BUILDING TECHNOLOGIES PROGRAM

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

Walk In Coolers and Walk In Freezers Energy Conservation Program Preliminary Analysis

May 19, 2010

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Energy Efficiency & Renewable Energy
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Welcome and Introduction

- Introductions
- Role of the Facilitator
- Ground Rules (norms)
  - Listen as an ally
  - Use short, succinct statements (keep to the point)
  - Hold sidebar conversations outside the room
  - Focus on issues, not personalities
  - One person speak at a time (raise hand to be recognized, state name for the record)
  - Set cell phones to silent/vibrate
- Housekeeping Items

Agenda (Morning)

9:00 – 9:30 am	Welcome, Introductions, Agenda Review, and Opening Statements
9:30 – 9:45 am	Rulemaking Overview
9:45 – 10:45 am	Market and Technology Assessment, Screening Analysis, and Engineering Analysis
10:45 – 11:00 am	Break
11:00 – 11:45 am	Markup Analysis and Energy Use Analysis
11:45 – 12:45 pm	Shipments Analysis, Life-Cycle Cost and Payback Period Analysis, and National Impact Analysis
12:45 – 1:45 pm	Lunch

Agenda (Afternoon)

1:45 – 2:15 pm	Manufacturer Impact Analysis (MIA)
2:15 – 2:45 pm	Notice of Proposed Rulemaking (NOPR) Analyses: Utility Impact Analysis, Employment Impact Analysis, Environmental Assessment, and Regulatory Impact Analysis
2:45 – 3:00 pm	Break
3:00 – 4:00 pm	Test Procedures
4:00 – 4:30 pm	Next Steps and Closing Remarks

Public Meeting Agenda

1. Introduction and Overview
2. Market and Technology Assessment; Screening and Engineering Analyses
3. Markups Analysis; Energy Use Analysis
4. Life Cycle Cost and Payback Period Analysis
5. Shipments Analysis; National Impact Analysis
6. Preliminary Manufacturer Impact Analysis; NOPR Analyses
7. Test Procedures

Request for Comments

Issue Box For the Notice of Public Meeting and Availability of the Preliminary Technical Support Document, DOE welcomes comment. Throughout this presentation, specific issues will be raised for discussion in yellow issue boxes. However, comments concerning any part of the document or presentation are welcome.

DOE Seeks Comments on its Proposal

In all correspondence, include all of the following:

- Energy Conservation Standards for Walk-In Coolers and Walk-In Freezers
- Docket Number EERE-2008-BT-STD-0015
- Regulatory Identification Number (RIN) 1904-AB86

Email: WICF-2008-STD-0015@ee.doe.gov

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Comment period closes May 28, 2010

Purpose of the Public Meeting

- Present the procedural and analytical approaches to evaluate energy conservation standards for walk-in coolers and walk-in freezers (WICF or walk-ins).
- Provide a forum for public discussion of rulemaking issues.
- Encourage interested parties to submit data, information, and written comments.
- Inform interested parties and facilitate the rulemaking process.

Opening Statements

At this time, DOE welcomes opening remarks on the preliminary analyses for walk-in coolers and walk-in freezers.

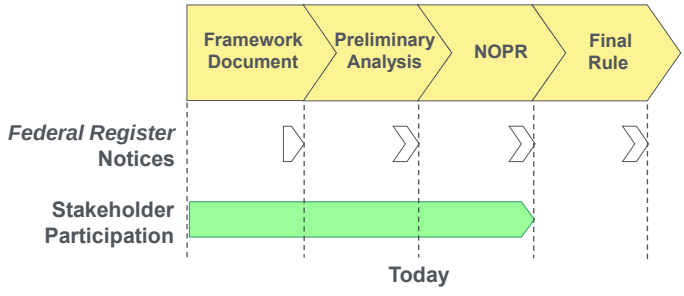
Statute and Context: Introduction

- As amended by the Energy Independence and Security Act (EISA) of 2007 (Public Law 110-140), the Energy Policy and Conservation Act (EPCA):
  - Sets prescriptive standards on certain components of WICF.
  - Directs DOE to publish test procedures for WICF.
    - The subject of a separate but concurrent rulemaking.
  - Directs DOE to "publish performance based standards for walk-in coolers and walk-in freezers that achieve the maximum improvement in energy that the Secretary determines is technologically feasible and economically justified" by January 1, 2012.
    - The subject of this rulemaking.

WICF Rulemaking Schedule

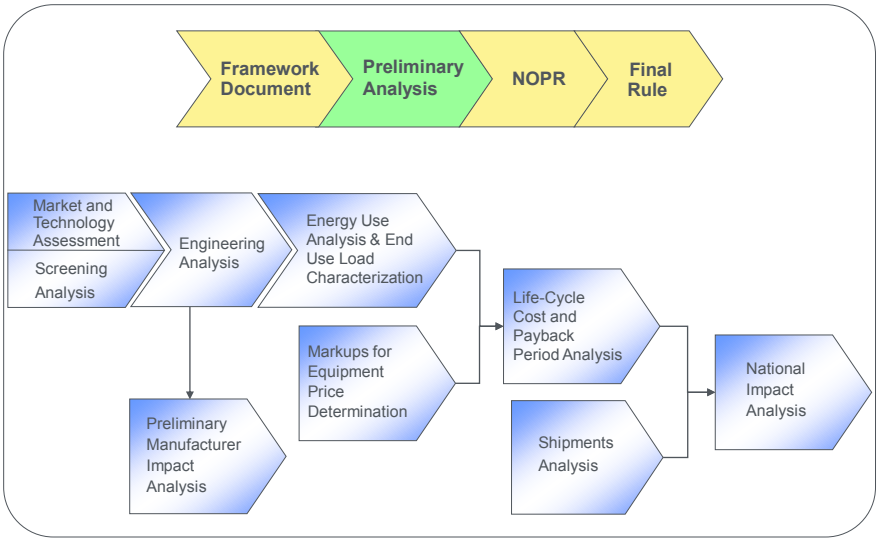
Milestone	Date
Framework Document published	January 6, 2009
Federal Register Notice of Public Meeting (NOPM) and Availability of the Preliminary Technical Support Document	April 5, 2010
Issue NOPR	Spring 2011
Issue Final Rule	January 1, 2012
Standard Effective Date	January 1, 2015

Stakeholder Participation in the Rulemaking Process



- Public meetings and oral comments
- Written comments on *Federal Register* notices, Technical Support Documents (TSDs), and analytical spreadsheets
- Data input from manufacturers and other interested parties

Preliminary Analysis Rulemaking Stage



Statute and Context: Overall Approach

- DOE is developing separate standards for envelopes and refrigeration systems.
  - Approach was based on feedback from interested parties in the framework stage.
  - Proposed test procedures: separate tests.
- DOE conducted the Market and Technology Assessment and the Engineering Analysis separately for envelopes and refrigeration systems.
- DOE conducted downstream analyses on combinations of envelope and refrigeration classes at all efficiency levels.

Item 1-1 DOE seeks comment on developing separate standards for envelopes and refrigeration systems. (Question ES.4.1 in the Executive Summary)

Public Meeting Agenda

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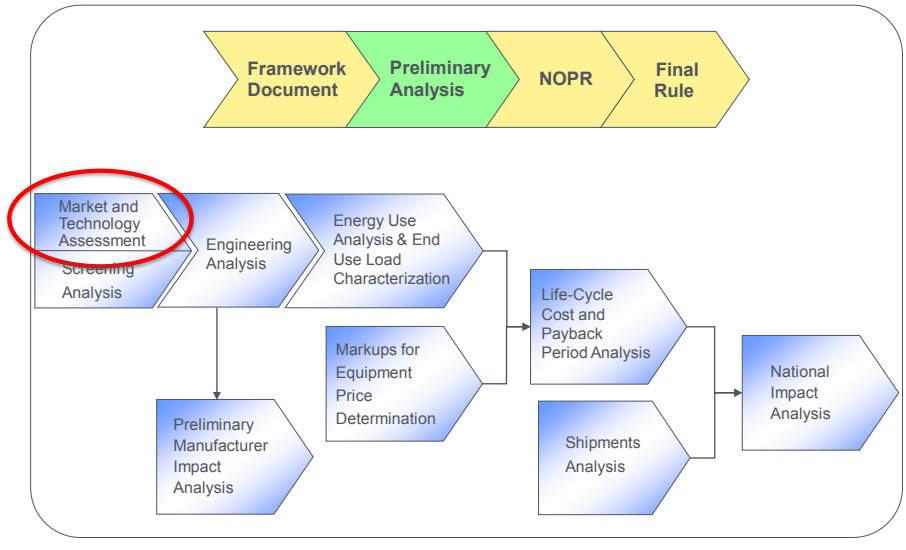
Preliminary Analysis Rulemaking Stage



Market Assessment: Purpose & Method

- Purpose
  - Characterize the WICF market and manufacturers
  - Determine appropriate equipment classes
- Method
  - Determine scope of coverage
  - Identify and characterize manufacturers of WICF
  - Use historical shipment data to characterize market trends
  - Classify covered equipment into appropriate equipment classes
- Detailed description of methodology and results is contained in Chapter 3 of the preliminary TSD.

Market Assessment: Equipment Classes (cont.)

Equipment Classes for Envelopes

Equipment Type	Operating Temperature	Equipment Class Designation
Non-Display	Cooler	ND.C
	Freezer	ND.F
Display	Cooler	D.C
	Freezer	D.F

Equipment Classes for Refrigeration Systems

Condensing Type	Operating Temperature	Condenser Location	Equipment Class Designation
Multiplex	Medium	--	MC.M
	Low	--	MC.L
Dedicated	Medium	Indoor	DC.M.I
	Low		DC.L.I
	Medium	Outdoor	DC.M.O
	Low		DC.L.O

Market Assessment: Request for Comment

Item 2-1 DOE seeks comment on these equipment classes. (Question ES.4.3 in the Executive Summary)

Technology Assessment: Purpose & Method

- Purpose
  - To develop a preliminary list of technology options that could improve the efficiency of walk-in coolers and walk-in freezers.
- Method
  - DOE identified technology options from:
    - Literature review
    - Manufacturer marketing brochures
    - Comments and input from stakeholders
- All technology options are described in Chapter 3 of the preliminary TSD.

Technologies Identified: Envelope

All Envelope Classes	
Wall, Ceiling, and Floor Insulation	Door Gaskets
Automatic Door Opening and Closing Systems	Electronic Ballasts and High-Efficiency Lighting
Occupancy Sensors	Panel Interface Systems
Air Curtains	Strip Curtains
Refrigeration System Override	Air and Water Infiltration Sensors
Humidity Sensors	Heat Flux Sensors
Vestibule Entryways	Revolving Doors
Fiber Optic Natural Lighting	Energy Storage Systems
Non-Penetrative Internal Racks and Shelving	

Technologies Identified: Envelope (cont.)

Display Envelopes Only	
Anti-Sweat Heater Controls	Non-Electric Anti-Sweat Systems
No Anti-Sweat Systems	Automatic Insulation Deployment
Display and Window Glass System Insulation Performance	

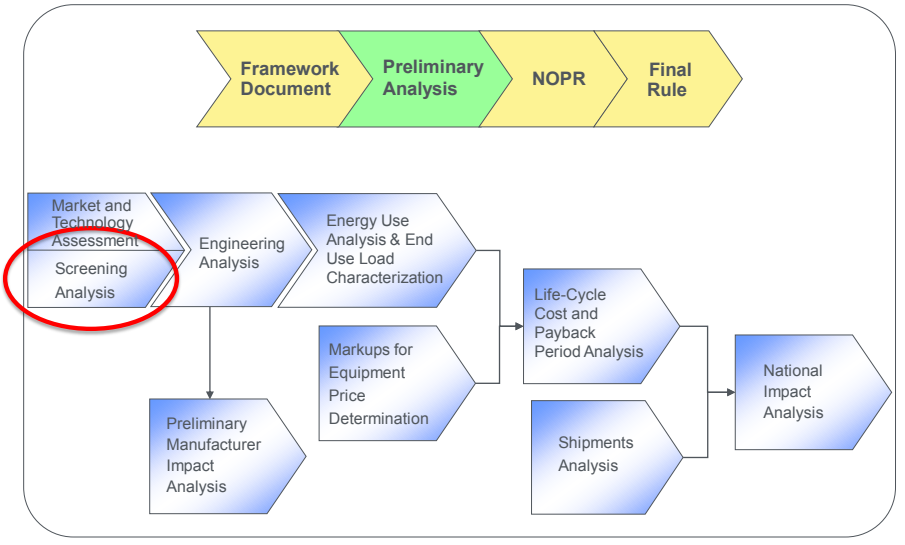
Technologies Identified: Refrigeration Systems

All Refrigeration System Classes	
High-Efficiency Evaporator Fan Blades	Improved Evaporator Coils
Evaporator Fan Control	High-Efficiency Evaporator Fan Motors
Three-Phase Motors	
Dedicated Condensing Refrigeration Systems Only	
Ambient Sub-Cooling	High-Efficiency Condenser Fan Motors
Automatic Evaporator Fan Shutoff	High-Efficiency Condenser Fan Blades
High Efficiency Compressors	Improved Condenser Coil
Low Temperature Refrigeration Systems Only	
Hot Gas Defrost	Defrost Controls
Outdoor Refrigeration Systems Only	
Floating Head Pressure	Economizer Cooling

Technology Assessment: Request for Comment

Item 2-2 DOE asks interested parties to comment on other technologies that DOE should consider.

Preliminary Analysis Rulemaking Stage



Screening Analysis: Purpose

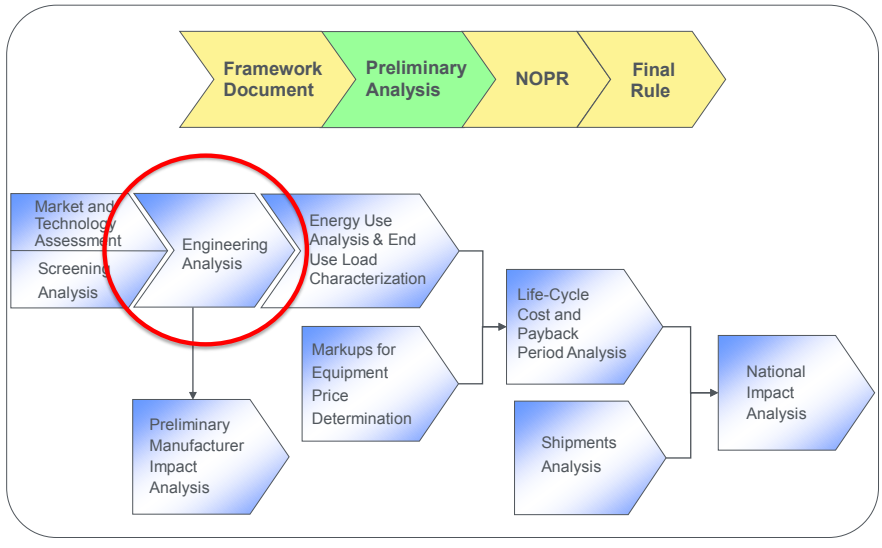
- Purpose
  - To determine which technology options will be considered in downstream analyses.
- Technology options are ~~s~~creened out" if they
  - Are not technologically feasible
  - Are not practicable to manufacture, install, and service
  - Have adverse impacts on equipment utility or availability to customers
  - Have adverse impacts on health or safety
- The methodology and results are presented in detail in Chapter 4 of the preliminary TSD.

Screening Analysis (cont.)

- Screened-Out Technologies:
  - For Envelopes:
    - Revolving doors
    - Fiber-optic natural lighting
    - Energy storage systems
    - Non-electric anti-sweat systems
    - Automatic insulation deployment systems
  - For Refrigeration:
    - Higher efficiency evaporator fan motors
    - Three-phase motors
    - Economizer cooling

Item 2-3 DOE seeks comment on the screened-out technologies.

Preliminary Analysis Rulemaking Stage



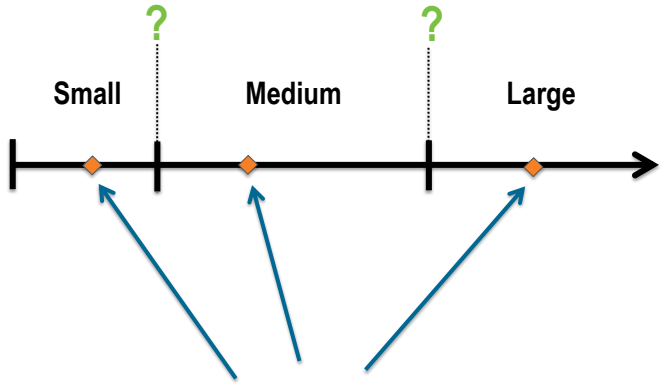
Engineering Analysis: Purpose and Methods

- Purpose
  - To characterize the relationship between manufacturer selling price and walk-in equipment energy consumption.
- Methods
  - DOE performed the engineering analysis on envelopes and refrigeration systems separately.
  - DOE chose representative units on which to perform the analysis:
    - Envelope: Three sizes per class
    - Refrigeration system: Two sizes per class
  - For each unit, DOE determined the **baseline configuration**.
  - DOE also analyzed the technology options for each class.
- The methodology and results are presented in detail in Chapter 5 of the preliminary TSD.

Engineering Analysis: Approach

- DOE used a design-option approach to estimate the effect of implementing advanced technologies.
  - For a baseline unit, DOE first calculated:
    - Energy consumption
    - Cost
  - DOE added advanced technologies to the baseline and calculated:
    - Reduction in energy consumption
    - Incremental cost
  - Finally, DOE sorted the technologies in order from most to least cost-effective.
- Result: Cost-Efficiency Curves, which describe the relationship between energy consumption and manufacturer selling price.

Engineering Analysis: Representative Sizes Analyzed



- DOE selected "representative" sizes for <u>each</u> equipment class

Engineering Analysis: Representative Sizes Analyzed (cont.)

Equipment Sizes for Envelopes

	Dimensions [length x width x height, ft]		
Class	Small	Medium	Large
ND.C	10 x 8 x 7.6	12 x 20 x 9.5	25 x 30 x 12
ND.F	8 x 6 x 7.6	9 x 20 x 9.5	25 x 20 x 12
D.C	6 x 6 x 6.6	10.2 x 7 x 7.6	80 x 15 x 7.6
D.F	6 x 6 x 6.6	10.2 x 7 x 7.6	80 x 15 x 7.6

Equipment Sizes for Refrigeration Systems

	Nominal Capacity [Btu/hr]	
Class	Small	Large
DC.M.I	12,000	24,000
DC.L.I	6,000	12,000
DC.M.O	15,000	24,000
DC.L.O	6,000	12,000
MC.M	9,000	30,000
MC.L	6,000	30,000

Engineering Analysis: Technologies Analyzed

All Envelopes
Improved Wall, Ceiling, and Floor Insulation
Improved Door Gaskets and Panel Interface Systems
Electronic Lighting Ballasts and High-Efficiency Lighting
Occupancy Sensors and Automatic Door Opening and Closing Systems
Air Curtains and Strip Curtains
Vestibule Entryways
Display Only
Display and Window Glass System Insulation Enhancement
Anti-Sweat Heater Controls and No Anti-Sweat Systems

All Refrigeration Systems
Improved Evaporator Fan Blades
Improved Evaporator Coil
Evaporator Fan Control
Dedicated Condensing Only
Larger Condenser Coil
Improved Condenser Fan Blades
ECM Condenser Fan Motors
High-Efficiency Scroll Compressors
Outdoor Only
Floating Head Pressure
Low Temperature Only
Defrost Controls

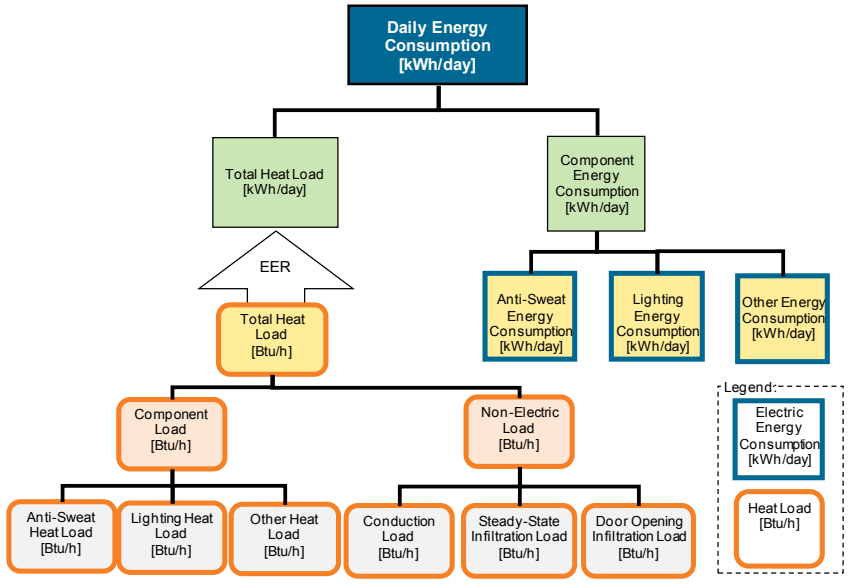
Engineering Analysis: Request for Comment

Item 2-4 DOE seeks comment on the representative equipment sizes analyzed.

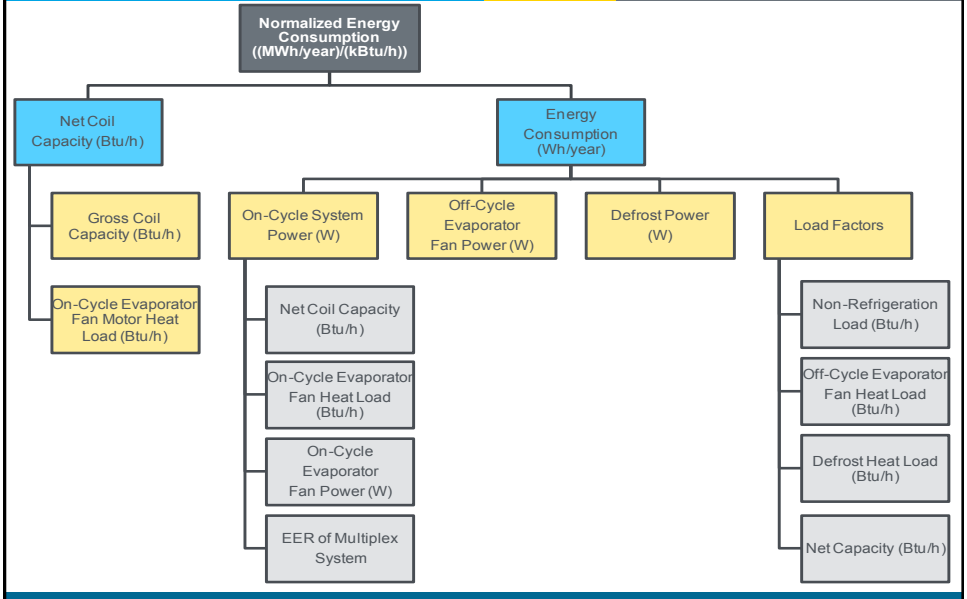
Item 2-5 DOE seeks comment on divisions between sizes for each equipment class.

Item 2-6 DOE seeks comment on other technologies that are currently available that could improve the efficiency of WICF equipment.

Engineering Analysis: Envelope Energy Model

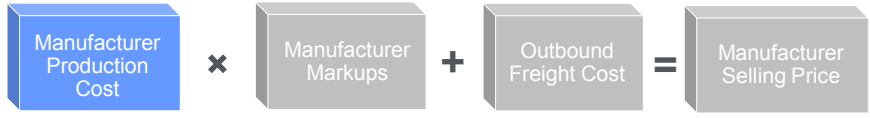


Engineering Analysis: Refrigeration Energy Model



Engineering Analysis: Cost Model

- Manufacturer Production Cost
  - Total material and part costs were derived from a review of envelopes and refrigeration systems.
  - Factory parameter assumptions (labor, overhead, and depreciation costs) were based on DOE's internal expertise and manufacturer feedback.



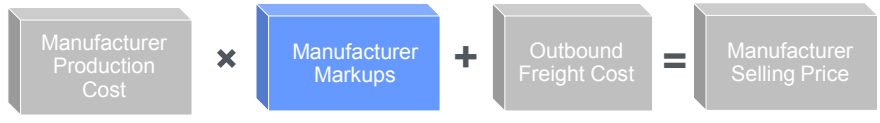
- **Direct material**
- **Direct labor**
- **Factory overhead**
- **Depreciation**

- Sales & marketing
- Research & development
- Interest
- Profit

Shipping from manufacturer to distributor

Engineering Analysis: Cost Model (cont.)

- Manufacturer Markup
  - DOE developed manufacturer markups using SEC form 10-K reports from publicly owned WICF manufacturing companies.
    - Net Sales
    - Costs of Sales
    - Gross Profit
  - The aggregate manufacturer markup was found to be **1.39**.



- Direct material
- Direct labor
- Factory overhead
- Depreciation

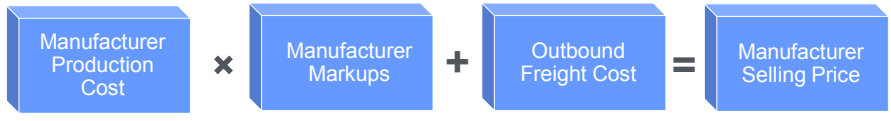
- **Sales & marketing**
- **Research & development**
- **Interest**
- **Profit**

Shipping from manufacturer to distributor

Engineering Analysis: Cost Model (cont.)

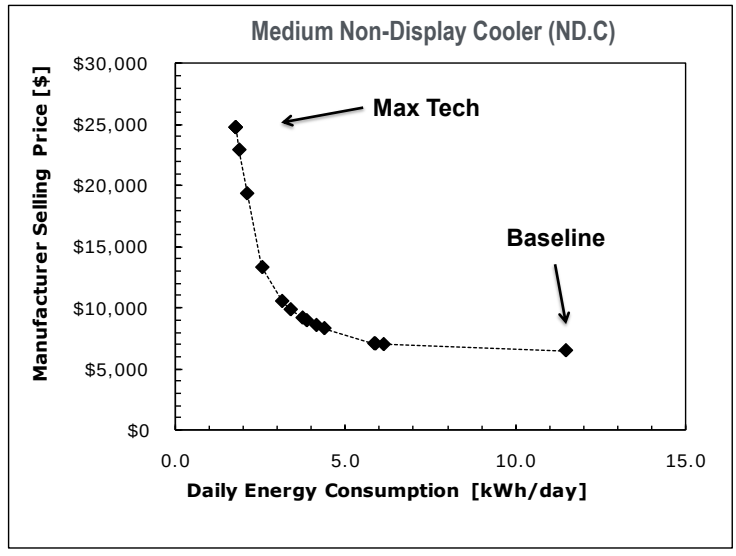
- Outbound Freight
  - DOE assumed that manufacturers included their outbound freight cost in the equipment selling price.
  - Outbound freight cost varies by:
    - Volume
    - Weight

Engineering Analysis: Cost Model (cont.)

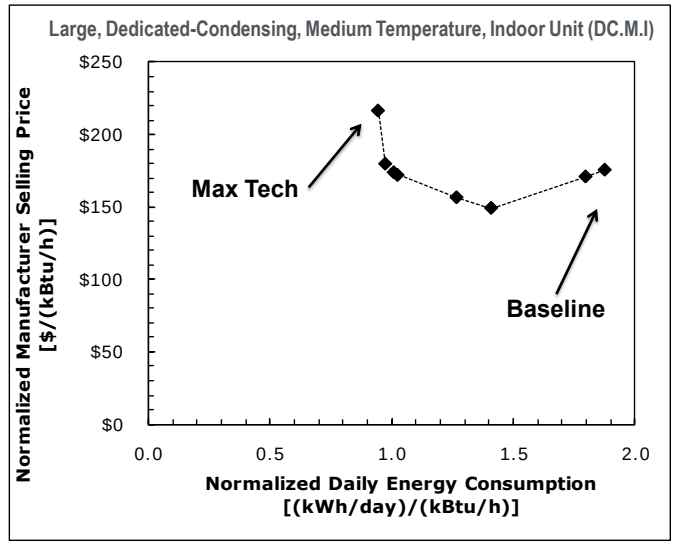


Item 2-7 DOE seeks comment on its costs, markup, and outbound freight assumptions.

Engineering Analysis: Envelope Cost-Efficiency Curve

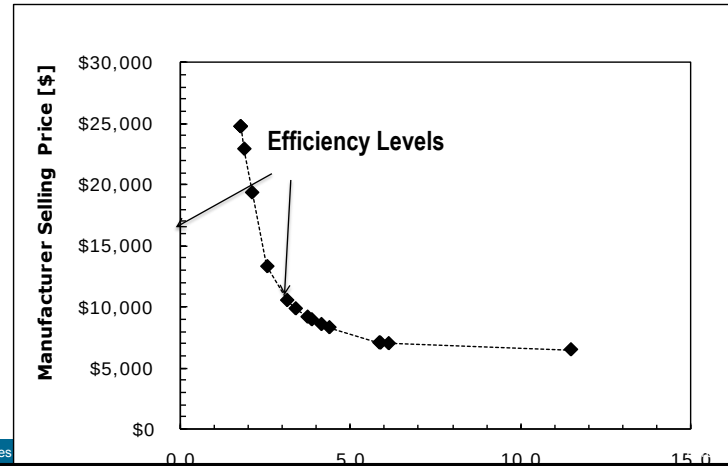


Engineering Analysis: Refrigeration Cost-Efficiency Curve



Engineering Analysis: Efficiency Levels

- Each point on a cost-efficiency curve is called an Efficiency Level.
- DOE conducted downstream analyses at each combination of Efficiency Levels for envelope and refrigeration system pairs.



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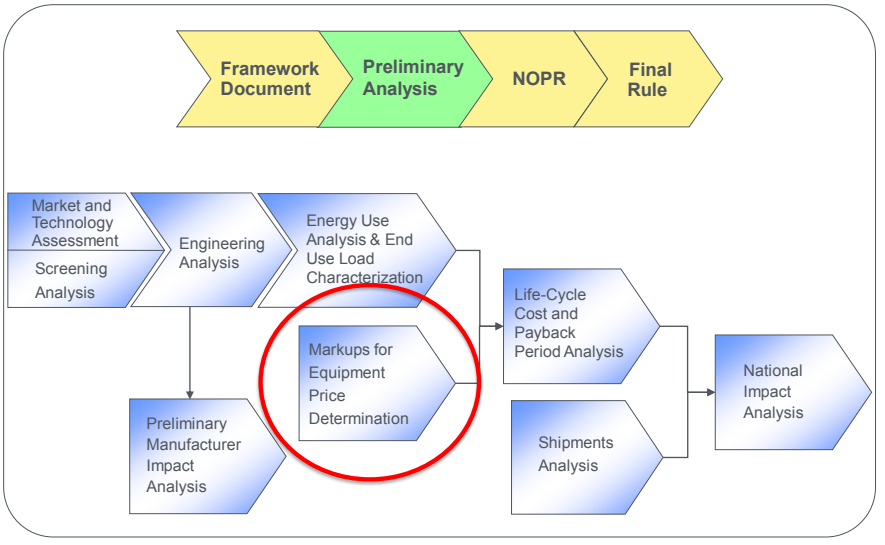
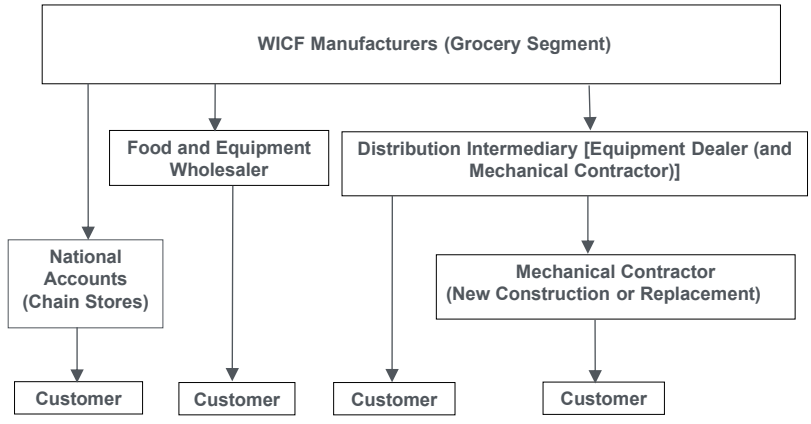
Preliminary Analysis Rulemaking Stage



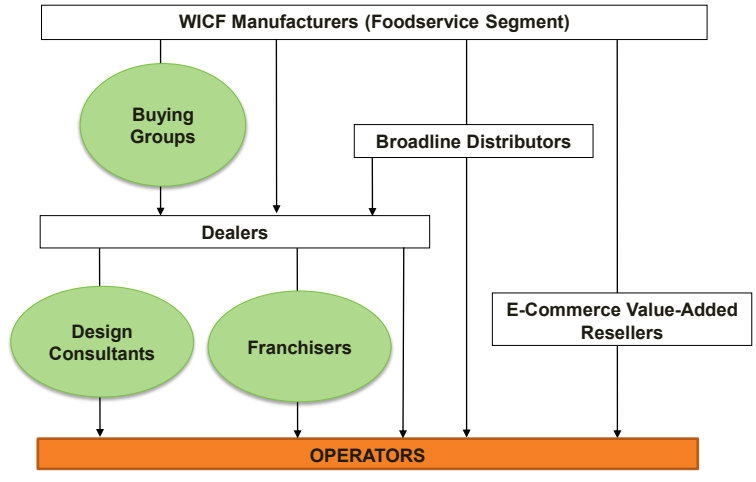
Markups Analysis: Purpose

- Purpose
  - Determine end-user prices based on manufacturer costs
  - Characterize equipment distribution channels
  - Reflect WICF distribution direct costs, expenses, and profits
- Inputs
  - Firm balance sheets from HARDI (wholesalers) and ACCA (mechanical contractors) data
  - U.S. Census Bureau on wholesalers, mechanical contractors, general contractors
- Output
  - Baseline and incremental markups
- The methodology and results are presented in detail in Chapter 6 of the preliminary TSD.

Markups Analysis:
Distribution Channels for Equipment to Grocery Segment

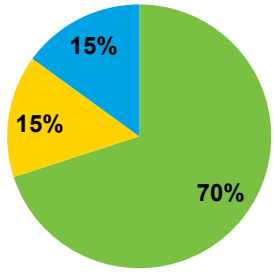


Markups Analysis:
Distribution Channels for Equipment to Foodservice Segment



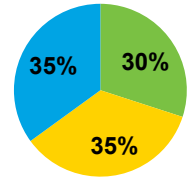
Markups Analysis: Distribution Channel Shares

Multiplex Condensing Equipment

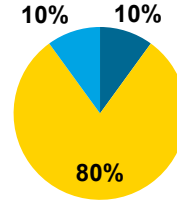


- National Account
- Distributor
- Contractor
- E-commerce Reseller

Dedicated Condensing Equipment



Convenience Stores and Small Grocery Stores (50%)



Food Service (50%)

Distribution Channels: Request for Comment

Item 3-1 DOE seeks comment on the markups analysis modeling approach (i.e. using multiple distribution channels). (Question ES.4.4 in the Executive Summary)

Item 3-2 DOE seeks comment on the accuracy of these distribution channels and the distribution channel shares.

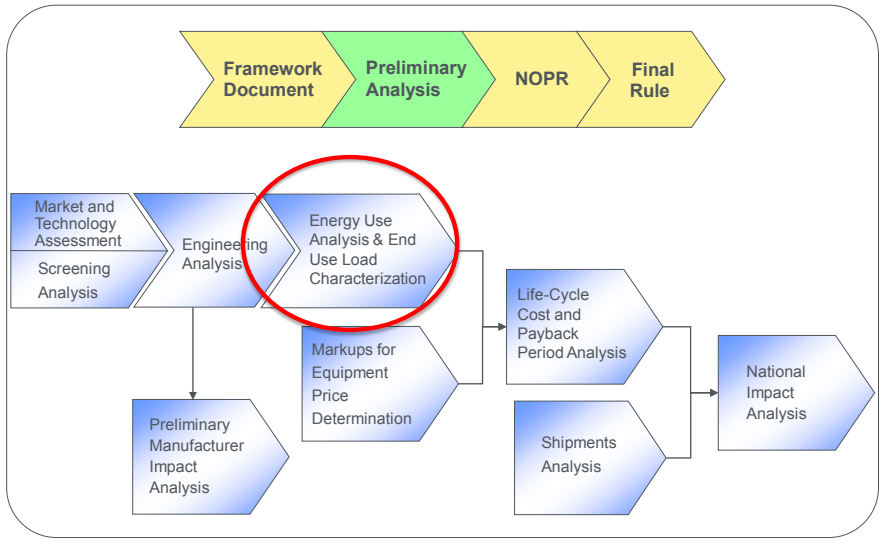
Markups Analysis: Preliminary Average Markups

Markups (Baseline / Incremental)					
	Distributor	Mechanical Contractor (Includes Distributor)	National Account (Mfg Direct)	Overall Weighted Average Markup	
				Multiplex Equipment	Dedicated Equipment
Distributor(s) Markup	1.45/1.12	2.21/1.38	1.23/1.06	1.41/1.12	1.83/1.25
Overall Markup (Incl. Sales Tax)	1.56/1.20	2.36/1.48	1.31/1.13	1.51/1.20	1.96/1.34

Sales Tax Multiplier	1.07

Item 3-3 DOE seeks comment on the baseline and incremental markups.

Preliminary Analysis Rulemaking Stage



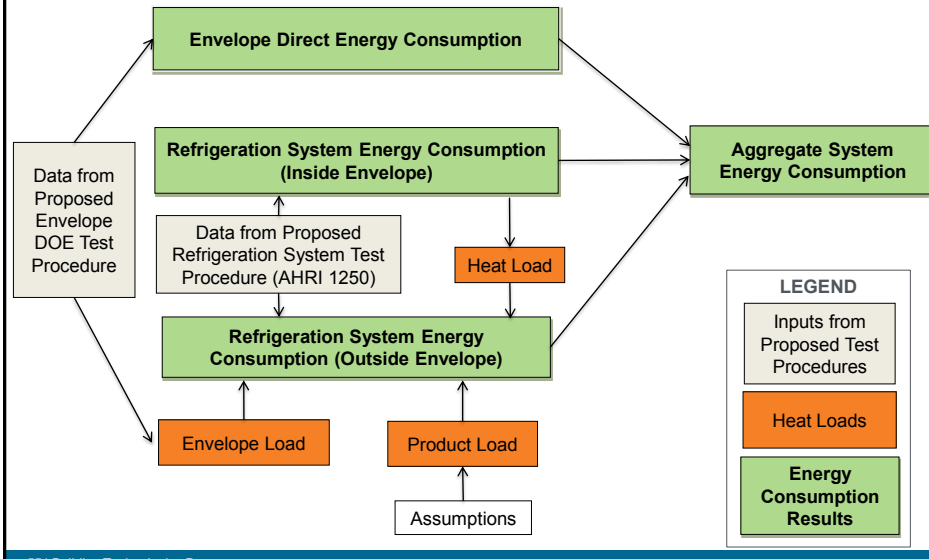
Energy Use Analysis: Purpose

- Purpose
  - To provide annual energy consumption estimates by efficiency level for walk-in equipment
  - For units with outdoor condensers, to estimate and analyze state-wide annual energy consumption by efficiency level
- Outputs
  - Annual WICF energy consumption for all envelope and refrigeration system combinations at all efficiency levels.
- The methodology and results are presented in detail in Chapter 7 of the preliminary TSD.

Energy Use Analysis: Methodology

- Analyzed 12 representative envelopes (4 equipment classes x 3 sizes).
- Matched each envelope with one of three refrigeration system types:
  - Dedicated indoor system
  - Dedicated system with external condenser
  - Multiplex system
- Assumed product loading and duty cycle.
- Determined direct electrical energy consumption using proposed envelope test procedure methodology.
- Estimated energy for the refrigeration system using proposed test procedure (AHRI 1250-2009).
- Added energy consumption of the envelope and refrigeration system to calculate the total energy consumption of the walk-in.

Data Inputs and Methodology



Energy Use Analysis: Assumptions for Product Load

	Coolers		Freezers	
Product Pull Down Temperature Difference (°F)	10			
Product Specific Heat (Btu/lb-°F)	0.9		0.45	
	Small	Medium/ Large	Small	Medium/ Large
Loading Ratio (lbs/ft^3-24 hr)	4	2	1	0.5

Item 3-4 DOE seeks comment on the assumptions made for calculating the product load.

Energy Use Analysis: Assumptions for Duty Cycle

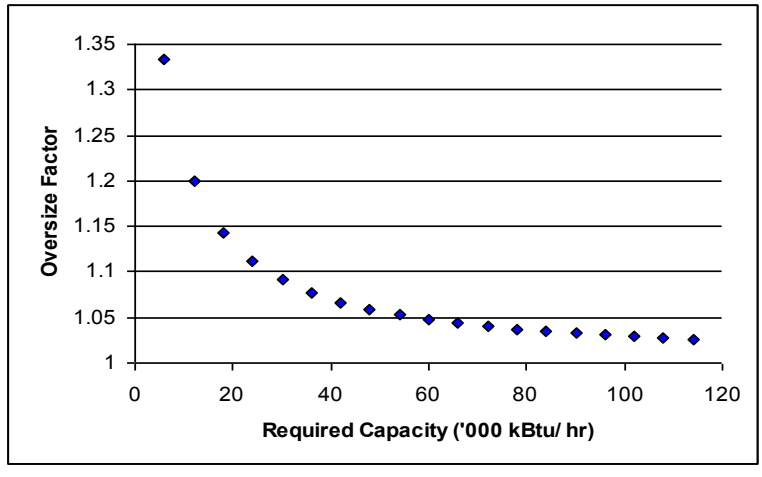
	Coolers	Freezers
High Box Load (BLH)	BLH = 0.7 x q_{ss}*	BLH = 0.8 x q_{ss}*
Low Box Load (BLL)	BLL = 0.1 x q_{ss}*	BLL = 0.4 x q_{ss}*
Average Box Load (BLA)	BLA = (8 BLH + 16 BLL) / 24	

*q_{ss}=steady state capacity of the refrigeration system

Item 3-5 DOE seeks comment on the duty cycle assumptions and the rationale to use the duty cycle assumptions from the proposed refrigeration system test procedure (AHRI 1250-2009).

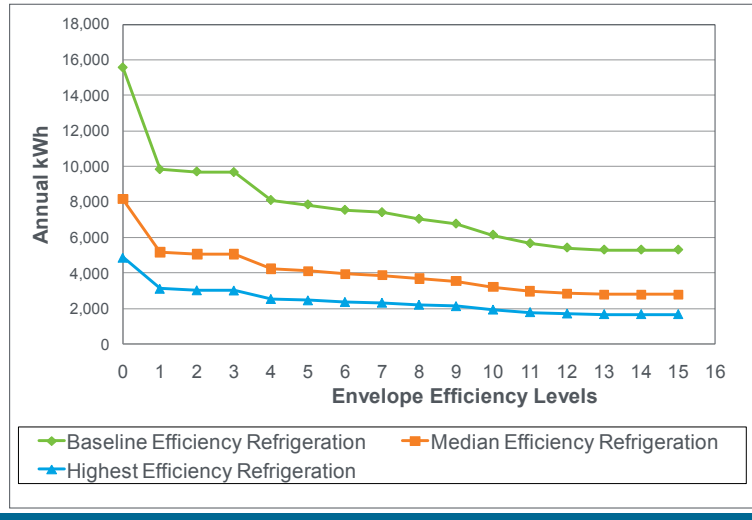
Energy Use Analysis: Oversize Factor

- Oversize factor (or mismatch factor) is the ratio between the required capacity and the closest available (size) refrigeration system capacity
- The mismatch factor is used to calculate the nearest matched refrigeration system capacity



Energy Use Analysis:
Sample Estimates of Annual Energy Consumption

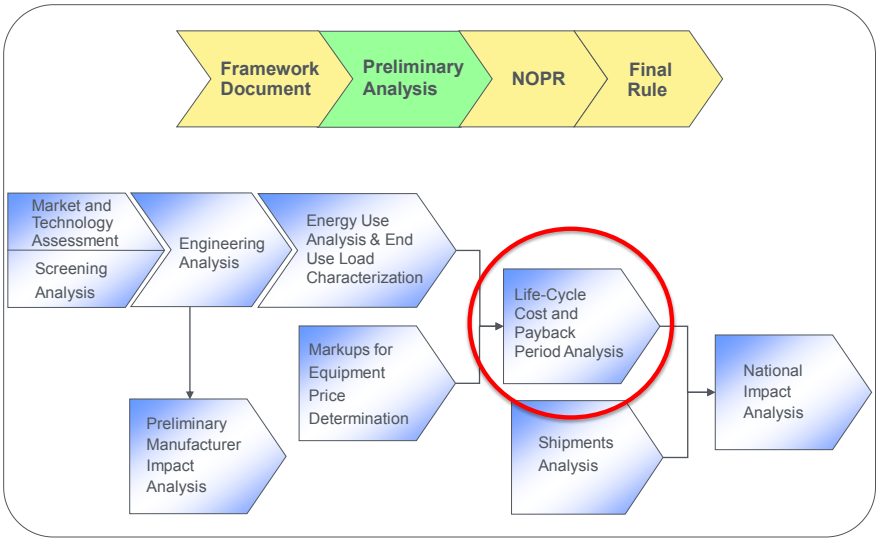
Energy Consumption for a Medium Non-Display Cooler with a Dedicated Medium-Temperature Outdoor System (12' x 20' x 9.5'):



Public Meeting Agenda

1. Statute and Context
2. Market and Technology Assessment; Screening and Engineering Analyses
3. Markups Analysis; Energy Use Analysis
4. Life Cycle Cost and Payback Period Analysis
5. Shipments Analysis; National Impact Analysis
6. Preliminary Manufacturer Impact Analysis; NOPR Analyses
7. Test Procedures

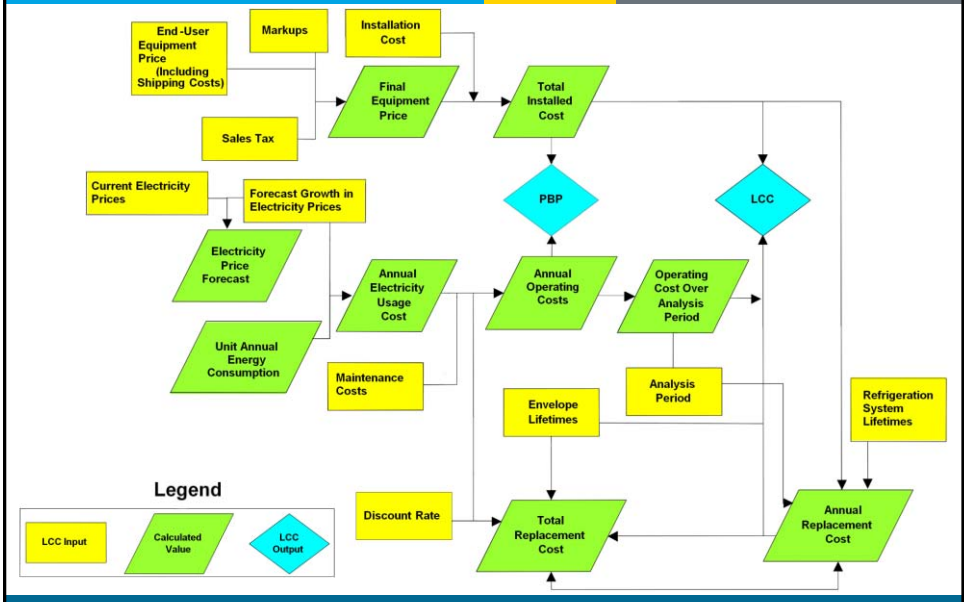
Preliminary Analysis Rulemaking Stage



Life-Cycle Cost Analysis: Purpose & Methodology

- Purpose
  - Estimates financial impacts for a single consumer over time in two ways:
    - Life-cycle cost (LCC) savings
    - Payback period (PBP)
- Methodology
  - Life Cycle Cost: Equipment-installed price + sum of operating cost stream
    - LCC savings: Baseline minus standard level
  - Payback Period: Equipment-installed price / one year's operating costs
  - LCC is discounted; PBP is not discounted (—simple" PBP)
- The methodology and results are presented in detail in Chapter 8 of the preliminary TSD.

Life-Cycle Cost and Payback Period Analysis: Analysis Flow Chart



Life-Cycle Cost and Payback Period Analysis: Electricity Prices

- Current electricity prices based on EIA form 861 data
  - Specific to state and sector
- Growth rates based on EIA's *Annual Energy Outlook* (*AEO*)
  - Specific to sector only
- Both will be updated again for the NOPR
  - Current EIA form 861 data is 2008-2009, current *AEO* is April 2009
- Average energy prices
  - Not time-of-use pricing or marginal pricing
  - Assumes no variation by building type

Life-Cycle Cost and Payback Period Analysis: Repair, Maintenance, and Replacement Costs

- Major repairs = Replacement of entire refrigeration system and doors
  - Probability of replacing refrigeration system during envelope lifetime = 0.5
  - Annualized
- Annual maintenance costs = $158 to $239
  - One national figure
  - Independent of size, efficiency level
- Replacement accounted separately and considered as maintenance activity
- Main data source for all three: RS Means

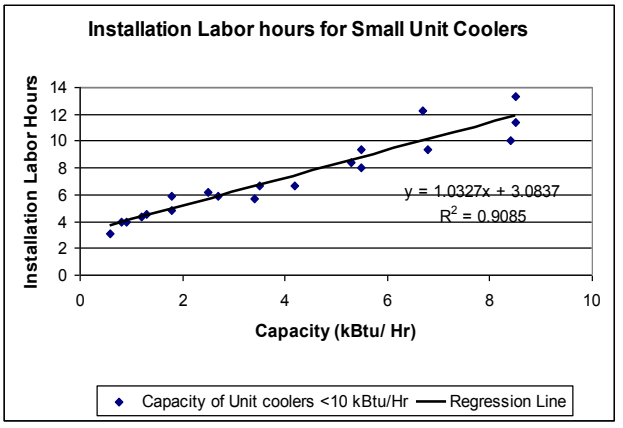
Life-Cycle Cost and Payback Period Analysis: Request for Comment

Item 4-1 DOE seeks comment on whether the maintenance and repair costs are reasonable and how maintenance and repair costs may vary with efficiency level.

Item 4-2 DOE seeks comments on any additional sources that could be considered for maintenance, repair, and installation costs.

Life-Cycle Cost and Payback Period Analysis: Installation Costs

- Installation costs
  - Unit cooler and condensing units installations considered separately
  - Labor hour and rates based on *RS Means* for various sizes.
  - Data extrapolated to cover full range



Life-Cycle Cost and Payback Period Analysis: Other Inputs

- Discount Rates
  - Real rates based on weighted average cost of capital (WACC)
  - Different rates by establishment type
    - Grocery stores
    - Convenience stores
    - Food service establishments
    - Dairy farms
    - Miscellaneous
- Lifetimes
  - Used average lifetime for one envelope (15 years)
  - Includes two refrigeration systems in that time
  - More detail in shipments section

Life-Cycle Cost and Payback Period Analysis: Sample Results

- Difficult to summarize LCC results (many equipment classes, Efficiency Levels)
- Need summary statistic: max LCC for each class, size
- Typically occurs at high Efficiency Levels, but not max tech

Box Efficiency Level	LCC Savings by Refrigeration Efficiency Level (2009, $) for Medium Display Cooler with Large Dedicated, Indoor Refrigeration System							
	0	1	2	3	4	5	6	7
0		5,280	31,025	36,814	46,001	46,376	46,829	39,655
1	16,417	21,348	45,391	50,780	59,328	59,675	60,090	53,347
2	24,014	28,767	51,943	57,129	65,353	65,686	66,081	59,560
3	38,774	42,913	63,092	67,579	74,686	74,970	75,300	69,551
4	42,788	46,799	66,349	70,691	77,564	77,839	78,155	72,569
5	67,718	70,585	84,560	87,616	92,439	92,627	92,828	88,717
6	84,588	86,243	94,301	96,020	98,718	98,818	98,912	96,431
7	78,058	79,638	87,335	88,973	91,543	91,639	91,726	89,348
8	78,085	79,659	87,329	88,961	91,522	91,617	91,705	89,334
9	78,091	79,665	87,330	88,961	91,520	91,615	91,702	89,333
10	78,089	79,656	87,289	88,912	91,460	91,555	91,641	89,281
11	66,008	67,160	72,768	73,944	75,784	75,851	75,906	74,129
12	65,991	67,139	72,730	73,903	75,737	75,803	75,858	74,086
13	65,899	67,039	72,590	73,754	75,574	75,640	75,694	73,934
14	65,746	66,880	72,403	73,560	75,371	75,436	75,490	73,739
15	63,565	64,689	70,161	71,307	73,100	73,165	73,218	71,481

Life-Cycle Cost and Payback Period Analysis: Monte Carlo Simulation

- For NOPR stage, DOE will also conduct Monte Carlo analysis for LCC.
- Allows DOE to consider variations in:
  - Energy use (based on climate region/state)
  - Prices (based on state taxes/labor prices/markups)
  - Discount rates (based on sector/WACC)
  - Possibly other factors (e.g., shipping distance)
- Correlates inputs where necessary (e.g., state taxes and state climate region)
- Key value: shows how many consumers ~~"~~win" or ~~"~~lose" financially
  - As opposed to average consumer's financial gain or loss

Life-Cycle Cost and Payback Period Analysis: Other Comments

Item 4-3 DOE welcomes any other comments on the Life Cycle Cost and Payback Period Analysis at this time.

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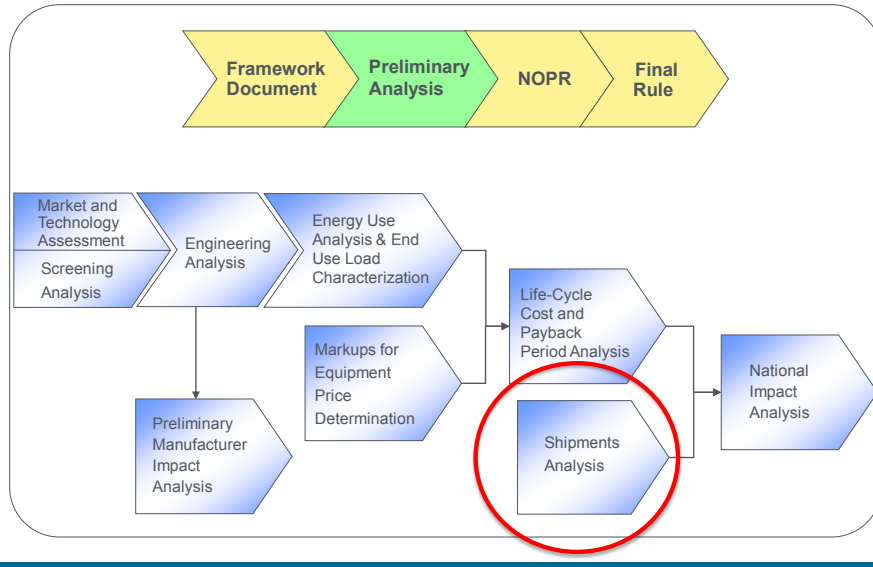
Preliminary Analysis Rulemaking Stage



Shipments Analysis: Outputs & Purpose

- Purpose:
  - Estimate future stock & future shipments of envelopes and refrigeration systems
  - Estimate efficiency mix of the stock over time
- Supports numerous downstream analyses including:
  - National Impact Analysis
  - Manufacturer Impact Analysis
- The methodology and results are presented in detail in Chapter 9 of the preliminary TSD.

Shipments Analysis: Method

- Future shipments are based on historical shipments.
- DOE could not find historical data for walk-in shipments.
- Solution:
  - Estimate historical stock (1997-2009)
  - Estimate equipment replacement rates
  - Estimate market growth rates
- Calculate for many possible walk-in types (equipment classes, efficiency levels…)

Shipments Analysis:
Step 1 Estimate historical stock

- DOE estimated historical stock by combining two data sources:
  - Commercial Building Energy Consumption Survey (CBECS): walk-ins per building square foot ("saturation")
  - Census: number and size (square feet) of buildings with walk-ins
- Next, DOE apportioned the estimated historical stock:
  - By building type (based on Census data)
  - By equipment class (using DOE estimates and manufacturer interviews)
- Results (for 2007):

Envelope Stock – 2,010,000	
Equipment Class	**Percent of Stock**
Non-Display Coolers	45%
Display Coolers	25%
Non-Display Freezers	10%
Display Freezers	20%

Refrigeration System Stock – 2,010,000	
Equipment Class	**Percent of Stock**
Multiplex Condensing, Medium Temp	31%
Multiplex Condensing, Low Temp	15%
Direct Condensing, Indoor, Medium Temp	4%
Direct Condensing, Indoor, Low Temp	2%
Direct Condensing, Outdoor, Medium Temp	29%
Direct Condensing, Outdoor, Low Temp	19%

Shipments Analysis Historical Stock: Request for Comment

Item 5-1 DOE seeks comment on its methodology for estimating historical stock.

Shipments Analysis: Step 2 Estimate equipment replacement rates

- DOE estimated equipment replacement rates
  - Received input from manufacturers
  - Accounted for variation in lifetimes
- Envelopes
  - For historical analysis, DOE assumed average replacement rate of 5%.

	Replacement Rate	2007 Stock	2007 Shipments
Rate Used in Analysis	5% (~ every 20 years)	2,010,000	102,000
Hypothetical Rate	10% (~ every 10 years)		202,000

- Refrigeration systems
  - For historical analysis, DOE assumed average replacement rate of 15%.

	Replacement Rate	2007 Stock	2007 Shipments
Rate Used in Analysis	15% (~ every 8 years)	2,010,000	288,000
Hypothetical Rate	30% (~ every 3 years)		575,000

Shipments Analysis Growth: Request for Comment

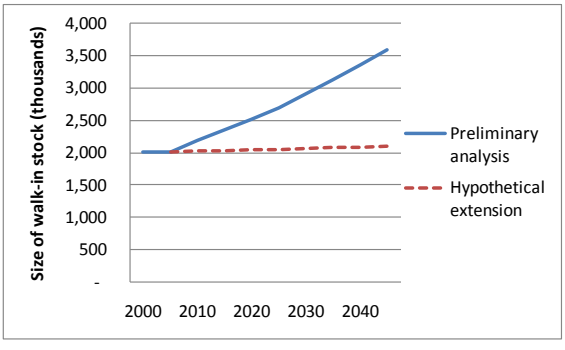
Item 5-2 DOE seeks comment on the quantity and growth rate of historical shipments and the methodology for estimating these shipments. DOE requests that interested parties submit historical shipment data for WICF equipment.

Item 5-3 DOE seeks comment regarding average lifetimes for envelopes and refrigeration systems, as well as variation around these averages.

Shipments Analysis:
Step 3 Estimate market growth rates

DOE estimated future growth of the WICF market based on growth in the square footage of *buildings that use walk-ins*

- Restaurants, grocery stores, convenience stores, dairy farms, and —other"
- Standard DOE procedure for a mature / saturated market
- Note that this growth rate was *NOT* observed in 1997-2007
- Sources: *AEO2009* (most walk-ins) and Ag Census (dairy farm walk-ins)



Growth Rate	2045 Stock	2045 Envelope Shipments
~1.6% (prelim. analysis)	3,596,000	223,000
~0.1% (historical rate)	~2,100,000	~105,000

Shipments Analysis Trends: Request for Comment

Item 5-4 DOE seeks comment on the assumption that growth of WICF stock will match the square foot growth of the building stock of restaurants, grocery stores, convenience stores, and dairy farms in America.

Item 5-5 DOE seeks to know of any notable trends toward higher or lower shipments of WICF equipment in recent years, as well as high or low demand events in recent years.

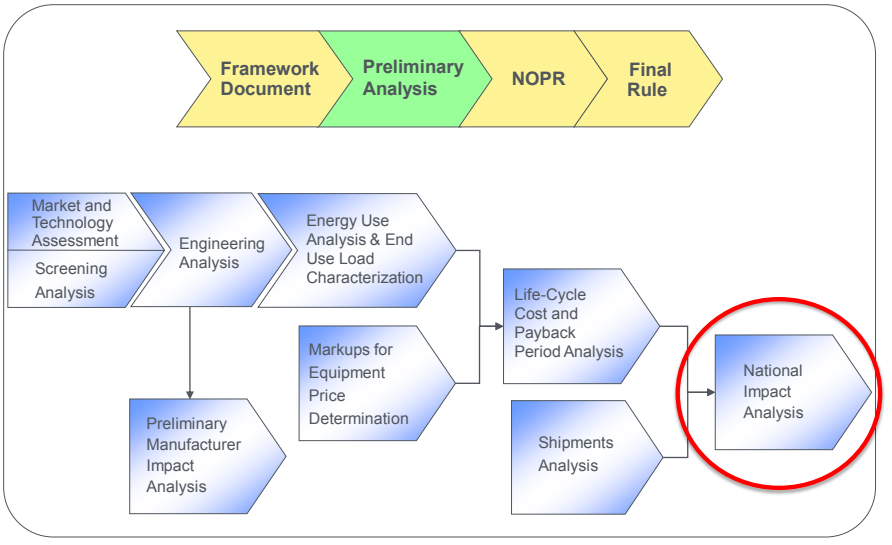
Shipments Analysis: Sizes

- Shipments are distributed across different sizes of walk-ins:
  - Needed for energy use & costs in National Impact Analysis.
  - Used representative sizes from engineering analysis.
- DOE's estimates used publicly available information about commonly manufactured sizes.

Share of Shipments by Size (Example)

Item 5-6 DOE seeks comment on any trends in WICF shipments in recent years.

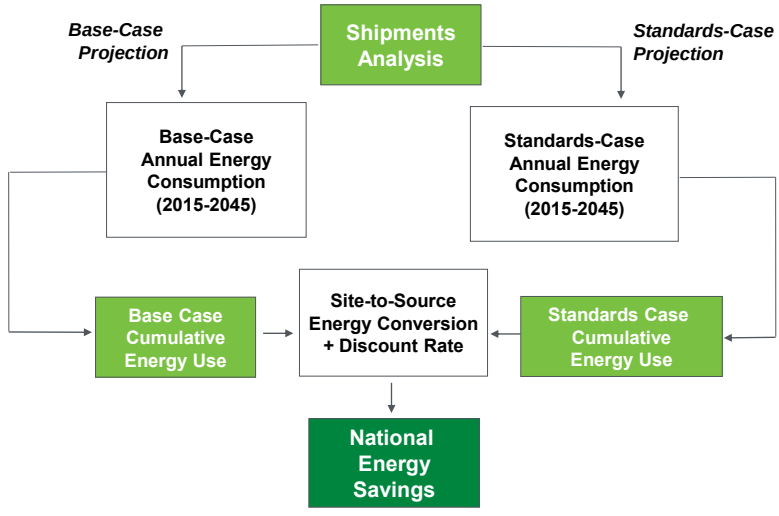
Preliminary Analysis Rulemaking Stage



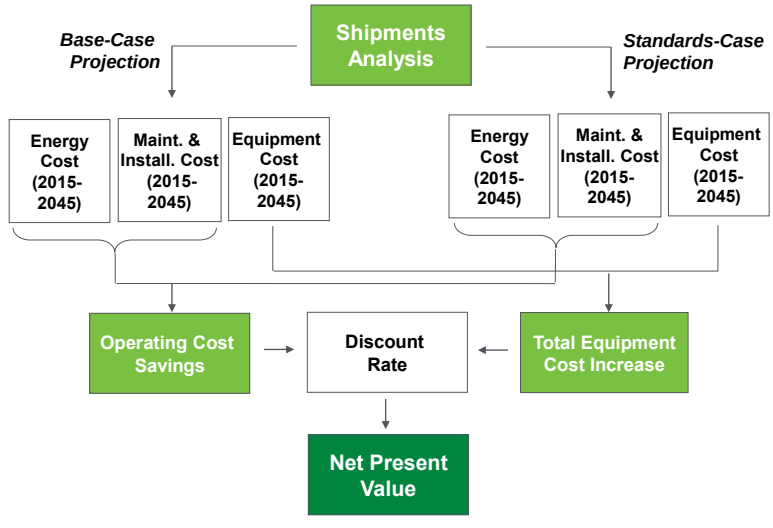
National Impact Analysis: Purpose & Method

- Purpose
  - To assess the aggregate impacts at the national and regional level at each Efficiency Level as measured by:
    - NES
    - NPV of total consumer economic impacts
- Method
  - For each year, for both the base-case and standards-cases, DOE calculates:
    - National energy consumption (energy use per unit per year times size of stock)
    - Total consumer expenditures on walk-ins is the sum of:
      - National equipment expenditures (total installed cost per unit x forecasted shipments in that year)
      - National operation and maintenance costs (costs per unit per year x size of stock)
  - Take difference between base-case and standards-cases in each year for NES and NPV of consumer economic impacts.
  - Years are then discounted and summed
- The methodology and results are presented in detail in Chapter 10 of the preliminary TSD.

National Impact Analysis:
National Energy Savings Flow Diagram



National Impact Analysis:
National Consumer Net Present Value Flow Diagram



National Impact Analysis: Inputs from Prior Analyses

- Key inputs: walk-in stock and number of shipments by Efficiency Level (Shipments Analysis)
  - NES requires stock (for energy per year)
  - NPV requires shipments (for installed cost) and stock (for operating cost)
  - Includes the number of pre-standard vs. post-standard efficiency units per year
    - Some walk-ins are a hybrid (pre-standard envelope with a replaced, post-standard refrigeration system)
  - DOE assumes all pre-standard walk-ins do not meet standard, and all post-standard walk-ins meet but do not exceed standard (a "roll-up" effect)

- Additional cost/energy use inputs (LCC/PBP Analysis)
  - Annual electricity costs per walk-in
  - Installed cost per walk-in
  - Annual operating costs other than energy costs per walk-in

National Impact Analysis: New Inputs

- Discount Factor
  - Used 7 percent and 3 percent real discount rates from the Office of Management and Budget's Regulatory Analysis Guideline A-4
  - Future expenses are discounted to present (2010)

- Electricity Site-to-Source Conversion Factors
  - Used to convert on-site energy consumption to primary (or source) energy generation
  - Depend on variables such as:
    - Time-varying generation mix
    - Distribution and transmission losses
  - For pre-analysis, used average factor over time
    - For NOPR stage, will derive specific rate for each year (similar results expected)

National Impact Analysis: New Inputs (cont.)

- Heating, Ventilating, and Air Conditioning (HVAC) factor
  - Measures interactions between walk-ins and HVAC systems
  - For this analysis, DOE assumed a factor of 1 (no effect): heat output largely outdoors
- Rebound factor
  - Measures tendency of consumers to make more use of highly efficient equipment
  - For this analysis, DOE assumed a factor of 1 (no effect): operation already constrained

National Impact Analysis: NES and NPV Summary Statistics

- Too many scenarios to characterize easily
- One summary statistic: maximum NES where NPV > 0
  - Other metrics possible

National Energy Savings (in quads at a 7% Discount Rate) for Large Display Freezer with Large Dedicated Condensing Outdoor Refrigeration System

Envelope Efficiency Level	Refrigeration Efficiency Level									
	0	1	2	3	4	5	6	7	8	9
0	N/A	0.03	0.12	0.17	0.27	0.31	0.33	0.33	0.35	0.38
1	0.02	0.06	0.14	0.19	0.29	0.33	0.34	0.35	0.36	0.39
2	0.15	0.18	0.24	0.28	0.36	0.39	0.40	0.40	0.42	0.44
3	0.15	0.18	0.24	0.28	0.36	0.39	0.40	0.40	0.42	0.44
4	0.17	0.19	0.25	0.29	0.37	0.40	0.41	0.41	0.43	0.45
5	0.22	0.24	0.30	0.33	0.40	0.43	0.44	0.44	0.46	0.47
6	0.33	0.35	0.39	0.42	0.47	0.49	0.49	0.50	0.50	0.52
7	0.33	0.35	0.39	0.42	0.47	0.49	0.49	0.50	0.50	0.52
8	0.33	0.35	0.39	0.42	0.47	0.49	0.49	0.50	0.50	0.52
9	0.34	0.35	0.39	0.42	0.47	0.49	0.50	0.50	0.51	0.52
10	0.34	0.36	0.40	0.42	0.47	0.49	0.50	0.50	0.51	0.52
11	0.38	0.39	0.43	0.45	0.49	0.51	0.51	0.52	0.52	0.53
12	0.38	0.39	0.43	0.45	0.49	0.51	0.51	0.52	0.52	0.54
13	0.38	0.40	0.43	0.45	0.49	0.51	0.52	0.52	0.52	0.54
14	0.38	0.40	0.43	0.45	0.49	0.51	0.52	0.52	0.52	0.54
15	0.38	0.40	0.43	0.45	0.49	0.51	0.52	0.52	0.53	0.54

Note: Highlighted cells are Efficiency Level combinations for which NPV > 0.

National Impact Analysis:
NES and NPV Summary Statistics (cont.)

- For many rules, this approach highlights max tech
  - Other summary statistics (e.g. maximum NPV) different

National Energy Savings (in quads at a 7% Discount Rate)
for Medium Non-Display Cooler with Large Dedicated, Indoor Refrigeration System

Envelope Efficiency Level	Refrigeration Efficiency Level							
	0	1	2	3	4	5	6	7
0	N/A	0.00	0.02	0.03	0.05	0.05	0.05	0.05
1	0.03	0.03	0.05	0.05	0.06	0.06	0.06	0.06
2	0.03	0.03	0.05	0.05	0.06	0.06	0.06	0.06
3	0.03	0.03	0.05	0.05	0.06	0.06	0.06	0.06
4	0.04	0.04	0.05	0.06	0.07	0.07	0.07	0.07
5	0.04	0.04	0.05	0.06	0.07	0.07	0.07	0.07
6	0.04	0.04	0.06	0.06	0.07	0.07	0.07	0.07
7	0.04	0.04	0.06	0.06	0.07	0.07	0.07	0.07
8	0.04	0.05	0.06	0.06	0.07	0.07	0.07	0.07
9	0.04	0.05	0.06	0.06	0.07	0.07	0.07	0.07
10	0.05	0.05	0.06	0.06	0.07	0.07	0.07	0.07
11	0.05	0.05	0.06	0.07	0.07	0.07	0.07	0.08
12	0.05	0.05	0.06	0.07	0.07	0.07	0.07	0.08
13	0.05	0.05	0.06	0.07	0.07	0.07	0.08	0.08
14	0.05	0.05	0.06	0.07	0.07	0.07	0.08	0.08
15	0.05	0.05	0.06	0.07	0.07	0.07	0.08	0.08

Note: Highlighted cells are Efficiency Level combinations for which NPV > 0.

National Impact Analysis:
NES and NPV Preliminary Results

- Results
  - Typically occurs at a high Efficiency Level combination
    - Occasionally at max tech
  - NPV varies more than NES (because NPV is based on maximum NES)

- Considerable savings available at max tech for both envelopes and refrigeration systems.
  - NES: 6 quads at 7% DR (13 quads at 3% DR)
  - NPV: $33B over 30 years at 7% DR ($72B at 3% DR)

Item 5-7 DOE welcomes any comments on the National Impacts Analysis at this time.

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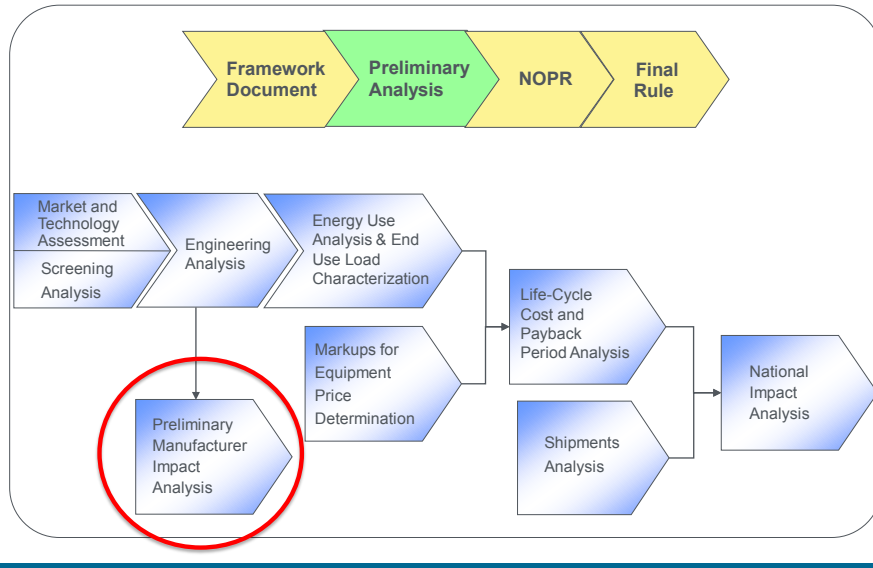
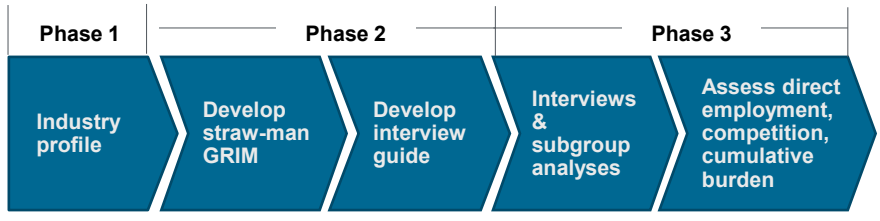


Manufacturer Impact Analysis: Overview

- Purpose
  - Assess the impacts of new standards on manufacturers.
  - Identify and estimate impacts on manufacturer subgroups that may be more severely impacted than the industry as a whole.
  - Examine the impact of cumulative regulatory burden on the industry.
- Method
  - Analyze industry cash flow and net present value through use of the Government Regulatory Impact Model (GRIM).
  - Interview manufacturers to refine inputs to the GRIM, develop subgroup analyses, and address qualitative issues.
- Outputs
  - Industry NPV impacts
  - Subgroup NPV impacts
  - Other impacts (employment, competitive landscape, cumulative burden)

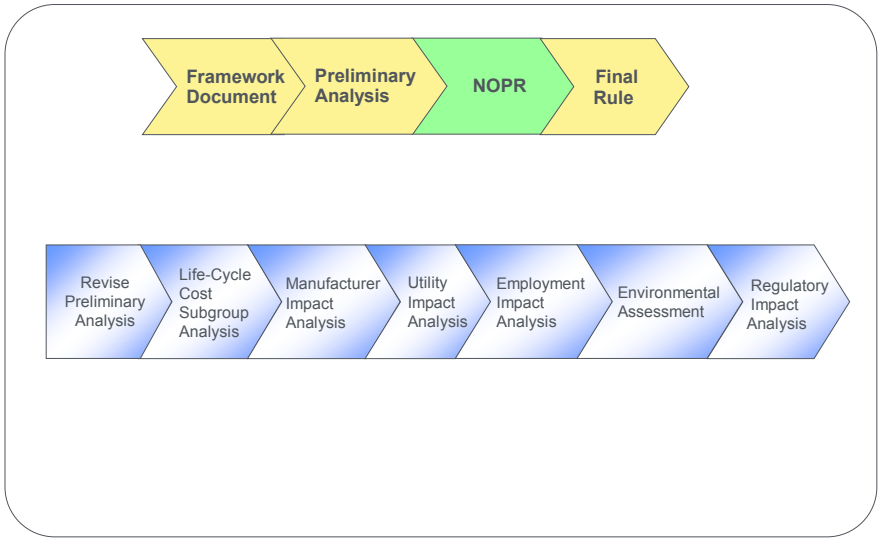
Manufacturer Impact Analysis: Methodology

- Three main phases of the Manufacturer Impact Analysis:



- The methodology and results are presented in detail in Chapter 12 of the preliminary TSD.

NOPR Analyses



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Major Test Procedure Issues: Overview

- Definition of Manufacturer
- Testing and Compliance Responsibility
- Basic Model of Envelope
- Modifications to Envelope Test Procedure
  - Accounting for Heat Conduction through Structural Members
  - New Door Tests

Definition of Manufacturer

- EPCA provides that [t]he term ~~-~~manufacture" means to manufacture, produce, assemble or import.' 42 U.S.C. 6291(10)
- At the NOPR public meeting, **interested parties requested clarification of the definition and responsibilities associated with "manufacture."**
- DOE is considering applying the term ~~-~~assemble" (within the definition of ~~-~~manufacture") to cover those entities that design and/or select components for an envelope or refrigeration system for walk-ins.

Testing and Compliance Responsibility

- In the test procedure NOPR, DOE assumed that the manufacturer should be responsible for testing equipment and complying with the standard.
- Interested parties submitted comments on the NOPR:
  - Indicating a strong preference for allowing component manufacturers to test their own products.
  - Noting that requiring a component manufacturer to test another component manufacturer's products would be burdensome.
- In response to these comments:
  - DOE is considering that the assembler of the walk-in shall be the manufacturer responsible for demonstrating compliance with the performance standard.
  - DOE is considering allowing the assembler to conduct tests or to rely on test results provided by component suppliers.

Request for Comment

Item 7-1 DOE seeks comment on the proposed interpretation of the term "assemble" within the context of the statutory definition of "manufacture."

Item 7-2 DOE seeks comment on the proposal to allow the assembler to conduct tests or to rely on test results provided by component suppliers.

Basic Model of Envelope

- Definition proposed in the NOPR:
  - —Basic Model means all units of a given type of walk-in equipment manufactured by a single manufacturer, and— (1) With respect to envelopes, which do not have any differing construction methods, materials, components, or other characteristics that **significantly affect** the energy consumption characteristics."
- **DOE is considering changing the definition of Basic Model in order to be consistent with other changes to the test procedure.**
- Revised definition that DOE is considering:
  - —Basic Model means—(1) with respect to envelopes, all envelopes manufactured by a single entity, which do not have **any differing** features or characteristics that affect normalized energy consumption."

Basic Model of Envelope (cont.)

- Justification:
  - Provides a way to distinguish envelopes that vary in normalized energy consumption from those that differ only cosmetically.
- Impact on Manufacturer Burden
  - Testing burden: this change would not result in an increased testing burden because of the burden-reducing measures proposed elsewhere in the test procedure.
    - Calculating energy consumption by scaling results of physical testing
    - Allowing manufacturers to rely on suppliers' test data
  - Compliance and reporting burden: DOE will consider reducing compliance and reporting burden in a future rulemaking establishing compliance, certification, and enforcement regulations for WICF.

Item 7-3 DOE seeks comment on the revised definition of basic model for envelopes.

Modifications to Envelope Test Procedure: Heat Conduction Through Structural Members

- In the NOPR, DOE proposed to determine heat conduction through the envelope by measuring the R-value of the foam used in the panels.
- **Interested parties stated that DOE must also account for heat conduction through structural members of panels.**
- DOE is considering ASTM C1363-05: Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus
  - First, manufacturers find the U-factor of the fully assembled panel using ASTM C1363-05.
  - Second, the U-factor is de-rated using the R-value of the foam as found by ASTM C1303-09a.

Item 7-4 DOE seeks comment on the use of ASTM C1363-05.

Modifications to Envelope Test Procedure: New Door Tests

- In the NOPR, DOE proposed certain procedures for testing doors:
  - U-Factor of display doors: NFRC Rating or Window 5.2 methodology
  - Steady-state infiltration around doors: Gas tracer method for each door.
- DOE is considering expanding and clarifying testing to make it easier for door manufacturers to complete testing.
- DOE is considering the following tests for display and non-display doors:
  - U-factor of doors: NFRC 100-2010, Procedure for Determining Fenestration Product U-Factors
  - Steady-state infiltration around doors: NFRC 400-2010, Procedure for Determining Fenestration Product Air Leakage
    - Incorporates ASTM E283-04, Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

Item 7-5 DOE requests comment on these test procedures.

DOE Seeks Comments on its Proposal

In all correspondence, include all of the following:

- Energy Conservation Standards for Walk-In Coolers and Walk-In Freezers
- Docket Number EERE-2008-BT-STD-0015
- Regulatory Identification Number (RIN) 1904-AB86

Email: WICF-2008-STD-0015@ee.doe.gov

Postal Mail:
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Comment period closes May 28, 2010

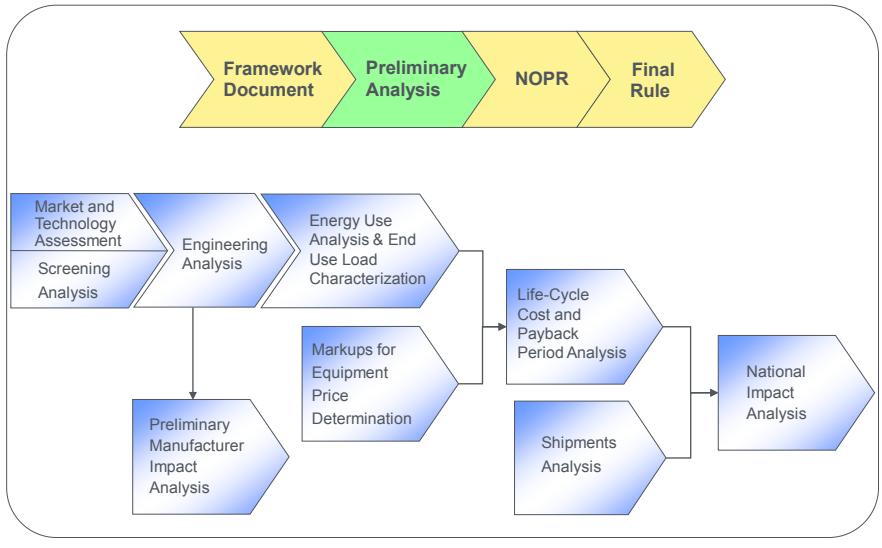
Relevant Webpages

- **DOE Appliance Standards**
  - http://www1.eere.energy.gov/buildings/appliance_standards/
- **Walk-in Coolers and Walk-in Freezers Rule**
  - http://www1.eere.energy.gov/buildings/appliance_standards/commercial/wicf.html
- **Contact Charles Llenza, Project Manager, from the Appliance Standards Program for additional information:**
  - Charles.Llenza@ee.doe.gov
  - **202.586.2192**
- **Contact John Cymbalsky, Supervisor, from the Appliance Standards Program for additional information:**
  - John.Cymbalsky@ee.doe.gov
  - **202.287.1692**

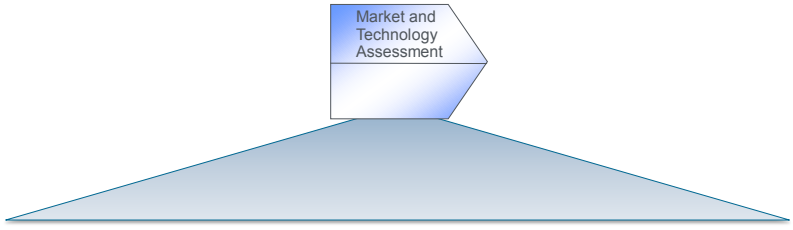
Appendix: Acronyms & Abbreviations

AEO	Annual Energy Outlook
AHRI	Air-Conditioning, Heating, and Refrigeration Institute
ARI	Air-Conditioning and Refrigeration Institute
ASM	Annual Survey of Manufacturers
BT	building technologies
BTU	British thermal units
CBECS	Commercial Building Energy Consumption Survey
DF	discount factor
EIA	Energy Information Agency
EISA 2007	Energy Independence and Security Act of 2007
EPA	U.S. Environmental Protection Agency
EPCA	Energy Policy and Conservation Act of 1975
FTC	U.S. Federal Trade Commission
GRIM	Government Regulatory Impact Model
HARDI	Heating, Air-Conditioning, and Refrigeration Distributors International
HVAC	heating, ventilation, and air conditioning
INPV	industry net present value
kWh	kilowatt hour
LBNL	Lawrence Berkeley National Laboratory
LCC	life-cycle cost
LFH	load factor at high load
LFL	load factor at low load
MIA	manufacturer impact analysis
MPC	manufacturer production cost
MSP	manufacturer selling price
MTA	market and technology assessment
NAFEM	North American Association of Food Equipment Manufacturers
NAICS	North American Industry Classification System
NEMS	National Energy Modeling System
NES	national energy savings
NIA	national impact analysis
NPV	net present value
NOPR	Notice of Proposed Rulemaking
PBP	payback period
PNNL	Pacific Northwest National Laboratory
RIA	regulatory impact analysis
SBA	U.S. Small Business Administration
SEC	Securities and Exchange Commission
SST	saturated suction temperature
TSD	Technical Support Document
USC	United States Code
VIP	vacuum insulated panel
WACC	weighted-average cost of capital
WICF	walk-in coolers and walk-in freezers

Preliminary Analysis Rulemaking Stages

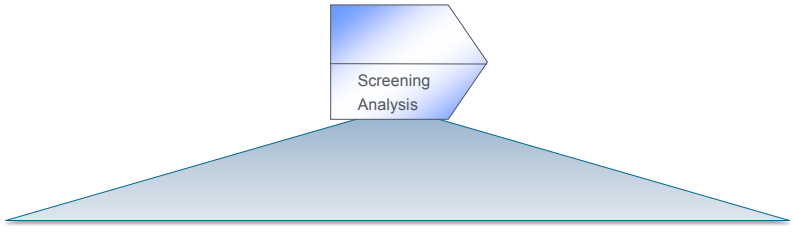


Appendix: Rulemaking Stage Details



1. **Characterizes the market**
2. **Identifies technologies that can improve efficiency**

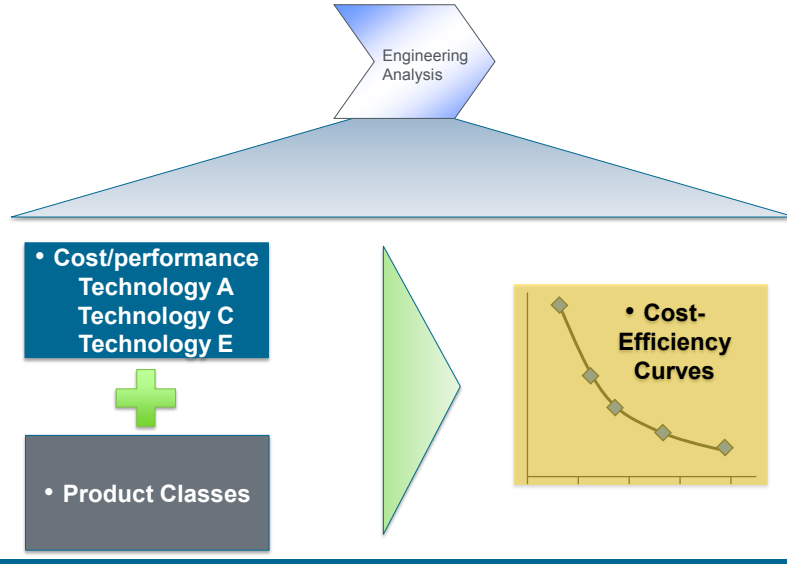
Appendix: Rulemaking Stage Details



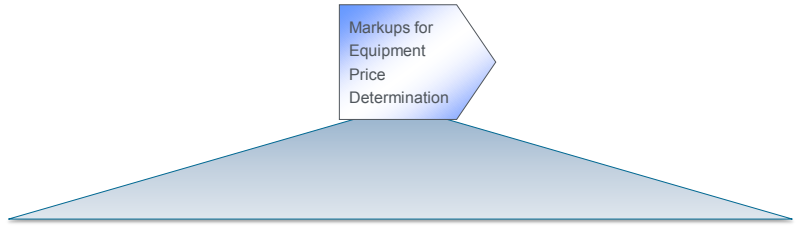
- **Technology A**
- **Technology B**
- **Technology C**
- **Technology D**
- **Technology E**

- **Technology A**
- **Technology C**
- **Technology E**

Appendix: Rulemaking Stage Details

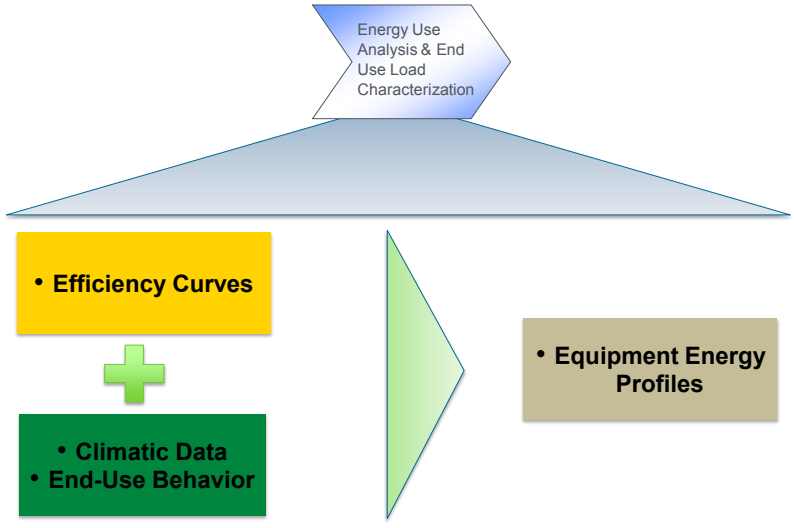


Appendix: Rulemaking Stage Details



1. **Determine end-user equipment price by:**
   - **Determining distribution channel markups.**

Appendix: Rulemaking Stage Details



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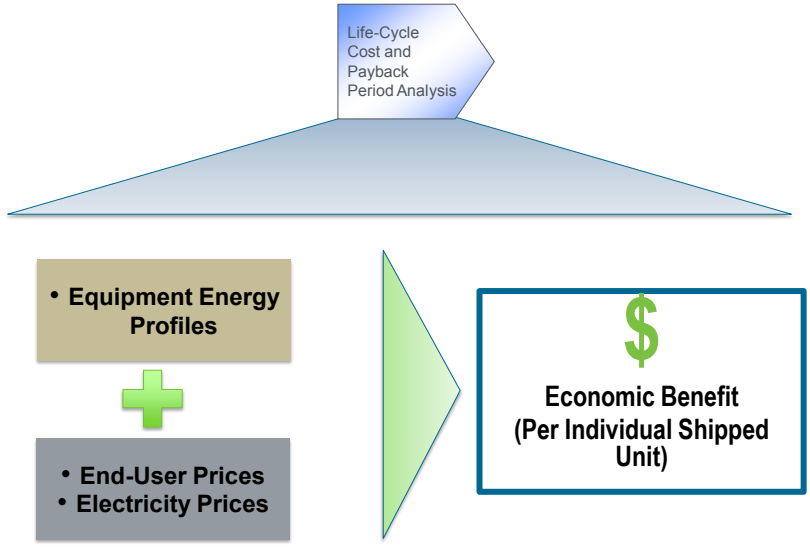
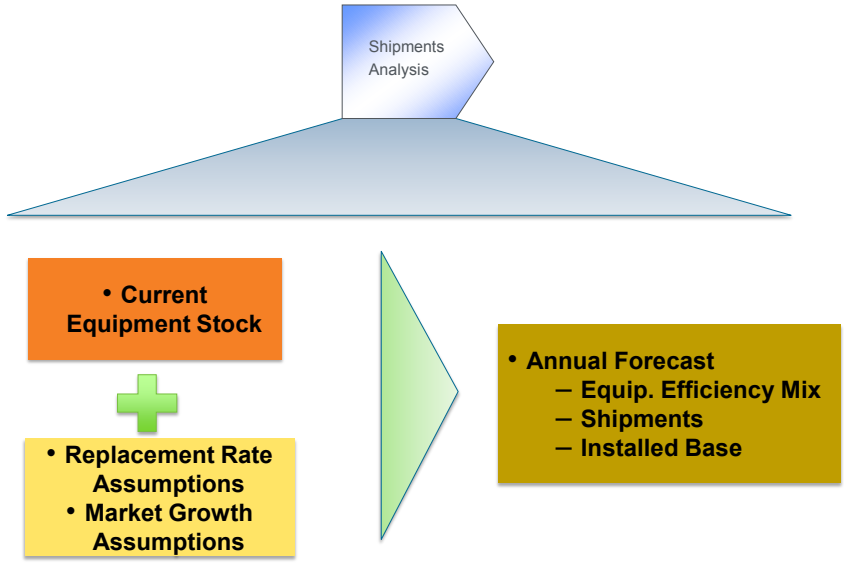
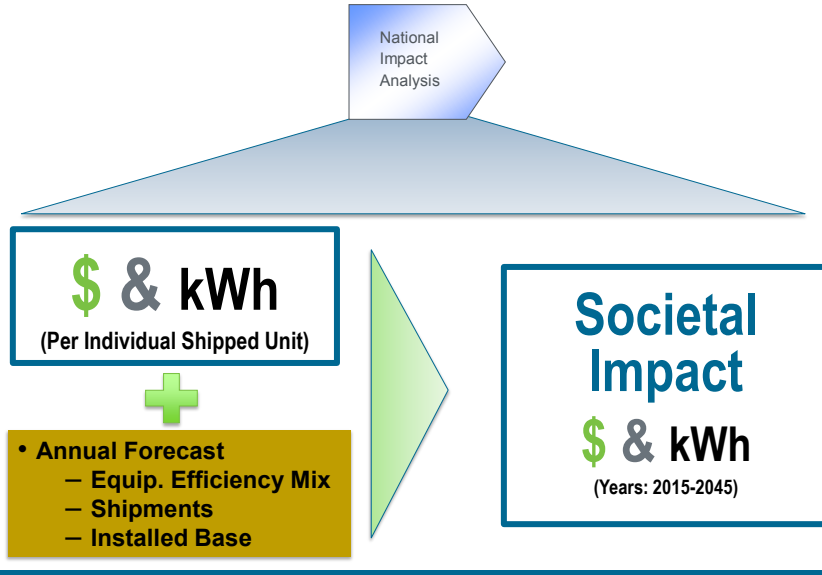


Appendix: Rulemaking Stage Details



Appendix: Rulemaking Stage Details