Energy Conservation Standards
Rulemaking Framework Document for
Residential Refrigerators, Refrigerator-Freezers, and Freezers

U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Building Technologies Program

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AEO	Annual Energy Outlook
AHAM	Association of Home Appliance Manufacturers
ANOPR	advance notice of proposed rulemaking
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
BT	Building Technologies Program
Btu	British thermal units
CEC	California Energy Commission
CEE	Consortium for Energy Efficiency
CFC	chlorofluorocarbon
CFR	Code of Federal Regulations
CO_2	carbon dioxide
CSL	candidate standard level
DOE	U.S. Department of Energy
DOJ	U.S. Department of Justice
EER	energy efficiency ratio
EERE	Office of Energy Efficiency and Renewable Energy
EIA	Energy Information Administration
EISA	Energy Independence and Security Act of 2007
EPACT	Energy Policy Act of 2005
EPA	U.S. Environmental Protection Agency
EPCA	Energy Policy and Conservation Act
FR	*Federal Register*
GRIM	Government Regulatory Impact Model
GWP	global warming potential
HCFC	hydrochlorofluorocarbon
HFC	hydrofluorocarbon
IEC	International Electrotechnical Commission
ImSET	Impact of Sector Energy Technologies
kWh	kilowatt-hour
LCC	life-cycle cost
NAECA	National Appliance Energy Conservation Act of 1987
NECPA	National Energy Conservation Policy Act of 1978
NEMS	National Energy Modeling System
NES	national energy savings
NIST	National Institute of Standards and Technology
NOPR	notice of proposed rulemaking
NOx	oxides of nitrogen
NPV	net present value
NRCan	Natural Resources Canada
PBP	payback period
PNNL	Pacific Northwest National Laboratory
R&D	research and development
RECS	Residential Energy Consumption Survey

RoHS	Reduction of Hazardous Substances directive
SEC	Securities and Exchange Commission
SG&A	selling, general, and administrative costs
SO_2	sulfur dioxide
SWEF	shipment-weighted efficiency
TBD	to be determined
TSD	technical support document
TSL	trial standard level
TTAF	test temperature adjustment factor
TTD	through-the-door
U.S.	United States
U.S.C.	United States Code

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1. INTRODUCTION

The U.S. Department of Energy (DOE) Appliances and Commercial Equipment Standards Program, within the Office of Energy Efficiency and Renewable Energy (EERE) Building Technologies Program (BT), develops and promulgates test procedures and energy conservation standards for consumer appliances and commercial equipment. The process for developing standards involves analysis, public notice, and consultation with interested parties. Such parties, known as stakeholders, include manufacturers, consumers, energy conservation and environmental advocates, State and Federal agencies, and any other groups or individuals with an interest in these standards and test procedures.

This framework document seeks to describe DOE's anticipated procedural and analytical approaches for evaluating energy conservation standards for residential refrigerators, refrigerator-freezers, and freezers.

This document also intends to inform stakeholders of the standards rulemaking process for residential refrigerators, refrigerator-freezers, and freezers, and to encourage and facilitate stakeholder input during the rulemaking. This document serves as the starting point for developing standards and is not a definitive statement about any issue that the rulemaking will determine.

Section 1 provides an overview of the rulemaking process. Sections 2–16 discuss DOE's projected analyses for fulfilling the statutory requirements and guidance for this standards rulemaking.

Information about this rulemaking will be maintained on the DOE website at http://www.eere.energy.gov/buildings/appliance_standards.

> *DOE invites stakeholder comments on all aspects of the material presented in this document. This comment box and others highlight issues on which DOE seeks comment and requests feedback from interested parties. DOE uses these comment boxes to ask specific questions about the approaches that it proposes to follow for the analyses required for the standards rulemaking. Such requests for stakeholder feedback are numbered according to the section in which they appear.*

1.1 The Appliances and Commercial Equipment Standards Program

The Energy Policy and Conservation Act (EPCA) of 1975, Pub. L. 94-163 (42 United States Code (U.S.C.) 6291–6309), established an energy conservation program for major household appliances. The National Energy Conservation Policy Act of 1978 (NECPA), Pub. L. 95-619, amended EPCA to add Part C[1] of Title III (42 U.S.C. 6311–6317), which established an energy conservation program for certain industrial equipment. Additional amendments to EPCA give DOE the authority to regulate the energy efficiency of several products, including residential refrigerators, refrigerator-freezers, and freezers—the products that are the focus of this document. The amendments to EPCA in the National Appliance Energy Conservation Act of 1987 (NAECA), Pub. L. 100-12, established energy conservation standards for refrigerators, refrigerator-freezers, and freezers, as well as requirements for determining whether these standards should be amended. (42 U.S.C. 6295(b))

NAECA first established performance standards for residential refrigerators, refrigerator-freezers, and freezers, and further required that DOE conduct two cycles of rulemakings to determine if more stringent standards are justified.[2] (42 U.S.C. 6295(b)) On November 17, 1989, DOE published a final rule in the *Federal Register* updating the performance standards; the new standards became effective on January 1, 1993. 54 FR 47916. Subsequent to this final rule, DOE determined that new standards for some of the product classes were based on incomplete data and incorrect analysis. As a result, DOE published a correction that amended the new standards for three product classes: (1) refrigerators and refrigerator-freezers with manual defrost, (2) refrigerator-freezers—automatic defrost with bottom-mounted freezer but without through-the-door (TTD) ice service, and (3) chest freezers and all other freezers. 55 FR 42845 (Oct. 24, 1990). DOE updated the performance standards once again for refrigerators, refrigerator-freezers, and freezers by publishing a final rule in the *Federal Register* on April 28, 1997. 62 FR 23102. The new standards became effective on July 1, 2001. By completing a second standards rulemaking, DOE had fulfilled its legislative requirement to conduct two cycles of standards rulemakings.

Stakeholders submitted a petition in 2004 requesting that DOE conduct another rulemaking to amend the standards for residential refrigerator-freezers. In April 2005, DOE granted the petition and conducted a limited set of analyses to assess the potential energy savings and economic benefit of new standards. DOE issued a report in October 2005 detailing the analyses.[3] The analysis examined the technological and economic feasibility of new standards set at Energy Star levels effective in 2005 for the two most popular product classes of refrigerators: top-mount refrigerator-freezers without TTD features and side-mount refrigerator-

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[1] Part C has been redesignated Part A-1

[2] DOE defines "electric refrigerator" under EPCA as "a cabinet designed for the refrigerated storage of food at temperatures above 32°F and below 39°F, configured for general refrigerated food storage, and having a source of refrigeration requiring single phase, alternating current electric energy input only. An electric refrigerator may include a compartment for the freezing and storage of food at temperatures below 32°F, but does not provide a separate low temperature compartment designed for the freezing and storage of food at temperatures below 8°F." DOE defines "electric refrigerator-freezer" as "a cabinet which consists of two or more compartments with at least one of the compartments designed for the refrigerated storage of food at temperatures above 32°F, and with at least one of the compartments designed for the freezing and storage of food at temperatures below 8°F, which may be adjusted by the user to a temperature of 0°F, or below. The source of refrigeration requires single phase, alternating current electric energy input only." DOE defines "freezer" as "a cabinet designed as a unit for the freezing and storage of food at temperatures of 0°F, or below, and having a source of refrigeration requiring single phase, alternating current electric energy input only." 10 CFR 430.2.

[3] U.S. Department of Energy. Technical Report: Analysis of Amended Energy Conservation Standards for Residential Refrigerator-Freezers. October 2005. <http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrigerator_report_1.pdf >

freezers with TTD features. DOE confined its updated analysis to these two classes because they accounted for a majority of current product shipments. Depending on assumptions about the impact that standards would have on market efficiency, DOE estimated that amended standards at the 2005 Energy Star levels would yield between 2.4 to 3.4 quads,[4] with an associated economic impact to the Nation ranging from a burden or cost of $1.2 billion to a benefit or savings of $3.3 billion.[5]

DOE published draft data sheets containing energy-savings potentials for refrigerator-freezers in October 2005 as part of its fiscal year 2006 schedule-setting process. These data sheets summarized the following in table format: (1) the potential energy savings from regulatory action in cumulative quads from 2010 to 2035, (2) the potential economic benefits or burdens, (3) the potential environmental or energy security benefits, (4) the status of required changes to test procedures, (5) other regulatory actions, (6) recommendations by interested parties, (7) evidence of market-driven or voluntary efficiency improvements, (8) regulatory issues, and (9) the 2005 priority. The data sheets for refrigerators and refrigerator-freezers were based on the October 2005 draft technical report analyzing potential new amended energy conservation standards for residential refrigerator-freezers described above. This report and the associated data sheets provided input to the setting of priorities for rulemakings activities. Other products were given a higher priority, and limited rulemaking work on refrigerators and freezers was carried out in the following years prior to the enactment of the Energy Independence and Security Act of 2007 (EISA).

EISA, signed into law on December 19, 2007, requires that DOE publish a final rule no later than December 31, 2010, to determine whether to amend the standards in effect for refrigerators, refrigerator-freezers, and freezers manufactured on or after January 1, 2014. As a result, DOE is embarking on a standards rulemaking for these products to comply with the requirements of EISA.

1.2 Overview of the Rulemaking Process

1.2.1 Test Procedures

The Code of Federal Regulations (CFR) describes the DOE test procedures for refrigerators, refrigerator-freezers, and freezers.[6] DOE recently addressed issues pertaining to defrost systems, wine cooling refrigeration products, anti-sweat heaters, chest freezers with automatic defrost, and refrigerator-freezers with bottom-mounted freezers incorporating through-the-door (TTD) features. Additional issues relevant to the test procedures include test result repeatability, references to an older version of the ANSI-AHAM HRF-1 test standard, circumvention, convertible bottom-drawer refrigerator-freezers and other configurations with more than two compartments, standby and off mode energy use, and international test procedure harmonization. DOE intends to initiate a rulemaking to modify the test procedures but has not yet decided which of these issues will be addressed. One issue—harmonization of test procedures with international standards, for which test procedure compartment temperatures are different than for

[4] A quad represents a quadrillion Btu (or 10^{15} Btu).

[5] Economic impact based on a discount rate of 7 percent real.

[6] Title 10—Energy, Chapter II—Department of Energy, Part 430—Energy Conservation Program for Consumer Products, Subpart B—Test Procedures, Appendices A1 and B1.

the DOE test procedure—has significant impact on the rulemaking process. Section 1.2.2 discusses this issue separately.

In the case of defrost systems, DOE published a direct final rule on March 7, 2003, which amended the test procedure for refrigerators and refrigerator-freezers to modify the test period for "long-time" automatic defrost refrigerator-freezers. 68 FR 10957. This revision became effective in May 2003 and amended the test time period for the second of the tests on these units. The measurement for this second part of the test, which measures added energy consumption associated with automatic defrost, originally was specified to start as the refrigerator-freezer initiates defrost during a compressor "on" cycle. Electrolux developed a refrigerator-freezer that turns off the compressor, allowing the evaporator to warm up somewhat before initiation of defrosting, thus saving a portion of the defrost energy consumption. DOE modified the test procedure to allow the measurement to start when the defrost is initiated after the compressor has turned off. This revision has no effect on the testing of refrigerators and refrigerator-freezers that do not use long-time automatic defrost or variable defrost systems.

DOE granted a test procedure waiver to General Electric Company (GE) for anti-sweat heaters. Specifically, GE developed a new product line of refrigerators and refrigerator-freezers that contain sensors to detect temperature and humidity, and that interact with controls to vary the effective wattage of anti-sweat heaters to evaporate excess moisture. DOE awarded this waiver on February 27, 2008. 73 FR 10425. The waiver provides a method for determining the energy use of an adaptive anti-sweat heater.

The following two test procedure issues have prompted DOE to propose new product classes (see section 3.2).

DOE's Office of Hearings and Appeals has granted exemptions to Maytag Corporation, LG Electronics Inc., and Samsung Electronics on brands of automatic defrost refrigerator-freezers with bottom-mounted freezer and TTD ice service. DOE granted an exception to Maytag on August 11, 2005, to LG on November 9, 2005, and to Samsung on July 26, 2007. Before these rulings, there was no appropriately defined category for this type of product, since the minimum standard for Product Class 5 (refrigerator-freezers with automatic defrost and bottom-mounted freezer without TTD ice service) was established to cover only products without TTD ice-service at the time of its development. The actual energy consumption of this new product (*i.e.*, with TTD ice service) is higher than that of Product Class 5 because of heat loss associated with the TTD feature. The exemption actions established maximum energy use levels for the new product class.

DOE's Office of Hearings and Appeals granted an exemption to Electrolux Home Products for a specific brand of chest freezer with automatic defrost. The Association of Home Appliance Manufacturers (AHAM) filed a letter supporting this exemption and recommended that DOE use the direct final rule process to establish a new class of chest freezers that would correspond to the minimum efficiency standard for automatic defrost chest freezers. Before this ruling, there was no appropriate defined category for this type of product, because the minimum standard for product class 10 (chest freezers and all other freezers) was established to cover products without automatic defrost at the time of its development. The actual energy consumption of this new product (*i.e.*, with automatic defrost) is higher than that of Product Class 10 because of the added energy consumption associated with the automatic defrost system. The exemption action established maximum energy use levels for the new product class.

For wine-cooling refrigeration products, DOE recently granted a waiver to Liebherr from the existing test procedure for residential electric refrigerators and refrigerator-freezers on April 24, 2007, for combination wine storage-freezers. 72 FR 20333. In granting the waiver, DOE required that Liebherr test or rate its combination wine storage-freezer products using the modified version that Liebherr proposed for the electric refrigerator-freezer energy test procedure—specifically, using a wine storage compartment temperature of 55°F and a freezer compartment temperature of 5°F. The wine storage compartment of units tested by this method must not be convertible to any other type of compartment, and must account for 50 percent or more of the total volume.

For wine coolers in general, DOE amended the definition of "electric refrigerator," effective December 19, 2001, to include a maximum temperature of the fresh food storage compartment, and to exclude certain appliances whose physical configuration makes them unsuitable for general storage of perishable foods. 66 FR 57845. Because wine coolers maintain storage temperature above 39ºF, they are exempt from existing refrigerator product classifications and are not required to meet minimum efficiency standards. Because wine coolers are exempted from Federal efficiency standards, the California Energy Commission (CEC) has established state energy conservation standards for them. To rate wine coolers, the CEC requires testing them to the existing DOE test procedure, but with a standardized rating temperature of 55°F. The CEC also specifies a modified formula for calculating the energy expended in the test cycle.[7] Natural Resources Canada's (NRCan) Office of Energy Efficiency (OEE) proposes to amend Canada's Energy Efficiency Regulations to add energy performance standards for residential wine coolers.[8] The proposed standard includes a test procedure and minimum energy performance standard levels for wine coolers harmonized with those in effect in California.

Because of inconsistencies in test results for compact refrigerators, the National Institute of Standards and Technology (NIST) investigated repeatability issues and published a report, *Repeatability of Energy Consumption Test Results for Compact Refrigerators*.[9] In addition, NIST participated in a task force formed by AHAM to revise its AHAM HRF-1 test procedure. The latest version of AHAM's test procedure is now AHAM HRF-1-2007.[10] The existing DOE test procedure still references an older version of the AHAM test procedure, AHAM HRF-1-

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[7] California Energy Commission. *2007 Appliance Efficiency Regulations*, December 2007. CEC-400-2007-016-REV1.

[8] Natural Resources Canada. *Energy Efficiency Regulations, Proposed Regulations Bulletin – February 2007, Residential Wine Chillers (or Wine Coolers)*, 2007. Ottawa, Canada. <http://oee.nrcan.gc.ca/regulations/bulletin/wine-chillers-feb-2007.cfm?text=N&printview=N>

[9] Yashar, D.A. *Repeatability of Energy Consumption Test Results for Compact Refrigerators*, September 2000. U.S. Department of Commerce, National Institute of Standards and Technology, Gaithersburg, MD. NISTIR 6560. <http://www.fire.nist.gov/bfrlpubs/build00/PDF/b00055.pdf>

[10] Association of Home Appliance Manufacturers. *American National Standard, Household Refrigerators/Household Freezers*, 2007. ANSI-AHAM HRF-2007. Washington, DC.

1979. DOE has initiated work to amend the DOE test procedure to reference the most recent version of AHAM HRF-1.

Recent versions of AHAM HRF-1 clarified that the distance between the rear wall of the test sample and the test room wall or simulated wall should be at the *minimum* distance recommended by the manufacturer's installation instructions. In contrast, the 1979 version of HRF-1 specified that this distance be "in accordance with the manufacturer's instructions." It is not clear that other issues discussed in the NIST report have been addressed in past HRF-1 updates. However, AHAM is working on a further modification of the HRF-1 standard, which will address, among other issues, simplification of determining cabinet compartment internal volume, one of the issues discussed in the NIST report.

Another issue that DOE expects to address in a rulemaking to amend the test procedure is the use of controls or features in products that have the effect of circumventing or frustrating the objective of the test procedure. Some refrigerator-freezer models, for example, deactivate certain energy-using components during testing, resulting in a rated performance that is significantly different than actual field performance. EPCA provides that test procedures must be "reasonably designed to produce test results which measure energy efficiency, energy use, water use . . ., or estimated annual operating cost of a covered product during a representative average use cycle or period of use, as determined by the Secretary . . . ." 42 U.S.C. 6293(b)(3). *See also* 42 U.S.C. 6314(a)(2) (regarding test procedures for commercial and industrial equipment testing). This statutory requirement may be undermined if products are purposefully designed to use controls or features that produce test results that are so unrepresentative of a product's actual energy or water consumption as to provide materially inaccurate comparative data. DOE will amend its test procedures to address any product controls or features that it determines have the effect of undermining the purpose of the test procedure. DOE will follow the enforcement procedures in 10 CFR 430.70 if information submitted to it indicates that a particular covered product of a particular manufacturer or private labeler is not in compliance with the applicable energy performance standard or water performance standard. Finally, DOE notes that in its updated Energy Star requirements for refrigerator-freezers in 2008, the Energy Star program has included a provision to prohibit models from meeting the Energy Star criteria through this type of circumvention scheme.[11] AHAM also incorporated provisions that address circumvention in its latest test procedure, AHAM HRF-1-2007. Thus, DOE will consider implementing similar provisions in its test procedure in order to ensure that test procedure results reflect real, as opposed to illusory, energy efficiency.

Convertible bottom-drawer refrigerator-freezer models, where the bottom drawer can be used as either a freezer or a fresh food section, have recently come on to the market.[12] For rating purposes, the bottom drawer of these products is tested as a fresh food compartment instead of a freezer. This approach is inconsistent with AHAM HRF-1, which states that convertible compartments be tested in their highest energy use position. DOE will need to determine

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[11] U.S. Environmental Protection Agency. *Energy Star Program Requirements for Residential Refrigerators and/or Freezers*, August 3, 2007. Washington, DC. < http://www.energystar.gov/ia/partners/product_specs/program_reqs/refrig_prog_req.pdf >

[12] Haier America Trading, LLC. *Convertible Bottom Drawer Refrigerator, Model PRCS25EDAS*. <http://www.haieramerica.com/en/product/PRCS25EDAS> (Accessed September 26, 2007.)

whether the bottom drawer should be tested only as a fresh food compartment and whether any test procedure revisions are necessary to rate this equipment.

Convertible bottom-drawer refrigerator-freezer models also are inconsistent with current product class definitions because they have three compartments. The placement of thermocouples in the compartments should be consistent with Figures 7-1 and 7-2 of AHAM HRF-1-1979. The DOE test procedure also specifies that compartment average temperatures should be equal to the average of the measurements of the thermocouples in that compartment. 10 CFR 430 Subpart B, Appendix A1, Section 5.1.1. However, DOE does not provide guidance regarding weighting of average temperatures of two fresh food or two freezer compartments to calculate temperatures TR and TF used in the interpolation calculations of Step 6.2.2.2 of the DOE test procedure found in 10 CFR Part 430, Subpart B, Appendix A1.

EISA also requires DOE to include consideration of standby mode and off mode energy consumption in future amendments to both its test procedures and energy conservation standards. Specifically, section 310 of EISA amends section 325 of EPCA (42 U.S.C. 6295) by adding the following definitions and other requirements pertaining to standby and off mode energy use:

> (gg) STANDBY MODE ENERGY USE.
>
> (1) DEFINITIONS.—
>
> (A) IN GENERAL.—Unless the Secretary determines otherwise pursuant to subparagraph (B), in this subsection:
>
> (i) ACTIVE MODE.—The term "active mode" means the condition in which an energy-using product:—
>
> (I) is connected to a main power source;
> (II) has been activated; and
> (III) provides 1 or more main functions.
>
> (ii) OFF MODE.—The term "off mode" means the condition in which an energy-using product:—
>
> (I) is connected to a main power source; and
> (II) is not providing any standby or active mode function.
>
> (iii) STANDBY MODE.—The term "standby mode" means the condition in which an energy-using product:—
>
> (I) is connected to a main power source; and
> (II) offers 1 or more of the following user-oriented or protective functions:
>
> (aa) To facilitate the activation or deactivation of other functions (including active mode) by remote switch (including remote control), internal sensor, or timer.
> (bb) Continuous functions, including information or status displays (including clocks) or sensor-based functions.
>
> (B) AMENDED DEFINITIONS.—The Secretary may, by rule, amend the definitions under subparagraph (A), taking into consideration the most current versions of Standards 62301 and 62087 of the International Electrotechnical Commission (IEC).
>
> (2) TEST PROCEDURES.—
>
> (A) IN GENERAL.—Test procedures for all covered products shall be amended pursuant to section 323 to include standby mode and off mode energy

consumption, taking into consideration the most current versions of Standards 62301 and 62087 of the International Electrotechnical Commission, with such energy consumption integrated into the overall energy efficiency, energy consumption, or other energy descriptor for each covered product, unless the Secretary determines that:—

(i) the current test procedures for a covered product already fully account for and incorporate the standby mode and off mode energy consumption of the covered product,; or

(ii) such an integrated test procedure is technically infeasible for a particular covered product, in which case the Secretary shall prescribe a separate standby mode and off mode energy use test procedure for the covered product, if technically feasible.

*   *   *   *   *

(3) INCORPORATION INTO STANDARD.—

(A) IN GENERAL.—Subject to subparagraph (B), based on the test procedures required under paragraph (2), any final rule establishing or revising a standard for a covered product, adopted after July 1, 2010, shall incorporate standby mode and off mode energy use into a single amended or new standard, pursuant to subsection (o), if feasible.

(B) SEPARATE STANDARDS.—If not feasible, the Secretary shall prescribe within the final rule a separate standard for standby mode and off mode energy consumption, if justified under subsection (o).

For refrigerators, refrigerator-freezers, and freezers, the current test procedure captures standby and off mode energy use. All energy input for the test duration, including during times of compressor off cycle is measured, for a test time period which is at least 3 hours long. Hence, under provision (gg)(2)(A)(i), establishing standby and off modes and test procedures to incorporate them into the overall energy use is not required. Complications potentially arise for refrigerator features not mentioned by the test procedure that might involve some standby energy use during normal consumer use, but that might be disconnected or otherwise turned off during energy testing (*e.g.*, a computer integrated with the refrigerator).

Item 1-1 *DOE requests input from stakeholders on the merits of revising its test procedures for residential refrigerators, refrigerator-freezers, and freezers. Specifically, should DOE revise its test procedure to (1) measure the performance of anti-sweat heater systems that are controlled through temperature and humidity sensing, (2) rate combination wine storage-freezer appliances and wine coolers, (3) incorporate by reference the most recent version of the AHAM HRF-1 test standard that includes revised test methods for rating compact refrigerators, (4) incorporate provisions to prevent circumvention schemes, (5) rate convertible bottom-drawer refrigerator-freezer models?*

1.2.2 Test Procedure Compartment Temperature Changes

Working Group 12 of Technical Committee 59 of the IEC is developing IEC 62552, an international test procedure for refrigerators, refrigerator-freezers, and freezers. One of the goals of this effort is to maximize harmonization among energy test procedures for countries representing key markets for these products. As a result, AHAM is working on a revision of AHAM HRF-1 that will include test procedure modifications, including (1) standard test temperatures of 0°F rather than 5°F for the freezer compartment of a refrigerator-freezer and 39°F rather than 45°F for the fresh food compartment, (2) standard test temperature of 39°F rather than 38°F for an all-refrigerator, and (3) standard test temperature of 39°F rather than 45°F for the fresh food compartment of a refrigerator having a freezer compartment. This test procedure change will also incorporate calculation of internal volumes using a computer-aided-drafting (CAD) approach, which addresses one of the issues pointed out in the NIST report mentioned above in section 1.2.1. AHAM requests that DOE revise the DOE energy test procedure to adopt the modified temperatures and to carry out the energy conservation standards rulemaking based on the temperature changes. The change in temperatures will clearly result in higher test energy use for refrigerator-freezers and refrigerators with freezer compartments and lower test energy use for all-refrigerators, thus necessitating an adjustment to kilowatt-hour (kWh)-per-year values for all efficiency levels for these products. These new temperatures are more consistent with actual temperature levels consumers use[13] and it is argued that the energy use measured using the new temperatures may be more representative of actual field energy use. The temperature changes do not affect freezers, which are already tested with the new 0˚F freezer compartment temperature.

DOE will consider adopting these temperature changes on the basis of stakeholder comments received during the framework document comment period and workshop.

If DOE amends the test procedures for the new proposed compartment temperatures, it expects to establish a new test procedure for refrigerators and refrigerator-freezers as Appendix A of Subpart B of 10 CFR 430 separate from the current test procedure of Appendix A1. The new test procedure would be identical to the Appendix A1 procedure, except for the compartment temperatures. The test procedure B1 for freezers will not require amendment, since this procedure is already based on a freezer compartment temperature of 0°F. The new test procedure would not affect minimum energy efficiency levels of products prior to the effective date of the new standard because products will continue to be rated based on the existing Appendix A1 procedure. DOE may adopt other test procedure amendments first into Appendix A1 so that they can take effect earlier.

Testing of refrigerators and refrigerator-freezers with the new proposed temperatures will result in different test energy usage, so it will be necessary to determine the magnitude of the difference prior to setting any new standard levels. Guidelines for establishing new energy or efficiency standards based on an amended test procedure that changes the measured energy or efficiency are provided in EPCA 42 U.S.C. 6293, which reads as follows.

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[13] *See* Kosa et al., *Consumer Home Refrigeration Practices: Findings from a Consumer Survey*, presented at the American Dietetic Association Food and Nutrition Conference and Expo, Honolulu, Hawaii, September 16–19, 2006 *and* Godwin et al., "A Comprehensive Evaluation of Temperatures within Home Refrigerators," *Food Protection Trends* (March 2007).

(e) Amendment of standard

(1) In the case of any amended test procedure which is prescribed pursuant to this section, the Secretary shall determine, in the rulemaking carried out with respect to prescribing such procedure, to what extent, if any, the proposed test procedure would alter the measured energy efficiency, measured energy use, or measured water use of any covered product as determined under the existing test procedure.

(2) If the Secretary determines that the amended test procedure will alter the measured efficiency or measured use, the Secretary shall amend the applicable energy conservation standard during the rulemaking carried out with respect to such test procedure. In determining the amended energy conservation standard, the Secretary shall measure, pursuant to the amended test procedure, the energy efficiency, energy use, or water use of a representative sample of covered products that minimally comply with the existing standard. The average of such energy efficiency, energy use, or water use levels determined under the amended test procedure shall constitute the amended energy conservation standard for the applicable covered products.

As discussed above, the test temperature amendment would be implemented in a new Appendix A test procedure which would not take effect until the new efficiency standard takes effect. For this reason, the test temperature amendment would not be subject to the above requirement. Further, because efficiency levels will be increased, the described approach of testing minimally compliant products with the new test procedure also is not applicable. Instead, DOE expects during the standard rulemaking process to develop an approach for relating energy use measured using the current set of temperatures to energy use using the new proposed temperatures. DOE expects that test temperature adjustment factors (TTAFs) can be used for this purpose. The TTAF as envisioned would be defined such that energy consumption using the new proposed temperatures would be equal to TTAF multiplied by consumption using the current temperatures. Different TTAFs may be required for each product class, but may not depend on other factors (*i.e.*, product volume, ratio between freezer compartment volume and total volume, percent energy use lower than the standard). The work carried out during the rulemaking would include the determination of appropriate TTAFs and would establish their validity. The TTAFs would then be used to aid subsequent setting of the new energy standard levels. For example, if a new energy standard is set to reduce energy use by 15 percent, the new standard based on the new proposed temperatures would be established as 0.85 × TTAF × the current standard based on the current temperatures.

Section 5.3 discusses plans for establishing the relationships between energy usages based on the current and new test procedure temperature levels (*i.e.,* determining appropriate TTAFs). The process will combine energy testing with energy use modeling and significant data input from manufacturers to ensure the establishment of appropriate TTAFs.

Item 1-2 *DOE requests input from stakeholders regarding the plan to consider the compartment temperature changes under discussion for the IEC Standard 62552 that AHAM plans to adopt into an updated Standard AHAM HRF-1.*

1.3 Rulemaking Process and Stakeholder Participation

When DOE evaluates any new or amended energy conservation standard for "covered products" under EPCA, the statute, as amended, specifies that any standard DOE prescribes for consumer products shall be designed to "achieve the maximum improvement in energy efficiency. . . which the Secretary [of Energy] determines is technologically feasible and economically justified." (42 U.S.C. 6295(o)(2)(A)) Moreover, EPCA states that the Secretary may not establish an amended standard if such standard would not result in "significant conservation of energy" or "is not technologically feasible or economically justified." (42 U.S.C. 6295(o)(3)(B)) In determining whether a standard is economically justified, DOE considers, to the greatest extent practicable, the following seven factors:

(1) The economic impact of the standard on the manufacturers and on the consumers of the products subject to such standard;
(2) The savings in operating costs throughout the estimated average life of the covered products in the type (or class) compared to any increase in the price, or in the initial charges for, or maintenance expenses of the covered products likely to result from the imposition of the standard;
(3) The total projected amount of energy (or as applicable, water) savings likely to result directly from the imposition of the standard;
(4) Any lessening of the utility or the performance of the covered products likely to result from the imposition of the standard;
(5) The impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from the imposition of the standard;
(6) The need for national energy and water conservation; and
(7) Other factors the Secretary considers relevant.

(42 U.S.C. 6295(o)(2)(B)(i) and 42 U.S.C. 6316(a))

Additional statutory requirements for prescribing new or amended standards are set forth in 42 U.S.C. 6295(o)(1)–(2)(A), (2)(B)(ii)–(iii), and (3)–(5)); 42 U.S.C. 6316(a).

The process for developing efficiency standards involves analysis, public notice, and consultation with interested parties. Such parties (collectively referred to as stakeholders) generally include manufacturers, consumers, energy conservation and environmental advocates, State and Federal agencies, and any other groups or individuals with an interest in energy conservation standards and test procedures. DOE believes that stakeholder participation is an extremely important part of the rulemaking process. The broad array of stakeholders who routinely provide comments during this process promotes a balanced discussion of critical information required to conduct the standards rulemaking. Accordingly, DOE actively encourages the participation and interaction of all stakeholders during the comment period provided at each stage of the rulemaking.

In conducting the test procedure rulemakings and the energy (and water) conservation standards rulemakings, DOE involves stakeholders through a variety of means, including formal public notifications (*i.e.*, *Federal Register* notices) and public meetings. As discussed in further detail below, the standards rulemaking process involves three major public notices, which are published in the *Federal Register*:

- Advance Notice of Proposed Rulemaking (ANOPR, see section 1.4). The ANOPR is designed to publicly vet the models and tools that DOE will use in the rulemaking, and to facilitate public participation before the proposed rule stage. Candidate standard levels, which span the range of efficiencies from baseline products to the most efficient technology, are the basis for demonstrating the functionality of the models and tools.

- Notice of Proposed Rulemaking (NOPR, see section 1.5). The NOPR presents a discussion of comments received in response to the ANOPR; the analysis of the impacts of standards on consumers, manufacturers, and the nation; DOE's weighting of the impacts; and the proposed standard levels for public comment.

- Final Rule (see section 1.6). The final rule presents a discussion of comments received in response to the NOPR, the revised analysis of the impacts of standards, DOE's weighting of the impacts, the standard levels that DOE is adopting. The final rule also establishes the effective date of the standards.

Recently, section 305 of EISA amended EPCA, by removing the requirement for DOE to publish an ANOPR when amending standards for consumer products. Specifically, section 305 of EISA replaces section 325(m) of EPCA (42 U.S.C. 6295(m)), with the following:

> (m) AMENDMENT OF STANDARDS.—
>
> (1) IN GENERAL.—Not later than 6 years after issuance of any final rule establishing or amending a standard, as required for a product under this part, the Secretary shall publish:—
>
> (A) a notice of the determination of the Secretary that standards for the product do not need to be amended, based on the criteria established under subsection (n)(2); or
>
> (B) a notice of proposed rulemaking, including new proposed standards based on the criteria established under subsection (o) and the procedures established under subsection (p).
>
> (2) NOTICE.—If the Secretary publishes a notice under paragraph (1), the Secretary shall:—
>
> (A) publish a notice stating that the analysis of the Department is publicly available; and
>
> (B) provide an opportunity for written comment.
>
> (3) AMENDMENT OF STANDARD; NEW DETERMINATION.—
>
> (A) AMENDMENT OF STANDARD.—Not later than 2 years after a notice is issued under paragraph (1)(B), the Secretary shall publish a final rule amending the standard for the product.

DOE understands that removing a step in the rulemaking process could reduce the total time required to issue an amended standard. However, DOE believes that the ANOPR is an important step that provides an early opportunity for the Department to vet its assumptions and analysis, and for interested parties to provide feedback, comments, and data.

> ***Item 1-3*** *DOE requests feedback from interested parties on eliminating the ANOPR step in the rulemaking process, both as a general matter and in the context of this specific rulemaking.*

1.4 Advance Notice of Proposed Rulemaking

DOE's initial rulemaking activities include identifying available product design options and then subjecting them to a screening analysis in which each equipment technology option is analyzed in detail to determine whether it should be eliminated from further consideration. This process includes a market and technology assessment (section 3) and a screening analysis (section 4). DOE applies four screening criteria in the screening analysis to determine which technology options to eliminate from further consideration. These four criteria are (1) technological feasibility; (2) practicability to manufacture, install, and service; (3) adverse impacts on product or equipment utility or availability; and (4) adverse impacts on health or safety. Technologies that pass through the screening analysis are referred to as "design options" in the engineering analysis.

These activities include secondary research, consultations with stakeholders and independent technical experts who can help identify the key issues and design options or efficiency levels for DOE to consider in the rulemaking. DOE intends this framework document, and the public meeting that follows its publication to initiate dialogue with stakeholders and provide an opportunity for comment and input into the structure and analytical approach proposed for this energy conservation standards rulemaking.

At the start of the ANOPR analysis, DOE considers design options or efficiency levels for each product class. DOE uses these design options or efficiency levels to collect manufacturer cost data, historical shipment data, shipment-weighted average efficiency data, and preliminary manufacturer impact data (*e.g.*, capital conversion expenditures, marketing costs, and research and development costs). During the ANOPR stage, DOE also conducts other principal analyses, including (1) the engineering analysis (section 5); (2) the consumer life-cycle cost (LCC) and payback period (PBP) analyses (section 8); (3) the national impact analyses, which include national energy savings (NES) and consumer net present value (NPV) (section 10) for a range of efficiency or energy use levels; and (4) a preliminary manufacturer impact analysis (section 12). DOE will present the results of these analyses in the ANOPR *Federal Register* notice.

Discussion of various candidate standard levels (efficiency levels) in the ANOPR will facilitate stakeholder review of the spreadsheet models that underpin the analyses. DOE will use stakeholder comments to refine the models for the next stage of the rulemaking analyses, where DOE will propose specific efficiency levels for adoption. Based on the results of the ANOPR analysis, DOE selects candidate standard levels (CSLs) from the energy efficiency or energy use levels considered in the ANOPR analysis. In addition to the efficiency corresponding to the maximum technologically feasible ("max-tech") design and the efficiency corresponding to the minimum LCC point, DOE generally selects levels or design options for consideration that span the full range of technologically achievable efficiencies. DOE's analysis typically includes the following range of levels:

- The baseline efficiency level is defined by the product with the lowest energy efficiency level currently sold on the market for a given category. For product categories where minimum energy standards already exist, the baseline is typically defined by the existing energy conservation standard;

- The highest energy efficiency level or lowest energy consumption level that is technologically feasible (the "max-tech" level);

- The level with the minimum LCC or greatest LCC savings; and

- Levels that incorporate noteworthy technologies or fill in large gaps between other efficiency levels considered.

The efficiency or energy use levels that DOE analyzes serve to demonstrate the models' and tools' functions and outputs. At the ANOPR stage, DOE uses analytical models and tools to assess the different product classes at each efficiency or energy use level analyzed. Many of these analytical models and tools are in spreadsheet form. Some of these spreadsheets are used to conduct the LCC and PBP analysis and to determine the NES and NPV of prospective standards. In addition, preliminary ANOPR results may facilitate discussions among interested parties on potential joint recommendations for standard levels.

DOE will make the spreadsheet tools and results of the ANOPR analyses available on its website for review and will consider comments on them after publication of the ANOPR.[14] When it publishes the ANOPR, DOE will also make available a technical support document (TSD) containing the details of all the analyses performed to date. After the publication of the ANOPR, DOE will provide a 75-day public comment period and hold one public meeting. At this point, DOE encourages stakeholders, to the extent possible, to develop joint recommendations for standard levels.

1.5 Notice of Proposed Rulemaking

In developing the NOPR, DOE will first review and consider all the comments received after the publication of the ANOPR. This process may result in revisions or refinements to the ANOPR analyses, including the engineering and LCC analyses. After the ANOPR, DOE will conduct further economic and environmental impact analyses at this stage of the rulemaking. These analyses generally include a consumer LCC subgroup analysis (section 11), a complete manufacturer impact analysis (section 12), a utility impact analysis (section 13), an employment impact analysis (section 14), an environmental assessment (section 15), and a regulatory impact analysis (section 16).

[14] All materials associated with the residential refrigerator, refrigerator-freezer, and freezer analyses, test procedures, and energy conservation standards are available on DOE's website at http://www.eere.energy.gov/buildings/appliance_standards/residential/refrigerators_freezers.html.

DOE will describe the methodology used and make the results of all the analyses available on its website for review and comments. DOE may revise the analysis further on the basis of stakeholder comments. This analytical process ends with the selection of proposed standard levels (if any) that DOE will present in the NOPR. DOE selects the proposed standard levels from the trial standard levels (TSLs) analyzed during the NOPR phase of the rulemaking. The NOPR, published in the *Federal Register*, will document the evaluation and selection of any proposed standards levels, along with a discussion of other TSLs considered but not selected (and the reasons for not selecting them).

The selection process for proposed efficiency standards generally runs as follows: For each product class, DOE will identify the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible. If DOE proposes a level that is below this max-tech level, it will sequentially explain the reasons for eliminating higher levels, beginning with the highest level considered. DOE will present the analysis results in the NOPR, with the details of the analysis provided in an accompanying TSD.

DOE considers many factors in selecting proposed standards, as described above in section 1.3. EPCA established these factors and criteria, which take into account the many benefits, costs, and impacts of energy conservation standards. Additionally, DOE encourages stakeholders to develop joint recommendations for standard levels. DOE will carefully consider such recommendations in its decision process.

When DOE publishes the NOPR, it will provide the U.S. Department of Justice (DOJ) with a copy of the NOPR and TSD to solicit feedback on the impact of the proposed standard levels on competition. DOJ will review these standard levels in light of any lessening of competition that is likely to result from the imposition of standards. (42 U.S.C. 6295(o)(2)(B)(i)(V) and (B)(ii)) DOE will consider DOJ's determination on the impacts of the proposed standard on competition in preparing the final rule. The NOPR is followed by a 75-day public comment period that includes one public meeting.

1.6 Final Rule

After the publication of the NOPR, DOE will consider public comments that it receives on the proposal (including TSLs) and accompanying analyses. On the basis of the public comments, DOE will review the engineering and economic impact analyses and proposed standards and make modifications as necessary. In addition, before it issues the final rule, DOE will consider DOJ's comments on the NOPR relating to the impacts of the proposed standard levels on competition.

The standards rulemaking will conclude with the publication of the final rule. DOE will select the final standard levels based on the complete record of the standards rulemaking. The final rule will promulgate the final standard levels and their effective date and explain the basis for their selection. A final TSD will accompany the final rule.

2. OVERVIEW OF ANALYSES FOR RULEMAKING

The purpose of the analyses conducted in support of the standards rulemaking is to ensure that DOE selects energy conservation standards that achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified, and will result in significant energy savings. The concept of economic justification within this context includes consideration of the economic impacts on domestic manufacturers and consumers, national benefits, including environmental impacts, and issues of consumer utility. DOE expects the selection of such standards to achieve the maximum energy savings that are economically justified without imposing an undue financial burden on any particular party.

This section offers an overview of DOE's analytical methodology and discusses the major components of the analyses DOE will conduct. DOE will ensure a consistent approach to analysis throughout the rulemaking by considering each analysis as a part of the overall standards-setting framework.

Figure 2-1 summarizes the analytical components of the standards-setting process. The center column presents the analyses. Each analysis has a set of key inputs, which are data and information required for the analysis. The identified approaches are the methods that DOE will use to obtain key inputs, which may vary depending on the information in question. DOE will collect inputs from stakeholders or others with special knowledge, as well as develop other information independently in support of the rulemaking. The results of each analysis are key outputs, which feed directly into the rulemaking. Arrows indicate the flow of information between the various analyses.

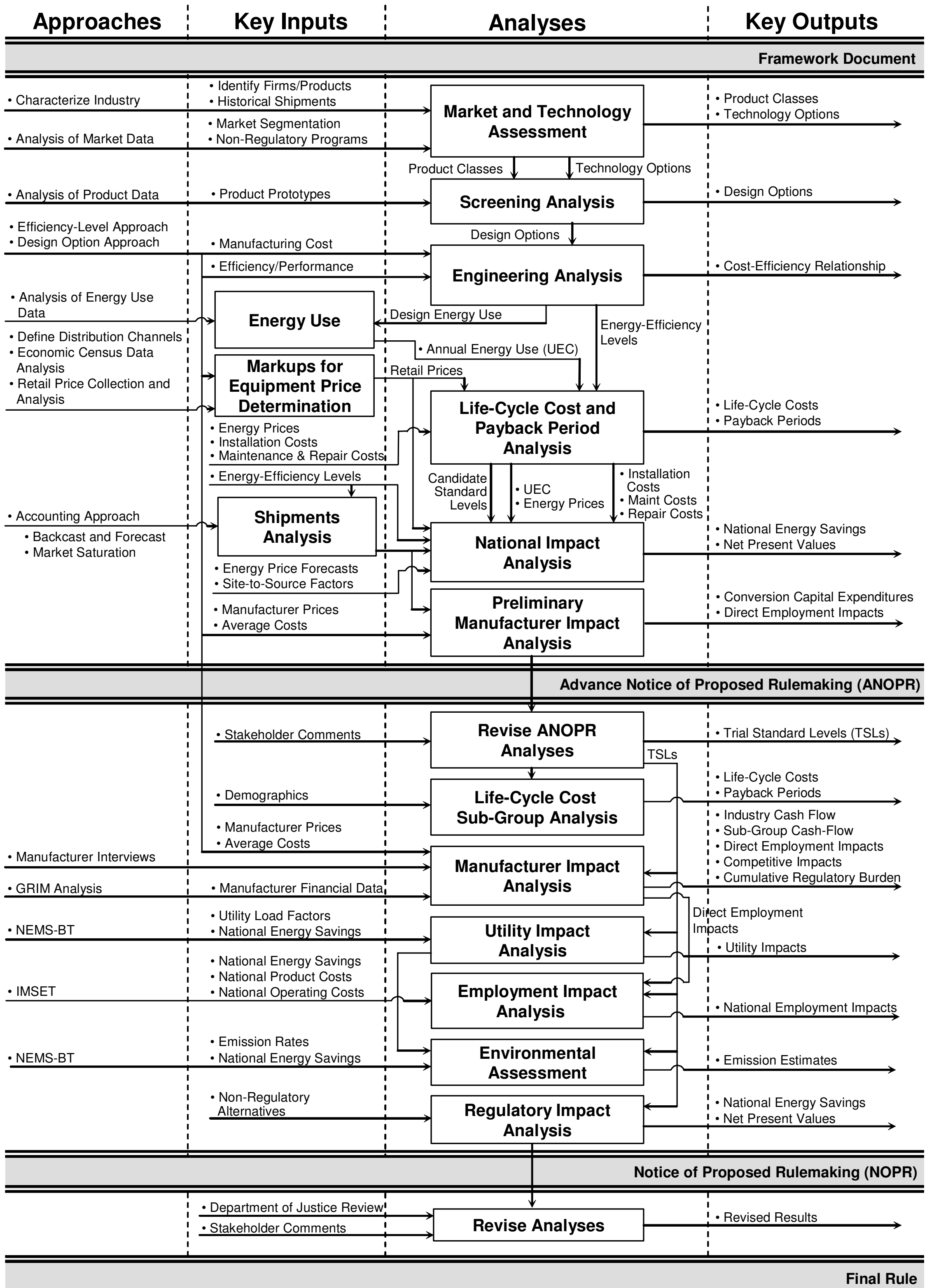

Figure 2-1. Flow Diagram of Analyses for the Residential Refrigerator, Refrigerator-Freezer, and Freezer Energy Conservation Standards Rulemaking Process

3. MARKET AND TECHNOLOGY ASSESSMENT

The market and technology assessment will provide information about the residential refrigerator, refrigerator-freezer, and freezer industry and specifics about the performance attributes of these products. DOE will use this assessment throughout the rulemaking. This assessment is particularly important at the outset of the rulemaking to determine product classes and to identify potential design options or efficiency levels for each product class.

3.1 Market Assessment

DOE will qualitatively and quantitatively characterize the structure of the residential refrigerator, refrigerator-freezer, and freezer industry and markets. DOE's market assessment will identify and characterize the manufacturers of this equipment, estimate market shares and trends, address regulatory and nonregulatory initiatives intended to improve the energy efficiency or reduce the energy consumption of products covered by this rulemaking, and explore the potential for technological improvements in the design and manufacturing of such equipment.

The market assessment phase allows DOE to gather data that will help identify important issues later in the rulemaking (*e.g.*, potential small business impacts, competitive disruptions, and other factors that may arise from enacting standards). For example, DOE will use historical equipment shipments and prices as an indicator of future shipments and prices. Market structure data will be particularly useful for assessing competitive impacts as part of the manufacturer impact analysis. This phase also allows DOE to start updating design options by reviewing product literature, industry publications, and company websites.

> ***Item 3-1*** *DOE requests information that would contribute to the market assessment for the residential refrigerators, refrigerator-freezers, and freezers covered in this rulemaking (e.g., current product features and efficiencies, product-feature and efficiency trends, historical product shipments and prices).*

3.2 Product Classes

DOE will develop separate product classes and formulate separate energy conservation standards for each class. The general criteria for separation into different classes include (1) type of energy used, (2) capacity, and (3) other performance-related features such as those that provide utility to the consumer, or others deemed appropriate by the Secretary that would justify the establishment of a separate energy conservation standard. (42 U.S.C. 6295(q) and 6316(a))

DOE plans to consider 20 product classes for refrigerators, refrigerator-freezers, and freezers as shown in **Table 3-1**. Of the 20 product classes, the CFR establishes Product Classes 1-18 based on the following characteristics: type of unit (refrigerator, refrigerator-freezer, or freezer), geometric configuration for refrigerator-freezers (*i.e.,* freezer mounting on top, side or bottom), size of the cabinet (standard or compact), type of defrost system (manual, partial, or automatic), and presence or absence of TTD ice service.[15] As described in the final rule, which updated the performance standards for refrigerators, refrigerator-freezers, and freezers, DOE established nine separate product classes for compact products (<220 L or <7.75 cubic feet) (numbered as Product Classes 11–18 in **Table 3.1**). 62 FR 23102. Before the 1997 final rule, DOE did not designate separate classes for compact products because energy conservation standards are a function of adjusted volume and inherently account for the smaller volumes associated with compact units. However, DOE created separate classes for compact products, which have fewer opportunities available for reducing energy consumption. Compact units are typically designed to fit under the counter and are subject to space limitations that preclude increasing the wall thickness. Improvement in the compressor performance is limited because of the smaller compressor size and the constant losses associated with a compressor motor. These units typically rely on natural convection heat transfer in the evaporator and the condenser and cannot employ more efficient fan motors as an energy-saving option.

Table 3-1 shows two additional product classes (19 and 20) beyond those presented in the CFR: automatic defrost refrigerator-freezers with bottom-mounted freezer with TTD ice service, and chest freezers with automatic defrost. DOE included both of these classes pursuant to its decision orders to grant exemptions to standards for these specific product categories. Section 1.2.1 describes these waivers.

Also as discussed earlier in section 1.2.1., another product that recently has entered the market is a convertible bottom-drawer refrigerator-freezer where the bottom drawer can be used as either a freezer or a fresh food section. This product is currently classified as a side-mount refrigerator-freezer with TTD features by the Energy Star program.[16] For rating purposes, the bottom drawer is tested as a fresh food compartment, rather than a freezer. As section 1.2.1 mentions, this is inconsistent with AHAM HRF-1-1979, which the DOE test procedure references. DOE may need to conduct a closer inspection of these units to determine whether another product class is warranted for these products.

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[15] Title 10—Energy, Chapter II—Department of Energy, Part 430—Energy Conservation Program for Consumer Products, Subpart A—General Provisions, Section 430.32—Energy and Water Conservation Standards and Effective Dates—(a) Refrigerators/refrigerator-freezers/freezers.

[16] Energy Star. *Find Energy Star Qualified Refrigerator and Freezers.* <http://www.energystar.gov/index.cfm?fuseaction=refrig.search_refrigerators> (Accessed September 26, 2007.)

Table 3-1. Proposed Refrigerator, Refrigerator-Freezer, and Freezer Product Classes

No.	Product Class
Classes Listed in the CFR	
1	Refrigerators and refrigerator-freezers with manual defrost
2	Refrigerator-freezers—partial automatic defrost
3	Refrigerator-freezers—automatic defrost with top-mounted freezer without TTD ice service and all-refrigerators—automatic defrost
4	Refrigerator-freezers—automatic defrost with side-mounted freezer without TTD ice service
5	Refrigerator-freezers—automatic defrost with bottom-mounted freezer without TTD ice service
6	Refrigerator-freezers—automatic defrost with top-mounted freezer with TTD ice service
7	Refrigerator-freezers—automatic defrost with side-mounted freezer with TTD ice service
8	Upright freezers with manual defrost
9	Upright freezers with automatic defrost
10	Chest freezers and all other freezers except compact freezers
11	Compact refrigerators and refrigerator-freezers with manual defrost
12	Compact refrigerator-freezers—partial automatic defrost
13	Compact refrigerator-freezers—automatic defrost with top-mounted freezer and compact all-refrigerators—automatic defrost
14	Compact refrigerator-freezers—automatic defrost with side-mounted freezer
15	Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer
16	Compact upright freezers with manual defrost
17	Compact upright freezers with automatic defrost
18	Compact chest freezers
Classes Established Through Decision Order	
19	Refrigerator-freezers—automatic defrost with bottom-mounted freezer with TTD ice service
20	Chest freezers with automatic defrost

Item 3-2 *DOE requests input from stakeholders on the proposed product classes and the criteria used for creating these product classes. What other factors, if any, should DOE consider beyond those identified above as a basis for developing product classes? When answering, please explain in detail and cite specific examples to the extent possible.*

Item 3-3 *DOE seeks input from stakeholders on whether product classes should be established for wine coolers. Although currently exempted from existing refrigerator standards, should a separate product class be established for them? If so, how should DOE revise its test procedure to rate the performance of these products?*

> ***Item 3-4*** *DOE seeks input from stakeholders on the classification and rating of convertible bottom-drawer refrigerator-freezers where the bottom drawer can be used as either a freezer or a fresh food section. Should DOE classify and rate this product in the same manner as the Energy Star program—namely, as a side-mount refrigerator-freezer with TTD features where the bottom drawer is tested as a fresh food compartment? If not, how should DOE classify and rate the product?*

To estimate the market share of the above product classes, DOE reviewed shipment data from *Appliance Magazine*.[17] Although *Appliance Magazine* does not provide enough detail to determine the market share of each product class, it does indicate the market share of general product categories (*e.g.*, standard-sized refrigerators and refrigerator-freezers). The above product classes cover the entire residential refrigeration market as follows: standard-sized refrigerators and refrigerator-freezers (66 percent), compact-sized refrigerators and refrigerator-freezers (15 percent), standard-sized freezers (15 percent), and compact-sized freezers (4 percent). Based on data from AHAM (which were published in DOE's October 2005 analysis to assess the energy savings and economic benefit potential of new refrigerator-freezer standards), automatic defrost top-mount and bottom-mount refrigerator-freezers without TTD features (Product Classes 3 and 5) represent 41 percent of the overall market, compared to 23 percent for automatic defrost side-mount refrigerator-freezers with TTD features (Product Class 7). Product Classes 3, 5, and 7 comprise 64 percent of the overall market and 98 percent of the standard-sized refrigerator and refrigerator-freezer market. For the standard-sized refrigerator and refrigerator-freezer market, the focus of the analysis clearly should be on Product Classes 3, 5, and 7.

To determine which product classes from the other three product categories (compact-sized refrigerators and refrigerator-freezers, standard-sized freezers, and compact-sized freezers) comprise the greatest fraction of the market, DOE reviewed CEC's appliance database[18] and Energy Star program's database.[19] The CEC database provides a listing of the refrigerator, refrigerator-freezer, and freezer models available in California while the Energy Star database provides a listing of models that meet or surpass current Energy Star qualifications. Assuming that product availability in California and of Energy Star models provide a good approximation of national market share, the databases can be used to identify which product classes are most representative of the compact-sized refrigerator and refrigerator-freezer, standard-sized freezer, and compact-sized freezer product categories. For compact-sized refrigerators and refrigerator-freezers, units with manual defrost (Product Class 11) have the most available models in the CEC database, whereas refrigerator-only units with automatic defrost (Product Class 13) comprise the greatest share of Energy Star-compliant models. For standard-sized freezers, upright freezers with and without automatic defrost (Product Classes 8 and 9) and chest freezers (Product Class 10) all have equal product availability in the CEC database, whereas automatic

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[17] "Statistical Review," *Appliance Magazine*, May issues, 2000–2006, Vols. 60–66, No. 5.

[18] California Energy Commission. *Appliances Database – Refrigeration*. Sacramento, CA. <http://www.energy.ca.gov/appliances/database/excel_based_files/Refrigeration/>

[19] Energy Star. Refrigerators and Freezers, Residential Refrigerators. <http://www.energystar.gov/index.cfm?c=refrig.pr_refrigerators> (Accessed January 8, 2008.)

defrost upright freezers (Product Class 9) and chest freezers garner the greatest share of Energy Star-compliant models. For compact-sized freezers, chest freezers (Product Class 18) have the most available models in the CEC database, whereas no models are shown to meet Energy Star qualifications.

Based on the market share analysis, DOE plans to conduct a full analysis of only the following seven representative product classes: Product Classes 3, 5, and 7 for standard-sized refrigerator-freezers; Product Class 11 for compact-sized refrigerators; Product Classes 9 and 10 for standard-sized freezers; and Product Class 18 for compact-sized freezers. **Table 3-2** lists these representative classes. DOE proposes to extend the analysis on the above seven representative product classes numerically to the remaining 13 product classes. Specifically, for a class that has not been fully analyzed, DOE will derive a manufacturer cost and efficiency relationship based on the results determined for a similar class that was analyzed. Section 5.4 discusses this approach in more detail.

Table 3-2. Proposed Refrigerator, Refrigerator-Freezer, and Freezer Representative Product Classes

Product Category	Representative Product Classes
Standard-sized refrigerators and refrigerator-freezers	3. Refrigerator-freezer—automatic defrost with top-mounted freezer without TTD ice service
	5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without TTD ice service
	7. Refrigerator-freezers—automatic defrost with side-mounted freezer with TTD ice service
Standard-sized freezers	9. Upright freezers with automatic defrost
	10. Chest freezers and all other freezers except compact freezers
Compact-sized refrigerators and refrigerator-freezers	11. Compact refrigerators and refrigerator-freezers with manual defrost
Compact-sized freezers	18. Compact chest freezers

Item 3-5 *DOE seeks input from stakeholders on its planned approach to analyze seven representative product classes and to extend that analysis to the remaining 13 product classes. DOE seeks input from stakeholders on the number and type of representative product classes it intends on analyzing—three for standard-sized refrigerators and refrigerator-freezers (Product Classes 3, 5, and 7), one for compact-sized refrigerators and refrigerator-freezers (Class 11), two for standard-sized freezers (Product Classes 9 and 10), and one for compact-sized freezer (Product Class 18).*

3.3 Technology Assessment

The technology assessment centers on understanding how energy is used by the product or equipment and potential changes that would reduce energy consumption. DOE typically uses information about existing "technology options," based on existing technologies and prototype designs and concepts, as input in identifying technologies that manufacturers of those products could use to attain higher energy efficiency levels. In consultation with interested parties, DOE will develop a list of technologies to consider in this analysis. Initially, this list will include all those technologies considered to be technologically feasible and will help DOE determine the max-tech design, based on a review of efficiencies of available products and their features.

DOE will consider technologies from its last standards rulemaking (that concluded in 1997), supplemented by technologies described in recent trade publications, research reports, and manufacturer product offerings. The technologies considered in DOE's last standards rulemaking are identified in the corresponding 1995 TSD.[20] Most of the technologies listed in **Table 3-3**—with exceptions noted below—are from the 1995 TSD. Technologies not identified in the 1995 TSD include improved door face frame,[21] anti-sweat electric heater sizing and controls, linear compressors,[22] compressor cycling defrost systems, temperature and air-distribution control systems, and alternative refrigeration systems. Of the alternative refrigeration cycles and alternative refrigeration systems listed in **Table 3-3**, DOE expects that many, if not all, will not pass the screening criteria for consideration as viable technologies.

[20] U.S. Department of Energy-Office of Codes and Standards. *Technical Support Document: Energy Efficiency Standards for Consumer Products: Refrigerators, Refrigerator-Freezers, and Freezers*, July 1995. Washington, D.C. DOE/EE-0064.

[21] Boughton, B.E., Clausing, A.M., and Newell, T.A. "An Investigation of household refrigerator cabinet thermal loads," *HVAC & Research 2* (2): 135-48, 1996.

[22] Unger, R. "Development and Testing of a Linear Compressor Sized for the European Market," *Proceedings of the International Appliance Technology Conference*, May, 1999. Sunpower Inc., Athens, Ohio. <http://www.sunpower.com/lib/sitefiles/pdf/publications/Doc0074.pdf>

Table 3-3. Refrigerator, Refrigerator-Freezer, and Freezer Technologies

Insulation	**Expansion Valve**
1. Improved resistivity of insulation	21. Improved expansion valves
2. Increased insulation thickness	**Cycling Losses**
3. Vacuum-insulated panels	22. Fluid control or solenoid valve
4. Gas-filled panels	**Defrost System**
Gasket and Door Design	23. Reduced energy for automatic defrost
5. Improved gaskets	24. Adaptive defrost
6. Double door gaskets	25. Compressor cycling defrost
7. Improved door face frame	26. Condenser hot gas
8. Reduced heat load for TTD feature	**Control System**
Anti-Sweat Heater	27. Temperature control
9. Condenser hot gas	28. Air-distribution control
10. Electric heater sizing	**Other Technologies**
11. Electric heater controls	29. Alternative refrigerants
Compressor	30. Component location
12. Improved compressor efficiency	
13. Variable-speed compressors	**Alternative Refrigeration Cycles**
14. Linear compressors	31. Lorenz-Meutzner cycle
Evaporator	32. Dual-loop system
15. Increased surface area	33. Two-stage system
16. Improved heat exchange	34. Control valve system
Condenser	35. Ejector refrigerator
17. Increased surface area	36. Tandem system
18. Improved heat exchange	**Alternative Refrigeration Systems**
Fans and Fan Motor	37. Stirling cycle
19. Evaporator fan and fan motor improvements	38. Thermoelectric
20. Condenser fan and fan motor improvements	39. Thermoacoustic

4. SCREENING ANALYSIS

The purpose of the screening analysis is to screen out design options that DOE will not consider in the rulemakings for residential refrigerators, refrigerator-freezers, and freezers.

As an initial matter, DOE will develop a list of design options developed through its own research and in consultation with interested parties for consideration in the engineering analysis (section 5). Development of the list will be based on the technologies shown in **Table 3-3**. The identified candidate design options will encompass all those technologies that may be technologically feasible. Thereafter, DOE will review each design option considering the following four criteria, as provided in sections 4(a)(4) and 5(b) of *Procedures, Interpretations,* *and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products* (the "Process Rule")[23] and tailored to the current rulemaking:

1. *Technological feasibility.* DOE will not further consider technologies that are not incorporated in commercially available products or in working prototypes.

2. *Practicability to manufacture, install, and service.* If DOE determines that mass production of a technology in commercial products and reliable installation and servicing of the technology could not be achieved on the scale necessary to serve the relevant market by the time of the effective date of the standard, then it will not consider that technology further.

3. *Adverse impacts on product or equipment utility or availability.* If DOE determines that a technology will have significant adverse impact on the utility of the product to significant subgroups of consumers, or result in the unavailability of any covered product type with performance characteristics (including reliability), features, size, capacities, and volumes that are substantially the same as products generally available in the United States at the time, it will not consider that technology further.

4. *Adverse impacts on health or safety.* If DOE determines that a technology will have significant adverse impacts on health or safety, it will not consider that technology further.

DOE will fully document the reasons for eliminating any design options during the screening analysis and will publish this documentation for stakeholder review and comment as part of the ANOPR.

Item 4-1 *Are there any technologies listed in **Table 3-3** that DOE should not consider because of their impacts on safety, performance, or consumer utility of the product?*

Item 4-2 *Are there other unlisted technologies that DOE should consider as design options and what, if any, impacts would the design options be expected to have on safety, performance, and consumer utility?*

Item 4-3 *Are the criteria listed for screening design options appropriate? Should DOE consider additional criteria? If so, which additional criteria should be considered and why?*

[23] 10 CFR Part 430, Subpart C, Appendix A.

5. ENGINEERING ANALYSIS

After conducting the screening analysis described above, DOE will perform an engineering analysis based on the remaining design options that would improve product efficiency. The engineering analysis consists of estimating the energy consumption and cost of products at various levels of increased efficiency. This section provides an overview of the engineering analysis (section 5.1), and discusses baseline units (section 5.2), DOE's proposed approach for determining the cost-efficiency relationship (section 5.4), efficiency levels (section 5.5), proprietary designs (section 5.6), and cumulative regulatory burdens that might affect the engineering analysis (section 5.7). Section 5.3 discusses the approach for addressing the new compartment temperatures that have been proposed to improve international test procedure harmonization (see the discussion of this topic in section 1.2.2).

5.1 Engineering Analysis Overview

The purpose of the engineering analysis is to determine the relationship between manufacturer cost and energy efficiency for residential refrigerators, refrigerator-freezers, and freezers. In determining the cost-efficiency relationship, DOE will estimate the increase in manufacturer cost associated with technological changes that increase the efficiency of these products relative to the baseline models.

DOE will request cost information from manufacturers for the incremental costs to achieve specified efficiency levels for the relevant product classes and representative product adjusted volumes.

DOE will carry out energy modeling for products to support the manufacturer-supplied data. The energy modeling will be carried out for a few important product classes. Initially, DOE will carry out calibration of the model for baseline product designs and for designs meeting Energy Star efficiency levels. DOE will take design data for these units from reverse engineering work and/or data supplied by AHAM or the industry. DOE will carry out energy modeling for product designs incorporating energy-saving design options and groups of energy-saving design options to determine the efficiency impact of these modified product designs.

DOE plans to carry out energy testing for a few selected models representing the most important product classes, such as 3, 5, and 7. DOE will conduct these tests according to its current energy test procedure as well as for the procedure using the proposed new compartment temperatures discussed in section 1.2.2. This testing will establish actual energy use of the products and will provide additional data to support energy modeling work. DOE may also carry out reverse heat leak testing to measure compartment thermal loads to further support the energy modeling.

DOE will use reverse engineering to identify design options used in baseline and improved efficiency products and to provide the basis for manufacturing cost analysis. The reverse-engineering process consists of a detailed product disassembly, whereby (1) representative units are torn down; (2) all components, processes, assembly, and manufacturing steps are noted in an activities-based cost model; and (3) all manufacturing costs are calculated. Representative units are chosen based on the range of efficiencies, design options, and capacities.

The result is a "green-field" model[24] of the subject unit and the factory in which it would be built. DOE can then aggregate these unit-specific factory requirements by market share, unit shipments, or any other method it wishes to use to derive industry-wide estimates.

The industry-wide estimates will consist of detailed incremental cost data, disaggregated into the incremental costs of material,[25] labor,[26] and overhead.[27] DOE will associate incremental costs with specific design options or design option combinations required to achieve a given efficiency level or with the efficiency levels themselves, as described in section 5.4.

Therefore, DOE seeks efficiency and cost information to determine the cost of improving the efficiency of the baseline models. Data is requested on the cost differentials required to achieve products with energy use at different levels, up to 30 percent less energy consumption than the existing baselines. In addition, in tandem with a review of the efficiencies of units currently on the market, DOE will use the energy modeling and reverse-engineering to identify design options or design option combinations associated with the most efficient products to establish the highest efficiency that is technologically feasible (*i.e.*, the max-tech level) within each product class.

5.2 Baseline Models

Once DOE establishes product classes, it will select a baseline model as a reference point for each product class subject to analysis against which it can measure changes resulting from energy conservation standards. The baseline model in each product class represents the characteristics of common or typical equipment in that class. Typically, a baseline model would be a model that just meets current required energy conservation standards.

At a subsequent stage in its analysis, DOE will use the baseline models to conduct the engineering analysis and the LCC and PBP analyses. To determine energy savings and changes in manufacturer selling price, DOE will compare each higher energy efficiency product design against the baseline model.

The current energy conservation standards for residential refrigerators, refrigerator-freezers, and freezers are expressed as maximum annual energy consumption as a function of the product's adjusted volume. For refrigerator-freezers, the adjusted volume is equal to the fresh food

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[24] A green-field model estimates the cost of a product as if it were built in a brand-new facility that had just broken ground.

[25] Direct material costs are the costs of raw materials such as steel, copper, and insulation, and also include scrap metal that can be traced to final or end equipment. Direct material costs do not include indirect material costs which are attributed to supplies that may be used in the production process, but are not assigned to final pieces of equipment (*e.g.*, lubricating oil for production machinery).

[26] Labor costs are the earnings of workers who assemble parts into a finished good or operate machines in the production process. Direct labor includes the fringe benefits of direct laborers such as group health care, as well as overtime pay. Direct labor does not include indirect labor, which is defined as the earnings of employees who do not work directly in assembling a piece of equipment—such as supervisors, janitors, stockroom personnel, inspectors, and forklift operators.

[27] Factory overhead excludes depreciation, but includes indirect labor, downtime, set-up costs, indirect material, expendable tools, maintenance, property taxes, insurance on assets, and utility costs. Factory overhead does not include selling, general, and administrative costs (SG&A), R&D, interest, or profit (which DOE accounts for separately).

internal volume plus 1.63 times the freezer internal volume. For freezers, the adjusted volume is equal to 1.73 times the freezer internal volume. For refrigerators where there is a freezer compartment but without a separate door (*i.e.*, single-door refrigerators), the adjusted volume is equal to the fresh food internal volume plus 1.44 times the freezer internal volume. The current energy conservation standards became effective on July 1, 2001.

Table 5-1 sets forth the current energy conservation standards for the 18 product classes listed in the CFR[28] as well as the two product classes established through DOE decision orders. As discussed in section 3.2, these two additional classes are being considered by DOE because of exemptions granted by DOE's Office of Hearings and Appeals for two product types: (1) automatic defrost refrigerator-freezers with bottom-mounted freezer and TTD ice service, and (2) automatic defrost chest freezers. The energy standard levels for these product classes are as established in the actions associated with the corresponding exemptions.

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[28] Title 10—Energy, Chapter II—Department of Energy, Part 430—Energy Conservation Program for Consumer Products, Subpart A—General Provisions, Section 430.32—Energy and Water Conservation Standards and Effective Dates—(a) Refrigerators/refrigerator-freezers/freezers.

Table 5-1. Refrigerator, Refrigerator-Freezer, and Freezer Energy Conservation Standards and Proposed Baseline Model Efficiencies

Product Class	Equations for Maximum Energy Use (kWh/yr)
1. Refrigerators and refrigerator-freezers with manual defrost.	8.82AV + 248.4 0.31av + 248.4
2. Refrigerator-freezer—partial automatic defrost.	8.82AV + 248.4 0.31av + 248.4
3. Refrigerator-freezer—automatic defrost with top-mounted freezer without TTD ice service and all-refrigerator—automatic defrost.	9.80AV + 276.0 0.35av + 276.0
4. Refrigerator-freezers—automatic defrost with side-mounted freezer without TTD ice service.	4.91AV + 507.5 0.17av + 507.5
5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without TTD ice service.	4.60AV + 459.0 0.16av + 459.0
6. Refrigerator-freezers—automatic defrost with top-mounted freezer with TTD ice service.	10.20AV + 356.0 0.36av + 356.0
7. Refrigerator-freezers—automatic defrost with side-mounted freezer with TTD ice service.	10.10AV + 406.0 0.36av + 406.0
8. Upright freezers with manual defrost.	7.55AV + 258.3 0.27av + 258.3
9. Upright freezers with automatic defrost.	12.43AV + 326.1 0.44av + 326.1
10. Chest freezers and all other freezers except compact freezers.	9.88AV + 143.7 0.35av + 143.7
11. Compact refrigerators and refrigerator-freezers with manual defrost.	10.70AV + 299.0 0.38av + 299.0
12. Compact refrigerator-freezer—partial automatic defrost.	7.00AV + 398.0 0.25av + 398.0
13. Compact refrigerator-freezers—automatic defrost with top-mounted freezer and compact all-refrigerator—automatic defrost.	12.70AV + 355.0 0.45av + 355.0
14. Compact refrigerator-freezers—automatic defrost with side-mounted freezer.	7.60AV + 501.0 0.27av + 501.0
15. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer.	13.10AV + 367.0 0.46av + 367.0
16. Compact upright freezers with manual defrost.	9.78AV + 250.8 0.35av + 250.8
17. Compact upright freezers with automatic defrost.	11.40AV + 391.0 0.40av + 391.0
18. Compact chest freezers.	10.45AV + 152.0 0.37av + 152.0
19. Refrigerator-freezer—automatic defrost with bottom-mounted freezer with TTD ice service.	5.0AV + 539.0 0.18av + 539.0
20. Chest freezers with automatic defrost.	14.76AV + 211.5 0.52av + 211.5

AV, adjusted volume in cubic feet; av, adjusted volume in liters

Item 5-1 *DOE seeks input from stakeholders on whether the above equations for maximum annual energy consumption are appropriate for characterizing the performance of baseline units.*

As described in section 3.2, DOE plans to conduct a full analysis of only the following seven representative product classes: Product Classes 3, 5, and 7 for standard-sized refrigerators and refrigerator-freezers; Product Class 11 for compact-sized refrigerators and refrigerator-freezers; Product Classes 9 and 10 for standard-sized freezers; and Product Class 18 for compact-sized freezers. DOE proposes to extend the analysis on the above seven product classes to the remaining 13 product classes. Specifically, for a class that has not been fully analyzed, DOE will derive a relationship between manufacturing cost and efficiency based on the results determined for a similar class that was analyzed.

Because annual energy consumption is a function of adjusted volume, DOE selected two total volumes for each of the representative product classes to highlight the relationship between annual energy consumption and adjusted volume as product efficiency is increased. Table 5-2 shows the representative total (not adjusted) volumes that DOE intends on analyzing for the product classes for which it intends on conducting full analyses (*i.e.,* teardowns and energy modeling). The volumes were selected based on volumes of refrigerators, refrigerator-freezers, and freezers shown on major manufacturers' websites during March 2008. Although the low and high volumes do not fully span the range of available volumes for the product classes, they bracket groups of products representing most of the product offerings for these classes.

Table 5-2. Refrigerator, Refrigerator-Freezer, and Freezer Proposed Representative Product Classes and Baseline Model Representative Volumes

Product Category	Product Class	Volume (cu. ft.)	
		Small	Large
Standard-sized refrigerators and refrigerator-freezers	3. Refrigerator-freezer—automatic defrost with top-mounted freezer without TTD ice service	15	21
	5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without TTD ice service.	18	25
	7. Refrigerator-freezers—automatic defrost with side-mounted freezer with TTD ice service.	22.0	25.0
Standard-sized freezers	9. Upright freezers with automatic defrost.	14.0	20.0
	10. Chest freezers and all other freezers except compact freezers.	15.0	22.0
Compact-sized refrigerators	11. Compact refrigerators and refrigerator-freezers with manual defrost.	2.5	5.5
Compact-sized freezers	18. Compact chest freezers	3.5	7.0

Item 5-2 *DOE seeks input from stakeholders on whether the above volumes are representative of the range of products available in the marketplace and whether the volumes are sufficient for characterizing the relationship between product annual energy consumption and adjusted volume.*

Item 5-3 *DOE seeks information regarding the specific technological characteristics of the representative baseline models for each product class, including the technologies described in section 3.3. Examples of the types of information DOE seeks include, but are not limited to the following: (1) what is the representative compressor EER, (2) what type of fan motor would be used and what is the typical input wattage, (3) what are the typical insulation thicknesses for the freezer and/or fresh food compartments.*

5.3 Approach for Adjustment to Proposed New Compartment Temperatures

As discussed in section 1.2.2, AHAM has requested that the DOE test procedure modify compartment temperatures as follows: (1) standard test temperatures of 0°F rather than 5°F for the freezer compartment of a refrigerator-freezer and 39°F rather than 45°F for the fresh food compartment, (2) standard test temperature of 39°F rather than 38°F for an all-refrigerator, and (3) standard test temperature of 39°F rather than 45°F for the fresh food compartment of a refrigerator having a freezer compartment. DOE plans to consider making these modifications to the test procedure. These changes will affect the kWh per year energy use as determined from the energy tests. A key step in the rulemaking process will be to set the new minimum efficiency energy usage values in kWh per year. This section discusses DOE's proposed approach for determining this "mapping" from the current test procedure temperatures to the proposed new temperatures.

AHAM has collected data on refrigerator-freezers and all-refrigerators tested at both sets of temperatures. These data provide a first step in suggesting what the conversion between the two sets of temperatures should be. DOE will request additional data from AHAM and manufacturers, as described in detail in Appendix A, Table A-8, for products representing significant sales in all of the product classes affected. DOE will use energy modeling to calculate expected energy use for a number of products, as described further in section 5.4 below. DOE will carry out the calculations for operation with both sets of temperatures to provide a model-based indication of the likely energy impact of the temperature change. Finally, DOE will conduct energy testing for some products. DOE will carry out these tests for both sets of temperatures to provide confirmation of the results provided by AHAM and manufacturers.

DOE will analyze these data to provide a statistically sound basis for conversion of kWh per year values from the current set of temperatures to the new proposed temperatures (*i.e.*, to determine the test temperature adjustment factors [TTAFs] described in section 1.2.2). The TTAFs will depend on product class and may depend on other variables such as adjusted volume. It is assumed that the conversion does not depend on efficiency level, so that a product with a given percent lower energy use than a baseline product for one set of compartment temperatures will show the same percentage lower energy use than a baseline product for the other set of compartment temperatures. This assumption is based on inspection of the preliminary AHAM data and the also on the treatment which AHAM has applied to the preliminary data.

5.4 Approach for Determining the Cost-Efficiency Relationship

DOE plans to use a combined approach for determining the cost-efficiency relationships for refrigerators, refrigerator-freezers, and freezers. The combined approach will include efficiency-level analysis, energy modeling, limited energy testing, and manufacturing cost analysis supported by reverse-engineering teardowns. Efficiency-level analysis is feasible because data contained within the CEC appliances database, for example, demonstrate a significant range of efficiencies for several of the product classes. Products with efficiencies above the existing energy conservation standards are available due to promotion by an Energy Star program. Current Energy Star models within the representative product classes are rated with an annual energy consumption of 10 to 30 percent lower than current energy conservation standards.

DOE will request cost information from manufacturers for the incremental costs necessary to achieve specified efficiency levels for the relevant product classes and representative product adjusted volumes.

DOE will carry out energy modeling for the key product classes identified in Table 5-2 to provide backup for cost-efficiency relationships established by the efficiency level analysis. DOE will base energy models on engineering design data provided by manufacturers and/or determined through reverse-engineering teardowns for both baseline and improved-energy product designs. Appendix A, Table A-10 describes design data request sheets for this process. DOE proposes at this point to carry out energy modeling based on current test procedure temperatures. DOE will carry out energy modeling using a range of design options for reduction of energy use and compare this design-option analysis with the efficiency level analysis.

DOE expects that manufacturer-provided efficiency-level data will be based on the current energy test procedure and its compartment temperatures. Thus, it makes sense to compare these cost-efficiency data with the result of DOE cost and energy models that have been developed based on the current sets of compartment temperatures. DOE may choose to reconsider this approach and instead carry out energy modeling using the new proposed sets of compartment temperatures, depending on the information and comments that are provided as the rulemaking process moves forward.

DOE plans to carry out energy testing for a few selected models representing the most important product classes, such as 3, 5, and 7. DOE will conduct these tests according to its current energy test procedure as well as for the procedure using the proposed new compartment temperatures discussed in section 1.2.2. This testing will establish actual energy use for the products and will provide information regarding differences in test results with the different compartment temperatures. DOE will use additional instrumentation beyond that required for the test procedure to provide additional data to support energy modeling work, including refrigeration circuit temperatures. DOE may also carry out reverse heat leak testing to measure cabinet thermal loads to further support the energy modeling. Reverse heat leak testing involves placing the product in an ambient at the freezer compartment temperature specified by the energy test procedure and providing metered electric resistive heating to the compartments to maintain the same temperature differentials that are established during energy testing.

DOE will use reverse engineering, as described above, to identify the incremental cost and efficiency improvement associated with each design option or design option combination, in effect supplementing the efficiency-level approach with a design-option approach as needed. DOE will conduct reverse engineering through physical teardowns and testing on refrigerator-freezer and freezer models at key efficiency levels to determine baseline manufacturing cost as well as incremental manufacturing costs above the baseline. DOE proposes to perform reverse engineering on units rated at baseline and improved (*i.e.,* Energy Star) energy consumption levels for the seven representative product classes that it proposes to analyze.

DOE may supplement the reverse-engineering data with information from catalogs, websites, and trade publications to create a wider set of units for its efficiency-cost analysis.

To support this analysis, DOE will seek to obtain incremental cost data from manufacturers for each efficiency level defined for each product class. These data are intended to represent the shipment-weighted average, industry-wide incremental production cost associated with each level of efficiency improvement. Appendix A contains drafts of the engineering analysis data-request sheets.

To be useful in the manufacturer impact analysis, manufacturer cost information should reflect the variability in baseline models, design strategies, and cost structures that can exist among manufacturers. This information allows DOE to better understand the industry and its associated cost structure, and, thus, helps predict the most likely impact that new energy efficiency regulations would have. For example, the reverse-engineering methodology allows DOE to estimate the green-field costs of building new facilities, yet the majority of plants in any given industry comprise a mix of assets in different stages of depreciation.

DOE will attempt to qualify the cost-efficiency data that it generates through the reverse-engineering activities with industry-supplied data and information arising from consultation with stakeholders or technical experts. Specifically, DOE will supplement these cost data with information obtained through follow-up manufacturer interviews. Interviews with manufacturers not only help DOE refine its capital expenditure estimates, but also allow DOE to refine depreciation and other financial parameters. Appendix B contains sample questions that DOE plans to ask during the follow-up interviews.

If DOE is unable to reconcile information collected during the manufacturer interviews with the generated or collected cost data, or with information contained in the market and technology assessment, it will supplement the collected data through consultation with outside experts and/or further review of publicly available cost and performance information.

DOE will estimate the contribution of the depreciation of conversion capital expenditures to the incremental overhead. During the interviews, DOE will gather information about the capital expenditures that would be necessary to increase the efficiency of the baseline models to various efficiency levels (*i.e.*, conversion capital expenditures by efficiency or energy-use level). DOE will also request information about the depreciation method that manufacturers use to expense the conversion capital.

> ***Item 5-4*** *DOE requests feedback on the use of an efficiency-level approach, supplemented by a design-option approach based on energy modeling and some energy testing as needed, to determine the relationship between manufacturer cost and annual energy consumption. Particularly, DOE is interested in whether this approach is appropriate for developing a cost/efficiency relationship for use as the basis for standards-setting. If not, why not?.*

> ***Item 5-5*** *DOE requests feedback on the intention to base the engineering analysis work on the current sets of compartment temperatures specified by the current test procedure. Are there strong arguments that favor carrying out the analyses using the new proposed compartment temperatures. In the alternative, is there another approach that DOE should consider? If so, why?.*

> ***Item 5-6*** *DOE requests feedback on the planned approach to develop TTAFs to relate energy usage based on current test procedure compartment temperatures and energy usage based on the proposed new temperatures to improve international harmonization. Specifically, do stakeholders agree that the proposed approach for relating the two sets of energy usages will lead to setting of appropriate maximum energy levels if the standard is based on the new sets of temperatures? If not, why?*

5.5 Efficiency Levels

Except as noted below, for each of the product classes presented in section 3.2, DOE will establish potential efficiency levels and seek to develop incremental cost data at each of these levels. DOE plans to conduct engineering analysis (and LCC and PBP analyses) on all representative product classes.

Steps taken in the efficiency level analysis will not depend on the compartment temperatures used for energy testing. It is assumed for the efficiency levels presented in the tables of this section that the definition of efficiency levels expressed in percentage energy use reduction as compared with baseline units does not depend on which set of compartment temperatures are used in a test. Hence, a unit with energy use 20 percent lower than the current energy standard as tested using the current test procedure temperatures would have energy use 20 percent lower than that of a baseline unit tested with the new proposed temperatures. This assumption depends on there being a consistent pattern of energy use differences between tests conducted using the different sets of temperatures -- i.e., that different units exhibit predicable increases or decreases in energy use if tested with different compartment temperatures. Verification that there is consistency in these energy use differences would be part of the determination of the TTAFs that would be the basis of adjusting the efficiency standards, as described in section 5.3.

The tables that follow at the end of this section show the efficiency levels that DOE intends to analyze for refrigerators, refrigerator-freezers, and freezers. The maximum available efficiency levels in the tables correspond to models with the maximum efficiency currently available in the market, but may not necessarily correspond to the max-tech levels. Maximum available models may not incorporate all possible design options for increasing efficiency and, therefore, may not achieve an annual energy use as low as the max-tech level. Also, it is possible that some of the design options that have met the screening criteria (*i.e.*, passed the screening analysis) may not yet be commercially available and, therefore, would not be found in today's maximum available products. Given this potential dichotomy between max-tech and maximum available levels, and because DOE is required to analyze max-tech levels, it will seek stakeholder input to determine appropriate max-tech efficiency levels. (42 U.S.C. 6295(p)(2))

It is not practicable for DOE to evaluate every product class or capacity range on the market, as the possible permutations are enormous. Instead, DOE proposes to evaluate seven representative product classes in its reverse-engineering analysis that represent the majority of shipments and to then extrapolate the results to the other 13 product classes. The following seven representative product classes fall within four product categories: Product Classes 3, 5, and 7 for standard-sized refrigerators and refrigerator-freezers; Product Class 11 for compact-sized refrigerators and refrigerator-freezers; Product Classes 9 and 10 for standard-sized freezers; and Product Class 18 for compact-sized freezers. For the seven representative product classes, DOE will analyze two representative volumes so that the analysis can consider the relationship between annual energy consumption and adjusted volume as product efficiency is increased.

Once DOE identifies the incremental product costs and design options for the seven representative product classes, it will extrapolate its results to determine similar results for the remaining 13 product classes. DOE will modify the cost models that it developed along with the reverse-engineering process to extend the analysis to the 13 product classes.

Tables 5-3, 5-4, 5-5, and 5-6 provide the efficiency levels and the reference source for each efficiency level of the seven representative product classes that DOE will analyze. All of the efficiency levels are expressed as a percent reduction in annual energy use relative to the baseline level. Baseline levels are set by the maximum energy use equations shown in Table 5-1. Table 5-3 covers the three representative classes for standard-sized refrigerators and refrigerator-freezers. Table 5-4 covers the two representative classes for standard-sized freezers. Table 5-5 covers the single representative class for compact-sized refrigerators and refrigerator-freezers. Table 5-6 covers the single representative class for compact-sized freezers. Several of the tabulated efficiency levels correspond to those set by the Energy Star Program and the Consortium for Energy Efficiency (CEE) Super-Efficient Home Appliances Initiative.

Efficiency levels that do not correspond to either Energy Star or CEE levels have been set by DOE to correspond to 20, 25, and 30 percent reductions in annual energy use. Note that in the tables below, the max-tech level is not yet known and will be determined during the course of the engineering analysis. Also presented in each of the tables is the maximum available efficiency level. For many of the representative product classes, the maximum available levels are not as efficient as Level 4 (either CEE Tier 3 or the 30 Percent Reduction), indicating that the max-tech level may fall short of efficiency level 4.

Table 5-3. Efficiency Levels for Representative Product Classes for Standard-Sized Refrigerators and Refrigerator-Freezers

Level	Source	3. Auto defrost with top mount freezer without TTD ice service Volume (cu. ft.)		5. Auto defrost with bottom mount freezer without TTD ice service Volume (cu. ft.)		7. Auto defrost with side mount freezer with TTD ice service Volume (cu. ft.)	
		15	21	18	25	22	25
1	Current E-Star	15%	15%	15%	15%	15%	15%
2	Proposed E-Star*	20%	20%	20%	20%	20%	20%
3	CEE Tier 2	25%	25%	25%	25%	25%	25%
4	CEE Tier 3	30%	30%	30%	30%	30%	30%
5	Max-Tech**	TBD	TBD	TBD	TBD	TBD	TBD
	Max Available#	36%	28%	20%	21%	23%	22%

*Proposed Energy Star is equivalent to CEE Tier 1.

**Max-tech efficiency level will be determined during the course of the engineering analysis.

#Source: Energy Star-qualified products as of January 3, 2008.

Table 5-4. Efficiency Levels for Representative Product Classes for Standard-Sized Freezers

Level	Source	9. Upright freezers with automatic defrost Volume (cu. ft.)		10. Chest freezers and all other freezers except compact freezers Volume (cu. ft.)	
		14	20	15	22
1	Current Energy Star	10%	10%	10%	10%
2	20% Reduction	20%	20%	20%	20%
3	25% Reduction	25%	25%	25%	25%
4	30% Reduction	30%	30%	30%	30%
5	Max-Tech*	TBD	TBD	TBD	TBD
	Max Available**	10%***	12%	12% #	11% ##

*Max-tech efficiency level will be determined during the course of the engineering analysis.

**Source: Energy Star-qualified products as of January 3, 2008.

***Units with volumes close to 14 cu. ft. have better efficiency (*i.e.,* 25% for 12 cu.ft. units and 20% for 15 cu. ft.).

#Units with volumes close to 15 cu.ft. have better efficiency (*i.e.*, 15% for 16.5 cu. ft.).

##One unit with 20.3 cu. ft. volume has 15% lower energy than the current DOE Energy Standard.

Table 5-5. Efficiency Levels for Representative Product Classes Compact-Sized Refrigerators and Refrigerator-Freezers

Level	Source	11. Compact refrigerators and refrigerator freezers with manual defrost. Volume (cu. ft.)	
		2.5	5.5
1	10% Reduction	10%	10%
2	Current Energy Star/CEE Tier 1	20%	20%
3	CEE Tier 2	25%	25%
4	CEE Tier 3	30%	30%
5	Max-Tech*	TBD	TBD
	Max Available**	7%***	29%

*Max-tech efficiency level will be determined during the course of the engineering analysis.
**Source: Energy Star-qualified products as of January 3, 2008.
***Units with volume close to 2.5 cu. ft. have better efficiency (*i.e.,* 31% for 2.9 cu. ft.)

Table 5-6. Efficiency Levels for Representative Product Classes Compact-Sized Freezers

Level	Source	18. Chest freezers Volume (cu. ft.)	
		3.5	7.0
1	10% Reduction	10%	10%
2	Current Energy Star	20%	20%
3	25% Reduction	25%	25%
4	30% Reduction	30%	30%
5	Max-Tech*	TBD	TBD
	Max Available**	24%	31%

*Max-tech efficiency level will be determined during the course of the engineering analysis.
**Source: Products listed on CEC appliance database as of June 2007.

Item 5-7 *DOE seeks input from stakeholders about the adequacy of the proposed efficiency levels for collecting incremental cost data from manufacturers. DOE also seeks input from stakeholders on appropriate maximum technologically feasible efficiency levels.*

5.6 Proprietary Designs

DOE will consider in its engineering and economic analyses all design options that are commercially available or present in a working prototype, including proprietary designs and technologies. However, DOE will not consider a proprietary design in the subsequent analyses if it is the only option for achieving a specific efficiency level. If the proprietary design is the only approach available to achieve a given efficiency level, then DOE will reject that efficiency level, as the analytical results would appear to favor one manufacturer over others.

DOE is sensitive to manufacturer concerns regarding proprietary designs and will make provisions to maintain the confidentiality of any proprietary data submitted by manufacturers or discussed during manufacturer interviews. These data may be provided under a confidentiality agreement with DOE's contractor responsible for this part of the rulemaking analysis, Navigant Consulting, Inc. (NCI). As in other rulemakings, NCI regularly works with confidential data from manufacturers and other organizations, preparing aggregated results for DOE's analysis that do not divulge sensitive raw data, but that enable other stakeholders to review and comment on the aggregated dataset. Alternatively, stakeholders may submit confidential data to DOE, indicating in writing which data should remain confidential. To prevent public disclosure of the data due to actions taken by a third party, stakeholders providing confidential information to DOE must submit that data according to 10 CFR 1004.11. This information will provide input to the manufacturer impact analysis and other economic analyses.

> ***Item 5-8*** *Are there proprietary designs or technologies of which DOE should be aware for the products under consideration in this rulemaking? If so, how should DOE acquire the cost data necessary for evaluating these designs?*

5.7 Outside Regulatory Changes Affecting the Engineering Analysis

In conducting an engineering analysis, DOE takes into consideration the effects of regulatory changes outside DOE's statutory energy conservation standards rulemaking process that can affect the manufacturers of the covered equipment. Some of these changes can also affect the energy efficiency or energy consumption of the products covered under this rulemaking. For example, because of the mandatory phase-out of chlorofluorocarbons (CFCs) in the mid-1990s, the industry had to eliminate its use of CFC-12 as a refrigerant and now uses HFC-134a (a hydrofluorocarbon). More recently (in 2003), the industry has had to deal with the mandatory phase-out of HCFC-141b (a hydrochlorofluorocarbon), which was used by the industry as a blowing agent for polyurethane foam insulation. As a result, a majority of insulation is now blown with HFC-245fa. Both of the above changes occurred while the industry was making changes to address new standards; one set that became effective in 1993 and another set that became effective in 2001.

Currently, DOE does not anticipate any further mandatory changes in the type of refrigerants and blowing agents used by the industry.

DOE will attempt to identify this and all other cumulative engineering issues that could affect the engineering analysis. The consideration of these issues is closely related to the cumulative regulatory burden assessment that DOE will carry out as part of the manufacturer impact analysis. Based on consideration of the comments received on the engineering analysis documented in the ANOPR, DOE will make the necessary changes to the analysis. It will reflect those changes in the documentation of the NOPR.

> ***Item 5-9*** *Are there outside regulatory issues that DOE should consider in its analysis of residential refrigerators, refrigerator-freezers, and freezers? If so, identify what they are and how DOE should consider them for purposes of its analysis.*

6. ENERGY USE DETERMINATION

The purpose of the energy use determination is to establish the annual energy consumption of the appliance and assess the energy-savings potential of different product efficiencies. DOE uses the annual energy consumption and energy-savings potential in the LCC and PBP analysis to establish the consumer operating savings of product efficiency levels. This section describes the methodology that will be used to convert from a given baseline and efficiency level expressed in kWh per year to the actual expected energy use of typical households. This methodology takes into consideration the fact that the annual unit energy consumption will be based on testing with the new adjusted compartment temperatures for refrigerator-freezers and all-refrigerators.

DOE will use data from the Energy Information Administration (EIA)'s Residential Energy Consumption Survey[29] (RECS) to establish the annual unit energy consumption for each of the seven representative product classes analyzed in the engineering analysis. RECS provides enough information to establish the type (*i.e.*, product class) of refrigerator, refrigerator-freezer, or freezer used in each household. As a result, DOE will be able to develop a unique household sample for each of the seven representative product classes. DOE plans to use the household samples not only to establish each product's annual energy consumption, but also as the basis for conducting the LCC and PBP analysis (see section 8).

For each household within a given sample, RECS reports the annual unit energy consumption or field energy consumption of the refrigeration product, referred to as FEC_{RECS}. DOE will treat the RECS reported field energy consumption as the actual consumption of the refrigeration product in that household. For purposes of conducting the LCC and PBP analysis, DOE will effectively substitute the refrigeration product in RECS with a new product of identical product class and size that the household would normally purchase if their refrigeration product failed. (This purchase is assumed to be made in the year new standards are assumed to become effective.) To have the new refrigeration product's energy consumption reflect the field conditions of the RECS household, DOE will need to 'adjust' the new product's tested energy consumption, referred to as TEC_{NEW}, with a 'usage adjustment factor' or *UAF*.

To develop a *UAF* to 'adjust' each household record's new product consumption, DOE will utilize additional information that RECS provides on the size (*i.e.*, volume) and age of the refrigeration product. Using the product class, size, and age of the product, DOE will determine for each household, the corresponding maximum allowable tested energy consumption, referred to as TEC_{STD}, based on the energy conservation standard that was in effect at the time the household purchased the refrigeration product. Using both FEC_{RECS} and TEC_{STD}, DOE will then develop the *UAF* for the given household to capture the combined effects of consumer behavior (*e.g.*, door openings), operating conditions (*e.g.*, room temperature and humidity), and product

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[29] Available at http://www.eia.doe.gov/emeu/recs/contents.html.

characteristics (*e.g.*, efficiency). The *UAF* represents the adjustment that needs to be made to the maximum allowable tested energy use to arrive at the field energy consumption of the refrigeration product. The *UAF* is represented by the following expression:

$$UAF = \frac{FEC_{RECS}}{TEC_{STD}} \qquad \text{Eq. 6-1}$$

Where:

UAF = usage adjustment factor;

FEC_{RECS} = refrigeration product's field energy consumption as reported for the RECS household; and

TEC_{STD} = maximum allowable tested energy consumption based on the standard in effect at the time the household purchased the refrigeration product.

Low *UAFs* indicate that the combined effect of consumer behavior, operating conditions, and product characteristics result in an appliance that is relatively efficient with respect to the maximum allowable tested energy consumption.

As discussed in the engineering analysis (section 5), DOE may be conducting its analysis to account for proposed test procedure revisions that will rate the appliance's performance at fresh food and freezer temperatures which are lower (for refrigerator-freezers) than those prescribed in the existing DOE test procedure. Because lower compartment temperatures increase a product's tested energy consumption, the maximum allowable tested energy consumption corresponding to past and current energy conservation standards (TEC_{STD}) needs to be adjusted to reflect the performance under the proposed test procedure revisions, thereby ensuring consistency with the data generated by the engineering analysis. As described in section 5, if necessary, a process will be developed to establish the 'efficiency standard adjustment factor' or *ESAF* for each product class to convert past and existing product standards so they reflect the increased annual energy use due to the lower proposed fresh food and freezer compartment temperatures. Therefore, TEC_{STD} in Eq. 6-1 becomes a new term, $TEC_{STD\text{-}REV\text{-}TP}$, which is determined with the following expression:

$$TEC_{STD-REV-TP} = ESAF \times TEC_{STD-EXIST-TP} \qquad \text{Eq. 6-2}$$

Where:

$TEC_{STD\text{-}REV\text{-}TP}$ = maximum allowable tested energy consumption based on the standard in effect at the time the household purchased the refrigeration product with a revised tested energy consumption reflecting lower proposed fresh food and freezer compartment temperatures;

$ESAF$ = efficiency standard adjustment factor; and

$TEC_{STD\text{-}EXIST\text{-}TP}$ = maximum allowable tested energy consumption based on the standard in effect at the time the household purchased the refrigeration product with a tested energy consumption reflecting existing DOE test procedure conditions.

Substituting $TEC_{STD\text{-}REV\text{-}TP}$ for TEC_{STD} in Eq. 5-1 results in the following expression for *UAF*:

$$UAF = \frac{FEC_{RECS}}{ESAF \times TEC_{STD-EXIST-TP}}$$ Eq. 6-3

Once the *UAFs* have been determined for each household within a given sample, DOE will adjust the tested energy consumption from the engineering analysis, referred to as TEC_{NEW}, into a field-adjusted annual energy consumption, referred to as FEC_{NEW}, using the following expression:

$$FEC_{NEW} = TEC_{NEW} \times UAF$$ Eq. 6-4

Where:

FEC_{NEW} = field-adjusted annual energy consumption of new refrigeration product; and

TEC_{NEW} = tested energy consumption of new refrigeration product based on lower proposed fresh food and freezer compartment temperatures.

The engineering analysis will provide the tested energy consumption (TEC_{NEW}) as a function of the product efficiency. Each household will be assigned a tested energy consumption based on the *UAF* of the household and the base-case efficiency distribution for the product class. The base-case efficiency distribution represents the product efficiencies currently being sold in the marketplace (*i.e.*, the case without new standards). Along with the *UAF*, the base-case efficiency distribution is used to assign the efficiency of the refrigeration product that the household would normally purchase if their refrigeration product failed. For purposes of conducting the LCC and PBP analysis, the purchase is made in the year that new standards are assumed to become effective. The LCC and PBP analysis (see section 8) will describe in detail how *UAF*s and product efficiencies are assigned to the households within each sample. The result is a distribution of field-adjusted annual energy use values for the baseline level (*i.e.*, the case without new standards) for each household sample. The field-adjusted annual energy use values corresponding to each standard level are developed by forcing those households in each sample with product efficiencies below the standard level to purchase a product with an efficiency meeting the standard level. Households in the sample with product efficiencies above the standard level are left untouched.

To reiterate, DOE will develop seven household samples for each of the seven representative product classes evaluated in detail in the engineering analysis. Using the process described above, DOE will determine a weighted-average annual energy use value with its associated variability for the baseline and each standard level for each household sample.

> ***Item 6-1*** *DOE seeks stakeholder input on the approach presented for estimating the typical annual energy consumption of residential refrigerators, refrigerator-freezers, and freezers. Specifically, DOE is interested in stakeholder input on whether to use RECS as the primary source of information for establishing the annual energy use.*

DOE intends to account for the rebound effect in its determination of annual energy consumption. The rebound effect occurs when a piece of equipment, when it is made more efficient, would be used more intensively, so the expected energy savings from the efficiency improvement do not fully materialize. In the case of more efficient domestic refrigeration equipment, limited research has been conducted to show that there is no rebound effect for home appliances, although the consumer may choose to purchase larger models with more features that would result in increased energy use.[30]

> ***Item 6-2*** *DOE seeks comments on the rebound effect associated with more efficient refrigerators, refrigerator-freezers, and freezers. In other words, DOE seeks input on what portion of the energy savings resulting from more efficient equipment may be lost due to consumers purchasing larger or more feature laden equipment.*

7. MARKUPS FOR EQUIPMENT PRICE DETERMINATION

Because DOE needs retail (consumer) prices for the baseline efficiency level and all other efficiency levels under consideration for use in the LCC and PBP analysis and the national impact analysis, DOE uses manufacturer-to-consumer markups to convert the manufacturer selling price estimates from the engineering analysis to consumer prices. The manufacturer-to-consumer markups are in addition to the mark-ups on production costs that DOE uses to estimate manufacturer selling price in the engineering analysis. To validate these markups, DOE will collect data on existing prices in the market by either purchasing large data sets or downloading data from retailer Internet sites.

However, before it can develop markup information, DOE must first identify distribution channels (*i.e.*, how the product is distributed from the manufacturer to the consumer). AHAM's *2005 Fact Book* (the latest available version) shows that over 93 percent of all appliances are distributed from the manufacturer directly to some type of retailer. Retailers identified in AHAM's *2005 Fact Book* include home improvement stores (such as Lowe's or Home Depot), membership warehouse clubs/stores (such as Sam's Club or Costco), department stores (such as Sears or Kohl's), discount stores (such as Wal-Mart or Kmart), and appliance or consumer electronics stores. Because an overwhelming majority of appliances are sold through retail stores, DOE plans to analyze residential refrigerator, refrigerator-freezer, and freezer product sales based on the assumption that these appliances are sold in a manufacturer-to-consumer distribution channel consisting of three parties: (1) the manufacturers producing the products; (2) retailers purchasing the products from manufacturers and selling them to consumers; and (3) the consumers that purchase the products.

DOE plans to determine an average manufacturer markup by examining the annual Securities and Exchange Commission (SEC) 10-K reports filed by publicly traded manufacturers engaged in appliance manufacturing whose combined product range includes refrigerators, refrigerator-freezers, and freezers. DOE will determine an average retailer markup by analyzing both economic Census data from the U.S. Census Bureau as well as the annual SEC 10-K reports filed by publicly traded retailers.

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[30] L.A. Greening, D.L. Greene, and C. Difiglio. Energy efficiency and consumption – the rebound effect – a survey, Energy Policy 28 (2000) 389—401. Available for purchase at www.elsevier.com/locate/enpol

In addition to developing the manufacturer and retailer markups, DOE will develop and include sales taxes to calculate appliance retail prices. The Sales Tax Clearinghouse[31] is an Internet source that DOE intends to use to calculate applicable sales taxes.

To the extent possible, DOE also will use collected retail price data to validate the overall manufacturer-to-consumer markup. One source for retail price data is the NPD Group, Inc., which sells sales-weighted retail price data for refrigerators, refrigerator-freezers, and freezers for specific years. As an alternative to purchasing retail price data, DOE may rely on retailers' Internet sites, although the representativeness of any given price data point is unknown.

This analysis will generate retail prices for each possible efficiency level, assuming that each level represents a new minimum efficiency standard. DOE makes this assumption to capture the effect that higher manufacturer production volumes of more efficient products due to the standard have on retail price. Because DOE expects to develop a range of price estimates, it may describe new retail prices within a range of uncertainty. If the range of retail prices for each product is large enough, DOE will develop retail price probability distributions to use as inputs to the LCC and PBP analysis to determine the impact of the uncertainty on the economic feasibility of amended energy conservation standards.

> ***Item 7-1*** *DOE welcomes suggestions and comments concerning its proposed approach for developing estimates of future retail prices.*

8. LIFE-CYCLE COST AND PAYBACK PERIOD ANALYSIS

The effects of increased energy conservation standards on a consumer of a product include a change in operating expense (usually decreased) and a change in purchase price (usually increased). DOE analyzes the net effect on consumers by calculating the LCC and PBP using the engineering performance data (as described in section 5), the energy consumption data (as described in section 6), and the equipment retail prices (as described in section 7). Inputs to the LCC and PBP calculation include the total installed cost to the consumer (purchase price plus installation cost) and operating cost (energy expenses and, if applicable, repair costs, and maintenance costs). Additional inputs to the LCC calculation include energy price forecasts, the lifetime of the appliance or other defined period of analysis, and discount rates.

8.1 Approach for Conducting the LCC and PBP Analysis

In the ANOPR stage of the rulemaking, DOE will conduct the LCC and PBP analysis by modeling both the uncertainty and variability in the inputs using Monte Carlo simulation and probability distributions. The Monte Carlo approach provides a significant advantage over less sophisticated approaches (*e.g.*, an approach using typical or average values to characterize inputs) by identifying the percent of consumers benefiting and being burdened by a prospective standard.

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[31] Sales Tax Clearinghouse, Inc., *State sales tax rates along with combined average city and county rates*. Available at http://thestc.com/STrates.stm.

DOE will develop LCC and PBP models that incorporate both Monte Carlo simulation and probability distributions by using Microsoft Excel spreadsheets combined with Crystal Ball (a commercially available add-in program). Each Monte Carlo simulation will consist of 10,000 LCC and PBP calculations. The models will perform each calculation using input values that are either sampled from probability distributions and household samples or characterized with single point values. The analysis results will be a distribution of 10,000 data points showing the range of LCC savings and PBPs for a given efficiency level relative to the baseline level.

With the possible exception of repair and maintenance costs, DOE will use probability distributions to characterize the operating cost inputs to the LCC and PBP analysis, including product lifetimes and consumer discount rates. As described previously in section 6, DOE will use RECS to establish a sample of individual households for each of the seven representative product classes. For each household in the sample, DOE will then establish the product's annual energy consumption. DOE will also use the household samples as a basis to establish each household's electricity price. DOE will perform the LCC and PBP calculations on each household to account for the variability in energy consumption and electricity pricing associated with the household sample. Therefore, the household sample for each product becomes, in effect, a probability distribution for annual energy consumption and electricity price. DOE will likely describe maintenance and repair costs with single point values. The methodology for developing maintenance and repair costs is described below.

DOE expects to use point values to characterize most of the total installed cost inputs, including the manufacturer markup, the retailer markup, and the installation costs. If the manufacturer cost estimates developed in the engineering analysis are characterized with uncertainty or variability, DOE will use probability distributions to capture this uncertainty and variability; otherwise, DOE will use single point values for this input as well. DOE intends to characterize sales taxes with probability distributions to capture their regional variability.

Another factor in identifying which consumers benefit from or are burdened by a prospective standard is the distribution of product efficiencies currently being sold in the marketplace, referred to as base-case efficiency distributions or market-share efficiency data. In the case of refrigeration products, the efficiency metric is expressed as annual energy consumption. Assuming these data are available, DOE can characterize the current product mix with probability distributions. DOE will then assign a specific appliance efficiency level to each household in a sample based on that level's sales-weight. The assignment of appliance efficiency will be correlated to the UAF for each household. As discussed in the energy use determination (see section 6), the lower the UAF, the more likely the appliance has a high efficiency. Therefore, households with low UAFs will be assigned high product efficiencies while households with high ratios will be assigned low product efficiencies. Because DOE intends to perform the LCC and PBP calculations on a household-by-household basis, DOE expects to determine the LCC and PBP for a particular standard level based on the appliance efficiency in the given household. For example, if a household is assigned a product efficiency that is greater than or equal to the efficiency of the standard level under consideration, the LCC and PBP calculation would reveal that the household is not affected by the standard level. By accounting for the households that already purchase more-efficient products, DOE will avoid overstating the potential benefits from increasing product efficiency. To enable DOE to use this methodology, DOE expects to ask stakeholders — presumably either AHAM or individual manufacturers — to provide data on the current mix of product efficiencies to account for those households already purchasing high efficiency products.

As discussed in Section 6, DOE intends to take into account the rebound effect associated with more efficient refrigerators, refrigerator-freezers, and freezers. The take-back in energy consumption associated with the rebound effect provides consumers with increased value (*e.g.*, more refrigerator-freezer internal volume). The net impact on consumers is thus the sum of the change in the cost of owning the refrigeration equipment (*i.e.,* life-cycle cost) and the increased value for the enhanced product features or usage patterns. DOE believes that if it were able to monetize the increased value to consumers added by the rebound effect, this value would be similar in value to the foregone energy savings. For this standards rulemaking, DOE estimates that this value is equivalent to the monetary value of the energy savings that would have occurred without the rebound effect. Therefore, the economic impacts on consumers with or without the rebound effect, as measured in the LCC analysis, are the same.

DOE intends to conduct the LCC and PBP analysis only for the seven representative product classes on which it plans to perform an engineering analysis (see section 5.2). To identify the consumers that benefit from or are burdened by a prospective standard, DOE requests base-case efficiency distributions or market-share efficiency data from the industry. Appendix A, Tables A-3 through A-6, specifically identifies the market-share efficiency data that DOE is seeking.

During the post-ANOPR (NOPR stage) consumer analysis, DOE may evaluate additional parameters not included in the ANOPR analysis, based upon information provided by stakeholders or which otherwise becomes available to the agency.

Based on the results of the LCC analysis, DOE will select CSLs for the ANOPR analysis. The range of CSLs typically will include the efficiency level with the minimum LCC, the highest efficiency level that is technologically feasible, and other intermediate levels DOE has not yet determined.

The following sections discuss the methodologies DOE plans to use to develop several of the inputs to the LCC and PBP analysis, including (1) electricity prices; (2) maintenance, repair, and installation costs; (3) product lifetimes; and (4) discount rates. The other inputs to the LCC and PBP analysis—namely, manufacturer costs (section 5), annual energy consumption (section 6), and markups for the determination of consumer retail prices (section 7)—have been discussed previously.

DOE is also required to perform a PBP analysis to determine whether the three-year rebuttable presumption of economic justification applies (in essence, whether the purchaser will recover the higher installed cost of more energy efficient equipment through lowered operating costs within three years). (42 U.S.C. 6295(o)(2)(B)(iii)) To determine the rebuttable-presumption PBP, DOE will determine the value of the first year's energy savings by calculating the quantity of those savings in accordance with DOE's test procedure, rather than the field-based energy consumption data from RECS. Although DOE will examine the rebuttable-presumption criteria, it will determine economic justification of selected CSLs through a more detailed analysis of the economic impacts of increased efficiency pursuant to section 325(o)(2)(B)(i) of EPCA. (42 U.S.C. 6295(o)(2)(B)(i))

For the NOPR, DOE will carefully review all of the comments it receives on the ANOPR LCC analysis, make any necessary revisions to the analysis, and evaluate additional parameters not included in the ANOPR analysis, if necessary.

> ***Item 8-1*** *DOE seeks stakeholder input on the planned approach of using Monte Carlo simulation and probability distributions to conduct the LCC and PBP analysis.*
>
> ***Item 8-2*** *DOE requests data from stakeholders to characterize the current mix of residential refrigerator, refrigerator-freezer, and freezer efficiencies in the market.*

8.2 Electricity Prices

DOE plans on developing average electricity prices from EIA data for each of 13 geographic areas — the nine U.S. Census divisions, with four large States (New York, Florida, Texas, and California) treated separately. For Census divisions containing one of these large States, DOE intends to calculate the regional average values, leaving out data for the large State—for example, the Pacific region average will not include California, and the West South Central region average will not include Texas. As just described in section 8.1, DOE plans to use RECS to develop a sample of individual households for each representative product class. Depending on the household's geographic location, DOE will assign the appropriate electricity price from one of the 13 geographic areas. Therefore, DOE will be able to assess the variability of energy prices at the regional level for residential refrigerators, refrigerator-freezers, and freezers.

To calculate electricity prices for residential consumers in each of the above geographic areas, DOE intends to use information provided by electric utilities as summarized in the most recent EIA Form 861 data.[32] These data, which cover the residential, commercial, and industrial sectors for every utility serving final customers, are published annually and include annual electricity sales in kWh, revenues from electricity sales, and number of consumers. The calculation of an average residential electricity price will proceed in two steps: (1) for each utility, estimate an average residential price by dividing the residential revenues by residential sales; and (2) calculate a regional average price, weighting each utility with customers in a region by the number of residential consumers served in that region.

DOE will use projections of national average electricity prices to residential consumers to estimate future energy prices in its LCC analysis. DOE will use the most recent available edition of EIA's *Annual Energy Outlook* (AEO) as the default source of projections for future energy prices.

[32] Available at http://www.eia.doe.gov/cneaf/electricity/page/eia861.html.

> ***Item 8-3*** *DOE seeks stakeholder input on the planned approach for estimating current and forecasted energy prices.*

8.3 Maintenance, Repair, and Installation Costs

DOE will consider any expected changes to maintenance, repair, and installation costs for the residential refrigeration products covered in this rulemaking. Typically, small incremental changes in product efficiency incur little or no changes in repair and maintenance costs over baseline products. There is a greater probability that equipment with efficiencies that are significantly higher than the baseline will incur increased repair and maintenance costs, since such equipment is more likely to incorporate technologies that are not widely available. DOE will rely on input from manufacturers and other stakeholders in developing appropriate repair and maintenance cost estimates, as necessary.

With regard to installation costs, unless the efficiency increases considered for this rulemaking result in significantly larger or heavier products, DOE expects that more-efficient refrigerators, refrigerator-freezers, and freezers will not incur increased installation costs.

> ***Item 8-4*** *DOE seeks stakeholder input on whether it is correct to assume that changes in maintenance, repair, and installation costs will be negligible for more-efficient residential refrigerators, refrigerator-freezers, and freezers. If it is incorrect, DOE is interested in the reasons why this is so and in specific ways in which to correct this assumption.*

8.4 Product Lifetimes

DOE's previous priority-setting analyses have established the product lifetimes of residential refrigerators, refrigerator-freezers, and freezers. In DOE's October 2005 draft technical report analyzing potential new amended energy conservation standards for residential refrigerator-freezers, an average product lifetime of 19 years was estimated based on information in DOE's 1995 TSD.

DOE will use information from various literature sources (*e.g.*, *Appliance Magazine*) as well as input from manufacturers and other stakeholders to establish whether the above product lifetimes are still representative.

> ***Item 8-5*** *DOE seeks stakeholder input on appropriate product lifetimes for the residential refrigeration products covered in this rulemaking. For example, DOE seeks other data sources for establishing product lifetimes.*

8.5 Discount Rates

The calculation of consumer LCC requires the use of an appropriate discount rate. DOE uses the discount rate to determine the present value of lifetime operating expenses. The discount rate used in the LCC analysis represents the rate from an individual consumer's perspective.[33] For consumers of residential refrigeration products, DOE plans to use the same approach that it relied on to develop discount rates for its recent residential furnaces and boilers—*i.e.*, deriving the discount rates from estimates of the interest or "finance cost" to purchase residential products. The finance cost of raising funds to purchase these products can be interpreted as (1) the financial cost of any debt incurred to purchase products (principally interest charges on debt), or (2) the opportunity cost of any equity used to purchase products (principally interest earnings on household equity). Household equity is represented by holdings in assets such as stocks and bonds, as well as the return on homeowner equity. Much of the data required to determine the cost of debt and equity comes from the Federal Reserve Board's triennial *Survey of Consumer Finances*.[34]

Item 8-6 *DOE seeks stakeholder input on the planned approach for estimating discount rates for residential consumers.*

Based on consideration of the comments received on the LCC and PBP analysis documented for the ANOPR, DOE will make the necessary changes to the analysis. It will reflect those changes in the documentation of the NOPR.

9. SHIPMENTS ANALYSIS

Shipments forecasts are required to calculate the national impacts of standards (NES and NPV) and to calculate the future cash flows of manufacturers. DOE plans to develop shipments forecasts based on an analysis of key market drivers for the particular products.

9.1 Base-Case Forecast

To evaluate the various impacts of standards, DOE develops a base-case forecast against which to compare forecasts for higher efficiency levels. (Higher efficiency level forecasts are also referred to as standards-case forecasts.) DOE designs the base-case to depict what would be anticipated to happen to energy consumption and costs over time if DOE does not adopt energy conservation standards. In determining the base-case for each set of products, DOE plans to calibrate its forecasts against historical shipments. DOE will also consider the mix of efficiencies sold in the absence of new standards and how that mix might change over time. As a result, DOE will need to collect data on historical product shipments and the market shares of the different efficiency levels offered in each product class. Based on detectable trends in the collected efficiency data, DOE will forecast base-case shipment-weighted efficiencies (SWEF) by product class. Forecasts of SWEFs are discussed in greater detail below in section 10.1.

DOE plans to determine annual shipments in the base-case by primarily accounting for sales to two market segments: (1) new construction and (2) the replacement market. DOE intends to

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[33] The consumer discount rate is in contrast to the discount rates used in the national impact analysis, which are intended to represent the rate of return of capital in the U.S. economy as well as the societal rate of return on private consumption. Refer to section 10.3 for additional information.

[34] Available at http://www.federalreserve.gov/pubs/oss/oss2/scfindex.html.

determine shipments to new construction by accounting for new housing construction and historical rates of product ownership (saturation rates). DOE plans to rely on the latest available edition of EIA's *AEO* to forecast new residential construction. With regard to historical product saturation rates, both AHAM's *2005 Fact Book* and EIA's RECS provide relevant data. DOE plans to use both sources to establish product saturation rates. DOE will also take into consideration other input provided by stakeholders. To determine replacement shipments, DOE will use the same product lifetimes and retirement functions that it generates for the LCC and PBP analysis. In addition, DOE will consider other market segments as appropriate, such as households that may retire their appliances early.

For residential refrigerators, refrigerator-freezers, and freezers, DOE plans to develop four sets of base-case shipments forecasts for the following four product categories: (1) standard-sized refrigerators and refrigerator-freezers covering product classes 1–7 and 19; (2) standard-sized freezer covering product classes 8–10 and 20; (3) compact-sized refrigerators and refrigerator-freezers covering product classes 11–15; and (4) compact-sized freezers covering product classes 16–18. Therefore, for purposes of developing calibrated base-case forecasts, DOE will require and use the historical shipments data in the AHAM *2005 Fact Book*[35] and *Appliance Magazine*[36] which disaggregate shipments into the above four product categories. Once the base-case forecasts have been established, DOE plans to divide each of the four forecasts into individual product class forecasts that cover each of the 20 product classes, e.g., the forecast for standard-sized refrigerators and refrigerator-freezers will be divided into the eight classes which comprise it. To perform this disaggregation, DOE will collect market share data for each of the 20 product classes. To enable DOE to perform an accurate and representative disaggregation, the market share data would ideally cover the time period starting in the year 2000. Appendix A, Table A-1, identifies the specific years for which DOE seeks historical market share data for the 20 product classes.

Item 9-1 *DOE seeks historical market share data showing the percentage of product shipments in each product class.*

9.2 Standards Impacts on Product Shipments

For each product, DOE will develop a set of shipment forecasts for the covered equipment for each set of efficiency levels analyzed. It will use these standards-case forecasts to evaluate the impacts of standards on product shipments. DOE will derive standards-case forecasts using the same data sets as it used for the base-case forecasts. However, because the standards-case forecasts take into account the increase in purchase price and the decrease in operating costs caused by standards, forecasted shipments typically deviate from the base-case. Household income also factors into consumer purchase decisions. Therefore, the magnitude of the difference between the standards-case and base-case shipment forecasts depends on the estimated purchase price increase and the operating cost savings caused by the standard, relative to household income. Because the purchase price tends to have a larger impact than operating

[35] Available for purchase at http://www.aham.org/ht/d/Store/name/FACTBOOK/pid/ (select 'Industry Research and Data).

[36] Available at http://www.appliancemagazine.com.

cost on appliance purchase decisions, standards-case forecasts typically show a drop in product shipments relative to the base-case.

DOE's past standards analyses have attempted to quantify the sensitivity of shipments to increased purchase prices and operating cost savings as well as to changes in household income. For example, DOE has conducted literature reviews and analyses of historical appliance price and efficiency data to develop sensitivities. Although DOE will attempt to develop purchase price and operating cost sensitivities for residential refrigeration products, because the data required to develop these sensitivities are limited and often difficult to obtain, DOE will also consider modeling standards-case shipments forecasts with scenarios (*i.e.*, specified impacts to product shipments), if necessary.

Market-pull programs, such as consumer rebate programs that encourage the purchase of more-efficient products and manufacturer tax credits that encourage the production of more-efficient products, also affect standards-case shipments forecasts. To the extent that such programs exist, DOE considers their impact on the forecast of both base-case and standards-case shipments.

Item 9-2 *As part of its preliminary manufacturer impact analysis, DOE seeks input from manufacturers on the potential impact of new energy conservation standards on refrigeration product shipments. DOE also seeks input from other stakeholders on the potential impact of standards on product shipments.*

Item 9-3 *DOE also requests input on any market-pull programs that currently exist to promote the adoption of more-efficient residential refrigeration products.*

10. NATIONAL IMPACT ANALYSIS

Section 8 discusses methods for estimating the LCC savings and PBP for individual consumers. This section discusses DOE's assessment of the aggregate impacts of potential efficiency standards at the national level. Measures of impact that DOE will report include the future NES from candidate standards and the NPV of total consumer life-cycle costs.

10.1 Inputs to NES and NPV Forecasts

Analyzing impacts of Federal energy conservation standards for residential refrigeration products requires a comparison of projected U.S. energy consumption with, and without, new or amended energy conservation standards. The forecasts contain projections of annual appliance shipments (as discussed in section 9), the annual energy consumption of new appliances (as discussed in section 6), and the purchase price of new appliances (as discussed in section Item 6-1).

A key component of DOE's estimates of NES and NPV are the product energy efficiencies forecasted over time for the base-case (without new standards) and each of the standards cases. For residential refrigeration products, the forecasted efficiencies represent the annual shipment-weighted annual energy consumption of the products under consideration over the forecast period (*i.e.*, from the assumed effective date of a new standard to 30 years after the standard becomes effective). Because key inputs to the calculation of the NES and NPV (annual energy consumption for the NES, and retail prices and annual operating costs for the NPV) are dependent on the estimated efficiencies, these efficiencies are very important to the analysis.

DOE intends to rely on input from stakeholders, particularly AHAM and appliance manufacturers, to develop base-case historical shipment-weighted average efficiencies. For past home appliance standards rulemakings, AHAM was able to provide SWEF data. DOE hopes that AHAM and manufacturers will provide the similar historical shipment-weighted average efficiency data for as many of the residential refrigerator, refrigerator-freezer, and freezer product classes as possible. Note that although the AHAM *2005 Fact Book* does provide historical SWEF data, these data are not disaggregated by product class. In the event that AHAM is unable to provide historical SWEF data by product class, DOE will make its own estimates based on the aggregated historical SWEF data, past and current energy conservation standards, and historical shipments data disaggregated by product class. To forecast base-case efficiencies, in addition to determining detectable trends in any historical SWEF data provided, DOE intends to review data from the Energy Star program to determine the effect that the program has had on increasing product efficiency. Based on the trends in the historical SWEF data and the Energy Star program's success at transforming the refrigerator market, as well its potential for future impacts on product efficiency, DOE will forecast base-case efficiency trends for each product class.

To develop shipment-weighted efficiencies for the various standards cases, DOE expects to collect market-share efficiency data (*i.e.*, data on the distribution of product shipments by efficiency) for the various product classes of each appliance. As discussed in section 8, these are the same market-share efficiency data (otherwise known as base-case efficiency distributions) that DOE is requesting for the LCC and PBP analysis so DOE can accurately quantify the percent of consumers that benefit from an increase in the minimum energy conservation standard. Realizing that this information may be difficult to collect, DOE hopes to obtain market-share efficiency data for at least the most predominant product classes from a recent year (*i.e.*, 2005 or 2006).

The market-share efficiency data will allow DOE to estimate the efficiency impact that standards may have in the year they become effective. For example, DOE has assumed a "roll-up" scenario for past standards rulemakings.[37] Under this scenario, DOE assumes (1) product efficiencies in the base-case that do not meet the standard level under consideration would "roll up" to meet the new standard level; and (2) product efficiencies above the standard level under consideration would not be affected. Once DOE establishes the shipment-weighed efficiency for the assumed effective date of the standard, it will estimate future shipment-weighted efficiencies using the same rate of forecasted efficiency growth as in the base-case efficiency trend.

Appendix A identifies the efficiency data DOE is requesting from the industry. As identified in Table A-2, DOE is seeking historical SWEF data for as many of the 20 product classes identified

[37] For example, the residential central air conditioner standards rulemaking considered a "roll-up" scenario when estimating the impact of standards. Refer to the Chapter 7 of the central air conditioner TSD for more details, which is available at http://www.eere.energy.gov/buildings/appliance_standards/residential/ac_central_1000_r.html.

in section 3.2 as stakeholders can provide. For the market-share efficiency data that DOE seeks, the efficiency bins encompass the efficiency levels in Tables A-3 through A-6. In the cases where market-share efficiency data are not available, DOE will use efficiency distributions based on available models as a proxy.

> ***Item 10-1*** *DOE seeks historical SWEF data by product class. DOE also seeks historical market share data showing the percentage of product shipments by efficiency level for as many product classes as possible.*

10.2 National Energy Savings

DOE intends to calculate national energy consumption for each year beginning with the expected effective date of the standards. It will calculate national energy consumption for the base-case and each standard level analyzed. DOE plans to perform this calculation through the use of a spreadsheet model that effectively multiplies annual shipment forecasts by unit energy savings, accounting for the stock of appliances affected by standards.

In response to comments by stakeholders who asked for a simple, transparent model, DOE has developed NES spreadsheet models for its standards rulemakings since 1996, to forecast energy savings and to demonstrate how the growth in efficiency can be accounted for over time.[38] Although these models are specific to each product, DOE believes their general structure is applicable to the residential refrigeration product market. DOE expects the NES spreadsheet model it develops for this rulemaking to provide a credible, stand-alone forecast of NES and NPV for residential refrigerators, refrigerator-freezers, and freezers.

As discussed in Section 6, DOE intends to take into account the rebound effect associated with more efficient refrigerators, refrigerator-freezers, and freezers. DOE will incorporate the rebound effect utilized in the energy use analysis into its calculation of national energy savings by diminishing the SWEFs in the standards-case forecasted efficiency trends.

Based on consideration of the comments DOE may receive on the ANOPR, DOE will make any necessary changes to the analysis. It will reflect those changes in the documentation for the NOPR.

> ***Item 10-2*** *DOE seeks input on its plan to develop NES spreadsheet models for estimating national impacts of amended energy conservation standards for residential refrigeration products. For example, are spreadsheet models still the preferred approach for estimating national impacts?*

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[38] Several NES spreadsheet models from previous rulemakings, including the rulemaking for residential clothes washers, can be found on DOE's website at www.eere.energy.gov/buildings/appliance_standards.

10.3 Net Present Value

DOE calculates the national NPV of energy conservation standards in conjunction with the NES. It calculates annual energy expenditures from annual energy consumption by incorporating forecasted energy prices, using the shipment and average energy efficiency forecasts described in section 9. DOE calculates annual equipment expenditures by multiplying the price per unit by the number of forecasted shipments. The difference between a base-case and a standards-case scenario gives the national energy bill savings and increased equipment expenditures in dollars. The difference each year between energy bill savings and increased equipment expenditures is the net savings (if positive) or net costs (if negative). DOE discounts these annual values to the present time and sums them to give a net present value. According to U.S. Office of Management and Budget (OMB) requirements, DOE will conduct two NPV calculations, one using a real discount rate of three percent and another using a real discount rate of seven percent (OMB, Circular A-4: Regulatory Analysis (Sept. 17, 2003). The discount rates for the determination of NPV are in contrast to the discount rates used in the LCC analysis (which are developed from a consumer's perspective). The seven percent real value is an estimate of the average before-tax rate of return to private capital in the U.S. economy. The three percent real value represents the "societal rate of time preference," which is the rate at which society discounts future consumption flows to their present value. Based on consideration of the comments received on the ANOPR, DOE will make any necessary changes to the analysis and the CSLs.

As noted above in Section 10.2, DOE intends to take into account the rebound effect associated with more efficient refrigerators, refrigerator-freezers, and freezers in its determination of national energy savings. As discussed Section 8, because the rebound effect provides consumers with increase value, DOE believes that if it were able to monetize the increased value to consumers added by the rebound effect, this value would be similar in value to the foregone energy savings. For this standards rulemaking, DOE estimates that this value is equivalent to the monetary value of the energy savings that would have occurred without the rebound effect. Therefore, the economic impacts on consumers with or without the rebound effect, as measured in the NPV, are the same.

11. LIFE-CYCLE COST SUBGROUP ANALYSIS

This section describes how DOE analyzes the consumer impact of any new standards by dividing consumers into subgroups and accounting for variations in key inputs to the LCC analysis. A consumer subgroup comprises a subset of the population that is likely, for one reason or another, to be affected disproportionately by new or revised energy conservation standards. The purpose of a subgroup analysis is to determine the extent of this disproportional impact. DOE will work with stakeholders early in the rulemaking process to identify any subgroups for consideration. In the case of residential refrigeration products, some possible subgroups DOE may consider are (1) low-income households; and (2) senior citizens. However, DOE will not analyze the consumer subgroups until the NOPR stage of the analysis.

In comparing potential impacts on the different consumer subgroups, DOE will evaluate variations in regional electricity prices, variations in energy use profiles, and variations in installation costs that might affect the LCC of an energy conservation standard to certain consumer subgroups. To the extent possible, DOE may obtain estimates of the variability in each input variable and consider this variability in its calculation of consumer impacts. It will discuss with stakeholders the variability in each input variable and likely sources of information.

> ***Item 11-1*** *DOE requests input as to what, if any, consumer subgroups are appropriate in considering standards for residential refrigeration products.*

12. MANUFACTURER IMPACT ANALYSIS

DOE announced changes to the manufacturer impact analysis format through a report issued to Congress on January 31, 2006 (as required by section 141 of the Energy Policy Act of 2005 (EPACT 2005)). This report, titled "Energy Conservation Standards Activities" (Standards Activities), is available on the DOE website at http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/congressional_report_013106.pdf.

Previously, DOE did not report any manufacturer impact analysis results during the ANOPR phase; however, under this new format, DOE will collect, evaluate, and report preliminary information and data in the ANOPR. (*See* Standards Activities, p. 48.) Such preliminary information includes the anticipated conversion capital expenditures by efficiency level and the corresponding anticipated impacts on employment. DOE will solicit further information during the ANOPR engineering analysis manufacturer interviews. Preliminary manufacturer impact analysis data needs are contained in Appendix B.

DOE intends the manufacturer impact analysis to provide an assessment of the potential impacts of energy conservation standards on manufacturers of residential refrigeration products. In addition to financial impacts, a wide range of quantitative and qualitative effects may occur following adoption of a standard that may require changes to the manufacturing practices for these products. DOE will identify these effects through interviews with manufacturers, as well as other stakeholders and experts.

For the NOPR, DOE intends to supplement the results of the preliminary MIA conducted as part of the ANOPR with more detailed analyses, described in sections 12.1 through 12.5. Specifically, DOE will carry out an industry-wide cash flow analysis using the Government Regulatory Impact Model (GRIM), identify and analyze subgroups of manufacturers whose business varies significantly from the industry as a whole, perform a competitive impacts assessment, and review the cumulative regulatory burden for the industry.

12.1 Sources of Information for the Manufacturer Impact Analysis

Many of the analyses described earlier provide important information that DOE uses as inputs for the manufacturer impact analysis. Such information includes financial parameters developed in the market assessment (section 3.1), manufacturing costs and prices from the engineering analysis (section 5.3), retail price forecasts (section 7), and shipments forecasts (section 9). DOE supplements this information with information gathered during manufacturer interviews.

DOE will conduct detailed interviews with manufacturers to gain insight into the range of potential impacts of standards. The interview process plays a key role in the manufacturer impact analysis, since it provides an opportunity for directly affected parties to express their views on important issues. During the interviews, DOE will solicit information on the possible impacts of standards on manufacturing costs, equipment prices, sales, direct employment, capital assets, and industry competitiveness. Both qualitative and quantitative information are valuable in terms of this analysis. DOE will schedule interviews well in advance to provide every opportunity for key individuals to be available to participate. In addition, DOE will provide manufacturers with the questionnaire before the interviews to facilitate the gathering of the appropriate information. Although a written response to its questionnaire is acceptable, DOE prefers an interactive interview process, because it helps clarify responses and provides the opportunity to identify additional issues.

DOE will ask interview participants to identify all confidential information provided in writing or orally, and DOE will determine whether the information submitted is entitled to confidential treatment. It will consider information gathered, as appropriate, in the energy conservation standards decision-making process. However, DOE will not make confidential information available in the public record. DOE also will ask participants to identify all information that they wish to have included in the public record but that they do not want to have associated with their interview that would identify that particular manufacturer; DOE will incorporate this information into the public record, but will report it without attribution.

DOE will collate the completed interview questionnaires and prepare a summary of the major issues and outcomes. This summary will become part of the TSD produced for this rulemaking.

12.2 Industry Cash Flow Analysis

The industry cash flow analysis relies primarily on the GRIM. DOE uses the GRIM to analyze the financial impacts of new or more stringent energy conservation standards on the industries that produce the products covered by the standard.

The GRIM analysis uses a number of inputs—annual expected revenues; manufacturer costs such as costs of goods sold; selling, general, and administrative costs; taxes; and capital expenditures (both ordinary capital expenditures and those related to standards)—to determine a series of annual cash flows beginning from the announcement of the new standard and continuing for several years after its implementation. DOE compares the results against base-case projections that involve no new standards. The financial impact of new standards is the difference between the two sets of discounted annual cash flows. Other performance metrics, such as return on invested capital, also are available from the GRIM.

DOE will gather the inputs needed for the GRIM from two primary sources: (1) the analyses conducted to this point; and (2) interviews with manufacturers and other stakeholders. Information gathered from previous analyses will include financial parameters, manufacturing costs, price forecasts, and shipments forecasts. Interviews with manufacturers and other stakeholders will be essential in supplementing this information.

12.3 Manufacturer Subgroup Analysis

It is possible that the use of average industry cost values may not adequately assess differential impacts among subgroups of manufacturers. DOE recognizes that smaller manufacturers, niche players, and manufacturers exhibiting a cost structure that differs significantly from the industry average may be affected differently by the imposition of standards. Ideally, DOE would consider the impact on every firm individually. In highly concentrated industries, this may be possible. In industries having numerous participants, however, DOE uses the results of the market and technology assessment to group manufacturers into subgroups, as appropriate.

Small businesses, as defined by the Small Business Administration (SBA) for household refrigerator and home freezer manufacturers, are enterprises with 1000 employees or fewer. Small business size standards are listed by North American Industry Classification System (NAICS) code and industry description. Household refrigerator and home freezer manufacturing is classified under NAICS 335222. A search of small businesses of this NAICS code listed in the U.S. Small Business Association website indicates that there are less than ten small businesses that manufacture residential refrigerators and freezers that would be covered by this rulemaking. As part of its subgroup analysis, DOE will identify small businesses that manufacture these products and interview small businesses affected by the rulemaking to determine if there are differential impacts on these companies that may result from new energy conservation standards. DOE will examine publicly available data and contact manufacturers, when needed, to determine if they meet the SBA's definition of a small manufacturing facility and if their manufacturing facilities are located within the United States.

The detailed manufacturer subgroup impact analysis will entail calculating cash flows separately for each defined class of manufacturer.

> ***Item 12-1*** *DOE seeks comment on appropriate manufacturer subgroups for residential refrigeration products, if any, that DOE should consider in a manufacturer subgroup analysis.*

12.4 Competitive Impacts Assessment

EPCA directs DOE to consider any lessening of competition that is likely to result from an imposition of standards. (42 U.S.C. 6295(o)(2)(B)(i)(V) and 6316(a)) It further directs the Attorney General to determine in writing the impacts, if any, of any lessening of competition. (42 U.S.C. 6295(o)(2)(B)(ii) and 6316(a))

DOE will make a determined effort to gather and report firm-specific financial information and impacts, and it will then report the aggregated impact of the standard on manufacturers. The competitive impacts analysis will focus on assessing the impacts to smaller, yet significant, manufacturers. DOE will base the assessment on manufacturing cost data and on information collected from interviews with manufacturers. The manufacturer interviews will focus on gathering information that will help in assessing asymmetrical cost increases to some manufacturers, increased proportion of fixed costs potentially increasing business risks, and potential barriers to market entry (*e.g.*, proprietary technologies). DOE will provide the Attorney

General with a copy of the NOPR for consideration in his/her evaluation of the impact of standards on the lessening of competition.

12.5 Cumulative Regulatory Burden

DOE is aware that other regulations may apply to equipment covered under this rulemaking, as well as to other equipment produced by the same manufacturers of equipment covered under this rulemaking. Multiple regulations may result in a significant, cumulative regulatory burden on these manufacturers. Accordingly, DOE will analyze and seek to mitigate the overlapping effects of amended DOE standards and other regulatory actions on manufacturers of residential refrigeration products. DOE is aware that home appliance manufacturers and trade groups have issued public comments concerning the excessive regulation of the home appliance industry in comparison to others. It will take these issues into consideration during the manufacturer impact analysis.

Regulations that could affect the industries affected by this rulemaking include:

- *DOE standards for residential refrigerators, refrigerator-freezers, and freezers –* Manufacturers have previously gone through redesign cycles mandated by standards for these products enacted since 1990, notably standards that took effect in July 2001, ;
- *Phaseout of HCFC blowing agents in 2003*—Manufacturers predominantly switched to HFC-245fa blowing agent when HCFC-141b was phased out in 2003. However different manufacturers may have chosen alternative approaches and as a result may be in differing positions with regard to foam insulation conductivity levels achieved in their production lines. Some manufacturers may have been utilizing HCFC-22, which does not phase out for new products until 2010, and will need to make a change in the coming years.
- *Anti-circumvention rulemaking* – DOE recognizes that manufacturers may misapply a test procedure or violate the intent of a test procedure while claiming to adhere to a literal reading of it. If such violations occur on a wide scale, the benefits of an energy conservation standard could be significantly reduced. In response, DOE plans to examine all options available to it to prevent these types of behavior by manufacturers in order to ensure the integrity of the Federal energy efficiency standards. This may include the promulgation of a rule to prevent the circumvention of these standards.;[39]
- *Reduction of Hazardous Substances (RoHS) directive* – The Directive on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment was adopted in February 2003 by the European Union (EU) and became effective July 1, 2006.[40] RoHS identifies specific categories of products that can contain no more than threshold amounts of mercury, lead, cadmium, hexavalent chromium, and two fire retardants. Although this legislation does not extend currently to residential refrigeration products in the U.S., domestic manufacturers selling to the EU market must produce

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[39] "Energy Conservation Standards Activities," U.S. Department of Energy, Submitted Pursuant to Section 141 of the Energy Policy Act of 2005 and to the Conference Report (109-275) to the FY 2006 Energy and Water Development Appropriations Act, January 2006. A copy of this report is available online at http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/congressional_report_013106.pdf.

[40] http://ec.europa.eu/environment/waste/weee/index_en.htm.

RoHS-compliant appliances. These manufacturers may choose to promulgate the associated design changes across their entire product line.

> ***Item 12-2*** *What other regulations or pending regulations should DOE consider in its examination of cumulative regulatory burden?*

13. UTILITY IMPACT ANALYSIS

To estimate the effects of energy conservation standards for residential refrigerators, refrigerator-freezers, and freezers on electric utility industries, DOE plans to use a variant of the EIA's National Energy Modeling System (NEMS), called NEMS-BT. BT refers to DOE's Building Technologies Program. NEMS is a large, multi-sectoral, partial-equilibrium model of the U.S. energy sector that EIA has developed over several years, primarily for the purpose of preparing the *AEO*. NEMS produces a widely recognized reference case forecast for the United States through 2030 and is available in the public domain.[41]

The utility impact analysis is a comparison between the NEMS-BT model results for the base-case and standards-cases. Outputs of the utility impact analysis usually parallel results that appear in the latest *AEO*, with some additions. Typical outputs of the utility impact analysis include forecasts of electricity sales, price, and avoided capacity. DOE plans to conduct the utility impact analysis as a scenario departing from the latest *AEO* reference case. In other words, DOE will model the energy savings impacts from amended energy conservation standards using NEMS-BT to generate forecasts that deviate from the *AEO* reference case.[42]

> ***Item 13-1*** *DOE seeks input from stakeholders on its plans to use NEMS-BT to conduct the utility impact analysis. Examples of the type of input sought by DOE include, but are not limited to, whether the NEMS-BT model is appropriate for assessing the utility impacts of efficiency standards — and if not, what would be a more appropriate model to use?*
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> ***Item 13-2*** *Should DOE consider using methods or tools other than NEMS in the utility impact analysis? If so, please discuss the identified alternatives and explain why these other methods or tools should be used in lieu of NEMS.*

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[41] For more information on NEMS, please refer to the U.S. Department of Energy, Energy Information Administration documentation. A useful summary is National Energy Modeling System: An Overview 2000, DOE/EIA-0581(March 2000) and is available at http://tonto.eia.doe.gov/ftproot/forecasting/05812000.pdf. EIA approves use of the name NEMS to describe only an official version of the model without any modification to code or data. Because this analysis entails some minor code modifications and the model is run under various policy scenarios that are variations on EIA assumptions, DOE refers to the model by the name NEMS-BT ("BT" refers to DOE's Building Technologies Program, under whose aegis this work has been performed).

[42] Several descriptions of NEMS-BT models from previous rulemakings, including residential furnaces and boilers, can be found on DOE's website at http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/chapter_13.pdf.

14. EMPLOYMENT IMPACT ANALYSIS

DOE estimates the impacts of standards on employment for equipment manufacturers, relevant service industries, energy suppliers, and the economy in general. This analysis covers both direct and indirect employment impacts. Direct employment impacts would result if standards led to a change in the number of employees at manufacturing plants and related supply and service firms. DOE will evaluate direct employment impacts in the manufacturer impact analysis, as described in section 12.

Indirect employment impacts are impacts on the national economy other than in the manufacturing sector being regulated. Indirect impacts may result both from expenditures shifting among goods (the substitution effect) and changes in income that lead to a change in overall expenditure levels (the income effect). DOE defines indirect employment impacts from standards as net jobs eliminated or created in the general economy as a result of increased spending driven by the increased equipment prices and reduced spending on energy.

DOE will investigate the combined direct and indirect employment impacts in the employment impact analysis using the Pacific Northwest National Laboratory (PNNL)'s "Impact of Sector Energy Technologies" (ImSET) model. PNNL developed ImSET for DOE's Office of Planning, Budget, and Analysis. The model estimates the employment and income effects of energy-saving technologies in buildings, industry, and transportation. In comparison with simple economic multiplier approaches, ImSET allows for more complete and automated analysis of the economic impacts of energy efficiency investments. Although DOE intends to use ImSET for its analysis of employment impacts, it welcomes input on other tools and factors it might consider.

Item 14-1 *DOE welcomes feedback on its planned approach for assessing national employment impacts, both direct and indirect, and it is interested in whether other tools or factors should be considered as part of its analysis. If other tools or factors should be considered, please identify them and explain why, and how, they should be integrated into DOE's analysis.*

15. ENVIRONMENTAL ASSESSMENT

The intent of the environmental impact analysis is to provide emissions results estimates and to fulfill requirements to properly quantify and consider the environmental effects of all new Federal rules. The primary environmental effects of energy conservation standards for refrigerators, refrigerator-freezers, and freezers are likely to be reduced emissions resulting from reduced electrical energy consumption. The environmental impact analysis will focus on the impact of possible energy conservation standards on the significant pollutants and emissions of electricity-generating power plants. Specifically, the environmental assessment for this rulemaking will consider three types of energy-related emissions — oxides of nitrogen (NOx), sulfur dioxide (SO_2), and mercury (Hg); it will also consider one other emission — carbon dioxide (CO_2). DOE intends to base this analysis on the NEMS-BT modeling work planned for the utility impact analysis. This approach has the advantage of examining the marginal impact of standards for refrigerators, refrigerator-freezers, and freezers on the utility generation mix and the subsequent environmental emissions.

DOE will conduct each portion of the environmental impact analysis performed under this rulemaking as an incremental policy impact (*i.e.*, an energy conservation standard for refrigerators, refrigerator-freezers, and freezers) of EIA's *AEO* forecast, applying the same basic set of assumptions used in the latest version of *AEO* available for use in this analysis. Also, forecasts conducted with NEMS-BT consider the supply-side and demand-side effects on the electric utility industry. Thus, DOE's analysis will account for any factors affecting the type of electricity generation and, in turn, the amount of airborne emissions the utility industry generates.

The NEMS-BT model tracks CO_2 emissions with a specialized carbon emissions estimation subroutine, producing reasonably accurate results due to the broad coverage of all sectors and inclusion of interactive effects. Past experience with carbon dioxide emission results from NEMS-BT suggests that emissions estimates are somewhat lower than emissions based on simple average factors. One of the reasons for this divergence is that NEMS-BT tends to predict that conservation measures displace generating capacity growth in future years, and new generating capacity is expected to be more efficient than existing capacity. On the whole, NEMS-BT provides carbon dioxide emission results of reasonable accuracy, at a level consistent with other Federal published results. In addition to providing estimates of quantitative impacts of standards for refrigerators, refrigerator-freezers, and freezers on carbon dioxide emissions, DOE will consider the use of monetary values to represent the potential value of such emissions reductions.

Item 15-1 *DOE invites comments on how to estimate such monetary values associated with CO_2 emissions reductions or on any widely accepted values which might be used in DOE's analyses.*

NEMS-BT also reports SO_2, NOx, and Hg, which DOE has reported in past rulemaking analyses. The Clean Air Act Amendments of 1990[43] set an SO_2 emissions cap on fossil fuel-fired power generation units of 25 megawatts or greater. The attainment of this target, however, is flexible among generators through the use of emissions allowances and tradable permits. Although NEMS-BT includes a module for SO_2 allowance trading and delivers a forecast of SO_2 allowance prices, accurate simulation of SO_2 trading implies that the effect of energy conservation standards on physical emissions will be zero because emissions will always be at or near the ceiling. However, there may be an SO_2 benefit from energy conservation, in the form of a lower SO_2 allowance price. But since the impact of any one standard on the allowance price is likely small and highly uncertain, DOE does not plan to monetize any potential SO_2 benefit.

The NEMS-BT modeling assumed that NO_X would be subject to the Clean Air Interstate Rule (CAIR) issued by the U.S. Environmental Protection Agency on March 10, 2005.[44] 70 FR 25162

[43] Information available at http://www.epa.gov/air/caa.

[44] *See* http://www.epa.gov/cleanairinterstaterule/.

(May 12, 2005). On July 11, 2008, the U.S. Court of Appeals for the District of Columbia Circuit (D.C. Circuit) issued its decision in *North Carolina v. Environmental Protection Agency*,[45] in which the court vacated the CAIR. If left in place, the CAIR would have permanently capped emissions of NO_X in 28 eastern States and the District of Columbia. As with the SO_2 emissions cap, a cap on NO_X emissions would have meant that equipment energy conservation standards are not likely to have a physical effect on NO_X emissions in States covered by the CAIR caps. While the caps would have meant that physical emissions reductions in those States would not have resulted from energy efficiency standards, the standards may produce an environmental-related economic impact in the form of lower prices for emissions allowance credits, if large enough.

Even though the D.C. Circuit vacated the CAIR, DOE notes that the D.C. Circuit left intact a voluntary program set in place by EPA's 1998 NO_X SIP Call rule, which capped seasonal (summer) NO_X emissions from electric generating units and other sources in 23 jurisdictions and gave those jurisdictions the option to participate in a cap and trade program for those emissions. *See* 63 FR 57356, 57359 (Oct. 27, 1998).[46] Accordingly, DOE is considering whether changes are needed to its plan for addressing the issue of NO_X reduction. DOE invites public comment on how the agency should address this issue, including how it might value NO_X emissions for States now that the CAIR has been vacated. [47]

Item 15-2 *Because court actions have vacated the CAIR, DOE seeks stakeholder input on how it should address NO_X emissions in this rulemaking.*

With regard to mercury emissions from electric power generation, the NEMS-BT model has an algorithm for estimating these emissions, and, as it has done in the past, DOE is able to report an estimate of the physical quantity of mercury emissions reductions associated with an energy conservation standard. Furthermore, DOE had assumed that these emissions would be subject to EPA's Clean Air Mercury Rule (CAMR),[48] which would have capped Hg emissions for new and existing coal-fired power plants in all States by 2010. As with SO_2 and NOx emissions, a cap on

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[45] Case No. 05-1244, 2008 WL 2698180 at *1 (D.C. Cir. July 11, 2008).

[46] In the NO_x SIP Call rule, EPA found that sources in the District of Columbia and 22 "upwind" states (States) were emitting NO_x (an ozone precursor) at levels that significantly contributed to "downwind" states not attaining the ozone National Ambient Air Quality Standards (NAAQS) or at levels that interfered with states in attainment maintaining the ozone NAAQS. In an effort to ensure that "downwind" states attain or continue to attain the ozone NAAQS, EPA established a region-wide cap for NO_x emissions from certain large combustion sources and set a NO_x emissions budget for each State. Unlike the cap that CAIR would have established, the NO_x SIP Call Rule's cap only constrains seasonal (summer time) emissions. States could elect to participate in the NO_x Budget Trading Program. Under the NO_x Budget Trading Program, each emission source is required to have one allowance for each ton of NO_x emitted during the ozone season. States have flexibility in how they allocate allowances through their State Implementation Plans but States must remain within the EPA-established budget. Emission sources are allowed to buy, sell and bank NO_x allowances as appropriate. It should be noted that, on April 16, 2008, EPA determined that Georgia is no longer subject to the NO_x SIP Call rule.

[47] In anticipation of CAIR replacing the NOx SIP Call Rule, many States adopted sunset provisions for their plans implementing the NOx SIP Call Rule. The impact of the NOx SIP Call Rule on NOx emissions will depend, in part, on whether these implementation plans are reinstated.

[48] The EPA's Clean Air Mercury Rule was published on May 18, 2005. 70 FR 28606.

Hg emissions would have been interpreted by DOE as having no physical effect on these emissions, but would instead be expected to result in an environmental-related economic benefit in the form of a lower price for emission allowance credits. However, on February 8, 2008, the U.S. Court of Appeals for the District of Columbia Circuit (D.C. Circuit) issued its decision in *New Jersey v. EPA,* 517 F.3d 574 (D.C. Cir. 2008), in which the Court, among other actions, vacated the CAMR referenced above. Accordingly, DOE is considering changes to its approach addressing the issue of Hg emissions in light of the D.C. Circuit's decision.

Item 15-3 *Because court actions have vacated the CAMR, DOE seeks stakeholder input on how it should address Hg emissions in this rulemaking.*

In sum, the methodology for the environmental impact analysis will be similar to the methodology (*i.e.*, based on NEMS) used to estimate the environmental impacts published in EIA's *AEO*. These results include power sector emissions for SO_2, NO_X, Hg, and CO_2 in five-year forecasted increments extrapolated to 2046. The outcome of the analysis for each trial standard level will be reported as a deviation from the *AEO* reference (base) case, with such analysis being conducted at the NOPR stage of the rulemaking.

Item 15-4 *DOE seeks input from stakeholders on its plans to use NEMS-BT to conduct the environmental impact analysis on the equipment covered by this rulemaking. DOE is particularly interested in whether there are any other approaches to the environmental assessment that it should consider and the advantages and disadvantages for each of those approaches.*

Item 15-5 *Are there any other environmental factors DOE should consider in this rulemaking? If so, what are they and why should they be considered?*

16. REGULATORY IMPACT ANALYSIS

In the NOPR stage of this rulemaking, DOE will prepare a regulatory impact analysis that will address the potential for non-regulatory approaches to supplant or augment energy conservation standards to improve the efficiency of residential refrigerators, refrigerator-freezers, and freezers on the market. DOE recognizes that voluntary or other non-regulatory efforts by manufacturers, utilities, and other interested parties can result in substantial efficiency improvements. DOE intends to analyze the likely effects of non-regulatory initiatives on product energy use, consumer utility, and LCCs. DOE will attempt to base its assessment on the actual impacts of any such initiatives to date, but will also consider information presented regarding the impacts that any existing initiative might have in the future.

If DOE proposes energy conservation standards for residential refrigeration products and the NOPR constitutes a significant regulatory action, DOE would prepare and submit to OMB for review the assessment of costs and benefits required under section 6(a)(3) of Executive Order 12866, "Regulatory Planning and Review," 58 FR 51735 (October 4, 1993).

APPENDIX A – DRAFT ENGINEERING ANALYSIS DATA REQUEST SHEETS

DOE seeks average **incremental production cost** to take basic models in the categories shown from the current DOE minimum efficiency level (or proposed baseline level) to the specified efficiency level. For those product classes where more than one basic model may exist, please indicate the minimum and maximum incremental costs that would be incurred across the array of basic models.

The data sheets are divided by product and contain tables requesting shipment and manufacturer cost data.

The shipment-weighted energy use data of Table A-2 should be based on the current DOE energy test procedure.

Shipments

For residential refrigerators, refrigerator-freezers, and freezers, the AHAM *2005 Fact Book* offers historical shipments data and efficiency data, but the information is not disaggregated by product class. As shown in the "shipment request" tables below, DOE hopes to collect both shipments data and shipment-weighted average efficiency data dating back to 1993. In addition, DOE hopes to collect market share efficiency (*i.e.*, data on the distribution of product shipments by efficiency) for each of the product classes.

Manufacturer Costs

Incremental cost data (in U.S. dollars) include the materials, labor, and overhead needed to take basic models from the current minimum DOE baseline efficiency standard to each higher efficiency level. The depreciation of the conversion capital expenditures is an important component of the overhead for DOE to understand. Therefore, DOE is requesting information about conversion capital expenditures by efficiency level.

APPENDIX A - ENGINEERING ANALYSIS DATA REQUEST SHEETS

Aggregated industry data is requested for tables A-1 through A-6.

Table A-1 Market Share Product Class Data (percent)*

	Standard Sized Refrigerators & Refrigerator Freezers								Standard Sized Freezers				Compact Sized Ref & Ref Freezer					Compact Freezer		
	Product Class								Product Class				Product Class					Product Class		
Year	1	2	3	4	5	6	7	19	8	9	10	20	11	12	13	14	15	16	17	18
2000																				
2001																				
2002																				
2003																				
2004																				
2005																				
2006																				

* Total market share percentages for each year should equal 100%.

Table A-2 Shipment-Weighted Efficiency Data (Annual Energy Consumption in kWh/year)

	Standard Sized Refrigerators & Refrigerator Freezers								Standard Sized Freezers				Compact Sized Ref & Ref Freezer					Compact Freezer		
	Product Class								Product Class				Product Class					Product Class		
Year	1	2	3	4	5	6	7	19	8	9	10	20	11	12	13	14	15	16	17	18
1990																				
1991																				
1992																				
1993																				
1994																				
1995																				
1996																				
1997																				
1998																				
1999																				
2000																				
2001																				
2002																				
2003																				
2004																				
2005																				
2006																				

Table A-3 Market Share Efficiency Data: Standard-Sized Refrigerators and Refrigerator-Freezers

Product Class													
1		2		3		4		5		6		7	
Effcy Bins*	Mkt Share for 2005 or 2006** (percent)	Effcy Bins*	Mkt Share for 2005 or 2006** (percent)	Effcy Bins*	Mkt Share for 2005 or 2006** (percent)	Effcy Bins*	Mkt Share for 2005 or 2006** (percent)	Effcy Bins*	Mkt Share for 2005 or 2006** (percent)	Effcy Bins*	Mkt Share for 2005 or 2006** (percent)	Effcy Bins*	Mkt Share for 2005 or 2006** (percent)
Baseline		Baseline		Baseline		Baseline		Baseline		Baseline		Baseline	
15%		15%		15%		15%		15%		15%		15%	
20%		20%		20%		20%		20%		20%		20%	
25%		25%		25%		25%		25%		25%		25%	
30%		30%		30%		30%		30%		30%		30%	

* Efficiency bins represent the baseline level and energy use reductions below the baseline. Bins are labeled according to the lowest efficiency value for the bin. Hence the energy use of the Baseline bin is between 0% and 14.9% less than that of the Maximum Energy Use, the energy use of the 15% bin is between 15% and 19.9% less than the Maximum Energy Use, etc.

** Total market share percentage should equal 100%

Table A-4 Market Share Efficiency Data: Standard-Sized Freezers

Product Class					
8		9		10	
Effcy Bins*	Mkt Share for 2005 or 2006** (percent)	Effcy Bins*	Mkt Share for 2005 or 2006** (percent)	Effcy Bins*	Mkt Share for 2005 or 2006** (percent)
Baseline		Baseline		Baseline	
15%		15%		15%	
20%		20%		20%	
25%		25%		25%	
30%		30%		30%	

* Efficiency bins represent the baseline level and energy use reductions below the baseline. Bins are labeled according to the lowest efficiency value for the bin. Hence the energy use of the Baseline bin is between 0% and 14.9% less than that of the Maximum Energy Use, the energy use of the 15% bin is between 15% and 19.9% less than the Maximum Energy Use, etc.

** Total market share percentage should equal 100%

Table A-5 Market Share Efficiency Data: Compact-Sized Refrigerators and Refrigerator-Freezers

Product Class									
11		12		13		14		15	
Effcy Bins*	Mkt Share for 2005 or 2006** (percent)	Effcy Bins*	Mkt Share for 2005 or 2006** (percent)	Effcy Bins*	Mkt Share for 2005 or 2006** (percent)	Effcy Bins*	Mkt Share for 2005 or 2006** (percent)	Effcy Bins*	Mkt Share for 2005 or 2006** (percent)
Baseline		Baseline		Baseline		Baseline		Baseline	
15%		15%		15%		15%		15%	
20%		20%		20%		20%		20%	
25%		25%		25%		25%		25%	
30%		30%		30%		30%		30%	

* Efficiency bins represent the baseline level and energy use reductions below the baseline. Bins are labeled according to the lowest efficiency value for the bin. Hence the energy use of the Baseline bin is between 0% and 14.9% less than that of the Maximum Energy Use, the energy use of the 15% bin is between 15% and 19.9% less than the Maximum Energy Use, etc.

** Total market share percentage should equal 100%

Table A-6 Market Share Efficiency Data: Compact-Sized Freezers

Product Class					
16		17		18	
Effcy Bins*	Mkt Share for 2005 or 2006** (percent)	Effcy Bins*	Mkt Share for 2005 or 2006** (percent)	Effcy Bins*	Mkt Share for 2005 or 2006** (percent)
Baseline		Baseline		Baseline	
15%		15%		15%	
20%		20%		20%	
25%		25%		25%	
30%		30%		30%	

* Efficiency bins represent the baseline level and energy use reductions below the baseline. Bins are labeled according to the lowest efficiency value for the bin. Hence the energy use of the Baseline bin is between 0% and 14.9% less than that of the Maximum Energy Use, the energy use of the 15% bin is between 15% and 19.9% less than the Maximum Energy Use, etc.

** Total market share percentage should equal 100%

Table A-7A Manufacturer Cost Data

Product Class	3. Auto defrost with top mount freezer without TTD ice service				3. Auto defrost with top mount freezer without TTD ice service				5. Auto defrost with bottom mount freezer without TTD ice service			
Total Volume (cuft)	**15**				**21**				**18**			
Efficiency Level	1 Old EStar 15%	2 New EStar 20%	3 CEE Tier 2 25%	4 CEE Tier 3 30%	1 Old EStar 15%	2 New EStar 20%	3 CEE Tier 2 25%	4 CEE Tier 3 30%	1 Old EStar 15%	2 New EStar 20%	3 CEE Tier 2 25%	4 CEE Tier 3 30%
Average Incremental Costs ($ Per Unit)*												
Material												
Labor												
Overhead#												
Minimum Incremental Costs ($ Per Unit)*												
Material												
Labor												
Overhead#												
Maximum Incremental Costs ($ Per Unit)*												
Material												
Labor												
Overhead#												
Conversion Capital Expenditures ($, Millions)												
Building CAPX												
Tooling/ Equipment CAPX												
One Time Product Conversion Expenses ($, Millions)												
R&D												
Marketing												

Depreciation on the conversion capital expenditure should NOT be included in the incremental overhead.

* Incremental costs per unit should be reported relative to the baseline unit's cost. The baseline unit complies with the federal standards as tabulated in Table 5-1.

Table A-7B Manufacturer Cost Data, continued

Product Class	5. Auto defrost with bottom mount freezer without TTD ice service				7. Auto defrost with side mount freezer with TTD ice				7. Auto defrost with side mount freezer with TTD ice			
Total Volume (cuft)	25				22				25			
Efficiency Level	1 Old EStar 15%	2 New EStar 20%	3 CEE Tier 2 25%	4 CEE Tier 3 30%	1 Old EStar 15%	2 New EStar 20%	3 CEE Tier 2 25%	4 CEE Tier 3 30%	1 Old EStar 15%	2 New EStar 20%	3 CEE Tier 2 25%	4 CEE Tier 3 30%
Average Incremental Costs ($ Per Unit)*												
Material												
Labor												
Overhead#												
Minimum Incremental Costs ($ Per Unit)*												
Material												
Labor												
Overhead#												
Maximum Incremental Costs ($ Per Unit)*												
Material												
Labor												
Overhead#												
Conversion Capital Expenditures ($, Millions)												
Building CAPX												
Tooling/ Equipment CAPX												
One Time Product Conversion Expenses ($, Millions)												
R&D												
Marketing												

Depreciation on the conversion capital expenditure should NOT be included in the incremental overhead.
* Incremental costs per unit should be reported relative to the baseline unit's cost. The baseline unit complies with the federal standards as tabulated in Table 5-1.

Table A-7C Manufacturer Cost Data, continued

Product Class	9. Upright freezers with automatic defrost				9. Upright freezers with automatic defrost			
Total Volume (cuft)	**14**				**20**			
Efficiency Level	1 EStar 10%	2 20%	3 25%	4 30%	1 EStar 10%	2 20%	3 25%	4 30%
Average Incremental Costs ($ Per Unit)*								
Material								
Labor								
Overhead#								
Minimum Incremental Costs ($ Per Unit)*								
Material								
Labor								
Overhead#								
Maximum Incremental Costs ($ Per Unit)*								
Material								
Labor								
Overhead#								
Conversion Capital Expenditures ($, Millions)								
Building CAPX								
Tooling/ Equipment CAPX								
One Time Product Conversion Expenses ($, Millions)								
R&D								
Marketing								

Depreciation on the conversion capital expenditure should NOT be included in the incremental overhead.
* Incremental costs per unit should be reported relative to the baseline unit's cost. The baseline unit complies with the federal standards as tabulated in Table 5-1.

Table A-7D Manufacturer Cost Data, continued

Product Class	10. Chest freezers and all other freezers except compact freezers				10. Chest freezers and all other freezers except compact freezers			
Total Volume (cuft)	**15**				**22**			
Efficiency Level	1 EStar 10%	2 20%	3 25%	4 30%	1 EStar 10%	2 20%	3 25%	4 30%
Average Incremental Costs ($ Per Unit)*								
Material								
Labor								
Overhead#								
Minimum Incremental Costs ($ Per Unit)*								
Material								
Labor								
Overhead#								
Maximum Incremental Costs ($ Per Unit)*								
Material								
Labor								
Overhead#								
Conversion Capital Expenditures ($, Millions)								
Building CAPX								
Tooling/ Equipment CAPX								
One Time Product Conversion Expenses ($, Millions)								
R&D								
Marketing								

Depreciation on the conversion capital expenditure should NOT be included in the incremental overhead.
* Incremental costs per unit should be reported relative to the baseline unit's cost. The baseline unit complies with the federal standards as tabulated in Table 5-1.

Table A-7E Manufacturer Cost Data, continued

Product Class	11. Compact refrigerators and refrigerator freezers with manual defrost.				11. Compact refrigerators and refrigerator freezers with manual defrost.			
Total Volume (cuft)	**2.5**				**5.5**			
Efficiency Level	1 10%	2 EStar/ CEE Tier1 20%	3 CEE Tier 2 25%	4 CEE Tier 3 30%	1 10%	2 EStar/ CEE Tier1 20%	3 CEE Tier 2 25%	4 CEE Tier 3 30%
Average Incremental Costs ($ Per Unit)*								
Material								
Labor								
Overhead#								
Minimum Incremental Costs ($ Per Unit)*								
Material								
Labor								
Overhead#								
Maximum Incremental Costs ($ Per Unit)*								
Material								
Labor								
Overhead#								
Conversion Capital Expenditures ($, Millions)								
Building CAPX								
Tooling/ Equipment CAPX								
One Time Product Conversion Expenses ($, Millions)								
R&D								
Marketing								

Depreciation on the conversion capital expenditure should NOT be included in the incremental overhead.
* Incremental costs per unit should be reported relative to the baseline unit's cost. The baseline unit complies with the federal standards as tabulated in Table 5-1.

Table A-7F Manufacturer Cost Data, continued

Product Class	18. Compact Chest Freezers.				18. Compact Chest Freezers.			
Total Volume (cuft)	**3.5**				**7**			
Efficiency Level	1 10%	2 EStar 20%	3 25%	4 30%	1 10%	2 EStar 20%	3 25%	4 30%
Average Incremental Costs ($ Per Unit)*								
Material								
Labor								
Overhead#								
Minimum Incremental Costs ($ Per Unit)*								
Material								
Labor								
Overhead#								
Maximum Incremental Costs ($ Per Unit)*								
Material								
Labor								
Overhead#								
Conversion Capital Expenditures ($, Millions)								
Building CAPX								
Tooling/ Equipment CAPX								
One Time Product Conversion Expenses ($, Millions)								
R&D								
Marketing								

Depreciation on the conversion capital expenditure should NOT be included in the incremental overhead.
* Incremental costs per unit should be reported relative to the baseline unit's cost. The baseline unit complies with the federal standards as tabulated in Table 5-1.
Direct material – Costs of raw materials including scrap that can be traced to final or end products. Direct material costs do not include indirect material costs which are attributed to supplies that may be used in the production process but are not assigned to final products (*e.g.*, lubricating oil for production machinery).
Direct labor – The earnings of workers who assemble parts into a finished good for operate machines in the production process. Direct labor includes the fringe benefits of direct laborers such as group health care, as well as overtime pay. Direct labor does not include indirect labor which is defined as the earnings of employees who do not work directly in assembling a product, such as supervisors, janitors, stockroom personnel, inspectors, and forklift operators.
Overhead – Factory overhead excluding depreciation. Factory overhead includes indirect labor, downtime, set-up costs, indirect material, expendable tools, maintenance, property taxes, insurance on assets, and utility costs. Factory overhead does not include selling, general, and administrative costs (SG&A); research and development (R&D); interest; or profit (accounted for by DOE separately).
Full Production Cost = Direct Material + Direct Labor + Overhead (factory) + Depreciation
Full Cost of Product = Full Production Cost + Non-production Costs (SG&A, R&D, interest, and profit)

Other Information:

1. What depreciation method would your company use to depreciate the conversion capital expenditures? ____.

Specific product information is requested from manufacturers to support the assessment of the impact of the test procedure change proposed by AHAM. This information is itemized in Tables A-8A and A-8B below. DOE requests general information and Energy Testing information according to the current test procedure and with the proposed new cabinet temperatures (Items A, B, and C listed in the tables) for all products with distinct energy characteristics that represent significant sales volume for a manufacturer. For example, different models that have the same geometry and system but different colors are considered to have the same energy characteristics.

Table A-8A: Product Data

A: General Information	**Product Class**	
	Manufacturer/Brand	
	Model Number	
	Freezer Volume (cuft)	
	Fresh Food Volume (cuft)	
	Energy Label Energy (kWh/year)	
	Defrost Type (Manual, Automatic, Long-Time, Variable)	
	Anti-sweat Heater Type: Hot Gas, Hot Liquid, Electric, Adaptive Electric, Refrigerant/Electric Combination	

Table A-8B: Product Data, continued

B: Energy Testing: Current Procedure	**Test Procedure Appendix A1 Section 3.2 or Appendix B1 Section 3.2 Standardized Test Temperatures[1]**	
	Use Second Test for Long-Time or Variable-Defrost Unit?	
	Use Third Test for Variable-Defrost Unit?	
	Use two-part test for dual-compressor unit with two automatic defrost systems?	
	1st Set of Temperatures **FF Temperature** **FZR Temperature** **ET** **ETA (if two-part test)[2]** **ETB (if two-part test)[3]** **Steady T_{FF} and T_{FZR}, MTBD (if var. defrost test)**	
	2nd Set of Temperatures **FF Temperature** **FZR Temperature** **ET** **ETA (if two-part test)[2]** **ETB (if two-part test)[3]** **Steady T_{FF} and T_{FZR}, MTBD (if var. defrost test)**	
	Calculated Energy Use E	
C: Energy Testing with proposed new cabinet temperatures[4]	**3rd Set of Temperatures (if needed for energy calculation)** **FF Temperature** **FZR Temperature** **ET** **ETA (if two-part test)[2]** **ETB (if two-part test)[3]** **Steady T_{FF} and T_{FZR}, MTBD (if var. defrost test)**	
	Calculated Energy Use E	

[1]Options of All-Refrigerator 38˚F FF Compartment; Refrigerator 15˚F FZR Compartment; Refrigerator-Freezer 5˚F FZR Compartment; Freezer 0˚F.
[2]ETA defined as 1440xEP1xK/T1, *i.e.*, the first expression in Equation 5.2.1.2 or Equation 5.2.1.3 of the DOE Test Procedure, where K=0.85 for Freezers and K=1 for all other products.
[3]ETB defined as (EP2-(EP1xT2/T1))xKx12/CT, *i.e.*, the second expression in Equation 5.2.1.2 or Equation 5.2.1.3 of the DOE Test Procedure, where K=0.85 for Freezers and K=1 for all other products.
[4]All-Refrigerator 39˚F FF Compartment; Refrigerator 15˚F FZR Compartment; Refrigerator-Freezer 5˚F FZR Compartment; Freezer 0˚F.

A list of models under consideration for analysis as prototypical products to be used for reverse engineering teardown and energy use analysis is listed in Table A-9 below. DOE welcomes input regarding selection of models of this prototypical product list and comment on whether other models may be more representative of their product classes than those listed. Complete design data allowing manufacturing cost analysis and energy use analysis are needed for models which are selected as representative models for the product classes. A nearly complete list of the needed data for energy use analysis is tabulated in Table 10.

Table A-9: List of Products Under Consideration for Reverse Engineering and Energy Use Analysis

Product Class	Manufacturer	Model	Total Volume (cuft)	Energy Star?
3	GE	GTH16BBSLCC	15.5	Yes
	GE	GTS16BBSRCC	15.7	No
	Frigidaire	FRT15HB3J	15	Yes
	Frigidaire	FRT15B3J	15	No
	Frigidaire	FRT21HS6A	20.5	Yes
	Frigidaire	FRT21S6A	20.6	No
5	Amana	ABB1921DEW	18.6	Yes
	Maytag	MBF2556KEW	25.1	Yes
	General Electric	PDSF5NBXWW	25.3	Yes
	Whirlpool	GB9SHKXM	18.6	Yes
7	GE	GSL22JFTBS	22	Yes
	GE	GSS22IBTCC	22	No
	Whirlpool	ED2FHEXS	21.8	Yes
	Whirlpool	ED2CHQXK	21.9	No
	Frigidaire	FRS6HR5J	26	Yes
	Frigidaire	FRS6R3J	26	No
9	GE	FUF14DURWW	13.7	Yes
	GE	FUF14SURWW	13.7	No
	W.C. Wood	F2003RW3	20.1	No
	W.C. Wood	F2017RW3	20.1	Yes
	Frigidaire	FFH1767G	16.7	Yes
	Frigidaire	FFU1764F	16.7	No
10	W.C. Wood	C1517W3	14.8	Yes
	W.C. Wood	C1501W3	14.8	No
	Frigidaire	GLFC2027F	19.7	No
	GE	FCM20DPWH	19.7	No
11	Haier	ESR042PBB	4.1	Yes
	Haier	HSE04WNCWW	4.4	No
	Haier	HNSB02	1.7	No
18	W.C. Wood	CF04WQ	3.6	No
	Haier	HNCM070E	7	No
	GE	FCM7SUWW	7	No

Table A-10A: Prototypical Product Data

A1: Cabinet Data	**Height** **Width** **Depth**	
	Gasket Depth **Door Edge Thickness**	
	Outer Liner Thickness **Material** **Inner Liner Thickness** **Material**	
	FZR Wedge Depth **Flange Thickness** **FF Wedge Depth** **Flange Thickness**	
	FZR Volume: Evaporator/Duct **Food** **Shelves** **FF Volume: Evaporator/Duct** **Food** **Shelves**	
	Compressor Compartment Height **Top Depth** **Bottom Depth** **Temp Elevation Above Ambient: Compartment** **Condenser Air Inlet**	
	FZR Insulation Thickness: Top **Bottom** **Sides** **Back** **Door** **FF Insulation Thickness: Top** **Bottom** **Sides** **Back** **Door** **Mullion Thickness** **Centerline distance from Top or Left Exterior**	
	Insulation k (at two representative temperatures if possible)	

Table A-10B: Prototypical Product Data, continued

A2: Cabinet Data 2	**Gasket Heat Leak per ˚F per ft: FZR** **FF**	
	Automatic Defrost Wattage **Timer Interval or Min/Max (hr)** **Shutdown Control: Time or Temperature?** **Shutdown Time (min) or Temp (˚F)**	
	Control Board Power (W) **Location (FF, FZR, Exterior)**	
	Electric Anti-sweat Power (W) **Control (None, On/Off Manual, Adaptive, On/Off and Adaptive)** **Power by Location: Mullion** **FF External Frame** **FZR External Frame** **Refrigerant Line Anti-sweat: Liquid/Vapor** **Tube OD/Wall (inch)** **Sequence: FZR, FF, External (including Pan)** **Length Each Section (ft)**	
	Other Loads: Watts, Location (FF, FZR, External) **Estimated Load of Penetrations, TTD, etc. (Btu/hr)**	

Table A-10C: Prototypical Product Data, continued

B: General System Data	**Number of Compressors[5]** **Number of Evaporators[5]** **Refrigerant** **Refrigerant Charge**	
	Refrigerant Flow Control: Cap Tube or Other? **Cap Tube ID/Length** **Suction Line OD/Wall** **SLHX Length** **Length, Cold End of Cap Tube** **Typical Evaporator Exit Superheat/Quality** **Typical Condenser Exit Subcooling**	

[5]If the product contains more than one compressor or evaporator, provide compressor or evaporator data for all compressors and/or evaporators contained in the product. Describe the integration of key system components, *i.e.*, sequence of evaporators in single-compressor/dual evaporator system with indication of additional components (*i.e.*, interchanger heat exchangers) between evaporators.

Table A-10D: Prototypical Product Data, continued

C: Forced-Convection Evaporator(s)	**Fan Input Wattage** **Air Flow (cfm)** **Blade Type (stamped metal, plastic, etc.)** **Blade diameter** **Motor Type (shaded pole, PSC, etc.)** **Motor Nominal Output (W)**	
	Tubing OD/Wall **Material** **Internal Enhancement Type (None, Rifled, etc.)**	
	Number of Parallel Refrigerant Circuits	
	Tube Arrangement In-line or Staggered? **Number of Rows parallel to air flow** **Tube Spacing** **Number of Rows transverse to air flow** **Tube Spacing** **Sketch of Refrigerant Circuiting vs. Air Flow** **Tube Finned Length**	
	Fin Density (FPI) **Fin Material** **Thickness** **Type (Flat, Wavy, etc.)**	
D: Natural-Convection Evaporator(s)	**Constitute FZR Section Walls?** **Plate Dimensions and Orientation** **Plate Exposures: Side 1** **Side 2 (FF, FZR, Exterior Wall, Liner to FF, etc.)**	
	Number of Parallel Refrigerant Circuits **Tube OD/Wall** **Length**	

Table A-10E: Prototypical Product Data, continued

E: Forced-Convection Condenser(s)	**Fan Input Wattage** **Air Flow (cfm)** **Blade Type (stamped metal, plastic, etc.)** **Blade diameter** **Motor Type (shaded pole, PSC, etc.)** **Motor Nominal Output (W)**	
	Tubing OD/Wall **Material** **Internal Enhancement Type (None, Rifled, etc.)**	
	Number of Parallel Refrigerant Circuits	

	Tube Arrangement In-line or Staggered?
	Number of Rows parallel to air flow
	   Tube Spacing
	Number of Rows transverse to air flow
	   Tube Spacing
	Sketch of Refrigerant Circuiting vs. Air Flow
	Tube Finned Length	

	Fin Density (FPI)
	Fin Material
	   Type (Wire, Flat, Wavy, etc.)
	   Thickness (Diameter if Wires)
	   Wire Fins Transverse to Air Flow?	

F: Natural Convection Condenser(s)	**Tubing OD/Wall** **Material** **Internal Enhancement Type (None, Rifled, etc.)**	
	Number of Parallel Refrigerant Circuits	

	Tube Arrangement In-line or Staggered?
	Tubes Vertical or Horizontal?
	Number of Rows Deep?
	   Tube Spacing
	Number of Rows Tall or Wide?
	   Tube Spacing
	Sketch of Refrigerant Circuiting
	Tube Finned Length	

	Fin Density (FPI)
	Fin Material
	   Type (Wire, Flat, Wavy, etc.)
	   Wire Diameter (or Thickness if not Wire)	

Table A-10F: Prototypical Product Data, continued

G: Compressor(s)	**Make/Model**
	Single-Speed or Variable-Speed?
	Rated Speed or Speed Range (rpm)
	Rating Point Capacity
	    Power Input
	    EER
	    Mass Flow
	Rating Point Conditions (SST, SCT, Superheat, Subcooling, Shell Cooling, other?)	

	ARI Performance Coefficients for Capacity, Power Input, Mass Flow (at multiple speeds as appropriate for variable-speed)	

APPENDIX B – SAMPLE QUESTIONS FOR ENGINEERING ANALYSIS FOLLOW-UP AND PRELIMINARY MANUFACTURER IMPACT ANALYSIS INTERVIEWS

DESIGN FOR ENERGY IMPROVEMENT INFORMATION REQUEST

DOE would like to confirm information on the incremental costs of increasing product efficiency by understanding the design options involved in the efficiency improvement.

1. Describe the typical design details as prompted below that affect energy use that are generally incorporated into a "baseline" refrigerator, refrigerator-freezer, or freezer separately for the broad categories (a) standard-size refrigerator or refrigerator-freezer with manual or partial automatic defrost, (b) standard-size refrigerator-freezer with automatic defrost, (c) standard-size upright freezer, (d) standard-size chest freezer, (e) compact refrigerator or refrigerator-freezer with manual defrost, and (f) compact chest freezer.
    - Compressor Single or Variable Speed?
    - Compressor Capacity?
    - Compressor EER?
    - Evaporator Fan Motor type (if applicable)?
    - Condenser Type (Forced-convection, natural convection)?
    - Condenser Fan Motor type (if applicable)?
    - Evap and Cond tube smooth, rifled, or other?
    - Evap and Cond fin styles?
    - Evap and Cond typical tube length?
    - Fan blade description, evaporator and/or condenser?
    - Average FZR compartment cabinet wall insulation thickness?
    - Average FF compartment cabinet wall insulation thickness?
    - Average FZR compartment door insulation thickness (if applicable)?
    - Average FF compartment door insulation thickness?
    - Describe any use of vacuum (or gas-filled) insulation panels?
    - Adaptive Defrost (if applicable)?
    - Defrost Initiation during off-cycle (if applicable)?
    - Anti-sweat heat refrigerant vapor, liquid, electric, or both for FZR compartment?
    - Anti-sweat heat refrigerant vapor, liquid, electric, or both for FF compartment?
    - Electric anti-sweat heater control?
    - Controls electronic or automatic?
    - If electronic, location of control board, user interface, and display(s)?
    - Advanced gasket designs?
    - Expansion Device Type(s)?

2. What design changes are typically associated with converting baseline products of each of the six broad categories mentioned above in Question 1 to Energy Star? What are the costs of the individual design options selected? Are the aggregated industry costs representative of your firm's costs?

3. Are there fundamental differences between required design changes that make the cost increment much higher for some product classes than others?

4. Would you help DOE understand and estimate the conversion capital investments that would be necessary at each candidate standard level? What is the nature of the capital investments?

PRELIMINARY MANUFACTURER IMPACT ANALYSIS TOPICS

1 Issues

1.1 What are the key issues for your company regarding a possible future product rulemaking?

2 Shipment Projections

2.1 What is your company's approximate market share in each of the product classes?
2.2 Would you expect your market share to change once standards become effective? Does your outlook change with higher efficiency levels?
2.3 How would you expect shipments to change for the industry as a whole as a function of standards and why?
2.4 Looking at price/cost effects only, how would you expect shipments to change for a 25 percent, 50 percent, 100 percent, or 200 percent manufacturer price/cost increase?

3 Conversion Costs

3.1 What level of capital expenditure and product conversion costs would you anticipate to make at higher standard levels? Please describe what they are and provide your best estimate of their respective magnitudes.
3.2 How would the imposition of new energy conservation standards affect capacity utilization and manufacturing assets at your domestic production facilities? Would a new standard result in stranded capital assets? Would any facilities be closed or downsized? Added or upgraded?
3.3 How might a new standard impact product innovation?

4 Product Mix and Profitability

4.1 How would your company's product mix and marketing strategy change with changes in the efficiency standard?
4.2 Would the current percentage of shipments at the Energy Star level be the same under a new standard?

4.3 What distribution channels are used from the manufacturer to the retail outlet? What is the share of product going through each distribution channel?
4.4 Generally, how would new product standards affect your customer mix, distribution channels, and corresponding profit margins?
4.5 How might a new standard affect the Energy Star program, and consequently your firm?

5 Market Shares and Industry Consolidation

5.1 In the absence of new standards, do you expect any industry consolidation?
5.2 How would new standards affect your ability to compete?
5.3 Could new standards disproportionately advance or harm the competitive positions of some firms?
5.4 Are there concerns over intellectual property?
5.5 Could new standards result in disproportionate economic or performance penalties for particular consumer/user subgroups?
5.6 Beyond price and energy efficiency, could new standards result in products that will be more or less desirable to consumers due to changes in product functionality, utility, or other features?

6 Cumulative Regulatory Burden

6.1 Are there recent or impending regulations on your specific product or other products that impose a cumulative burden on the industry?
6.2 If so, what is the total expected impact of those other regulations?

APPENDIX C – SUMMARY OF ITEMS FOR STAKEHOLDER COMMENT

Summary of all items for stakeholder comment contained in the framework document.

DOE invites stakeholder comments on all aspects of the material presented in this document. This comment box and others highlight issues on which DOE seeks comment and requests feedback from interested parties. DOE uses these comment boxes to ask specific questions about the approaches that it proposes to follow for the analyses required for the standards rulemaking. Such requests for stakeholder feedback are numbered according to the section in which they appear