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How to Make Appliance Standards Work: Improving Energy and Water Efficiency Test Procedures

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ABSTRACT

Many nations have minimum energy performance standards and voluntary labeling programs for appliances. Credible test procedures are the foundation upon which all standards and voluntary programs are built. Reliable test procedures are also the basis of a robust certification and enforcement program. Unfortunately not enough attention has been paid to the process of developing these test procedures. In many cases the test procedures do not reflect field usage or have not kept up with changes in technology. The regulatory structure is different in each country, but they all face similar problems. The purpose of this paper is to layout a framework to improve test procedures for existing programs. The focus of this paper is on U.S., but an analogous framework would be appropriate in other nations. The U.S. Department of Energy (DOE) currently regulates minimum energy and water levels for 30 classes of products, and voluntary programs such as Energy Star and utility efficiency programs cover at least another 20 types of products. This presentation describes a process the Federal government should undertake to ensure the test procedures used to measure the energy and water efficiency of products are effective, and are developed and updated in a timely manner.

We propose a continuous, iterative process consisting of six phases for each type of appliance. These six phases are; survey, investigate, develop, regulate, enforce, and inform. At each step of the process, the DOE would benefit from having a core team of qualified staff but would also engage independent, knowledgeable experts who are familiar with the existing test procedures for those products. DOE would work with all stakeholders who have an interest in that product. It is essential that all perspectives be considered. These stakeholders include manufacturers and their trade associations, utilities, other government agencies, other governments, standards bodies, consumer groups, and energy efficiency advocacy organizations. An important aspect of this program will be to harmonize the US test procedures with those of other countries. This is particularly important in a world of global products, where harmonized testing can lead to reduced burden on manufacturers and better data for policymakers.

Statement of Problem

Reliable and current test procedures are the technical foundation upon which all minimum energy performance standards (MEPS) and voluntary programs are built. It is important that the test procedures are updated in a timely manner to reflect changes in technology and habits of use by consumers. This has been recognized for many years (Meier & Hill 1996). Flaws with the test procedures can impact the credibility of the MEPS and voluntary programs. Unfortunately there are many cases around the world recently where exactly this has happened.

Goals

The purpose of this paper is to layout a framework to improve the test procedures for existing programs. It is not about setting minimum energy performance standards or levels for voluntary labeling programs such as Energy Star. This paper identifies many problems with the current situation and identifies possible general solutions. Developing specific solutions would be the purpose of the proposed enhanced process.

The Department of Energy has recently recognized the importance of a strong appliance efficiency standards program. DOE currently has minimum energy and water standards for 30 classes of products, and voluntary programs such as Energy Star and utility efficiency programs cover at least another 20 types of products. The Federal government should develop a process to ensure the test procedures used to measure the energy and water efficiency of products are effective, and are developed and updated in a timely manner. This process would compliment the MEPS and Energy Star programs. Our audience is primarily policymakers in charge of the MEPS and Energy Star programs. The general public would be a secondary audience.

Test procedure background

A good test procedure must have the following characteristics:

- Repeatable (testing the same unit repeatedly gives similar results each time).
- Replicable (any competent lab gets similar results).
- Reasonable to perform (clear and unambiguous instructions; no complicated or delicate procedures; laboratory setup is not overly complicated; inexpensive; relatively quick).
- Provides meaningful results (predict the energy and/or water use for typical households, tested under "realistic" conditions; produce a small number of parameters that can be used to accurately calculate use under a wide variety of field conditions; ranking of models by test representative of field ranking)
- Measures what's important (only consider the inputs and outputs of the device, i.e., the services and amenities it provides and the cost of running it)
- Easy to modify

In reality, test procedures are the result of balancing these sometimes conflicting goals.

Besides these factors that directly affect the measurement of energy and/or water consumption, there are several other issues that good test procedures must take into account. These include making adjustments for attributes that define product types or categories (e.g., manual vs. auto-defrost refrigerator-freezers), measurement of product capacity or volume (for calculation of energy efficiency), and estimating non-energy performance. It is also important to conduct the test in a way that requires the device to perform its primary functions in ways consumers expect, e.g., wash clothes, cool food, dehumidify, etc.

Proposed program

We propose a continuous, iterative process to improve existing government programs. To preserve independence much of this work would have to be government funded. consisting of six

phases for each type of appliance. These six phases or steps are; survey, investigate, develop, regulate, enforce, and inform. At each step of the process, DOE would benefit from having a core team of qualified staff but it should also engage independent, knowledgeable experts who are familiar with the existing test procedures for those products. DOE should work with all stakeholders who have an interest in that product. It is essential that all perspectives be considered. These stakeholders include manufacturers and their trade associations (AHAM, AHRI, NEMA, CEA), utilities, other government agencies (NIST, FTC, CEC, etc.), other governments (Canada, EU, etc.), standards bodies (ISO, IEC, IEEE, ASHRAE, AWWA, AHRI, etc.), consumer groups (Consumers Union), and energy efficiency advocacy organizations (CEE, ACEEE, etc.). An important aspect of this program would be to harmonize the US test procedures with those of other countries. This is particularly important in a world of global products, where harmonized testing can lead to reduced burden on manufacturers and better data for policymakers. One implication of this approach is that all future test procedures should be based on SI units.

The following sections provide more details on each step of the proposed program. Examples are provided to illustrate products for which an active test procedure program would have helped identify problems and more quickly develop solutions.

Survey

Survey the field for testing issues and prioritize products needing review. Gather knowledge from industry and other stakeholders about problems with test procedure. The Energy Independence and Security Act requires that appliance test procedures be updated at least once every seven years (U.S. Congress 2007 Sec 302). Significant updates may be needed more frequently for some products when significant technical innovation has occurred. To minimize the number of changes to efficiency standards, the timing of test procedures and efficiency standards should be coordinated. Test procedures should be updated before a new standard setting process begins and made effective when the new minimum efficiency standard becomes effective. The new standard level can then be based on the new test procedure, thereby avoiding having to use adjustment factors.

New test procedures may be triggered as a result of requests for waivers from tests and follow-up on complaints about the test procedure. Consumer Reports, a magazine representing the interests of consumers, has found cases of this with test procedures not representing typical use of refrigerators (Consumer Reports 2008).

New products enter the market place with different features that are not adequately addressed in the current test procedure. An example of this is the test procedure for residential water heaters (10CFR430BAppE 2009). The current test procedure consists of six equal draws of hot water spaced an hour apart followed by standby for the remainder of a 24 hour simulated day. In North America, typical hot water use involves about ten times as many smaller draws (Thomas et al. 2008). The result is that the efficiency of tankless water heaters is exaggerated in the test relative to field use (DEG 2006).

A similar case where the test procedure energy use results were significantly less than energy use in the field occurred with the Japanese test procedure for refrigerators (Tsurusaki et al. 2006)

Regulations sometimes incorporate references to old, outdated test procedures The test procedure for commercial water heaters cited in the current DOE regulations is in ANSI

Z21.10.3-1998 (10CFR431.105, 10CFR431..106). The ANSI standard for this type of water heater was updated in 2004, followed by addenda in 2007 and 2008 (ANSI Z21.10.3-2004, ANSI Z21.10.3a-2007, ANSI Z21.10.3b-2008).

DOE can monitor innovations in new products by surveying the relevant trade journals and product listserve discussions. This should be done continuously in order to catch changes in products early on.

As an example of how surveying the literature can be useful, several years before DOE began the process of changing the refrigerator test procedure, both consumer and trade publications reported on new refrigerator designs not covered by the test procedure.

A thorough market assessment should be done every few years. The knowledge revealed by this study, along with estimates of the amount of energy and water used by different types of products, can help set priorities on which test procedures should be revised soonest.

Investigate

The second step is to conduct more in-depth investigations of the issues raised in the surveys. This means looking into both how well the test procedure addresses the issues identified, as well as how energy and water are actually used in the field..

New products and products with new features should be tested in a laboratory to investigate how they use energy and water in ways that may not be captured by existing test procedures. Necessarily included in the investigations are identifying additional performance attributes that may impact efficiency Most notably, the biggest innovations in many products are due to software changes, not hardware, while most test procedures focus on the performance of hardware. Test procedures need to be improved to accommodate the increasing role of software in product performance. As more products are network-capable, the energy implications of networking and demand response also need to be considered. Ideally networking capability would lead to increased services at a reduced energy cost, such as delaying water heating until the times of day when electricity prices are lower. However this must be balanced against the possibility of increasing standby power use.

There are other aspects that should be investigated in the laboratory as well. The existing test may not deal well with things like advanced controls, maintenance issues, and current installation practice.

An example is the blowers used in gas furnaces, which are tested in a way that does not accurately represent the duct pressure drops (and attendant energy losses) that are typically seen in actual installations.

The investigations should also include field monitoring to see how products are used. A clear example of this is the number and type of cycles used on washing machines. The field monitoring will inform the laboratory testing. The monitoring should include energy use, water use, field conditions, and installation practices. What is important to monitor will depend on the appliance. Connecting appliances to the web may facilitate monitoring.

It is also important to coordinate with other organizations on the field monitoring. For example the information collected by EIA in RECS and CBECS can be used to enhance the field monitoring (and improved RECS and CBECS data would help the development of better test procedures). Many utilities run measurement and evaluation studies to justify their programs. DOE should review these activities to better understand field usage of the products under consideration.

Finally, there may be other innovative ways to gain an awareness of how products are being used. DOE could consider working with universities and industry to better understand behavioral issues – how people are (and perhaps should be) using products.

Develop

The third step is to modify existing test procedures - and possibly develop new ones. Before starting to develop new test procedures it is important to review existing non-federal and international standards. The department should work with stakeholders to revise test procedures. This will likely mean supporting active, ongoing participation in existing standards development organizations. The proposed tests should meet the goals outlined above.

Part of this development work will be to incorporate the knowledge from earlier laboratory and field investigations to determine the best methods to measure the energy and water use of new features or designs. The number of combinations of operating modes and control sequences could make it very difficult to evaluate all of them in the lab. It might be possible to include some subset of those combinations in the test protocol. The new tests could determine other parameters necessary for detailed energy calculations to cover products and conditions that are impractical to test in a laboratory. This subset of operating modes combined with key parameters could be extended by calculation to determine a metric that would be reasonably representative of efficiency in field use.

The results of the test should allow creation of a simplified metric for use by standards and voluntary programs. At this point in the test procedure development process, round robin testing with manufacturers can be used to reveal any unexpected difficulties in applying or interpreting the proposed test procedure.

Regulate

As a proposed test procedure is nearing completion, DOE should initiate a rulemaking to implement the proposed test procedures. Ideally, the implementation of a new test procedure will coincide with the development of new minimum efficiency standards. A positive example of coordinated test procedure and efficiency standard development is the current refrigerator rulemaking, in which the test procedure is being modified at the beginning of the rulemaking. If that is not possible and the proposed test procedure affects the DOE existing minimum efficiency standard, the existing standard level (or results from the previous test procedure) may need to be adjusted.

The test procedure rulemaking process will need to consider the outcomes of any round robin testing with manufacturers.

Enforce

The fifth step occurs when the test procedure has been finalized and is being implemented as part of standards or voluntary programs. All self-reporting programs must be linked to random third-party verification so as to preserve the program's integrity. This level of compliance and enforcement usually relies on check testing by independent third-party laboratories. In implementing its standards, DOE should develop a program to monitor the claimed results. The program should be quick to investigate any anomalous results, and the

consequences of fraudulent claims should be serious, swift and highly visible. The Department should work with stakeholders to determine the focus of any special compliance investigations. Enforcement mechanisms can include reviewing data submitted to the DOE as well as to the FTC. Plotting data can identify outliers that can then be further investigated. Any compliance or enforcement activities should be considered in the survey phase of the next cycle of test procedure development.

Part of this enforcement should be to ensure that manufacturers are providing certification data on all covered products. Fortunately the DOE and EPA are starting to take compliance and verification issues seriously now. The General Counsel office of the Department of Energy has started aggressively enforcing certification and compliance (DOE 2009, DOE 2010). The verification, testing and enforcement aspects of the Energy Star program bolstered as well. (EPA 2010).

Inform

The final step is to inform the public and stakeholders about the relative energy and water efficiency of products tested using the test procedure. Some activities in this area already exist, such as EnergyGuide labels, the FTC product directory, and the Energy Star qualified products list. But more activities are needed, such as expanding the FTC product directory to all energy-using products, and more effective product labels that estimate energy use in a range of usage scenarios. Web tools can provide public access to a comprehensive database.

Another form of public access to information would be to require an automatic, built-in efficiency display. This would certainly enhance the importance of the efficiency ratings as well as provide of other benefits such as indications of incorrect installation or operation.

Conclusion

The Department of Energy has recently recognized the importance of a strong appliance efficiency standards program. Credible test procedures are the foundation upon which all standards and voluntary programs are built. Reliable test procedures are also the basis of a robust certification and enforcement program. The Department should adopt a continuous, iterative process to update the test procedure for each type of appliance.

References

[10CFR430BAppE] Code of Federal Regulations. 2009. *Appendix E to Subpart B of Part 430--Uniform Test Method for Measuring the Energy Consumption of Water Heaters.* http://edocket.access.gpo.gov/cfr_2009/janqtr/pdf/10cfr430BAppE.pdf Washington, D.C.: U.S. Department of Energy,

[10CFR431.105] Code of Federal Regulations. 2009. *Part 431, Section 105 Energy Efficiency Program For Certain Commercial And Industrial Equipment, Materials incorporated by reference.* http://edocket.access.gpo.gov/cfr_2009/janqtr/pdf/10cfr431.105.pdf Washington, D.C.: U.S. Department of Energy,

[10CFR431.106] Code of Federal Regulations. 2009. *Part 431, Section 106 Energy Efficiency Program For Certain Commercial And Industrial Equipment, Uniform test method for the measurement of energy efficiency of commercial water heaters and hot water supply boilers (other than commercial heat pump water heaters).* http://edocket.access.gpo.gov/cfr_2009/janqtr/pdf/10cfr431.106.pdf Washington, D.C.: U.S. Department of Energy,

[ANSI Z21.10.3] American National Standards Institute. 2004. "ANSI Z21.10.3-2004/CSA 4.3-2004 Gas Water Heaters - Volume III, Storage Water Heaters With Input Ratings Above 75,000 Btu per Hour, Circulating and Instantaneous"

[ANSI Z21.10.3a] American National Standards Institute. 2007. "ANSI Z21.10.3a-2007/CSA 4.3a-2007 Addenda 1 to ANSI Z21.10.3-2004/CSA 4.3-2004, Gas Water Heaters - Volume III, Storage Water Heaters With Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous"

[ANSI Z21.10.3a] American National Standards Institute. 2008. "ANSI Z21.10.3b-2008/CSA 4.3b-200 Addenda 2 to ANSI Z21.10.3-2004/CSA 4.3-2004, Gas Water Heaters - Volume III, Storage Water Heaters With Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous"

Consumer Reports. 2008. "Energy Star has lost some luster." (October): 24-26.

[DEG] Davis Energy Group. 2006. "Field and Laboratory Testing of Tankless Gas Water Heater Performance." *Appendix K. Water Heaters and Hot Water Distribution Systems.* California Energy Commission Publication Number: CEC-500-2008-082 www.energy.ca.gov/pier/project_reports/CEC-500-2008-082.html

[DOE] Department of Energy. 2009. *Department of Energy to Take Steps to Remove ENERGY STAR Label on Certain LG Refrigerator-Freezer Models.* www.energy.gov/news2009/8367.htm Washington, D.C.: U.S. Department of Energy, Office of the General Counsel, December 7.

[DOE] Department of Energy. 2010. *DOE Institutes Enforcement Action Against AeroSys, Inc. for Failure to Certify Air Conditioners and Heat Pumps.* www.gc.energy.gov/1274.htm Washington, D.C.: U.S. Department of Energy, Office of the General Counsel, February 4.

Meier, A.K., and J.E. Hill. 1996. "Energy test procedures for appliances." *Energy and Buildings* 26 (1997) 23-33.

Thomas, M., A.C.S Hayden, K. Wittich, and D.MacKenzie. 2008. "Residential hot water use and its implications for gas-fired water heater efficiency and future canadian performance test standards." *in Proceedings of the International Gas Research Union Conference,* Paris: International Gas Union.

Takahiro Tsurusaki, Yumiko Iwafune, Yoshiaki Shibata, Chiharu Murakoshi, and Hidetoshi Nakagami. 2006. “Actual Energy Consumption of Top-Runner Refrigerators in Japan.” *In Proceedings of the Energy Efficiency In Domestic Appliances And Lighting 4th International Conference EEDAL'06*, 1: 49-58. London, United Kingdom: Institute Environment and Sustainability

[U.S. Congress] 2007. “Energy Independence and Security Act of 2007” Washington DC, January 4.