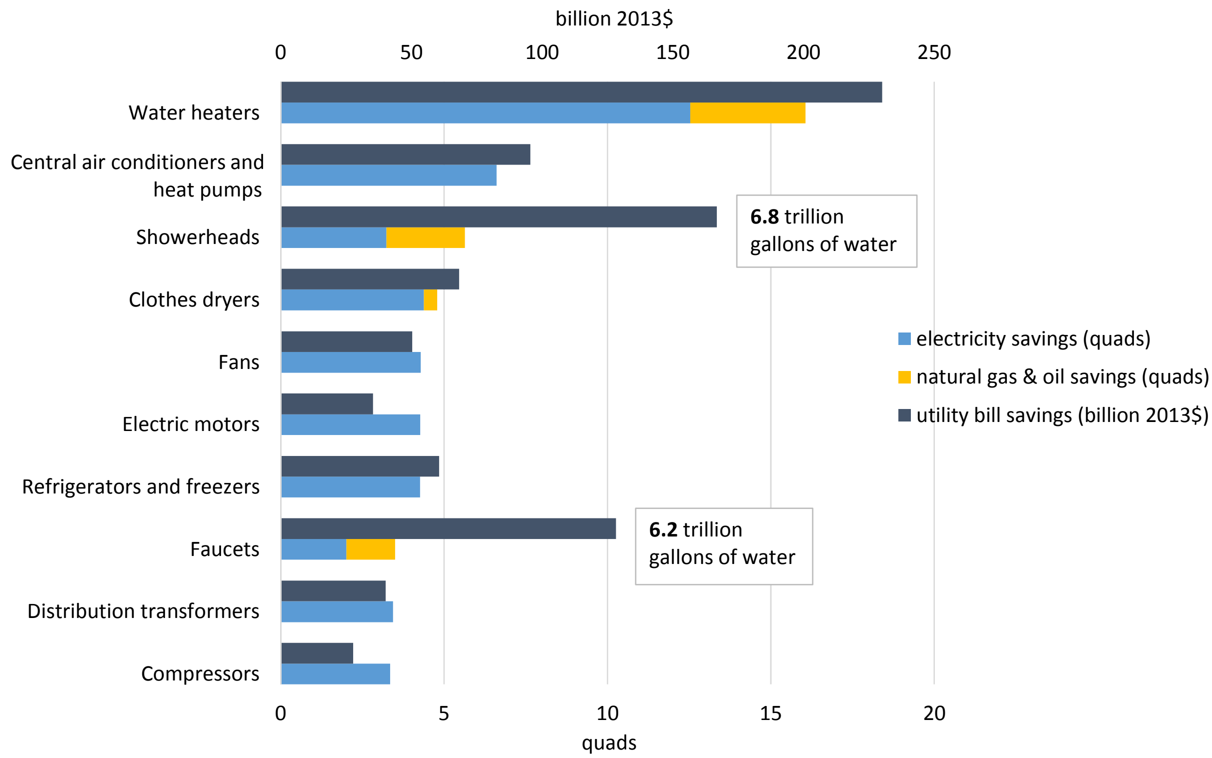

Figure 2. Cumulative energy savings and utility-bill savings through 2050 for top 10 standards

Notably six of the products with the greatest savings potential have already had multiple rounds of updated standards. The next refrigerator and central air conditioner standards updates will be the fifth national standard for each of these products, dating back to the original enacted in 1987. For water heaters it will be the fourth, and for others it will be the third. For four of the products on the list—showerheads, faucets, fans, and compressors—the next new standards will be only the second.

It may be surprising that products that have already been subject to multiple standards rank among those with the top savings potential. However several reasons explain these products' large potential. First, even though they have become more efficient over the past 30 years, each continues to account for a significant percentage of energy use in homes or businesses. Second, each has large annual sales levels. Third, in part due to the extent of their energy use and sales volume, these products get the attention of innovators and companies looking to improve efficiency. As a result technological progress has continued to open pathways to higher efficiency levels.

Strategic Recommendations for Further Increasing the Savings Potential from the DOE Standards Program

Part 1 of this paper showed that the next generation of MEPS has enormous savings potential; however the next administration has an opportunity to accomplish even more. For this part of the paper we explored potential strategies for further increasing savings or otherwise improving national standards. Based on two expert panels, individual expert interviews, and our own knowledge, we considered a wide range of ideas. We used two criteria—(1) the actions that are indisputably within DOE's control (i.e., that do not require new legislation) and (2) the actions that would potentially have very large savings benefits—to distill these ideas into five actionable recommendations. We discuss and describe each of these five recommendations below.

Recommendation 1: Invest in improved test methods including expedited updates for top priorities. Underlying virtually every national standard is a test procedure used for determining a product's efficiency (or energy or water use) and thereby its compliance with national standards. These test procedures are also used for other programs and purposes (e.g., ENERGY STAR, EnergyGuide labels, utility-program eligibility, and so on). Reviewing and updating test procedures is one of DOE's major responsibilities under existing law, which requires DOE to review and update each test method at least once every seven years.

Over the past few years DOE has significantly ramped up test-method work, developing major revisions to test methods for several products including central air conditioners, commercial rooftop air conditioners, and clothes dryers. It has reviewed and improved many other test methods. However DOE should continue to expand this work. We recommend a two-pronged approach: (1) DOE should identify top-priority test methods for revision, and (2) DOE's reviews of all test methods should systematically take into account specific recent developments and trends.

Top-priority test-method revisions should address those products that have the largest energy-savings potential and for which test-method shortcomings are already fairly well understood. We recommend that DOE prioritize updates for the following test procedures: clothes dryers, commercial rooftop air conditioners, walk-in coolers, and water heaters. Additional priorities include televisions, central air conditioners, and heat pumps and commercial boilers. In some instances DOE test methods are based on industry-developed methods; by initiating its own work DOE can help to motivate and speed up industry processes.

For the review of all test methods DOE should systematically take into account a number of cross-cutting developments that may affect many products:

- New modes of operation such as network standby
- Expanded user-selectable options or modes
- Controls, which may help save energy
- The effect of software or firmware updates post-installation

None of these topics are altogether new. For example, a recent revision to the clothes washer test method addresses post-installation software or firmware changes. By systematically considering each of these issues for all test methods however DOE will ensure that all of its test methods account for the latest developments in product design to approximate real-world conditions.

Recommendation 2: Systematically assess opportunities to expand scope and conduct rulemakings for the biggest opportunities. A systematic assessment of new standards opportunities within DOE's existing authority will enable the agency to prioritize standards work that can deliver increased savings. DOE can expand the scope of the national standards program in two ways. First, the agency can develop standards for categories of products not previously subject to national standards. Second, DOE can in some cases expand the types that are subject to standards within a given product category. Under the Obama administration DOE has exercised its authority in both of these areas; it has developed standards for products such as pumps and fans, and it has expanded coverage to include new types of already-regulated products such as motors and refrigerators.

There are constraints on DOE's authority. For DOE to establish standards consumer products must meet energy-use thresholds—150 annual kilowatt-hours (kWh) consumption per household and 4.2 terawatt-hours (TWh) total national consumption—and only a specified list of commercial and industrial products may be covered. Each product already covered by standards may have particular limitations or opportunities to expand depending on existing law.

Televisions are one product not currently subject to standards that DOE should consider, taking into account interactions with state standards. In addition, the growth of "other uses" suggests that there may be some hidden opportunities among these end uses. "Other uses" now represent 17% of residential and 34% of commercial energy use (EIA 2015). Examples of where DOE could extend coverage of existing standards to types previously excluded from standards include additional types of small motors, additional integral horsepower motors (including advanced motor technologies), high-CRI linear fluorescent lamps, and two-foot linear fluorescent lamps. Furthermore some of the categories of commercial and industrial products that DOE is permitted to develop standards for are very broad (e.g., "electric lights" and "refrigeration equipment"). This authority may be a mechanism for DOE to extend standards to technologies left out of current standards. For example, linear LED lights and fluorescent lights are both electric lights, but only the latter are subject to current standards. Standards developed under one of these categories of equipment would have the added advantage of being technology neutral; DOE could design standards based on the most efficient technologies in each category rather than limiting itself to the most efficient products within a specific technology type (e.g., incandescent reflector lamps).

Recommendation 3: Continue to improve analysis methods and data sources. This recommendation includes three components: further improving DOE's use of learning curves to model product prices, conducting retrospective analyses, and enhancing data gathering.

Extensive research has shown that historical price predictions made by DOE in standards rulemaking analyses, which assumed constant prices over time, have consistently overestimated the actual cost of improving efficiency (Desroches et al. 2011; Dale et al. 2009; deLaski and Nadel 2013). Starting in 2010 DOE began to incorporate learning rates (or experience curves) in estimating future product prices for products for which data show that real prices have declined over time. While incorporating price trends is a significant improvement to rulemaking analyses, analyzing price trends of whole categories of equipment fails to capture the price trends of the actual technologies that are employed to improve efficiency. In many cases the prices of the technologies used in high-efficiency equipment will decline much faster than the total price of the equipment. For example, the prices of high-efficiency compressors and vacuum insulation panels, which can be used to improve refrigerator efficiency, are likely to decline much faster than the total price of refrigerators. Similarly the price of heat pump water heaters is likely to decline much faster than the price of all water heaters. While we recognize the challenge of obtaining sufficient data, we recommend that DOE attempt where possible to incorporate learning rates for the actual technologies assumed to be employed to improve efficiency.

Second, we recommend that DOE undertake a retrospective analysis of standards that have taken effect within the past few years. This analysis could be used to assess whether the standards had the energy-savings, economic, and manufacturer impacts anticipated. To the extent that actual events have diverged from estimates DOE can use this information to help shape how analyses for future standards will be revised.

Finally, we recommend that DOE undertake a major data-gathering effort aimed at better characterizing the energy usage of products subject to standards. This effort should focus on the products with the largest energy-savings potential. In each rulemaking process DOE solicits data early and repeatedly, but available data on energy use are often regional, and DOE sometimes rejects them as nonrepresentative of national conditions. DOE should work in partnership with regional energy efficiency organizations, utilities, and states to develop a research and data-gathering project aimed at better characterizing the consumption of the highest-priority products that will be subject to standards revisions in the years ahead. This could assist standards development for years to come.

Recommendation 4: Consider how DOE test methods, ratings, and standards can achieve or facilitate systems-savings opportunities. DOE sets standards, which apply to the manufacturer or importer of a product. Many regulated products are installed in the field as part of a system of products designed to provide a service, e.g., office lighting. DOE regulates fluorescent lamps and their ballasts but does not regulate the fixtures in which they are installed, let alone their spacing, controls, interaction with daylight or occupants, or any number of other factors. DOE's regulatory structure is not designed to regulate efficiency at the building level; that is the province of building codes, which in general are better able to address systems that vary from building to building.

Nevertheless DOE can take some actions in developing specific test methods and standards to help facilitate systems savings. First, if a product's function directly affects the energy use of another product, this impact can be taken into account in the rating and standards for the regulated product. DOE's current standard for clothes washers includes the impact of clothes washer operation on water heater and dryer energy use (i.e., the household laundry system). Pool heaters may be a future candidate for this sort of approach, as good hydraulic efficiency in the heater will reduce energy use by the pool pump. Second, DOE rating methods can encourage system efficiency by allowing for higher efficiency ratings for products sold by the manufacturer as a packaged system of components than components that are sold separately. DOE's recent pump standards are an example: a pump sold with a variable-speed drive gets a higher efficiency rating than the same pump sold without a drive. DOE used a third approach with recent standards for walk-in cooler refrigeration systems. If the refrigeration-system components (unit coolers and condensing units) are sold separately, they must be rated based on nominal default values for the other major components. These default values are set such that the product and the manufacturer controls must achieve significant performance gains. Because manufacturers of all components must meet performance requirements designed to improve each component, the overall system efficiency improves. Manufacturers that sell both refrigeration-system components together have more flexibility in how they comply, as they do not have to use these nominal default values and can trade off efficiency between their components to improve the overall system efficiency. Each of these examples demonstrates how standards that apply to manufacturers can enhance system-level efficiency even though the entire system is not subject to DOE standards.

By making the consideration of system-efficiency opportunities a normal part of relevant DOE rulemakings, DOE may be able to uncover new savings opportunities that have previously been ignored by the national standards program.

Recommendation 5: Develop a strategic approach for addressing connected products. An increasing array of products will be connected to the Internet in the coming years, including products subject to DOE standards. Connectedness is designed to provide a range of benefits for consumers including remote control by consumers and the ability to update or service products remotely. Products may also communicate with one another. Some utilities as well as equipment and controls manufacturers envision that connected appliances will present energy-savings opportunities, and/or that they will be a tool for ramping up load shifting to times when energy is cheaper, cleaner, or more abundant and for providing grid services (Hledik 2016).

Some of the largest opportunities for savings among the updated standards identified in Part 1 (e.g., water heaters and air conditioners) are products that manufacturers are targeting to include connected functionality. Other manufacturers are also interested in enhancing products by connecting them. For purposes of the national appliance standards program we recommend that DOE develop a strategic approach that accounts for the potential benefits and energy use of connectedness. Elements of a strategic approach would include

- Including energy use due to connectedness in product ratings and standards. If including this energy use in the main metric is unlikely to limit energy waste, then DOE should consider separate standby requirements.
- Allowing for innovation, especially use of connectedness for energy efficiency purposes. Limits on energy allowed for connectedness should not be so restrictive as to inhibit innovation. In addition, products that have the potential to deliver real-world energy savings due to connected features may merit a higher efficiency rating. However DOE should not trade off relatively certain savings achieved by meeting a given efficiency

performance standard for benefits that depend on connected features that may or may not be used in the field.

- Ensuring that connected devices do not circumvent standards. Any product that is systematically altered by a manufacturer post-sale or post-installation in such a way that its consumption under the DOE test method would exceed minimum standards should be deemed noncompliant.
- Leveraging information potentially available from connected devices to better understand real-world usage patterns and energy use. Connected devices may dramatically lower the cost of data gathering, which can be used to better understand how products are used in the field including their energy use. This information can be used to shape test-method revisions to make them more representative of real-world usage and future standards revisions.

A strategic approach consistently applied across relevant dockets will enable DOE to systematically address the intersection of connected devices and national appliance standards.

Conclusion

The accomplishments of the current and past administrations in establishing and updating efficiency standards have resulted in very large energy and economic savings for the nation, but enormous opportunity remains from future standards. In this paper we have estimated the potential savings from the next round of standards and outlined potential strategies to further increase savings. Simply by updating existing and pending standards using current product scopes, metrics, test methods, and known technology improvements, CO_2 emissions could be reduced by 3.8 billion metric tons by 2050 while saving consumers and businesses $1.2 trillion on their utility bills. In addition, DOE can achieve additional savings by investing in improved test procedures, systematically assessing opportunities for expanding the scope of national standards, improving analysis techniques and data sources, assessing opportunities for standards to contribute to systems-level savings, and taking into account the effect of Internet connectedness.

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