Commercial Refrigeration Equipment (CRE)

Commercial Refrigeration: Regulatory History

August 2005

EPACT 2005 amended the Energy Policy and Conservation Act of 1975 (EPCA) to:

- Prescribe standards for self-contained commercial refrigerators, freezers, and refrigerator freezers with doors.
- Direct DOE to set standards by January 1, 2009 for remote condensing equipment, open cases, and ice-cream freezers.
- Direct DOE to determine whether to amend the standards set both by the 2009 DOE rulemaking and by EPACT 2005 and, if necessary, perform a rulemaking and publish amended standards by January 1, 2013.

January 2009

DOE published a Final Rule (74 FR 1092) establishing energy conservation standards (ECS) for the equipment types specified in 42 U.S.C. 6313(c)(5).

February 2012

DOE published CRE Test Procedure Final Rule—with IBRs for American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 72-2005, Air-Conditioning, Heating, and Refrigeration Institute (AHRI) 1200-2006, and AHRI 1200-2010.

December 2012

The American Energy Manufacturing Technical Corrections Act (AEMTCA) amended EPCA to prescribe standards for service over counter, self-contained, medium temperature equipment.

September 2013

DOE issued a notice codifying the AEMTCA amendment into the CFR.

Commercial Refrigeration: Regulatory History

March 2014
DOE published a Final Rule (79 FR 17726) to establish ECS for additional equipment types per 42 U.S.C. 6313(c)(5)(B), and amended ECS for previously covered equipment types per 42 U.S.C. 6313(c)(6)(A).

April 2014
DOE published CRE Test Procedure Final Rule (79 FR 22278) to reorganize the 2012 test procedures and improve clarity and accuracy of results.

May-June 2014
Multiple stakeholders filed petitions for review of the 2014 standards and test procedure rules.

August 2016
U.S. Court of Appeals for the 7th Circuit upheld DOE's 2014 energy conservation standard and test procedure rules for CRE.

March 2017
New CRE standards and test procedure went into effect.

Commercial Refrigeration: Market Overview

DOE defines commercial refrigerators, freezers, and refrigerator-freezers as refrigeration equipment that:

(1) Is not a consumer product (as defined in §430.2 of part 430)

(2) Is not designed and marketed exclusively for medical, scientific, or research purposes

(3) Operates at a chilled, frozen, combination chilled and frozen, or variable temperature

(4) Displays or stores merchandise and other perishable materials horizontally, semi-vertically, or vertically

(5) Has transparent or solid doors, sliding or hinged doors, a combination of hinged, sliding, transparent, or solid doors, or no doors

(6) Is designed for pull-down temperature applications or holding temperature applications

(7) Is connected to a self-contained condensing unit or to a remote condensing unit

Commercial Refrigeration: Market Overview

When beginning an ECS rulemaking, DOE develops information that provides a picture of the market for the equipment, including its purpose, the industry structure, and market characteristics.

- Major business types that use CRE:
  - **Food retail:** Supermarkets, supercenters, convenience stores, small grocery stores, and specialty stores such as meat markets
  - **Food service:** Limited-service and full-service restaurants and other foodservice businesses such as caterers and cafeterias
- DOE estimates 1.2 million units of commercial refrigeration equipment were shipped in 2019.
- Due to their use in food service and food retail operations that require product be constantly kept cold, commercial refrigeration equipment generally operates 24 hours per day, 365 days per year. Average energy consumption per unit is approximately 4,560 kWh/yr.
- At the time of the prior ECS Final Rule in 2014, CRE used 0.6 quads per year of primary energy, which accounted for approximately 4.0% of commercial building electricity use and 0.6% of total U.S. energy use.

Commercial Refrigeration: Market Failures

Pursuant to complying with Executive Order 12866, DOE identified market failures to justify the 2014 Final Rule's revision of CRE energy conservation standards.

Section 1(b)(1) of Executive Order 12866, ''Regulatory Planning and Review,'' 58 FR 51735 (October 4, 1993), requires each agency to identify the problem that it intends to address, including, where applicable, the failures of private markets or public institutions that warrant new agency action, as well as to assess the significance of that problem.

DOE identified the following problems:

- There may be a lack of consumer information and/or information processing capability about energy efficiency opportunities in the CRE market.
- There is asymmetric information among parties to a transaction and high costs of gathering information.
- There are external benefits resulting from energy efficiency that are not captured by the users of the equipment, e.g. benefits related to environmental protection, such as reduced emissions of greenhouse gasses.

EPCA Provisions for Equipment Classes

EPCA includes a provision for the establishment of separate equipment classes and separate standards based on performance-related features and the utility of such features to consumers.

- Product classes are established if DOE determines that covered products within such group:
  - (A) Consume a different kind of energy from that consumed by other covered products within such type (or class)
  - (B) Have a capacity or other performance-related feature which other products within such type (or class) do not have and such feature justifies a higher or lower standard from that which applies (or will apply) to other products within such type (or class).
- In making a determination of whether a performance-related feature justifies the establishment of a higher or lower standard, DOE must consider such factors as the utility to the consumer of such a feature, and such other factors DOE deems appropriate. (42 U.S.C. 6295(q)(1))

CRE Equipment Classes

CRE standards are established for 49 equipment classes (79 FR 17725) divided by equipment family name, condensing unit, and temperature.

Equipment Family Name	Abbreviation
Vertical Open	VOP
Semi-Vertical Open	SVO
Horizontal Open	HZO
Vertical Closed Transparent	VCT
Horizontal Closed Transparent	HCT
Vertical Closed Solid	VCS
Horizontal Closed Solid	HCS
Service Over Counter	SOC
Pull-Down	PD

Condensing Unit Designation	Abbreviation
Remote Condensing	RC
Self-Contained	SC

Temperature Designation	Rating Temperature	Abbreviation
Medium	38°F	M
Low	0°F	L
Ice-Cream	-15°F	I

Example 1: VOP.RC.M stands for Vertical Open equipment connected to a remote condensing unit and operating at medium temperature (38°F).

Example 2: HCT.SC.I stands for Horizontal Closed Transparent equipment that is self-contained operating at ice-cream temperature (-15°F).

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Existing CRE Standards

Each equipment class has a unique equation specifying the standard as a function of an equipment size descriptor.

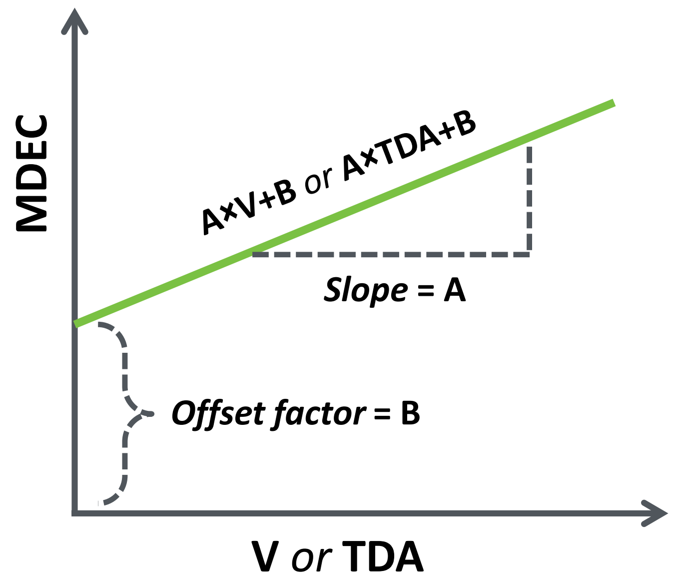
- Equipment size expressed in terms of:
  - **Total display area (TDA)** for all equipment classes covered by 2009 DOE Final Rule with transparent or open display areas
  - **Volume (V)** for all equipment classes previously covered by EPACT 2005 standards and for all equipment classes covered by 2009 DOE Final Rule with no transparent or open display areas

- Form of standards equations specifying maximum daily energy consumption (MDEC):

  MDEC = A × V + B

  or

  MDEC = A × TDA + B



CRE Technology Options

DOE identifies technologies that can be used to improve equipment efficiency as part of the Market and Technology Assessment.

- **Thermal load reduction** through thicker insulation, improved insulation, better doors, and reduced interior component power input.
- **Component power reduction**: lighting, fans, anti-sweat heaters.
- **Refrigeration system improvements**: compressors, heat exchangers.
- DOE identifies technologies through general research, discussion with manufacturers and other experts, review of equipment literature, and reverse engineering of equipment.

DOE Process to Preserve Product Utility, Performance

Screening factors described in the Process Rule elaborate on the statutory criteria provided in 42 U.S.C. 6295 and in part seek to eliminate problematic technology options early in the process of revising an energy efficiency standard.

- "Procedures, Interpretations and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products," 10 CFR Part 430 (**the Process Rule**) sets forth procedures to guide DOE in the consideration and promulgation of new or revised appliance efficiency standards under EPCA.
- The **Screening Analysis** eliminates design options that have adverse impacts on product utility or availability. Standards based on such design options are not considered technologically feasible.
- Specifically, technologies that would result in an adverse impact on the utility of the product to significant subgroups of consumers or would result in the unavailability of any covered product type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as products generally available in the United States at the time, will **not be considered further**. (Process Rule, section 5, paragraph (b)(3).)

CRE Technology Options Screened Out/Removed

Technologies were screened out or otherwise removed for reasons including utility concerns, inconclusive evidence, and insignificant improvement as measured by the test procedure.

Options that do not reduce Daily Energy Consumption (DEC) as measured by the test procedure	Description
Higher Efficiency Expansion Valves	Valves can be optimized for single-condition test.
Variable-Speed Condenser Fan Motors and Condenser Fan Motor Controllers	Insignificant benefit for single-condition test.
Anti-Sweat Heater Controllers	Insignificant benefit for constant-humidity test.
Liquid-Suction Heat Exchangers	Available information suggested little opportunity for efficiency improvement due in part to added pressure drop.
Options screened out	**Applicable screening criteria**
Air Curtain Design	Practicability to manufacture, install, and service: Viable advanced air curtain designs not identified.
Defrost Cycle Control	Practicability to manufacture, install, and service: Reliable sensor technologies not identified.
Antifog Films for Transparent Doors	Practicability to manufacture, install, and service: Inconclusive long-term performance, film degradation over equipment lifetime.

CRE Technology Options Screened Out/Removed

Options not considered in the Engineering Analysis	Description
Remote Ballast Location	Ballasts either already located remotely or purchased as part of transparent doors.
Variable-Speed Evaporator Fans/Controllers	Non-uniform cabinet temperature distribution, reduced air curtain performance.
Higher-Efficiency Fan Blades	Specific examples that can reduce shaft load not identified.
Low Pressure Differential Evaporators	Concerns about utility impacts of required face area and likely reduction in heat transfer performance in spite of fan power reduction.
Defrost Mechanisms (Hot Gas Defrost)	Remote condensing test procedure does not include hot gas defrost, insufficient demonstration of the technology for self-contained.

CRE Utility and Performance Issues

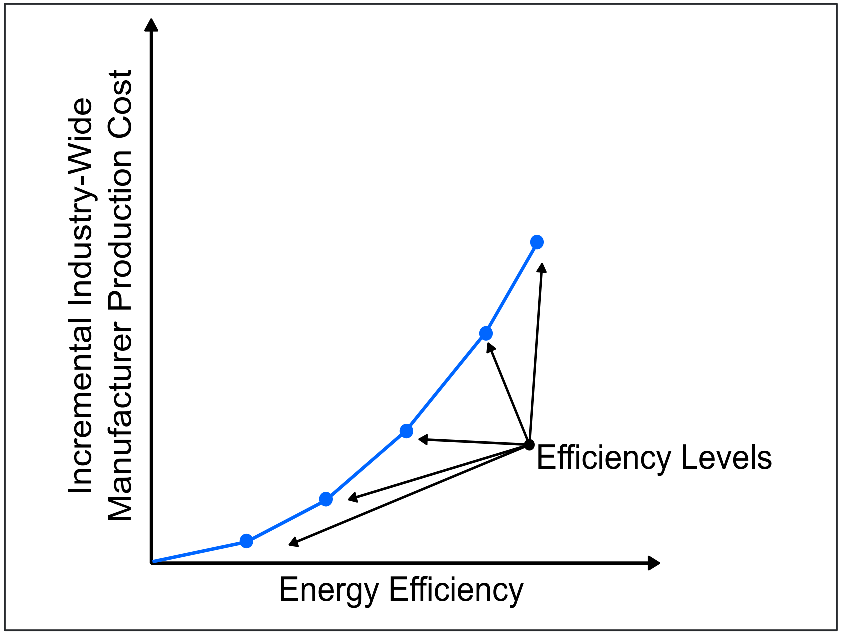
Stakeholders raised concerns regarding utility impacts of specific technology options. DOE screened out some technology options based on these comments but not others.

- **Variable-speed evaporator fans:** DOE did not consider variable-speed evaporator fans due to concerns about maintaining consistent product temperatures.
- **Insulation thickness increase:** DOE considered insulation thicknesses greater than baseline thickness but consistent with equipment observed in the market.
- **Evaporator size:** DOE considered a range of evaporator size and design details consistent with evaporators observed in the market.

Goal of Engineering Analysis

Our goal is to develop cost-efficiency curves that describe the relationship between efficiency level and cost.

- Efficiency levels are ***discrete energy efficiency tiers*** that serve as potential standard levels.
- Each efficiency level has an associated manufacturer production cost (MPC).
- Higher efficiency levels typically correspond to higher costs.
- To determine the relationships between efficiency levels and MPCs, DOE has multiple methodologies.
- Selection of methodology is generally dependent on the information available and characteristics of the regulated product.



Cost-Efficiency Curve

CRE Engineering: Representative Equipment Classes

Choose Representative Equipment

Define Baseline Models

Analyze More Efficient Designs

Calculate MPCs

Generate Cost Curves

Of the 49 CRE equipment classes, DOE directly analyzed 25 equipment classes.

Equipment Family		Remote Condensing			Self-Contained		
		Ice-Cream	Low	Medium	Ice-Cream	Low	Medium
Without Doors	VOP	x	✓	✓	x	x	✓
	SVO	x	x	✓	x	x	✓
	HZO	x	✓	✓	x	✓	✓
With Doors	VCT	x	✓	✓	✓	✓	✓
	VCS	x	x	x	✓	✓	✓
	HCT	x	x	x	✓	✓	✓
	HCS	x	x	x	x	✓	✓
	SOC	x	x	✓	x	x	✓
	PD	*	*	*	*	*	✓

✓ Equipment class directly analyzed

x Equipment class not directly analyzed

* Pull-down class is defined only for Self-Contained Medium Temperature

HCS = Horizontal Closed Solid
HCT = Horizontal Closed Transparent
HZO = Horizontal Open
PD = Pull-Down
SOC = Service Over Counter
SVO = Semi-Vertical Open
VCS = Vertical Closed Solid
VCT = Vertical Closed Transparent
VOP = Vertical Open

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CRE Engineering: Baseline Models

- Choose Representative Equipment
- **Define Baseline Models**
- Analyze More Efficient Designs
- Calculate MPCs
- Generate Cost Curves

DOE determined components and designs that would typically be used for baseline equipment.

Component	Equipment Class			
	HZO.SC.L	VCT.RC.M	VCT.SC.L	VCS.SC.M
Lighting		LED	T8 Electronic	
Evaporator	Enhanced	Standard	Standard	Standard
Evap Fan Motor	Brushless DC	Brushless DC	Shaded Pole	Shaded Pole
Doors (VCT)		High Perfor-mance	Standard	
Condenser	Enhanced	Standard	Standard	Standard
Cond Fan Motor	Brushless DC		Shaded Pole	Shaded Pole
Compressor	High-Efficiency Hermetic		Single-Speed Hermetic	Single-Speed Hermetic

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CRE Engineering: Design Option Approach

Choose Representative Equipment

Define Baseline Models

Analyze More Efficient Designs

Calculate MPCs

Generate Cost Curves

CRE used a design option approach to determine efficiency improvement levels (VCS.SC.M example).

Efficiency Level	Design Option Added	Daily Energy Use (kWh)
1	Baseline	6.31
2	Permanent Split Capacitor Evaporator Fan Motor	5.29
3	Brushless Direct Current Evaporator Fan Motor	4.03
4	Brushless Direct Current Condenser Fan Motor	3.84
5	Enhanced-UA Condenser Heat Exchanger	3.69
6	Additional 0.5 Inches of Insulation	3.48
7	High-Efficiency Reciprocating Compressor	3.45
8	Enhanced Evaporator Heat Exchanger	3.43
9	Vacuum Insulated Panels (max. tech)	3.03

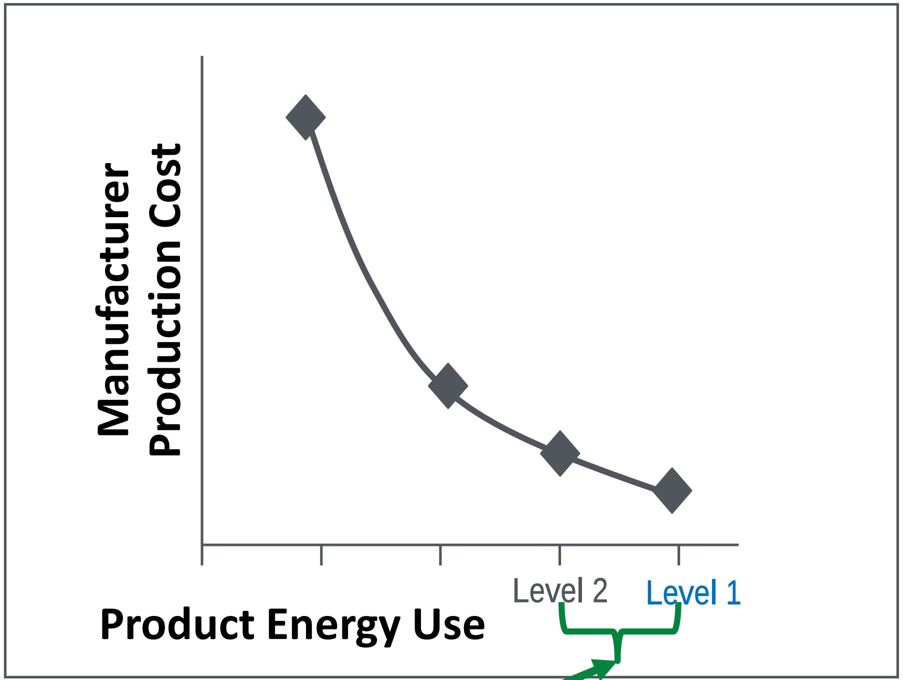
CRE Engineering: Design Option Approach

DOE calculated the incremental energy savings of each design option in the analysis that accounts for cabinet thermal load, refrigeration system performance, and component power input.

Design Option Level	Design Option Added Above Baseline
Level 1	Baseline
Level 2	Level 1 + PSC Evap. Fan Motor

Energy Consumption Calculation

Level 1 Energy Consumption − **Level 2 Energy Consumption** = **Level 2 Incremental Energy Savings**



Performance Analysis: Heat Load Calculations

Load calculations are based on the geometry and design parameters of the unit modeled, as well as on the conditions of the DOE test procedure, and include:

Lighting power emitted into case as heat.
Key parameters: lighting wattage per fixture, number of fixtures, run time.

Anti-sweat heat emitted into case (70% of input power).

Heat gain through glass.
Key parameters: case and ambient temperatures, door U-factor, glass area.

Fan power rejected into case as heat.
Key parameters: fan input power, number of fans, run time.

Conduction through walls.
Key parameters: insulation R-value, wall area, temperature differential.

Warm air infiltration from door openings.
Key parameters: temperature differential, humidity, infiltrated air mass.

DOE TP conditions: 75°F, 55% relative humidity, 8-hour door opening period

- Case geometries and design parameters based on manufacturer literature.
- Thermal performance of case and components based on manufacturer and supplier literature and interviews.

Performance Analysis: Refrigeration System

Refrigeration system performance was calculated based on heat exchanger effectiveness and compressor performance. Component energy use was summed to determine daily energy consumption.

Refrigeration System Performance

Evaporator: Evaporating temperature required to transfer system capacity or cabinet load based on design detail.

Remote Condensing: Test procedure defines compressor Energy Efficiency Ratio (EER) based on evaporating temperature.

Self-Contained Condensing: Compressor performance data provides capacity and power input based on evaporating and condensing temperatures. Condensing temperature based on heat rejection load and design detail.

Daily Energy Consumption Summation for Energy-Using Components:

Compressor:
Thermal Load / EER

Evaporator Fan

Condenser Fan

Lighting

Anti-Sweat Heaters

Condensate Pan Heaters

Defrost Heaters

CRE Engineering: MPCs

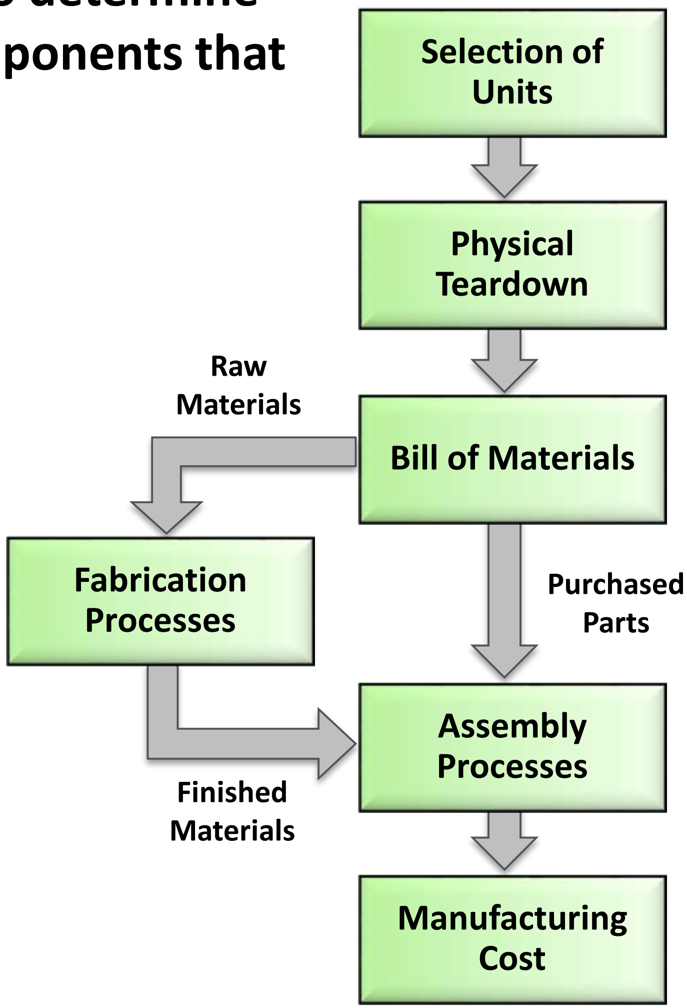
DOE used teardown analysis to estimate the cost of CRE equipment including the design options implemented.

- Costs for the core case of the refrigerated cabinets, including all non-energy-consuming components, were developed from teardowns of units currently on the market.
- Costs for energy-consuming components and design options were developed through research of industry literature, supplier price quotes, and manufacturer interviews.
- Estimates of manufacturer markup were developed with data from the manufacturer interview process.
- Design option costs were applied to core case costs at each modeled efficiency level to yield MPC values. Markups and outbound freight were added to yield manufacturer selling price (MSP) values.

Engineering Analysis: Product Teardowns

DOE uses a reverse engineering methodology to determine costs of representative equipment and the components that drive efficiency.

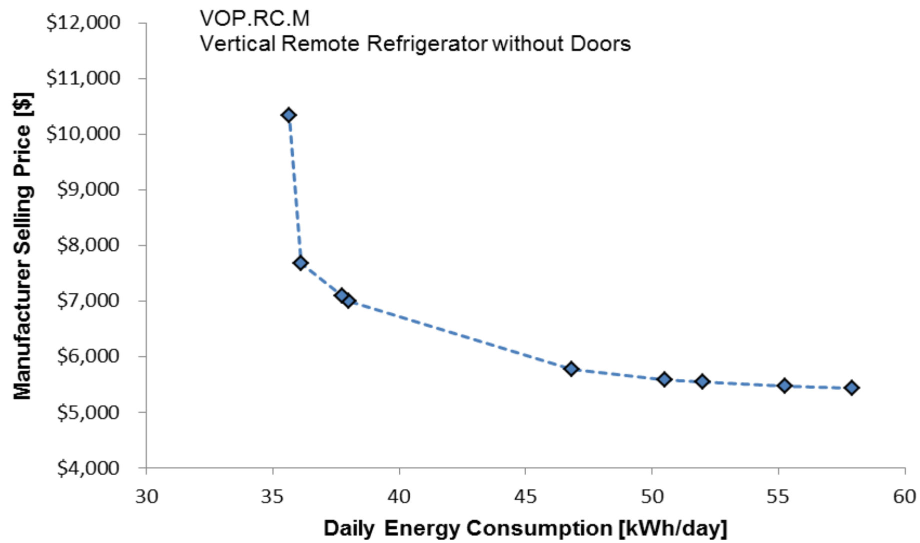
- Unit teardown requires recording size, weight, method of manufacture, and manufacturing details for each component as the unit is disassembled to generate a bill of materials (BOM).
- DOE incorporates raw materials prices, component costs, fabrication techniques, manufacturing line equipment, and production volumes estimates to develop MPCs.
- Teardown Analysis generates manufacturing, material, labor, and overhead costs.



CRE Engineering: Price-Efficiency Relationship

- Choose Representative Equipment
- Define Baseline Models
- Analyze More Efficient Designs
- Calculate MPCs
- **Generate Cost Curves**

The final output of the Engineering Analysis is a set of cost-efficiency curves, one for each analyzed equipment class, depicting equipment cost and performance at each efficiency level modeled.



Design Option Level	Calculated Daily Energy Consumption kWh/day	Manufacturer Selling Price $	Design Option Added Above the Baseline
Level 1	57.90	5,436	Baseline
Level 2	55.28	5,471	Level 1 + Permanent Split Cap. Evap. Fan Motor
Level 3	51.99	5,546	Level 2 + Brushless DC Evap. Fan Motor
Level 4	50.52	5,587	Level 3 + Super T8 Lighting
Level 5	46.84	5,763	Level 4 + Night Curtains
Level 6	38.02	7,003	Level 5 + LED Lighting with Occupancy Sensors
Level 7	37.76	7,081	Level 6 + Additional 1/2" Insulation
Level 8	36.10	7,681	Level 7 + Enhanced-UA Evaporator Coil
Level 9	35.65	10,324	Level 8 + Vacuum Insulated Panels

CRE Engineering: Scaling Results

- Choose Representative Equipment
- Define Baseline Models
- Analyze More Efficient Designs
- Calculate MPCs
- **Generate Cost Curves**

DOE estimates performance for equipment classes not directly analyzed.

- DOE developed an extension approach to apply standards developed for the 21 representative primary equipment classes to the remaining 28 secondary equipment classes.
- DOE's matched-pair analyses compared calculated energy consumption levels for pieces of equipment with similar designs but one major construction or operational difference that corresponds to a change in the equipment family, condenser configuration, or operating temperature.
- DOE developed a set of multipliers to account for differences between performance of directly analyzed and remaining equipment classes.

Examples of matched pairs used for extension analysis based on ratio of self-contained to remote condensing performance:

Primary Equipment Class	Secondary Equipment Class
SOC.RC.I	SOC.SC.I
HCT.RC.I	HCT.SC.I
VCS.RC.I	VCS.SC.I
HCS.RC.I	HCS.SC.I

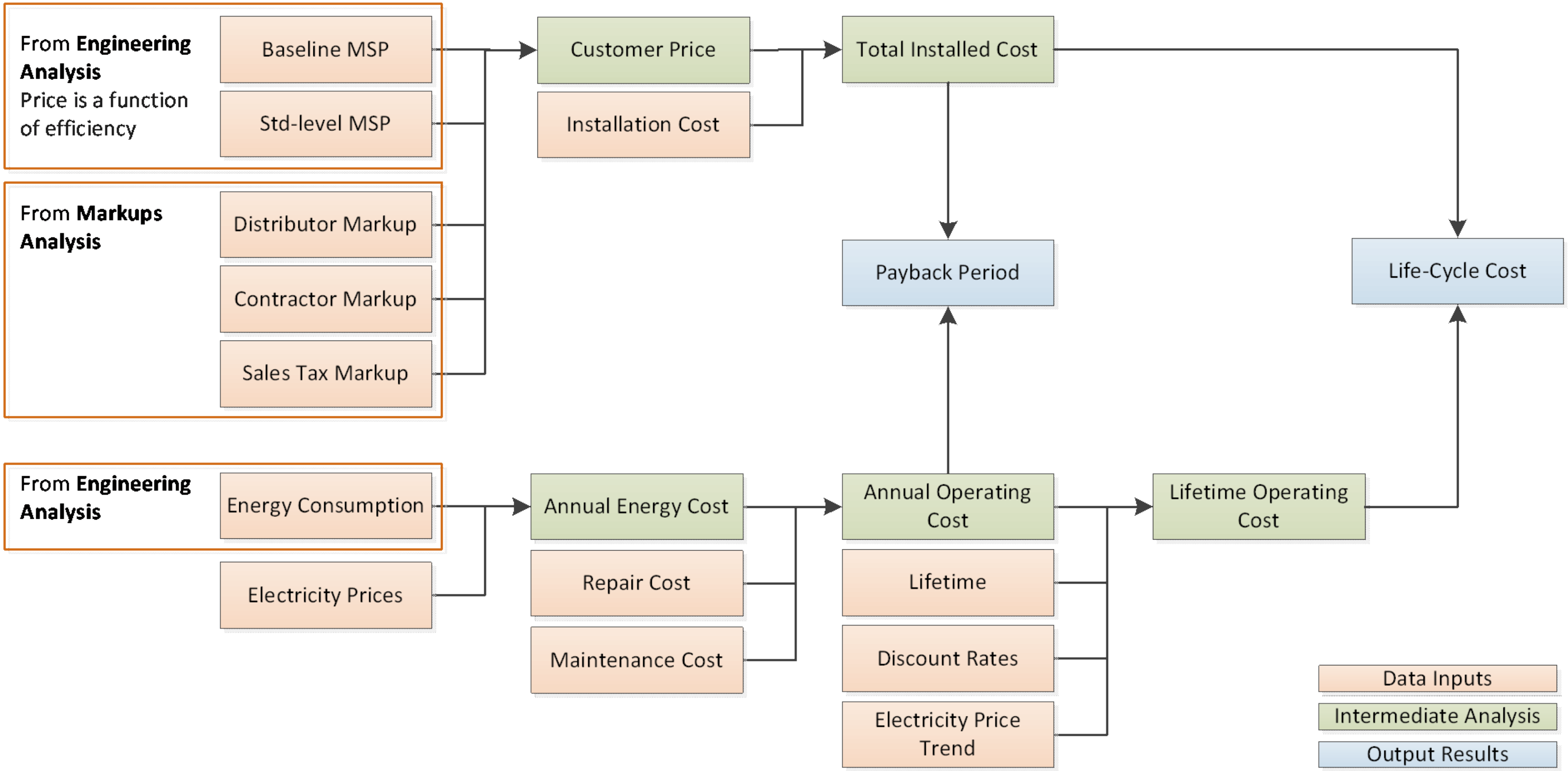
CRE Engineering: Utility and Performance Issues

Utility/Performance Concern	DOE Action/Response
Food Safety: Manufacturers expressed concern that more efficient equipment would have trouble maintaining food safety in extreme, but not uncommon, conditions.	• DOE screened out technologies that could result in adverse impacts—e.g. variable-speed evaporator fans. • Medium temperature analysis assumes 38 °F cabinet temperature, which provides margin vs. the 41 °F requirement in the NSF 7 food safety rating procedure.
General Customer Utility: Manufacturers expressed concern that amended standards would limit their ability to optimize their equipment for specific merchandise and to meet customer requirements	DOE modified the analysis in the Final Rule phase to address specific utility concerns—e.g., adding condensate pan heater energy use for some classes.
Refrigerants: Commenters raised the issue that the U.S. Environmental Protection Agency (EPA) was considering phasing out R-404A and R-134a refrigerants commonly used in CRE and used as the basis for the DOE analysis.	The phaseout was not final at the time of the rulemaking and adequate information regarding alternative refrigerants was not available. Hence, DOE based its final rule analysis on these most commonly used refrigerants.

CRE Engineering: Utility and Performance Issues

Utility/Performance Concern	DOE Action/Response
Vacuum Panels: Stakeholders raised questions about vacuum panels regarding impact on cabinet structural rigidity and integrity over the life of the CRE units.	• DOE analysis costs for vacuum panels include significant redesign costs and labor costs. Information is based on discussions with manufacturers in addition to other sources. • Max. tech efficiency levels using vacuum panels rejected due to high cost.
Triple-Pane Glass: Stakeholders raised concerns regarding use of triple-pane glass for transparent doors, citing the potential for a cabinet to tip when the door is opened and also the potential for reduced visibility of the merchandise on display.	• DOE removed triple-pane glass from the analysis for certain classes, primarily medium-temperature classes.

Life Cycle Cost (LCC): Overview



Energy Use Model

The system energy usage is calculated as the sum of the refrigeration system and auxiliary component energy consumption.

- Reduction in thermal loads (conduction through doors and walls, radiation through openings, heat and moisture addition due to warm air infiltration, and electricity use of internal components such as fans, lighting etc.) results in lower loads on the refrigeration system.
- The energy use of auxiliary components such as lighting, fans, and anti-sweat heaters is based on component power input and run time.
- The Engineering Analysis provides an estimate of daily energy use, which is multiplied by 365 to calculate annual energy use for input to the LCC.

Markups Background

Assumptions

- Product cost will increase while the other costs incurred in the distribution channel remain constant after standards. The product costs to the distributor are referred to as cost of goods sold (CGS).
- Firms are facing a relatively competitive market.
- When product costs increase following the standard and demand is relatively inelastic, firms are not likely to have medium/long run sustained higher profitability as a windfall resulting from standards.

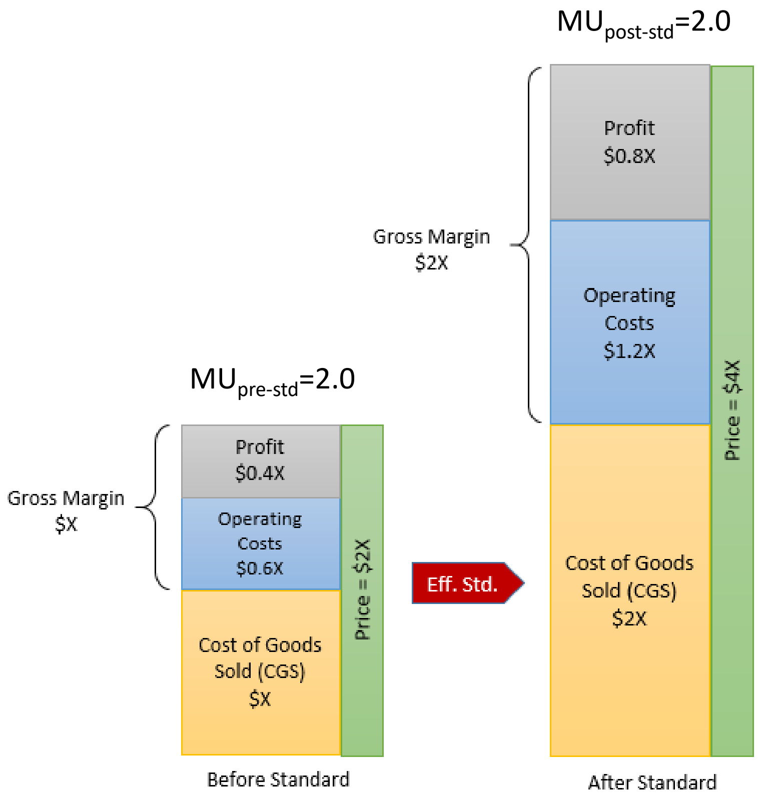
Possible Markup Scenarios

- **Fixed markup:** Markup multiplier applied to CGS remains constant and equal to baseline markup.
- **Incremental markup:** Markup multiplier applied to incremental increase in CGS induced by increased efficiency is smaller than baseline markup.

Dale, L., et al., 2004, An Analysis of Price Determination and Markups in the Air-Conditioning and Heating Equipment Industry. LBNL-52791

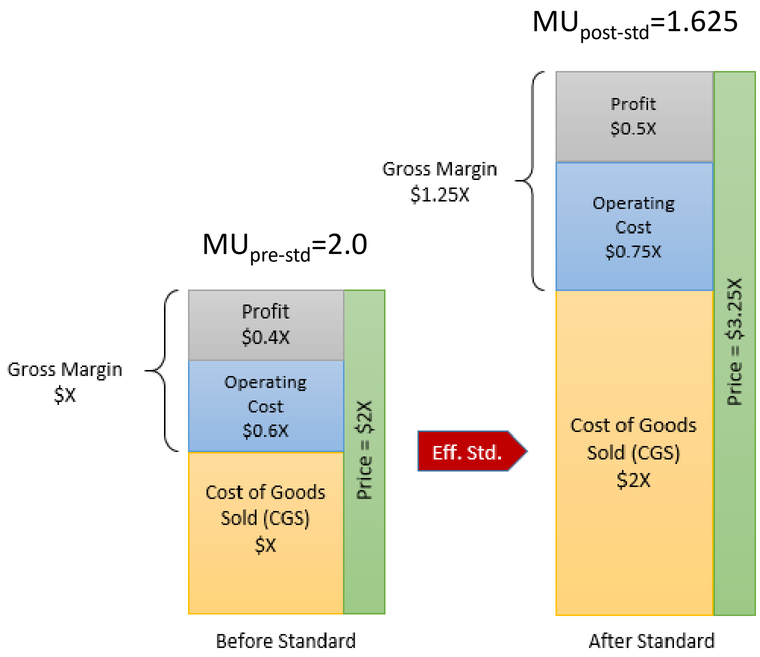
Markup Scenarios and Implications

Fixed Markup Scenario



Product cost increases then per-unit profit increases proportionally—not viable in a competitive market over time.

Incremental Markup Scenario



Product cost increases then per-unit profit increases moderately—reasonable outcome in a relatively competitive market over time.

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Markups Approach

DOE has reviewed literature, analyzed industry data, and conducted interviews. Based on this research, DOE notes:

- Wholesale prices may not always increase following a new standard, so there is no reason to suppose that retail markups changed.
- Appliance retailers could gain sales by reducing the markup to maintain pre-standard per-unit profits.
- HVAC contractors will attempt to use the same markup after the increase in input cost occurs but will eventually lower their markup based on market pressures.

DOE concludes that:

- The theory behind the concept of incremental markups has not been disproved.
- Industry data and consultant inputs justify not using fixed markup to measure the medium- to long-term impact of standards on consumer prices.

Hence, DOE has adopted the incremental markup approach.

CRE Distribution Channel Markups

DOE applies distribution chain markups to the MSP to determine the retail price paid by consumers. These markups are in addition to the manufacturer markup calculated in the Engineering Cost Analysis.

- DOE uses **baseline** and **incremental** markups.
  - Baseline markups are applied to the MSP in the base case.
  - Incremental markups are applied to the difference in MSP between the base standards case.
- For CRE, DOE analyzed three distribution channels:
  - National accounts (direct to consumer)
  - Wholesaler
  - Contractor/installer (equipment purchased from wholesaler)
- Each distribution channel is given a weight representing the percentage of total shipments that are distributed for this channel.
- Based on stakeholder input, separate distribution channel weights were calculated for display cases (glass-door or no door) and solid-door equipment.

CRE Distribution Channel Markups

Distribution Channel Weights

Equipment Type	Ntl. Acct Channel	Wholesaler Channel	Contractor Channel
Display Cases - VOP, SVO, HZO, VCT, HCT, SOC, and PD	70%	15%	15%
Solid-Door Equipment - VCS and HCS	30%	60%	10%

Baseline and Incremental Markups

	Ntl. Acct Channel	Wholesaler Channel	Contractor Channel*	Weighted-Average Markup	
				Display Cases	Solid-Door Equipment
Baseline	1.18	1.36	2.00	1.33	1.37
Incremental	1.05	1.10	1.31	1.10	1.11

* Includes wholesaler markup

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Product Price Forecasts: Lighting Technology Price Trends

- DOE incorporated the price projections for LED lighting into the projected equipment price for the National Impacts Analysis (NIA).
- These reduce the cost of lighting for certain equipment under some efficiency levels for the period of 2017 to 2030.

LED Price Deflators Used in the Final Rule Analysis: 2010-2046

Year	Normalized to 2013	Normalized to 2017
2010	3.00	5.65
2011	1.80	3.39
2012	1.29	2.42
2013	1.00	1.89
2014	0.82	1.54
2015	0.69	1.31
2016	0.60	1.13
2017	0.53	1.00
2018	0.48	0.90
2019	0.43	0.81
2020	0.39	0.74

Year	Normalized to 2013	Normalized to 2017
2021	0.36	0.68
2022	0.34	0.63
2023	0.31	0.59
2024	0.29	0.55
2025	0.27	0.52
2026	0.26	0.49
2027	0.25	0.46
2028	0.23	0.44
2029	0.22	0.42
2030	0.21	0.40
2031-2046*	0.21	0.40

* DOE did not have data available to project prices beyond 2030. Therefore, for years 2031-2046, the deflator was held constant.

Navigant Consulting, Inc. "Energy Savings Potential of Solid-State Lighting in General Illumination Applications 2010 to 2030." Building Technologies Program, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, Feb. 2010

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Consumer Choice Model: Approach

- To evaluate potential consumer selection of equipment efficiencies, DOE used a logit-type consumer choice model based on the technology choice model used in the U.S. Energy Information Administration's (EIA's) National Energy Modeling System (NEMS) commercial demand module
- The NEMS model divides the purchaser population into seven classes with different levels of sensitivity to first cost and discounting of operating cost savings.
- The technology choice model is used to develop base case efficiency distributions for each product class in the base case for the LCC.
- For the base case LCC efficiency distribution, there was a limited set of efficiencies available in the market; DOE mapped the market share percentages calculated using the logit model to this list of available products.

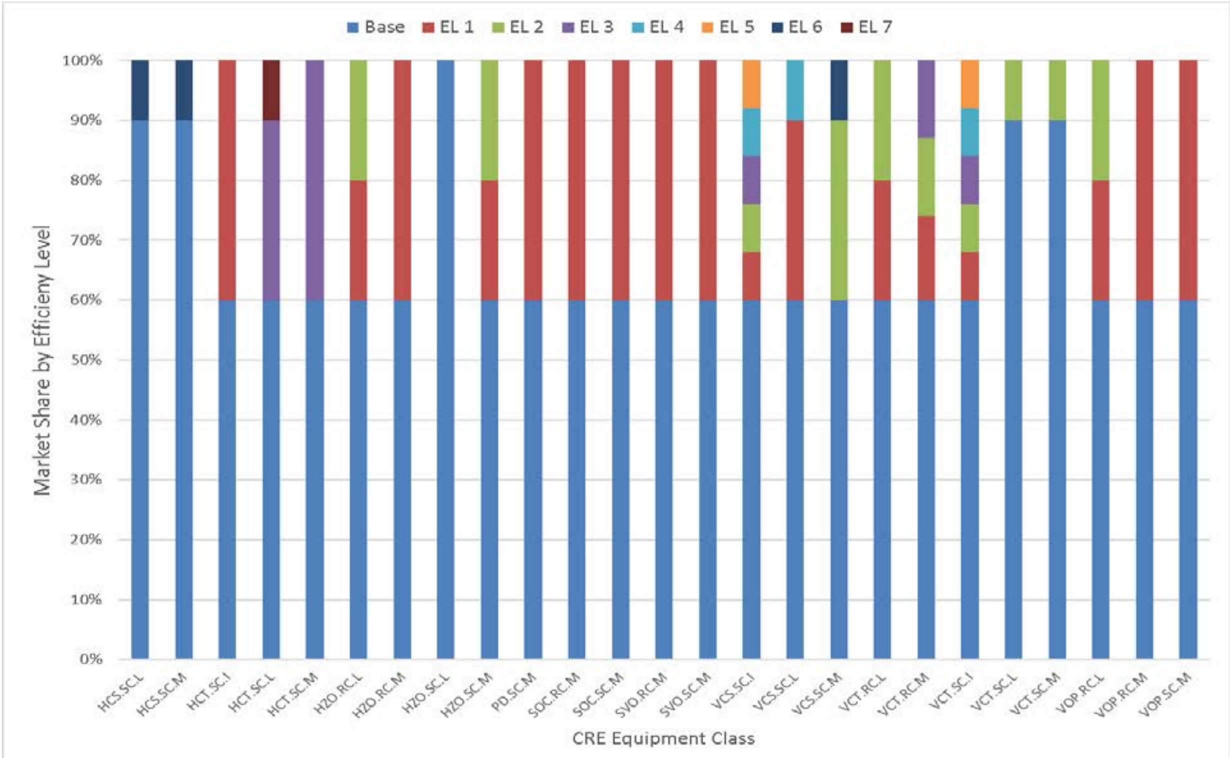
Consumer Choice Model: Base Case Efficiency Distribution

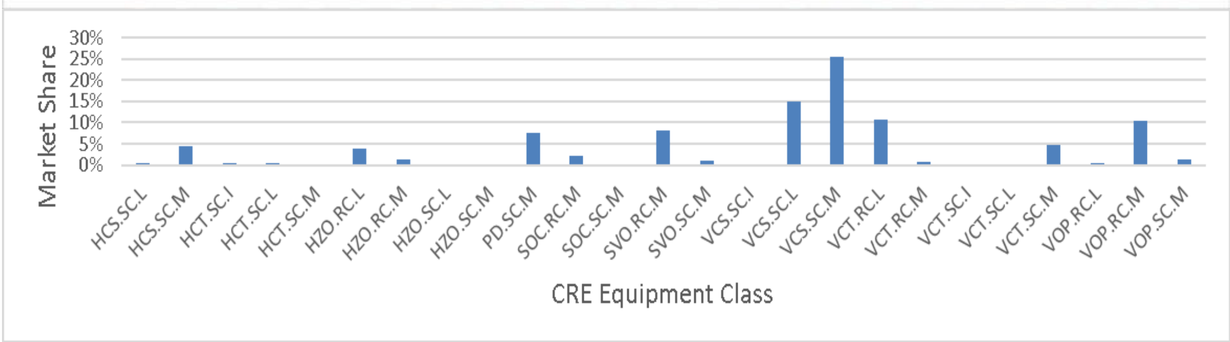
Upper Figure

Distribution by efficiency level (EL) for each equipment class

Lower Figure

Share of total market by equipment class





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Example LCC Results (by Efficiency Level)

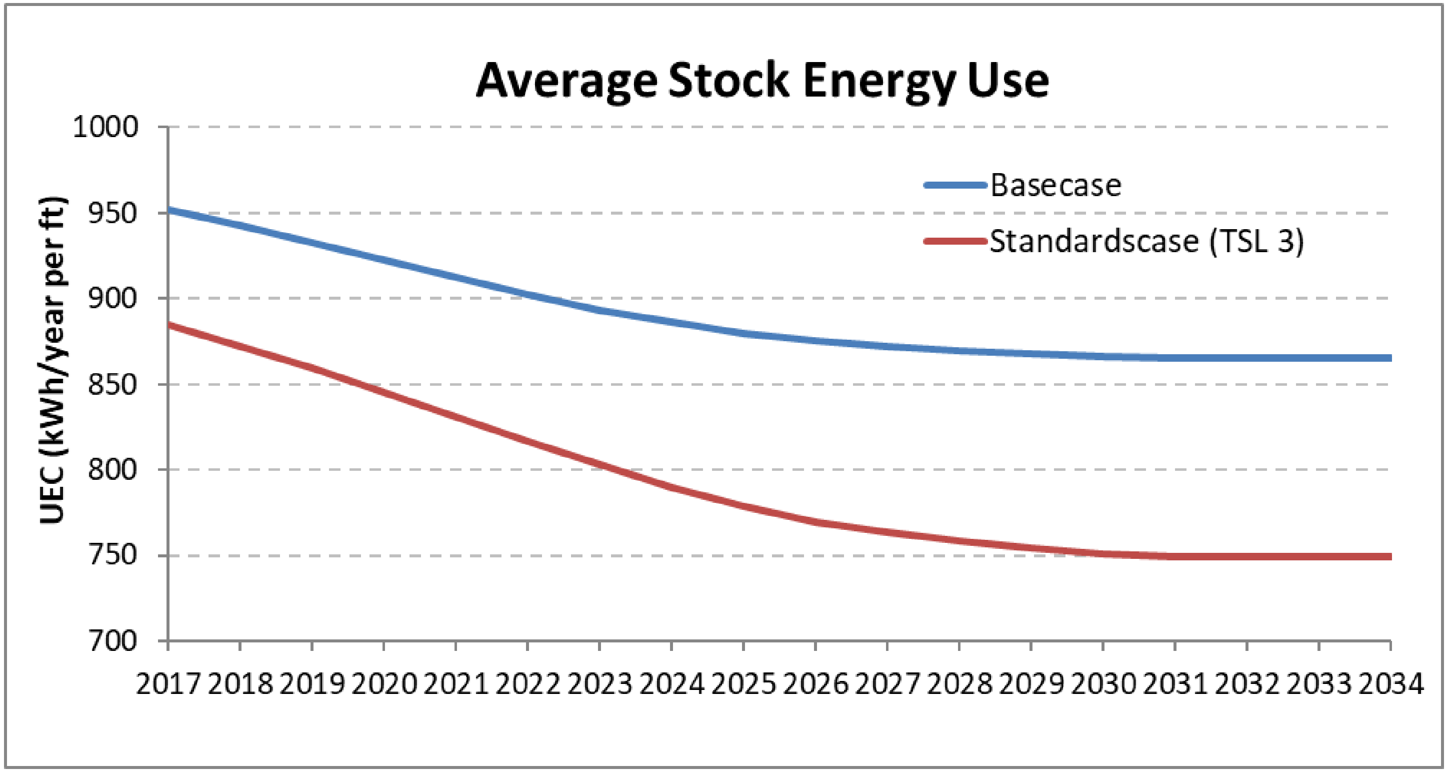
The LCC is calculated for each efficiency level (EL) and each product class. The left table shows the population-mean LCC savings by EL. The right-hand table shows the EL chosen for the amended standard TSL 3.

Equipment Class	Mean Life-Cycle Cost Savings (2012$)						
	EL 1	EL 2	EL 3	EL 4	EL 5	EL 6	EL 7
VOP.RC.M	922	482	-5	-4,203			
VOP.RC.L	53	-148	-6,701				
VOP.SC.M	-54	-1,384					
VCT.RC.M	542	323	41	-4,937			
VCT.RC.L	647	526	93	-6,036			
VCT.SC.M	-10	214	226	209	163	74	-1,541
VCT.SC.L	2,503	5,200	4,709	4,996	5,001	4,979	2,812
VCT.SC.I	18	4	-68	-2,834			
VCS.SC.M	223	518	365	363	313	305	-1,428
VCS.SC.L	588	513	550	565	507	495	-1,640
VCS.SC.I	41	114	111	113	-2,710		
SVO.RC.M	564	48	-19	-2,691			
SVO.SC.M	6	-51	-917				
SOC.RC.M	-128	-223	-287	-2,268			
SOC.SC.M	-144	-209	-274	-2,204			
HZO.RC.M	-2,180						
HZO.RC.L	-4,249						
HZO.SC.M	55	-4	-1,154				
HZO.SC.L							
HCT.SC.M	36	66	165	101	91	43	-599
HCT.SC.L	415	428	435	293	286	248	-613
HCT.SC.I	-1,240						
HCS.SC.M	12	17	15	5	-52	-568	
HCS.SC.L	31	50	64	58	33	-590	
PD.SC.M	8	163	165	150	97	32	-1,252

Equipment Class	Chosen EL TSL 3
VOP.RC.M	EL 1
VOP.RC.L	EL 1
VOP.SC.M	Baseline
VCT.RC.M	EL 1
VCT.RC.L	EL 2
VCT.SC.M	EL 3
VCT.SC.L	EL 5
VCT.SC.I	EL 1
VCS.SC.M	EL 4
VCS.SC.L	EL 5
VCS.SC.I	EL 4
SVO.RC.M	EL 1
SVO.SC.M	Baseline
SOC.RC.M	Baseline
SOC.SC.M	Baseline
HZO.RC.M	Baseline
HZO.RC.L	Baseline
HZO.SC.M	EL 1
HZO.SC.L	Baseline
HCT.SC.M	EL 4
HCT.SC.L	EL 4
HCT.SC.I	Baseline
HCS.SC.M	EL 3
HCS.SC.L	EL 3
PD.SC.M	EL 3

Evolution of Product Market in the Base Case

The changing mix of product efficiency levels over time can be summarized by calculating the stock average energy use, in kilowatt-hours per year per linear foot of equipment.



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Subgroup Analysis

- DOE analyzed an LCC subgroup consisting of small businesses, identified based on size standards from the Small Business Administration (SBA). The SBA established size standards for types of economic activity, or industry, under the North American Industry Classification System (NAICS).
- DOE analyzed 2007 economic census data to estimate the percentage of businesses by category that are small according to SBA criteria.
- Categories are grocery/supermarket, convenience stores, gasoline stations with convenience stores, full-service restaurants, and limited-service restaurants.
- The principal differences in LCC inputs for small businesses are:
  - Higher cost of capital
  - Higher electricity prices
  - Longer equipment lifetimes
- DOE performed a detailed subgroup analysis for gasoline station convenience stores (representing of food sales) and full-service restaurants (representing food service).

Subgroup Analysis Example Results

LCC Savings and PBP for the adopted TSL3 for food service restaurants

- For some equipment classes the standard level was left at the baseline
- Similar results obtained for food sales

Equipment Class	Mean LCC Savings (2013$)		Mean PBP (years)	
	Small Businesses	All Businesses	Small Businesses	All Businesses
VOP.SC.M	--	--	--	--
VCT.SC.M	$330	$226	4.5	5.3
VCT.SC.L	$6,254	$5,001	0.9	1.1
VCT.SC.I	$34	$18	5.8	7.2
VCS.SC.M	$652	$363	1.2	1.4
VCS.SC.L	$999	$507	2.0	2.5
VCS.SC.I	$321	$113	3.9	5.0
SOC.SC.M	--	--	--	--
SVO.SC.M	--	--	--	--
HZO.SC.M	$92	$55	5.7	6.9
HZO.SC.L	--	--	--	--
HCT.SC.M	$137	$101	4.7	5.8
HCT.SC.L	$487	$293	2.0	2.5
HCT.SC.I	--	--	--	--
HCS.SC.M	$48	$15	4.2	5.5
HCS.SC.L	$127	$64	2.1	2.5
PD.SC.M	$280	$165	4.7	5.6

Emissions Analysis

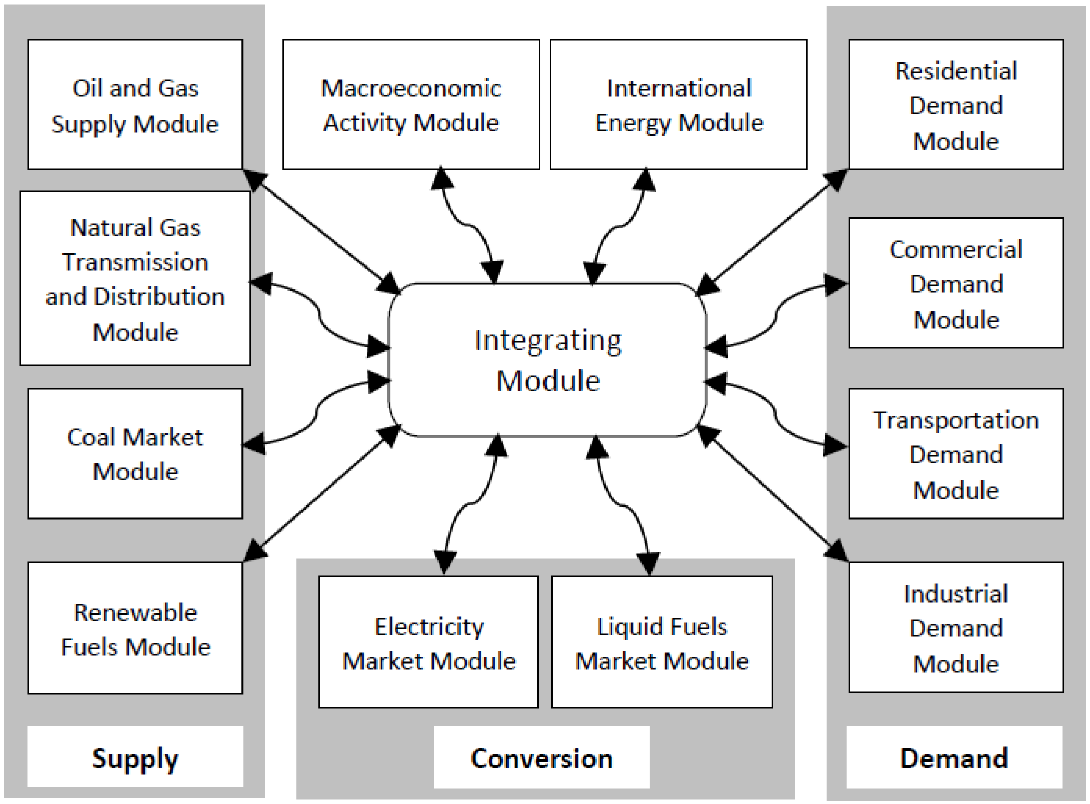
DOE estimates the cumulative emissions reductions resulting from amended ECS. DOE considers full-fuel cycle (FFC) emissions. Thus, both power plant emissions and upstream emissions are included in the analysis (includes fugitive methane emissions).

Cumulative Emissions Reduction for Potential Standards for CRE (30-year)

	Trial Standard Level				
	1	2	3	4	5
CO_2 (million metric tons)	13.0	23.1	50.4	54.9	70.0
NO_x (thousand tons)	19.1	34.2	74.5	81.1	103.4
Hg (tons)	0.0	0.1	0.1	0.1	0.1
N_2O (thousand tons)	0.3	0.5	1.1	1.2	1.5
CH_4 (thousand tons)	62.8	112.1	244.2	265.9	339.2
SO_2 (thousand tons)	16.6	29.6	64.4	70.1	89.4

NEMS

- Model DOE/EIA uses to generate the Annual Energy Outlook (AEO)
- Provides a detailed projection of energy supply and demand for 25-year period
- Incorporates only those policies that have been adopted in the year of publication



- EIA publishes multiple scenarios each year
- In alternate years, a restricted set appear
  - Low/high economic growth
  - Low/high oil & gas resource
  - Low/high oil & gas price
- Scenario data used to estimate marginal quantities used in the emissions analysis

Integrating Module of the NEMS Documentation 2014.
www.eia.gov/forecasts/aeo/nems/documentation/integrating/pdf/m057(2014).pdf

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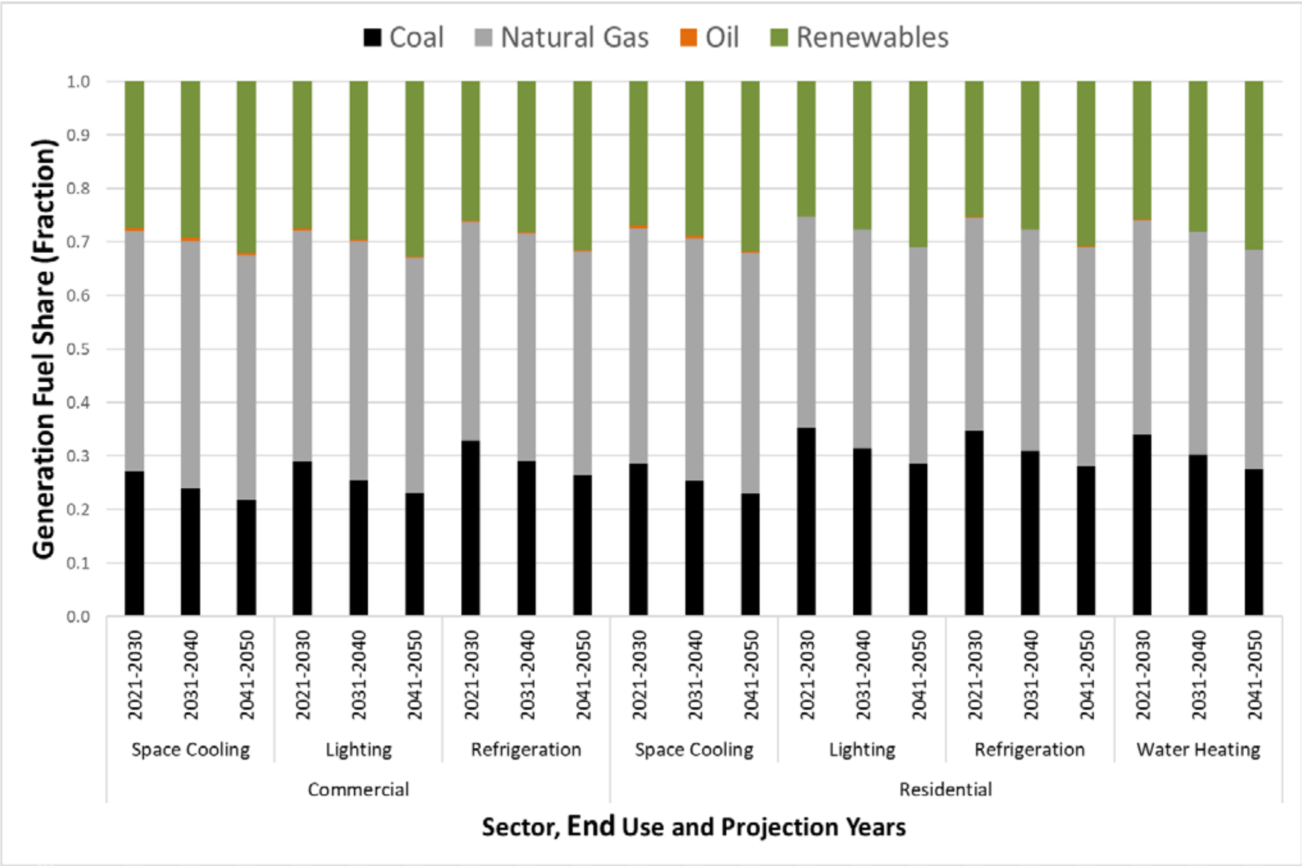
AEO-Based Approach

- The data published with the AEO are used to develop a series of coefficients that are combined to estimate emissions reduction scenarios generated by EIA.
- DOE uses the changes in generation, fuel consumption, and emissions between different scenarios to estimate marginal variations.
- On the supply side (electricity generation) DOE estimates:
  - **Marginal heat rates by fuel type:** Ratio of changes in fuel consumption to changes in generation
  - **Marginal emissions intensity by fuel type and pollutant species:** Ratio of the change in pollutant mass output to change in fuel consumption
- Changes to demand are estimated in the NIA.
- The relationship between demand by end-use and generation supply by fuel type is modeled based on the end-use load shapes included with the NEMS code.
  - End-use demand is allocated to three periods: peak, off-peak, and shoulder
- Generation by fuel type is mapped to these periods using the following rules:
  - Petroleum fuels consumed only during on-peak
  - Coal and nuclear allocated to all periods
  - Remaining peak demand is served by natural gas and renewables
  - Remaining gas and renewables allocated to shoulder and off-peak

End-Use Fuel Share Weights

- DOE calculates a set of fuel share weights, defining the fraction of annual end-use demand that is served by generation of a given fuel type.
- These are time dependent.



Marginal Emissions Intensities

- Marginal emissions intensities are calculated by averaging across different scenarios.
- The table below compares marginal values to grid-average values for AEO2019.

Emissions Rate for Coal-fired Generation

Period	CO2 MMsT:Quad		Hg sT:Quad		Nox MMsT:Quad		SO2 MMsT:Quad	
	Grid Average	Marginal	Grid Average	Marginal	Grid Average	Marginal	Grid Average	Marginal
2021-2025	104.7	105.4	0.38	0.44	0.062	0.115	0.085	0.070
2026-2030	104.7	104.6	0.38	0.41	0.060	0.079	0.089	0.091
2031-2035	104.7	104.5	0.38	0.39	0.058	0.071	0.092	0.088
2036-2040	104.7	104.5	0.37	0.37	0.058	0.070	0.095	0.094
2041-2045	104.7	104.4	0.37	0.36	0.057	0.071	0.096	0.095
2046-2050	104.6	104.5	0.37	0.35	0.057	0.080	0.101	0.104

Emissions Rate for Natural Gas-fired Generation

Period	CO2 MMsT:Quad		Hg sT:Quad		Nox MMsT:Quad		SO2 MMsT:Quad	
	Grid Average	Marginal	Grid Average	Marginal	Grid Average	Marginal	Grid Average	Marginal
2021-2025	58.5	58.5			0.019	0.035		
2026-2030	58.5	58.5			0.018	0.024		
2031-2035	58.4	58.5			0.017	0.021		
2036-2040	58.4	58.4			0.017	0.021		
2041-2045	58.4	58.4			0.017	0.021		
2046-2050	58.4	58.4			0.017	0.024		

Power Sector Emissions Impact Factors

- The supply-side analysis provides marginal emissions intensities in units of pollutant mass per unit of electricity generated by fuel type.
- The load shape analysis provides the percentage of demand served by generation fuel type, by sector, and by end-use.
- These are combined to define emissions **impact factors.**
- The impact factors represent the reduction in emissions by pollutant species per unit of demand reduction by sector and end-use.
  - These factors are time series.
- The impact factors are combined with the annual electricity demand reductions calculated in the NIA to estimate total emissions reductions.

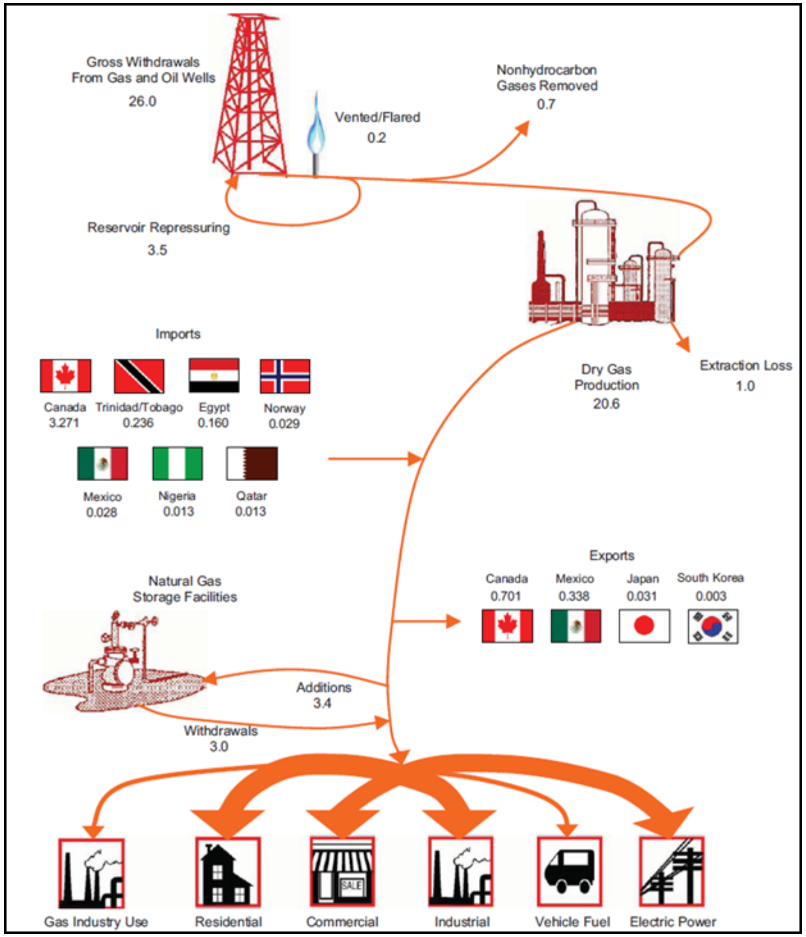
Coughlin, Katie, 2014. Utility Sector Impacts of Reduced Electricity Demand. LBNL-6864E.

Coughlin, Katie, et al, 2013. Modeling the Capacity and Emissions Impacts of Reduced Electricity Demand. LBNL-6092E.

Coughlin, Katie, 2013. Projections of Full-Fuel-Cycle Energy and Emissions Metrics. LBNL-6025E.

Full-Fuel Cycle (FFC) Analysis

- DOE also accounts for the energy and emissions that occur in the **upstream** portion of the fuel production chain.
- This includes extraction, refining, and transportation of fossil fuels.
- The upstream energy use is accounted for using FFC multipliers:
  - ~1.1 for natural gas
  - ~1.2 for oil
  - ~1.04 for grid electricity
- Emissions from upstream fuel and electricity use are added to the power sector emissions to define the FFC emissions reductions associated with a reduction in energy demand.



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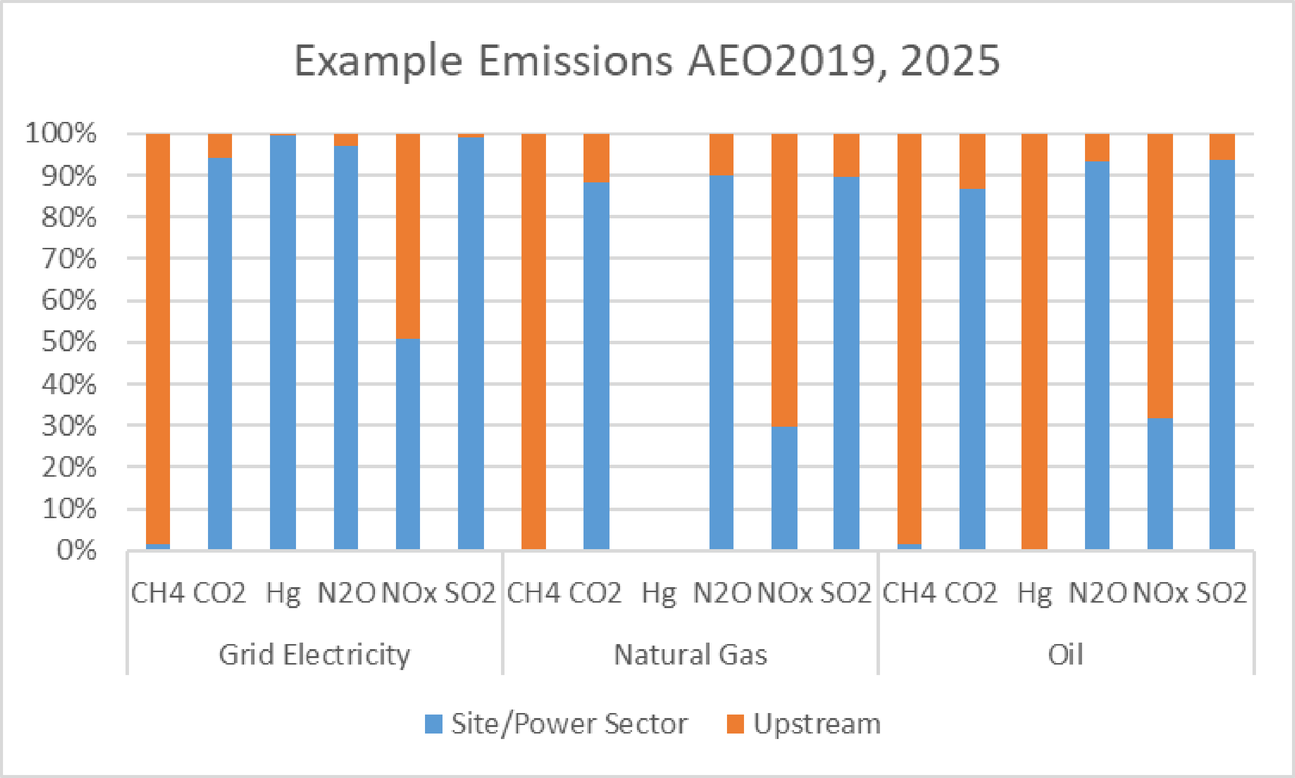
FFC Site vs. Upstream Emissions

- Emissions intensities are calculated for grid electricity and oil and natural gas.
- For oil and gas, upstream emissions are added to the site combustion emissions.
- For grid electricity, upstream emissions are added to power sector emissions.
- Chart shows percentage of total emissions from upstream in orange.

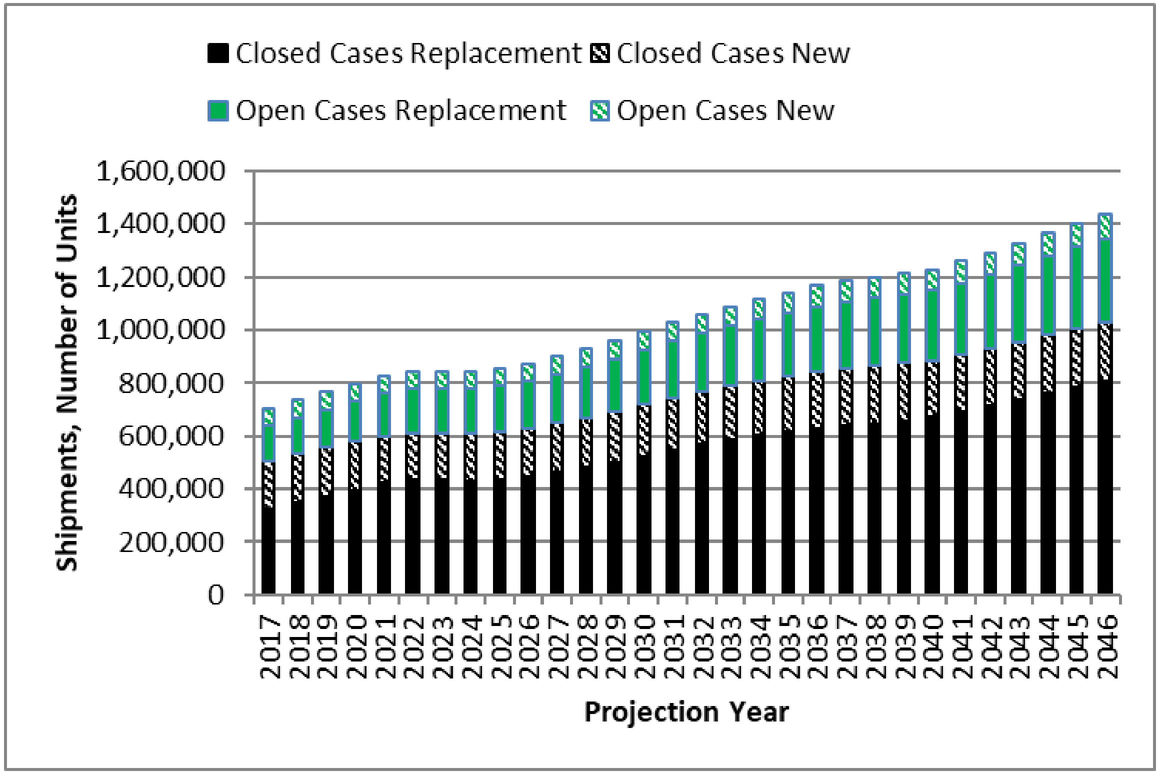


Emissions Monetization

- DOE uses the most current Social Cost of Carbon (SCC) values developed by interagency process.
- SCC is intended to be a monetary measure of the incremental damage resulting from greenhouse gas (GHG) emissions, including but not limited to agricultural productivity loss, human health effects, property damage from rising sea level, and changes in the ecosystem.
- The most recent (2013) U.S. government interagency estimates of the SCC for emissions in 2015 are $12.90, $40.80, $62.2, and $117.0 per metric ton avoided (2012 dollars). The SCC in constant dollars increases over time.
- DOE also monetizes the NOx emissions reductions resulting from amended standards. The medium estimate is $2,639 per ton of NOx.

Shipments Analysis: Methodology

- DOE estimates shipments based on a stock turnover model.
- DOE shipments forecast treats CRE as an inelastic good
- Projections of future shipments are based on AEO projections of floor space for food sales and food service businesses.
- The model calculates total shipments of open/closed cases for replacements and for new installations.
- Market share is allocated to each equipment class based on market reports, data submitted for previous rulemakings, and stakeholder input.



NIA: Results

	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
Primary Energy Savings (quads)	1.18	2.04	2.84	3.27	4.14
FFC Primary Energy Savings (quads)	1.19	2.07	2.89	3.32	4.21
Primary Energy Savings [9-yr] (quads)	0.29	0.50	0.71	0.81	1.03
Full-Fuel-Cycle Energy Savings [9-yr] (quads)	0.29	0.51	0.72	0.83	1.04
Value of CO_2 reductions (billion 2012$)[1]	0.4 to 6.0	0.7 to 10.1	1.0 to 14.0	1.2 to 16.2	1.5 to 20.4
NPV (billion 2012$) [2]:					
7% Discount Rate	2.52	4.14	4.93	3.64	(28.39)
3% Discount Rate	5.73	9.50	11.74	9.70	(49.20)
NPV [9 year] (billion 2012$) [2]:					
7% Discount Rate	1.13	1.87	2.19	1.54	(13.86)
3% Discount Rate	1.83	3.06	3.72	2.93	(17.80)
Indirect Employment Impacts in 2022 (Jobs)	1,500	2,600 to 2,700	3,700 to 3,800	4,100 to 4,300	2900 to 4400
NPV (billion 2012$) [2]: Breakdown	**TSL 1**	**TSL 2**	**TSL 3**	**TSL 4**	**TSL 5**
Incremental Product Cost, 7% Discount Rate	(0.68)	(1.42)	(2.77)	(4.58)	(29.98)
Operating Cost Savings, 7% Discount Rate	3.20	5.56	7.70	8.22	1.59
Incremental Product Cost, 3% Discount Rate	(1.21)	(2.51)	(4.89)	(8.07)	(53.06)
Operating Cost Savings, 3% Discount Rate	6.94	12.01	16.63	17.77	3.86

[1] Values for CO_2 emissions are: $11.8 to $117 per metric ton in 2015 (2012$).
[2] Values in parentheses are negative.

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Manufacturer Impact Analysis (MIA)

The MIA fulfils legislative and procedural requirements to determine if a proposed standard is economically justified.

EPCA

Consider the economic impact of standards on manufacturers and the impacts of any lessening of competition in the industry.

Process Rule

The Process Rule describes the process to be used in developing the MIA and the factors to be considered in the analysis. The analysis of manufacturer impacts will include:

- Estimated impacts on cash flow
- Assessment of impacts on manufacturers of specific categories of products and small manufacturers
- Assessment of impacts on manufacturers of multiple product-specific federal regulatory requirements, including efficiency standards for other products and regulations of other agencies
- Impact on manufacturing capacity, plant closures, and loss of capital investment

MIA: Methodology

The MIA relies on inputs from earlier analyses, public financial information, and manufacturer interviews to evaluate quantitative and qualitative impacts on industry.

Develop Financial Metrics

DOE develops financial metrics based on SEC filings and public financials.

Conduct Manufacturer Interviews

DOE conducts onsite interviews with manufacturers to get feedback on financial metrics and costs, as well as understand key industry concerns.

Financial Modeling

DOE models the financial impact of new or amended standards on the industry using the Government Regulatory Impact Model (GRIM). Key inputs include shipment forecasts, MPCs, financial metrics, and conversion cost estimates.

CRB & Additional Impacts

DOE evaluates cumulative regulatory burden (CRB), capacity constraints, competitive impacts, and small business impacts.

MIA: GRIM

The financial impacts of potential standards are calculated using the GRIM.

The GRIM was developed with funding from and the participation of GAMA, ARI, and AHAM. It is a discounted cash flow analysis modeled at the industry level.

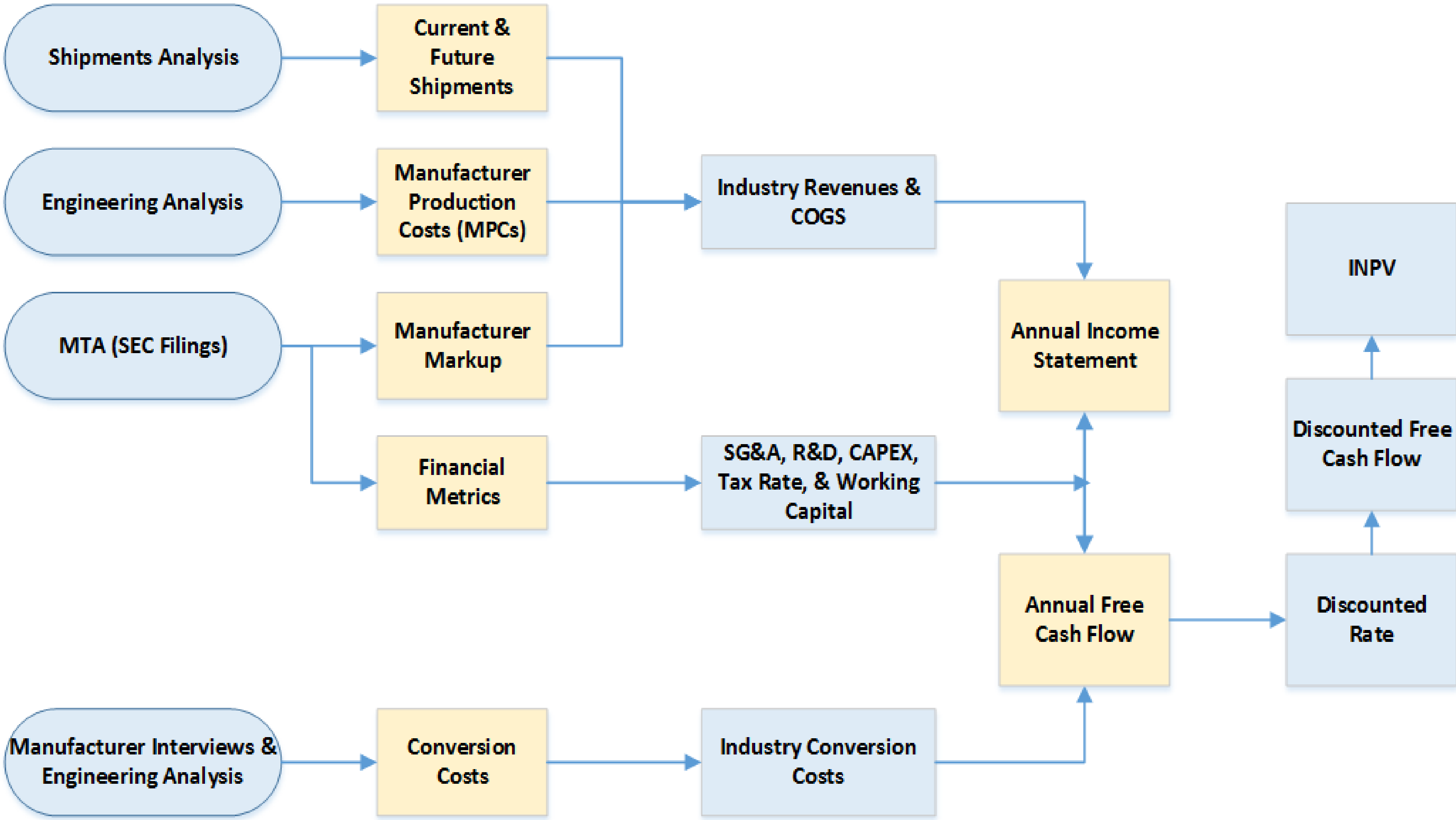
Key Inputs

- MPCs and MSPs from the Engineering Analysis
- Product shipments from the Shipments Analysis
- Financial information from the Market & Technology Assessment
- Conversion costs from manufacturer interviews and the Engineering Analysis

Key outputs/measures of impact:

- Computations of cash flow for both no-standards case (absence of standards) and standards cases
- Short-term impacts characterized by free cash flows (FCF) between the announcement year and standards years
- Long-term impacts characterized by the change in Industry Net Present Value (INPV)

MIA: GRIM Flowchart



MIA: CRE GRIM Results

Summary of MIA Results

	Units	Base Case	Trial Standard Level				
			1	2	3	4	5
INPV	2013$ Millions	2,660	2,636 – 2,650	2,617 – 2,653	2,495 – 2,566	2,339 – 2,470	1,515 – 2,476
Change in INPV	2013$ Millions	-	(23.9) – (9.9)	(42.9) – (8.7)	(165.0) – (93.9)	(320.9) – (189.4)	(1,144.8) – (184.4)
	(%)	-	(0.90) to (0.37)	(1.61) to (0.33)	(6.20) to (3.53)	(12.07) to (7.12)	(43.04) to (6.93)
Total Conversion Costs	2013$ Millions	-	24.1	35.6	184.0	354.9	781.8

Upper Bound

- The upper bound to industry profitability is the preservation of gross margin markup scenario.

Lower Bound

- The lower bound to industry profitability is the preservation of operating profit markup scenario.

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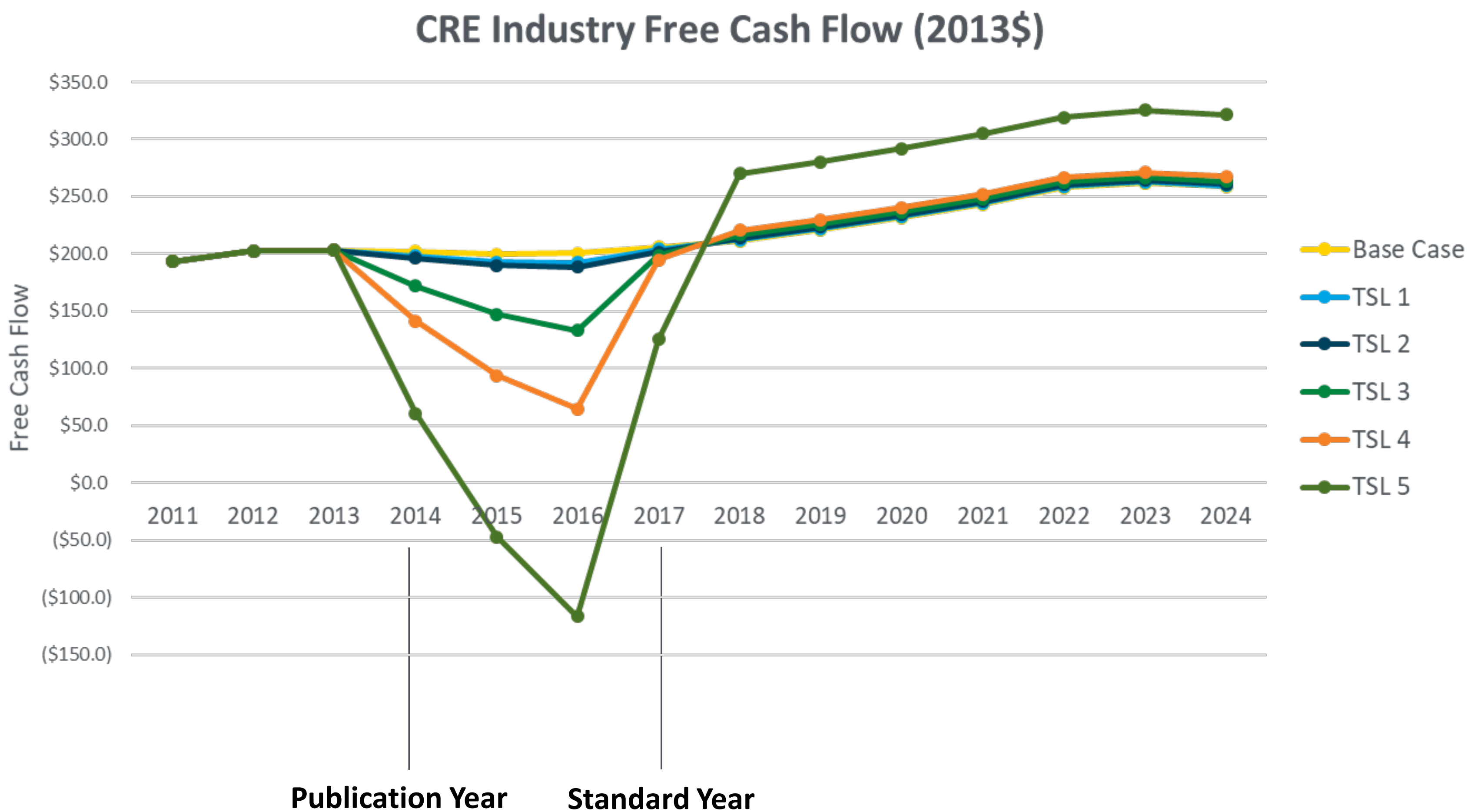
MIA: CRE FCF

Industry FCF drops after the publication year of the Final Rule, as manufacturers begin making investments to comply with amended standards.



MIA: CRE Cumulative Regulatory Burden (CRB)

Manufacturers note concerns about potential CRB from other appliance standards, other DOE regulations, other federal regulations, and from non-federal regulations.

Overlapping Appliance Standards Based on Compliance Date

Federal Energy Conservation Standard	Number of Manufacturers	Manufacturers from Today's Rule	Approx. Standards Year	Industry Conversion Costs	Industry Conversion Costs / Product Revenue
Walk-in Coolers & Freezers 78 FR55781 (September 11, 2013)	63	9	2016	$71 Million (2012$)	1.0%

Other DOE Regulations

Certification, Compliance, and Enforcement (CC&E) Final Rule: DOE issued a March 2011 CC&E Final Rule that revised certification regulations. DOE recognized that sampling requirements can create burden for certain CRE manufacturers who build one-of-a kind customized units and have a large number of basic models. In the Final Rule, DOE is allowing CRE manufacturers to rate their basic models using Alternative Efficiency Determination Methods (AEDMs), reducing the need for physical testing and reducing burden on manufacturers.

MIA: CRE Cumulative Regulatory Burden

Other Federal Regulations

Hydrofluorocarbon (HFC) refrigerant phase-out: Stakeholders raised concerns about a potential federal phaseout of HFC refrigerants. Their concerns focused on the higher cost and potential lower efficiency of alternative refrigerants. At the time of the Final Rule, there were no regulations mandating the phase-out of HFCs for CRE applications. It is DOE's policy that it does not include the impacts of pending legislation or unfinalized regulations in its analyses, as any impact would be speculative. Furthermore, at the time of the analysis, there was inadequate publicly available data on the design, construction, and operation of equipment featuring alternative refrigerants to facilitate analysis of equipment performance needed for standard-setting purposes.

ENERGY STAR: Stakeholders also cited burden from ENERGY STAR, stating that complying with multiple regulations and certification programs from different organizations results in cumulative burden. DOE notes that ENERGY STAR is a voluntary program and participation is not mandated. The Department does not consider voluntary programs in its estimate of cumulative regulatory burden.

Non-Federal Regulations

In general, DOE focuses on federal regulations in its analysis of CRB. However, the Department reviewed various state regulations submitted by stakeholders:

- California Code of Regulations, Title 24
- California Air Resources Board (CARB) Refrigerant Management Program

MIA: Competitive Impacts

As required by EPCA, DOE requested DOJ to provide a written determination of the impact, if any, of any lessening of competition likely to result from the amended standards, together with an analysis of the nature and extent of such impact. 42 U.S.C. 6295(o)(2)(B)(i)(V) and (B)(ii).

- The DOJ's determination focuses on assessing whether the rulemaking would have anti-competitive impacts.
- DOJ participated in drafting questions used in manufacturer interviews. The questions pertain to an assessment of the likeliness of increased concentration levels and other market conditions that could lead to uncompetitive pricing behavior, including:
  - Asymmetrical cost increases to some manufacturers
  - Increased proportion of fixed costs potentially increasing business risks
  - Barriers to market entry (proprietary technologies, etc.)
- In response to the CRE Notice of Proposed Rule Making (NPRM), DOJ concluded that "the proposed energy conservation standards for commercial refrigeration equipment are unlikely to have a significant adverse impact on competition."

MIA: Small Business Impacts, Reg. Flexibility Analysis

DOE analyzes the impacts on small businesses in the Regulatory Flexibility Analysis, as required by the Regulatory Flexibility Act.[1] (5 USC § 601)

- Threshold Analysis:
  - Will the rule have a significant economic impact on a substantial number of small entities?
- Initial Regulatory Flexibility Analysis for proposed rules:
  - Description and estimate number of small entities
  - Estimate of compliance requirements for small entities
  - Significant alternatives
  - Public comment
- Final Regulatory Flexibility Analysis for final rules:
  - Summary of significant issues raised by public comments
  - Updated description and estimate number of small entities
  - Updated estimate of compliance requirements for small entities
  - Steps taken to minimize adverse impacts

[1] Regulatory Flexibility Act, Pub. L. No. 96-354, 94 Stat. 1164

MIA: Regulatory Flexibility Analysis

- Identify Small Manufacturers
- Estimate Compliance Costs
- Consider Alternatives
- Public Comment

Identify small manufacturers: DOE identifies all manufacturers and then determines which domestic manufacturers meet the SBA definition for small, which is a maximum headcount or revenue based on industry.

Estimate compliance costs: DOE generally does not have access to the business details necessary to forecast individual company viability. DOE investigates:

- Small manufacturers' market share and sales volumes
- Number of models or product families requiring redesign
- Design differences between niche market and general market products
- Manufacturing processes differences due to lower production volumes

In alignment with SBA guidance, DOE assesses small business impacts relative to company revenues. Guidelines used are:

- Investments < 1% of revenues are not significant
- 1% < investments < 3% of revenues may be significant
- Investments > 3% of revenues are significant

Consider alternatives: DOE considers no-standard and alternative stringencies. DOE may also evaluate consumer rebates, consumer tax credits, manufacturer tax credits, and voluntary energy efficiency targets.

MIA: Regulatory Flexibility Analysis

DOE analyzed the impacts on small businesses as part of the Regulatory Flexibility Analysis in the CRE Final Rule.

- The SBA had a size threshold of 750 employees or fewer for the industry category "Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing" at the time of analysis.
- Based on public information, DOE identified 45 domestic manufacturers of covered equipment:
  - 13 large manufacturers
  - 32 small manufacturers
- Small manufacturers accounted for approximately 26% of CRE shipments. Most of these companies had less than 1% market share. However, there were exceptions (e.g., Continental has 4% market share in the food service CRE sector).

MIA: Regulatory Flexibility Analysis

DOE noted potential challenges for small manufacturers of CRE.

At TSL 3, the adopted level, the conversion costs are significant for small manufacturers.

Total Conversion Cost as a Percentage of Annual Revenue		
Trial Standard Level	**Average Small Manufacturer**	**Average Large Manufacturer**
TSL 1	1%	1%
TSL 2	2%	1%
TSL 3	11%	2%
TSL 4	26%	3%
TSL 5	70%	9%

The RegFlex states that small firms would likely be at a disadvantage relative to larger firms in meeting the amended ECS for CRE. The small businesses face disadvantages in terms of access to capital, the cost of re-tooling production lines and investing in redesigns, and pricing for key components. (79 FR 17725)

DOE evaluates significant alternatives in the Regulatory Impact Analysis (RIA): (1) no change in standard; (2) consumer rebates; (3) consumer tax credits; (4) manufacturer tax credits; (5) voluntary energy efficiency targets; and (6) bulk government purchases. DOE determined that the energy savings of these alternatives are significantly smaller than those that would be expected to result from adoption of the amended standard levels. Accordingly, DOE is declining to adopt these alternatives.

To minimize negative impact, manufacturers with less than $8M revenue may seek temporary exemption for all or part of an ECS. (42 USC § 6295). To date, this exemption has not been granted.

Indirect Employment Effects

- **Purpose:** To estimate the net jobs created or eliminated nationally as a consequence of amended ECS. This includes direct and indirect employment impacts.
- **Method:**
  - Uses the Impact of Sector Energy Technologies (ImSET) model for the evaluation of indirect employment impacts.
  - The changes in equipment and energy expenditures are taken from the National Energy Savings Analysis.
- **Output:** Net short-term changes in employment (jobs, in thousands)
  - Values for the adopted TSL3

    2017: 74-108

    2021: 719-749

Use of Proprietary Data

MIA

- DOE subscribed to market research that provides estimate revenues and headcounts for private companies.
- DOE contractors engaged in manufacturer interviews to discuss company financials, production costs, production volumes, past and future investment in PP&E, and technical constraints, which are all forms of sensitive business information.

Shipments Analysis

- DOE made use of AHRI shipments data that had been submitted in 2005; no additional data were submitted for the 2014 rule.
- DOE adjusted estimates of total shipments based on comments from manufacturers (on the record) in public meetings.
- DOE purchased market reports on food service and food sales equipment to estimate the market shares for different equipment classes.

Backup

Emissions Impacts (30-year)

	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
CO_2 reductions (million metric tons)	59	102	142	163	207
Value of CO_2 reductions (billion 2012$)[1]	0.4 to 6.0	0.7 to 10.1	1.1 to 14.0	1.2 to 16.2	1.5 to 20.4
CO_2 reductions 2017 — 2030 (million metric tons)	20	34	48	56	70
NO_x reductions (thousand tons)	39	68	94	108	137
Value of NO_x reductions at 3% discount rate (million 2012$)	43	75	104	120	152
Value of NO_x reductions at 7% discount rate (million 2012$)[2]	14	24	33	37	48
SO_2 reductions (thousand tons)	86	149	207	238	302
Hg reductions (tons)	0.10	0.18	0.25	0.28	0.36
N_2O reductions (thousand tons)	1.4	2.4	3.3	3.8	4.8
CH_4 reductions (thousand tons)	315	547	762	876	1109

[1] Values for CO_2 emissions are: $11.8 t0 to $117 per metric ton (2012$).
[2] Values for NO_x emissions are: $2,639 per ton (2012$).

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Regulatory Impact Analysis

Purpose

- To investigate the national impacts of non-regulatory alternatives to mandatory amended energy conservation standards.
- The non-regulatory alternatives that may be considered include no new regulatory action, early replacement, prescriptive standards, customer tax credits, manufacturer tax credits, customer rebates, voluntary efficiency targets, and bulk government procurement.

Method

- The NIA spreadsheet model is modified to consider different scenarios.
- The variables that may be modified include energy prices and escalation factors, implicit market discount rates, customer purchase price and operating cost, income elasticities, and equipment stock data.

Output

- National energy savings (NES) and net present value (NPV) for the non-regulatory alternatives
- Impact of non-regulatory alternatives on purchase price and use of energy efficient equipment

Regulatory Impact Analysis: Results

DOE identified five major non-regulatory alternatives that could potentially achieve similar improvements in CRE energy efficiency, and compared the NES and NPV of these alternatives to the values calculated for the proposed standards.

Policy Alternative	Cumulative Primary NES (quads)	Cumulative Net Present Value (billion 2012$)	
		7% Discount Rate	3% Discount Rate
No New Regulatory Action	0	0	0
Consumer Rebates	0.86	1.83	4.20
Consumer Tax Credits	0.52	1.09	2.52
Manufacturer Tax Credits	0.26	0.55	1.26
Voluntary Energy Efficiency Targets	0.44	0.75	1.90
Bulk Government Purchases	0.08	0.15	0.37
Proposed Standards (TSL 3)	2.89	4.93	11.74