BUILDING TECHNOLOGIES PROGRAM

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

Notice of Proposed Rulemaking (NOPR) Public Meeting on Energy Conservation Standards and Test Procedures for Certain Equipment in ASHRAE Standard 90.1-2010

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Welcome and Introductions

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- 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 speaks at a time (raise hand to be recognized; state your name for the record)
  - Set cell phones to silent/vibrate
- Housekeeping Items

Purpose of the Public Meeting

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- Purpose
  - To invite comment on proposed energy conservation standard levels;
  - To present methodologies and characterize results of the rulemaking analyses;
  - To discuss specific issues related to each analysis;
  - To seek input from interested parties on methodologies, assumptions, data sources, and results from the analyses; and
  - To describe next steps in the standards and test procedure rulemakings.

- Comments from Participants
  - Participants are invited to provide summary comments or statements and raise additional issues for discussion.
  - The NOPR was published in the *Federal Register* on January 17, 2012 (77 FR 2356), and the NOPR comment period closes Monday, April 2, 2012.

Request For Comment

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Issue Box: The U.S. Department of Energy (DOE) welcomes comments, data, and information concerning its NOPR for American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE) equipment. Issues that correspond to those raised in the DOE's published material will be numbered in accordance with that material. Whether invited by an issue box or not, comments are welcome on any part of DOE's analysis.

(Issue #)

Issue box numbering corresponds to the list of issues published at the end of the NOPR, available at:
http://www1.eere.energy.gov/buildings/appliance_standards/commercial/ashrae_Equipments_docs_meeting.html

DOE Seeks Comments on its Proposal

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- In all correspondence, include all of the following:
  - Energy Conservation Standards for ASHRAE Equipment
  - Docket Number: EERE-2011-BT-STD-0029
  - Regulatory Identification Number (RIN):1904-AC47

- Contact Information

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Comment period closes: Monday, April 2, 2012

Public Meeting Agenda

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

1. Introduction and Overview
2. Determination of Scope
3. Test Procedures
4. Market Assessment and Engineering Analysis
5. Markups Analysis; Energy Use Analysis; Life-Cycle Cost and Payback Period Analysis
6. Shipments Analysis; National Impact Analysis; Utility Impact and Emissions Impact Analysis
7. Certification, Compliance & Enforcement
8. Closing Remarks

Introduction and Overview

Statutory Authority

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

- The Energy Policy and Conservation Act (EPCA) directs DOE to consider amending the existing Federal energy conservation standard for each type of equipment listed at 42 U.S.C. 6313(a)(6)(A)(i), each time ASHRAE Standard 90.1 is amended with respect to such equipment. (42 U.S.C. 6313(a)(6)(A)-(B))
- For each type of equipment, EPCA directs that if ASHRAE Standard 90.1 is amended, DOE must review and adopt amended standards at the new efficiency level in ASHRAE Standard 90.1, unless clear and convincing evidence supports a determination that adoption of a more stringent efficiency level would:
  - Produce significant additional energy savings;
  - Be technologically feasible; and
  - Be economically justified. (42 U.S.C. 6313(a)(6)(A)(ii))

Introduction and Overview

Opening Remarks

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- Opening Remarks
  - At this time, DOE welcomes opening remarks from interested parties on the NOPR for certain ASHRAE equipment
- Comments from Participants
  - Participants are invited to provide summary comments or statements;
  - Participants are invited to raise additional issues for discussion today; and
  - Participants are invited to submit comments during the NOPR comment period, which is open through April 2, 2012

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Determination of Scope

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- To determine scope of coverage for the NOPR, DOE first reviewed all the changes made in ASHRAE Standard 90.1-2010.

- DOE identified any increase in the efficiency levels in ASHRAE Standard 90.1-2010 in comparison to the existing Federal conservation standards, thereby triggering DOE action.

- DOE also identified any changes to the relevant sections of test procedure documents for covered ASHRAE equipment.

Determination of Scope

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- DOE believes ASHRAE Standard 90.1 does not cover commercial package air conditioning and heating equipment used for industrial, manufacturing, or commercial processes, with the exception of the specific industrial equipment listed in the standard.
- DOE's standards for commercial package air conditioning and heating equipment are intended to have the same scope as ASHRAE Standard 90.1 and apply only to equipment used for comfort space conditioning, with the exception of those equipment types listed in ASHRAE that are used for commercial or industrial processes.
- To aid regulated entities in determining whether their equipment falls within the scope of DOE's regulatory requirements, DOE is providing the following guidance:
  - Equipment meeting the definition of "commercial package air conditioning and heating equipment" in 10 CFR 431.92 that is used exclusively for manufacturing and/or industrial processes and is not listed as one of the equipment types specifically added to ASHRAE Standard 90.1, are not covered under DOE's regulatory program.
  - Determinations of coverage will be made on a case-by-case basis depending on factors such as how the model is advertised, marketed, and/or sold for use in buildings, the extent to which the equipment provides comfort conditioning to occupants, and how the equipment is designed and manufactured.

Determination of Scope

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

DOE seeks comments on ways manufacturers currently differentiate commercial package air conditioning and heating equipment used solely for manufacturing and industrial processes from that equipment of the same type that is used in buildings.

(Issue #1)

Determination of Scope

Computer Room Air Conditioners

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- Previous editions of ASHRAE Standard 90.1 did not cover "equipment and portions of building systems that use energy primarily to provide for industrial, manufacturing, or commercial processes," such as computer room air conditioners (CRACs).

- ASHRAE Standard 90.1-2010 expanded its scope to include equipment used for process loads and created a product class for "air conditioners and condensing units serving computer rooms."

- Thus, DOE determined in the notice of data availability (NODA) and reiterated in the NOPR that DOE has the authority to cover computer room air conditioners.

Determination of Scope

Equipment with Amended ASHRAE Levels

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- The table below shows the equipment types amended in ASHRAE Standard 90.1-2010, and DOE's proposed action regarding these equipment classes.

Equipment Class	DOE's Proposed Action
Water-cooled Air Conditioners	Adopting ASHRAE levels*
Evaporatively-cooled Air Conditioners	Adopting ASHRAE levels*
Variable Refrigerant Flow (VRF) Multi-split Water-source Heat Pumps, <17,000 Btu/h	Adopting ASHRAE levels*
Variable Refrigerant Flow (VRF) Multi-split Water-source Heat Pumps, ≥135,000 Btu/h	Adopting ASHRAE levels*
Computer Room Air Conditioners	Adopting ASHRAE levels
Single-Package Vertical Air Conditioners (SPVACs) and Single-Package Vertical Heat Pumps (SPVHPs)	Further analysis in a separate rulemaking

* Due to a *de minimis* energy savings potential, DOE did not perform a cost/benefit analysis for this equipment class.

Rationale for Adoption of ASHRAE Standard 90.1-2010 Levels

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- There were minimal energy savings (or no models on the market) for the following equipment classes:
  - Water-cooled and evaporatively-cooled air conditioners
  - Water-source VRF heat pumps with a cooling capacity <17,000 Btu/h
  - Water-source VRF heat pumps with a cooling capacity ≥135,000 Btu/h
- For computer room air conditioners, there was a lack of clear and convincing evidence in the downstream analysis for higher standards due to:
  - Uncertainty in seasonal coefficient of performance (SCOP) efficiency data derived using "rule-of-thumb" method
  - Uncertainty in the price-efficiency relationship
  - Inability for DOE to assess future changes in equipment efficiencies
  - Lack of shipment information for the United States
- For SPVACs and SPVHPs, analysis will be conducted in a separate rulemaking.

Analysis of Water- and Evaporatively-Cooled Air Conditioners

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- DOE conducted a potential energy savings analysis for small, large, and very large water-cooled air conditioners, and for very large evaporatively-cooled air conditioner classes in the May 5, 2011 NODA (76 FR 25622).
- Energy savings were estimated for adoption of the efficiency levels in ASHRAE 90.1-2010 and for up to four efficiency levels above ASHRAE 90.1-2010 levels.
- Unit energy consumption was based on spreadsheet models of equipment energy consumption, incorporating annual cooling load profiles from large office building simulations.
- 30-year National Energy Savings (NES) estimates were calculated for two shipment scenarios for each product class for each higher efficiency level examined. The sum of NES for standards above ASHRAE 90.1-2010 levels was minimal.

Analysis of > 135 kBtu/h Variable Refrigerant Flow Water-Source Heat Pumps

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- DOE conducted a potential energy savings analysis for >135 kBtu/h Variable Refrigerant Flow Water-Source Heat Pumps with and without heat recovery for the NOPR.
- Unit energy consumption (UEC) estimates established for ASHRAE 90.1-2010 efficiency levels and four higher efficiency levels including a max-tech level (14.5 EER, ~4.6 COP). Max-tech level presumes only ductless indoor units.
- Unit energy consumption developed from building simulations that modeled water-source VRF heat pumps used in a 20,000 ft^2 office building in 15 U.S. climates.
- Shipment forecast estimated based on historical water-source heat pump shipments and relative fraction of models in analyzed VRF product classes.
- 30-year NES estimates calculated for both equipment classes. The sum of NES for standards exceeding ASHRAE 90.1-2010 levels were minimal.

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Test Procedures

Authority

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

- EPCA requires DOE to amend any test procedure for ASHRAE products to the latest version generally accepted by the industry, as referenced in ASHRAE/IES Standard 90.1, unless the Secretary determines that clear and convincing evidence exists that the latest version of the industry test procedure does not meet the requirements for test procedures under 42 U.S.C. 6314(a)(2)-(3). (42 U.S.C. 6314(a)(4)(A)-(B))

- EPCA also requires DOE to conduct an evaluation of the test procedures for covered equipment at least once every 7 years. (42 U.S.C.6314(a)(1)(A))

- 42 U.S.C. 6314(a)(2) states that test procedures shall be reasonably designed to produce test results which reflect the energy efficiency or energy use of a type of industrial equipment during a representative average use cycle and shall not be unduly burdensome to conduct.

- DOE reviewed the updated test procedures in ASHRAE Standard 90.1-2010.

Test Procedures

Updates

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

- DOE is proposing updating to the following test procedures:
  - AHRI 210/240-2008 for small (<65,000 Btu/h) commercial packaged air conditioning and heating equipment
  - AHRI 340/360-2007 for small (≥65,000 Btu/h), large, and very large commercial packaged air conditioning and heating equipment
  - UL 727-2006 for oil-fired commercial warm-air furnaces
  - ANSI Z21.47-2006 for gas-fired commercial warm-air furnaces
  - ANSI Z21.10.3-2004 for commercial water heaters
- DOE is proposing to adopt the following new test procedures:
  - AHRI 390-2003 for SPVACs and SPVHPs
  - AHRI 1230-2010 with Addendum 1 for VRF multi-split systems
  - ASHRAE 127-2007 for computer room air conditioners
- DOE notes that the AHRI and ASHRAE test procedures contain tolerances allowing the published ratings to be within a certain percentage of the measured ratings (e.g., measured test results shall not be less than 95% of published ratings). DOE does not intend to adopt these provisions in the final rule.

Test Procedures

Issues

DOE seeks comment on all relevant aspects of the proposed test procedures for ASHRAE equipment included in this rulemaking as part of the seven year review.

(Issue #2)

DOE seeks comment about the proposed adoption of the following updated test procedures: AHRI 210/240-2008, AHRI 340/360-2007, UL 727-2006, ANSI Z21/10.3-2004, and ANSI Z21.47-2006.

(Issue #3-5)

DOE seeks comment about the proposed adoption of the new test procedures: AHRI 390-2003, AHRI 1230-2010, and ASHRAE Standard 127-2007, especially on any shortcomings or potential modifications to these test procedures.

(Issue #6-8)

Test Procedures

General Guidelines

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- As part of its ongoing testing efforts in support of DOE's regulatory program, the Department has received ad hoc requests from manufacturers regarding the need for tailored modifications to the testing set-up or operating conditions for a basic model.

- For DOE's testing efforts, the Department uses only the conditions specified in the DOE test procedure for a given covered equipment along with any additional guidance that is presented in the installation and/or operating manuals shipped with those units for any DOE-initiated testing.

- No additional information (e.g., additional specificity for the placement or types of specific testing sensors) will be used for any DOE verification or enforcement testing that are not part of installation and/or operating manuals shipped with the unit.

- DOE wishes to harmonize the way it conducts its testing with the testing done by manufacturers, and does not intend to change the way manufacturers currently test their products for the purposes of determining their certified ratings.

Test Procedures

Issues

DOE seeks comments generally on whether there are additional settings beyond the tolerances and specifications in the test procedure for all types of commercial air conditioning and heating equipment that DOE should consider when testing such equipment. If additional settings are basic-model specific, DOE is interested in having manufacturers disclose these instructions as part of their initial certifications for a given basic model and seeks comment on this issue as well.

Test Procedures

Break-in Provision

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- Through review of the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) certification program, DOE discovered that AHRI testing allows for the use of a compressor "break-in" period for commercial unitary equipment, which manufacturers may be using when conducting certification testing.
- This "break-in" period would allow the performance of the compressor to be more representative of the actual field performance.
- DOE is proposing to allow the manufacturers to use the optional break-in period at their discretion, so that the test procedure may produce results that better reflect the energy efficiency of their units, as required by EPCA.
- DOE is proposing to allow manufacturers the option of a "break-in" period of up to 16 hours.
- If manufacturers choose to use this optional break-in period, they will be required to report the length of time (up to 16 hours) they used to break in their equipment and maintain it in the test data underlying their certified ratings.

Test Procedures

Issues

DOE seeks comment about the use of an optional compressor "break-in" period as part of the following test procedures: AHRI 210/240, AHRI 340/360, AHRI 390, and AHRI 1230, or the need for a "break-in" period for computer room air conditioners.

(Issue 3,4,7,8,17)

Test Procedures

VRF Systems

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- In reviewing AHRI 1230 for VRF systems, DOE found that there are provisions stating that skilled personnel with knowledge of the control software will be required for inverter driven equipment. Additionally, the procedure states that if the equipment cannot be maintained at steady state conditions by its normal controls, then the manufacturer shall modify or over-ride such controls so that steady state conditions are achieved.

- DOE would like to learn more about how these systems operate to achieve steady state conditions for testing. Specifically, DOE understands that at least some units require additional control instruction and/or control system override to conduct the test, which requires manufacturer assistance in order to test the unit according to AHRI 1230.

- DOE is interested in options that would eliminate manufacturer involvement in testing, but maintain the operation as specified by the manufacturer. DOE's goal is to not change how the unit is designed to operate, but to allow testing that follows set procedures that eliminates manufacturer intervention.

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DOE seeks comment about the testing conditions, the basic model operating points, and set-up for VRF multi-split air conditioners and heat pumps. Specifically, DOE is interested in how the procedure can be improved such that it can be run independently and manufacturer involvement in the testing is not required.

(Issue #9)

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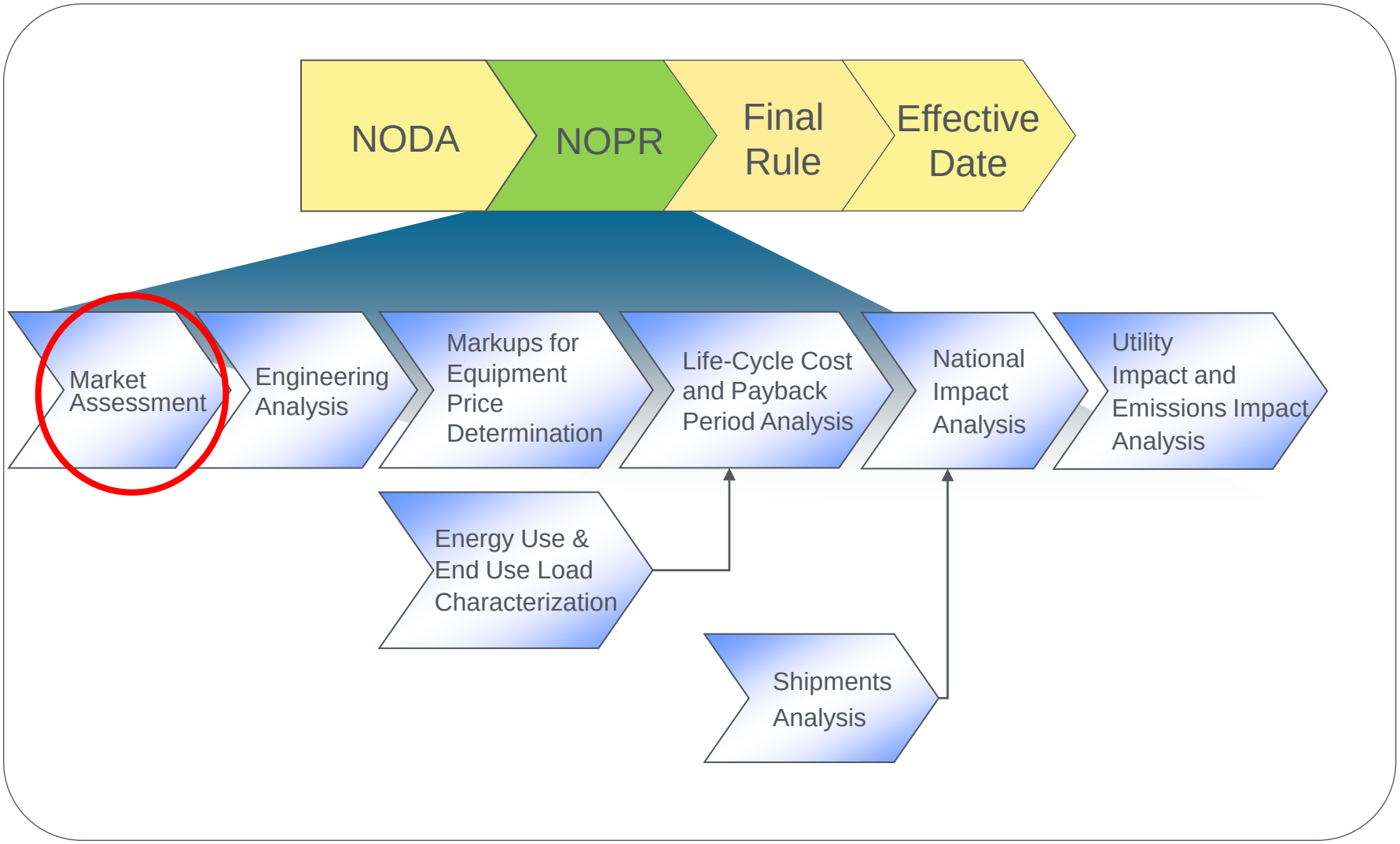
NOPR
Rulemaking Stage



Market Assessment

- Purpose
  - Characterize the market for applicable ASHRAE equipment types to determine available equipment efficiencies, manufacturers, and shipments

- Sources
  - AHRI Directory of Certified Product Performance
  - California Energy Commission (CEC) Appliance Efficiency Database
  - Manufacturers' websites

- A detailed description of the methodology and results is contained in Chapter 2 of the NOPR TSD.

VRF Air Conditioners and Heat Pumps Definitions

- There is currently no definition for variable refrigerant flow (VRF) air conditioners and heat pumps because DOE's existing standards do not separate this type of equipment from other classes of commercial air conditioners and heating equipment.

- DOE is proposing the following definitions for this equipment class:
  - Variable refrigerant flow multi-split air conditioner means a unit of commercial package air conditioning and heating equipment that is configured as a split-system air-conditioner incorporating a single refrigerant circuit, with one or more outdoor units, at least one variable-speed compressor or an alternate compressor combination for varying the capacity of the system by three or more steps, and multiple indoor fan coil units, each of which is individually metered and individually controlled by an integral control device and common communications network and which can operate independently in response to multiple indoor thermostats. Variable refrigerant flow implies three or more steps of capacity control on common, inter-connecting piping.

VRF Air Conditioners and Heat Pumps Definitions

- DOE is also proposing the following definitions for this equipment class:
  - Variable refrigerant flow multi-split heat pump means a unit of commercial package air conditioning and heating equipment that is configured as a split-system heat pump that uses reverse cycle refrigeration as its primary heating source and which may include secondary supplemental heating by means of electrical resistance, steam, hot water, or gas. The equipment incorporates a single refrigerant circuit, with one or more outdoor units, at least one variable-speed compressor or an alternate compressor combination for varying the capacity of the system by three or more steps, and multiple indoor fan coil units, each of which is individually metered and individually controlled by a control device and common communications network and which can operate independently in response to multiple indoor thermostats. Variable refrigerant flow implies three or more steps of capacity control on common, inter-connecting piping.
  - Heat recovery (in the context of variable refrigerant flow multi-split air conditioners or variable refrigerant flow multi-split heat pumps) means that the air conditioner or heat pump is also capable of providing simultaneous heating and cooling operation, where recovered energy from the indoor units operating in one mode can be transferred to one or more other indoor units operating in the other mode. A variable refrigerant flow multi-split heat recovery heat pump is a variable refrigerant flow multi-split heat pump with the addition of heat recovery capability.

Computer Room Air Conditioners Definitions

- There are also no definitions for computer room air conditioners since DOE previously did not cover this type of equipment.

- DOE is proposing the following definition:
  - Computer room air conditioner means a unit of commercial package air-conditioning and heating equipment that is advertised, marketed, and/or sold specifically for use in computer rooms, data processing rooms, or other precision cooling applications, and is rated for performance using ASHRAE Standard 127. Such equipment may not be marketed or advertised as equipment for any other space conditioning applications, and may not be rated for performance using AHRI Standard 210/240 or AHRI Standard 340/360.

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DOE seeks comment about the proposed definitions of "variable refrigerant flow multi-split air conditioner," "variable refrigerant flow multi-split heat pump," and "heat recovery."

(Issue #10)

DOE seeks comment about the proposed definition of "computer room air conditioner." Specifically, DOE is interested in whether there are any physical features or components that could allow DOE to differentiate between computer room air conditioners and commercial package air conditioners used for comfort conditioning.

(Issue #11)

Market Assessment

Computer Room Air Conditioners

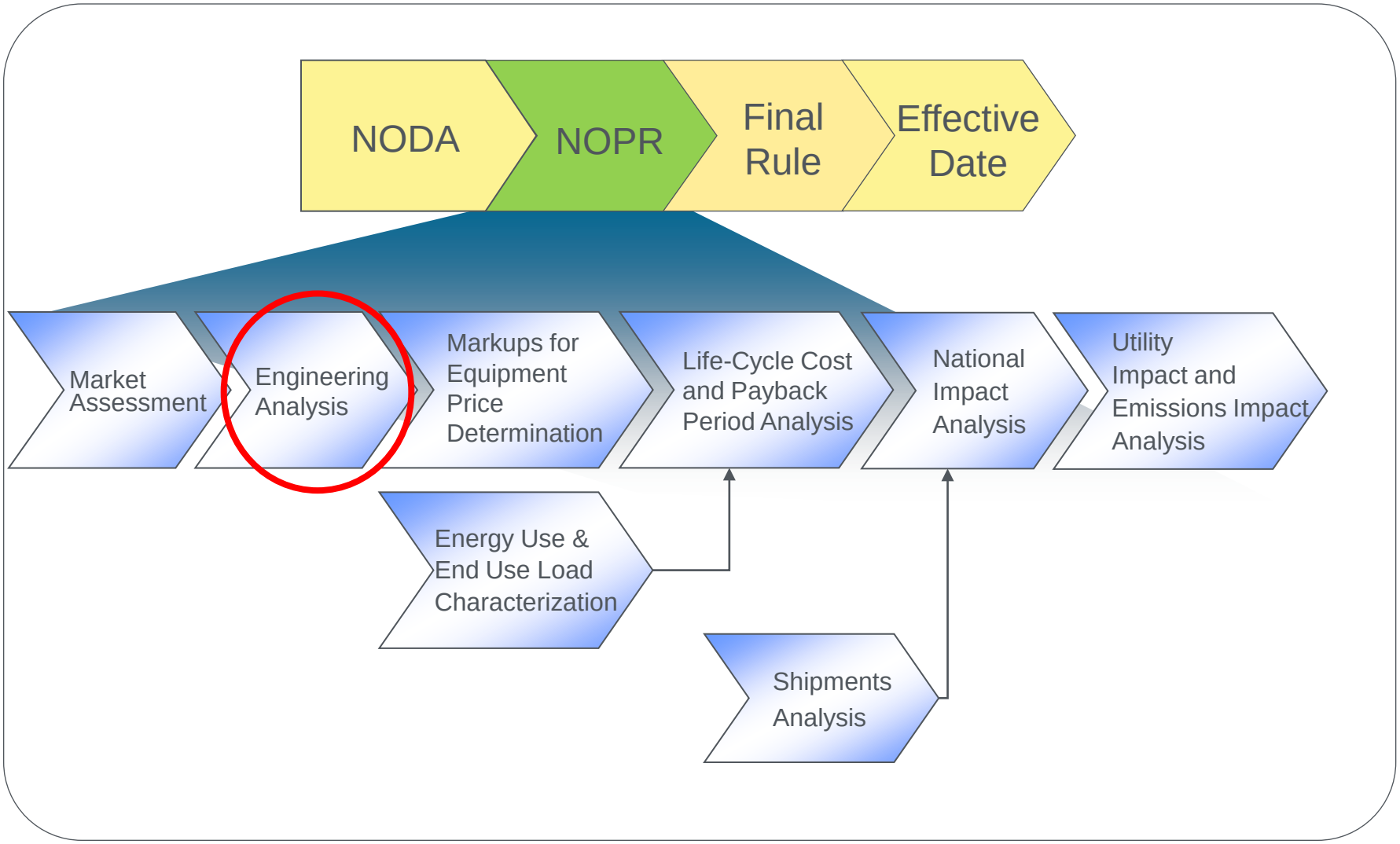
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- ASHRAE Standard 90.1-2010 divides computer room air conditioners into 30 equipment classes based on:
  - Cooling Type (Air-cooled, Water-cooled, Glycol-cooled)
  - Sensible Cooling Capacity (<65,000 Btu/h, ≥65,000 and <240,000 Btu/h, ≥240,000 Btu/h and <760,000 Btu/h)
  - Orientation (upflow, downflow)
  - Presence of a fluid economizer

- DOE compiled a database of computer room air conditioners divided into 30 equipment classes, as outlined above.

- DOE found 1364 different models (from 22 equipment lines) from the CEC database and manufacturers' websites.

NOPR
Rulemaking Stage



Engineering Analysis: Methodology

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- Choose Representative Equipment Size
- Define Baseline Models
- Develop Efficiency Levels
- Develop Pricing Data
- Scale to Equipment Classes Not Analyzed
- Results

⇦ Choose equipment classes sizes to be analyzed in the engineering and life-cycle cost analysis.

⇦ Define characteristics of baseline models in each representative equipment class.

⇦ Develop efficiency levels (ELs) that span the range of efficiency from baseline to max-tech level.

⇦ Determine prices for computer room air conditioners for the full range of efficiencies.

⇦ Scale results to equipment classes not directly analyzed.

⇦ Results of the price-efficiency curve.

Engineering Analysis: Representative Equipment Size

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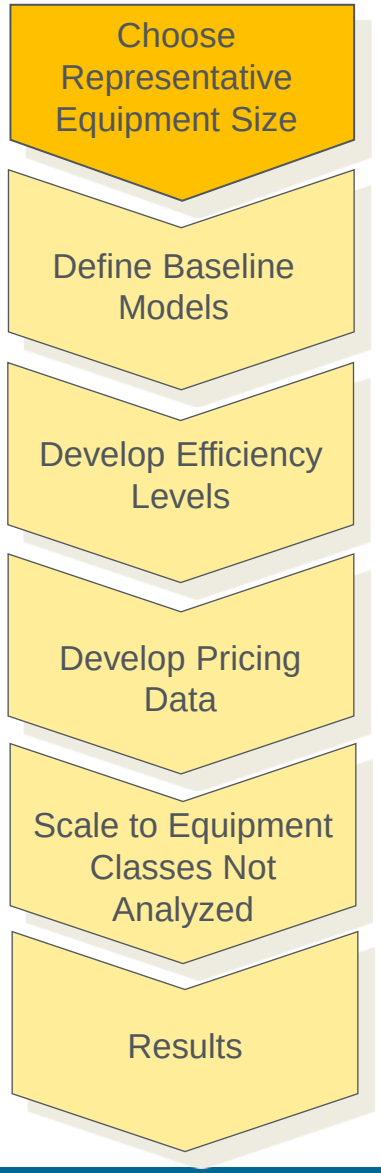

- DOE chose the average sensible capacity (rounded to the nearest ton) for each equipment class for computer room air conditioners as the representative capacity for analysis.
- DOE chose the representative sensible capacity based upon each of the following size categories:
  - <65,000 Btu/h – DOE chose 36,000 Btu/h (3 tons)
  - ≥65,000 Btu/h and <240,000 Btu/h – DOE chose 132,000 Btu/h (11 tons)
  - ≥240,000 Btu/h and <760,000 Btu/h – DOE chose 288,000 Btu/h (24 tons)
- DOE centered the downstream analyses around these representative sensible capacities.

Engineering Analysis: Baseline Models

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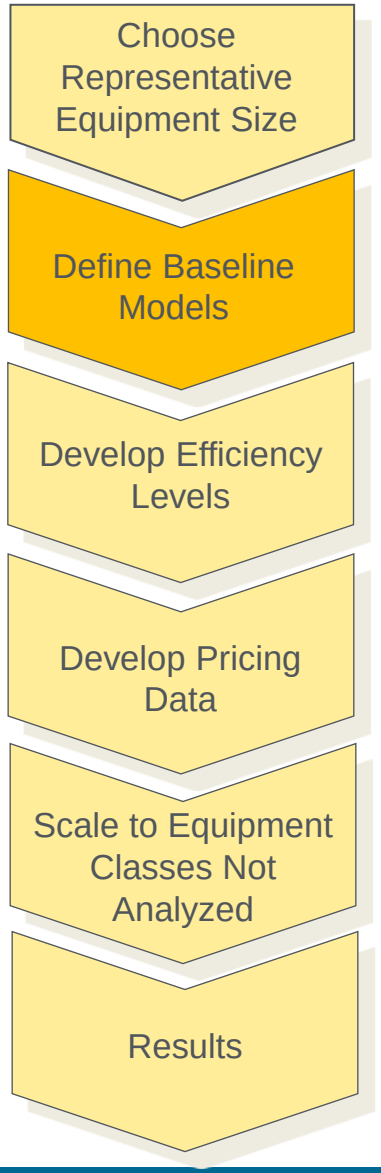

- DOE selects the baseline levels as reference points against which DOE measures changes resulting from potential amended energy conservation standards.
- A baseline piece of equipment refers to a model having features and technologies typically found in the equipment currently offered for sale.
- Usually, units at the baseline efficiency level just meet the Federal energy conservation standards; however, computer room air conditioners do not currently have a Federal energy conservation standard.
- Since EPCA requires DOE to adopt either the ASHRAE Standard 90.1 level or a more-stringent standard, DOE used the efficiency levels in ASHRAE Standard 90.1-2010 as the baseline efficiency level.
- To simplify the engineering analysis, DOE only selected baseline efficiency levels for equipment classes in the downflow orientation. (For upflow models, DOE assumed the results of the cost/benefit analysis would be the same as downflow and did not analyze these products directly in the engineering analysis.)

Engineering Analysis: Efficiency Levels

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- Choose Representative Equipment Size
- Define Baseline Models
- **Develop Efficiency Levels**
- Develop Pricing Data
- Scale to Equipment Classes Not Analyzed
- Results

- Since DOE does not currently regulate computer room air conditioners, manufacturers are not required to report the ratings of their equipment, and there was no SCOP data available at the time of DOE's analysis.
- DOE had to rely on efficiency information found in manufacturer literature and in the CEC appliance efficiency databases.
- Since SCOP is a new metric in ASHRAE Standard 127-2007, all efficiency information DOE found in these sources were in the form of energy efficiency ratio (EER).
- DOE converted the EER information (when available) into SCOP using the "rule of thumb" formula found in the appendix of ASHRAE Standard 127-2007 to approximate the SCOP ratings of equipment on the market.

$$SCOP = (EER_{Old})(\frac{SHR}{3.5})$$

Engineering Analysis: Efficiency Levels

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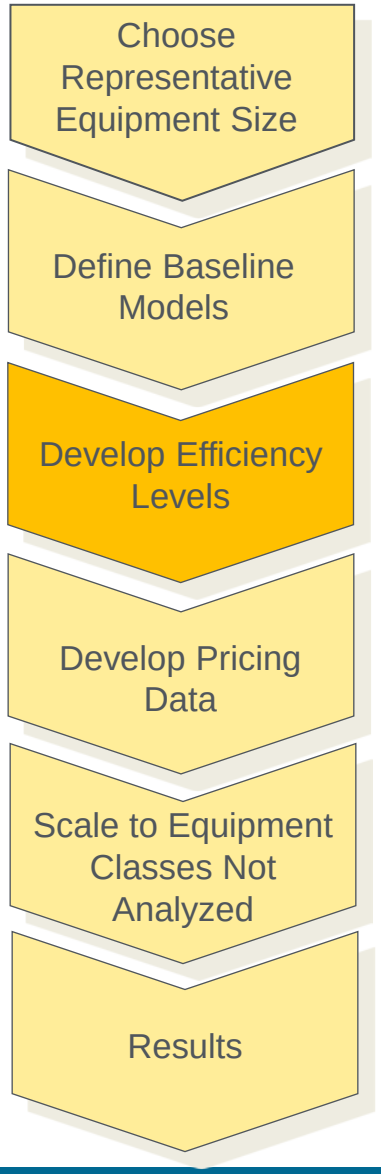
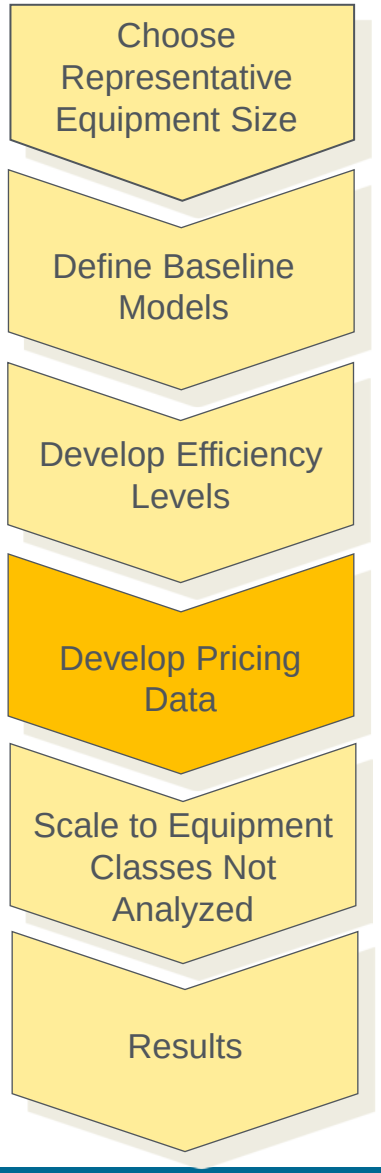


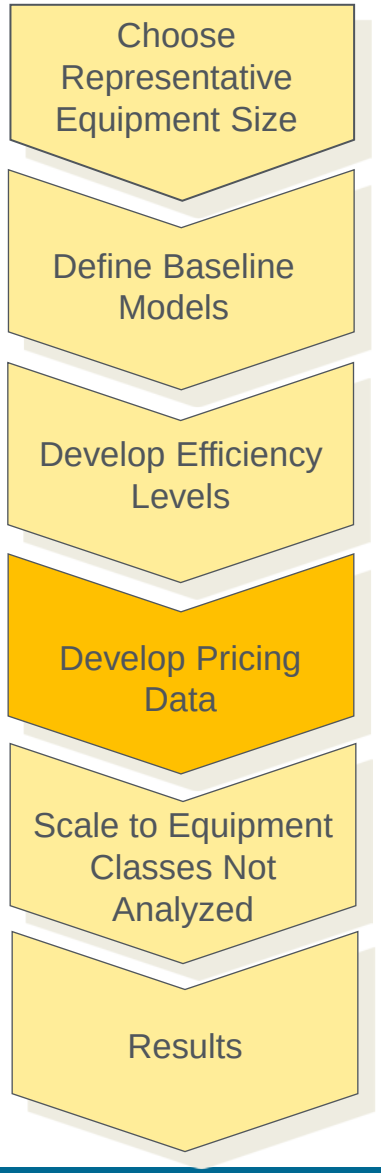
- For those equipment classes for which DOE had efficiency information, DOE identified the max-tech efficiency level on the market.
- DOE chose evenly-spaced levels between the baseline and max-tech levels for its analysis, which generally corresponded to the levels with the most models on the market
- For those equipment classes where little or no efficiency information was available, DOE selected levels for analysis based on the differences in efficiency between equipment classes in ASHRAE Standard 90.1-2010.

Engineering Analysis: Pricing Survey



- DOE contacted the 5 known manufacturers of this equipment and was able to obtain efficiency information and pricing information from 3 of those manufacturers.
- DOE selected models for pricing that were as close to the representative cooling capacity as possible (generally within 15%).
- DOE received pricing information for 32 models total.
- DOE used these pricing data together with the SCOP information to produce price-efficiency curves.

Engineering Analysis: Pricing Survey



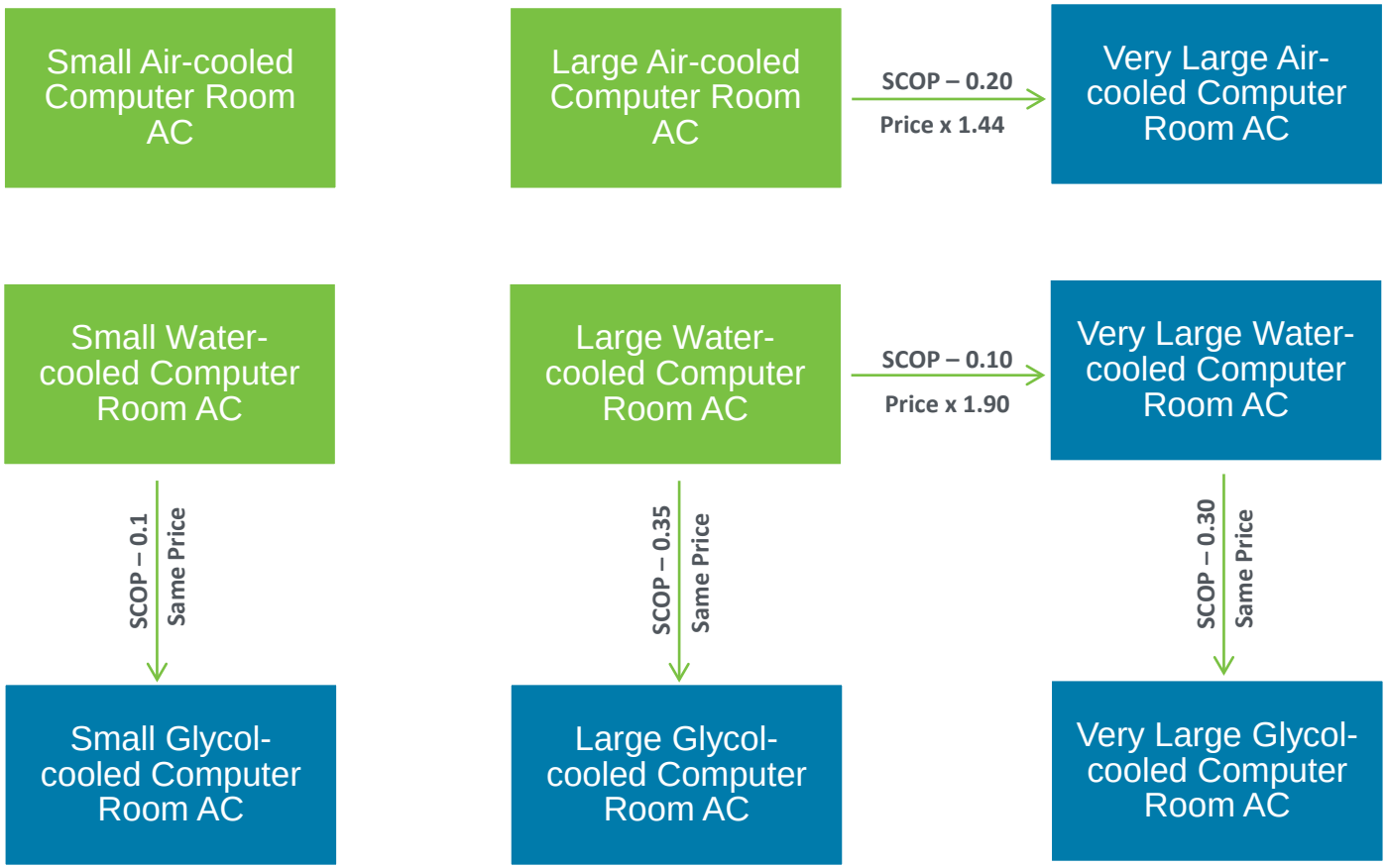
- Due to limited efficiency information, DOE only had enough pricing and efficiency data to directly analyze four equipment classes:
  - Air-cooled with a sensible cooling capacity <65,000 Btu/h
  - Air-cooled with a sensible cooling capacity ≥65,000 Btu/h and <240,000 Btu/h
  - Water-cooled with a sensible cooling capacity <65,000 Btu/h
  - Water-cooled with a sensible cooling capacity ≥65,000 Btu/h and <240,000 Btu/h
- For the remaining 11 equipment classes to be analyzed, DOE scaled the price-efficiency curves from these four classes.

Engineering Analysis: Scaling to Other Equipment Classes

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

- Choose Representative Equipment Size
- Define Baseline Models
- Develop Efficiency Levels
- Develop Pricing Data
- **Scale to Equipment Classes Not Analyzed**
- Results

Translation to Equipment Classes Without a Fluid Economizer



- For equipment classes with a fluid economizer, DOE used the corresponding equipment class without the fluid economizer and subtracted 0.05 from the SCOP and multiplied the price by 1.0582

Engineering Analysis: Results

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

Choose Representative Equipment Size

Define Baseline Models

Develop Efficiency Levels

Develop Pricing Data

Scale to Equipment Classes Not Analyzed

Results

- The results of the engineering analysis are a set of price-efficiency tables. The full set of tables for all equipment classes can be found in Chapter 3 of the NOPR TSD.
- Based on the pricing data that were obtained, DOE observed that the price increases with increased efficiency for small and large air-cooled equipment and large water-cooled equipment.*
- Based on the pricing data, DOE observed that the price decreases with increased efficiency for small water-cooled equipment.*
- DOE notes that factors other than the efficiency of equipment (e.g., how competitive the market is, warranty, and other features) impact pricing. DOE believes that the negative correlation for small water-cooled equipment may have occurred because of the impacts from such factors. These factors may also have influenced the results for the other equipment classes, even though the efficiency trend alone may have shown a positive correlation in those classes.

*Consequently, all equipment classes for which the price-efficiency relationship was translated from these classes have the same general trend for the price-efficiency relationship.

Engineering Analysis Issues

DOE seeks comment about the results of the pricing analysis and on any data or information on the price-efficiency relationship for computer room air conditioners.

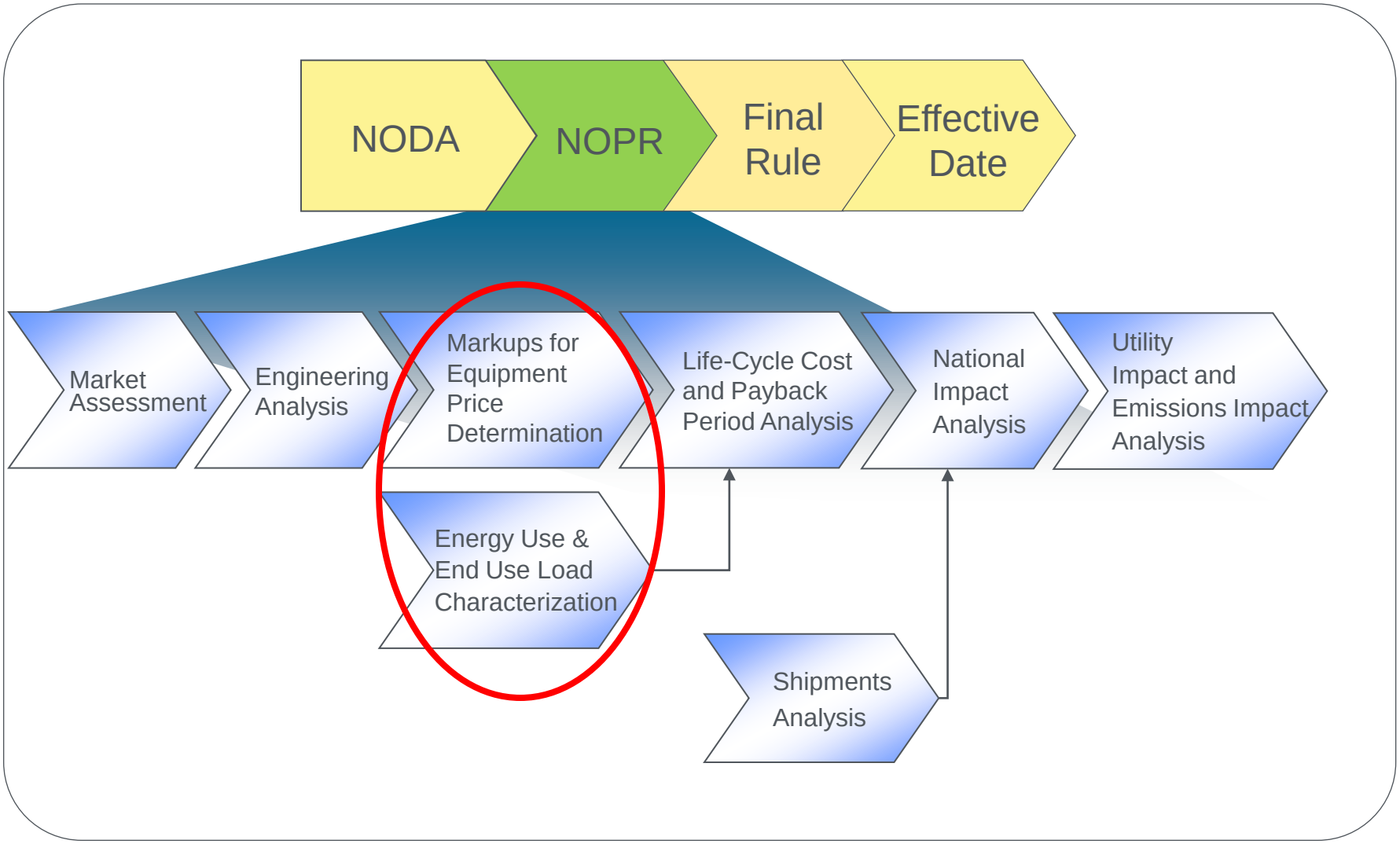
(Issue #12)

Public Meeting Agenda

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

1. Introduction and Overview
2. Determination of Scope
3. Test Procedures
4. Market Assessment and Engineering Analysis
5. Markups Analysis; Energy Use Analysis; Life-Cycle Cost and Payback Period Analysis
6. Shipments Analysis; National Impact Analysis ; Utility Impact and Emissions Impact Analysis
7. Certification, Compliance & Enforcement
8. Closing Remarks

NOPR
Rulemaking Stage



Energy Use Characterization
Computer Room Air Conditioners

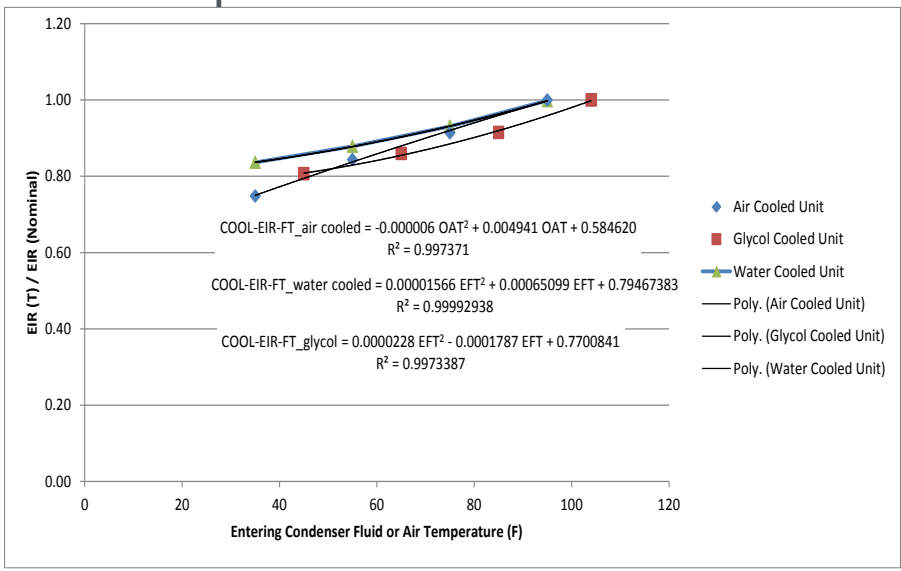
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- Energy use based on a temperature bin analysis.
- Temperature bin performance maps created for 15 classes of equipment.
  - Air-cooled, glycol-cooled, and glycol-cooled with economizer: use outdoor drybulb (T_{db}) temperature bins
  - Water-cooled with and without economizers: use outdoor wetbulb (T_{wb}) temperature bins.
- Annual unit energy consumption ($UEC_{climate}$) by efficiency level estimated for 239 climate locations using TMY3 climate data.
- Further aggregated to State-level UEC_{state} using population-based weighting factors.

Energy Use Calculation - CRAC Performance Map Development

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

- Server load averaged 65% of sensible capacity.
- Efficiency is a function of condensing fluid or ambient air temperature and, thus, varies with temperature bin.
- Load reductions for fluid economizers were included (separate airside economizers not considered in analysis).
- Supply fan power was based on a review of manufacturer data and held constant at all efficiency levels within a product class.
- Condenser performances varies with condensing conditions.
- Part-load performance curves were also included in the energy analysis.



Energy Use Calculation - CRAC UEC calculations

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

- $Power_{bin} = Power_{cond,T} + Power_{supplyfan}$

- Unit Energy Consumption by Climate ($UEC_{Climate}$)

$$UEC_{Climate} = \sum_{Bin} Power_{Bin} \times Hours_{Bin}$$

- Unit Energy Consumption by State (UEC_{State})

$$UEC_{State} = \sum_{Climate} Weight_{Climate\ in\ State} \times UEC_{Climate}$$

- National UEC reported in LCC spreadsheet output

Markups Analysis

Distribution Channels for computer room air conditioner (CRAC) Equipment (Replacement and New Construction)

Manufacturer or Distributor → **Mechanical Contractor** → **Consumer**

Markups Analysis

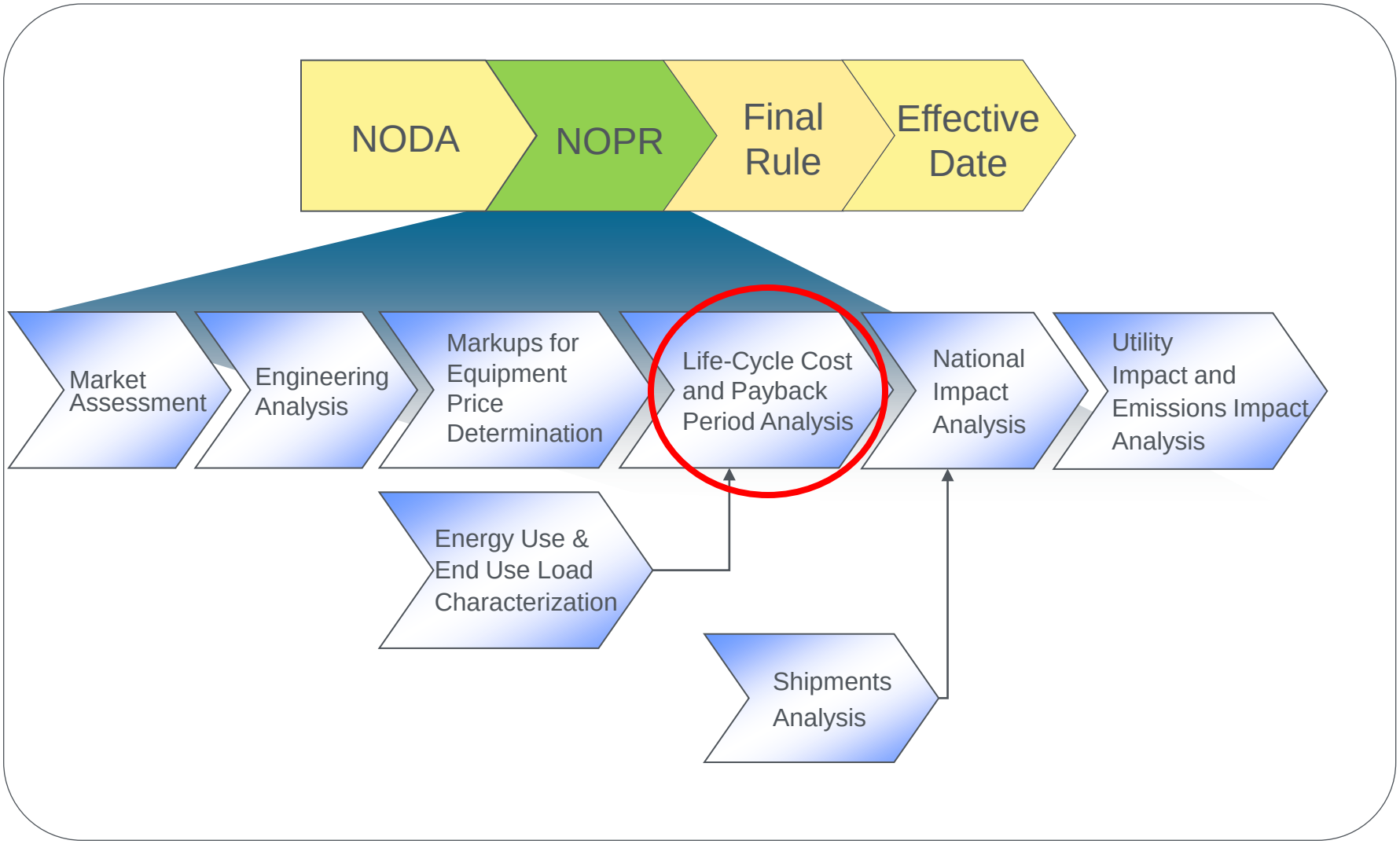
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- DOE developed markups to relate manufacturer selling prices (MSP) to end-user CRAC prices for one distribution channel for markups analysis.

Markup Factor	Baseline Markup	Incremental Markup
Mechanical Contractor	1.474	1.184
Sales tax (National population-weighted average)	1.073	1.073
Overall Markup	1.581	1.270

- DOE markups vary by State based on 2007 Economic Census (Mechanical Contractors).

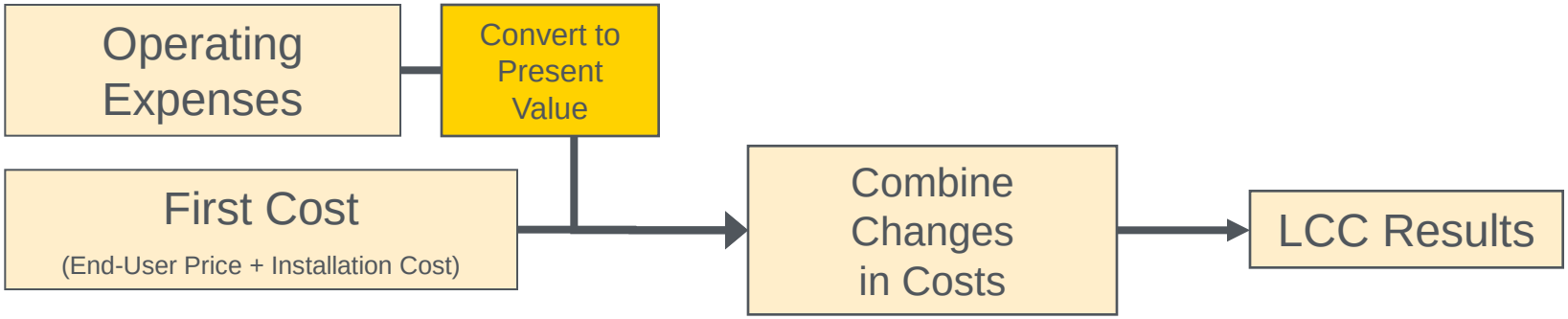
NOPR
Rulemaking Stage



Life-Cycle Cost and Payback Period Analysis

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

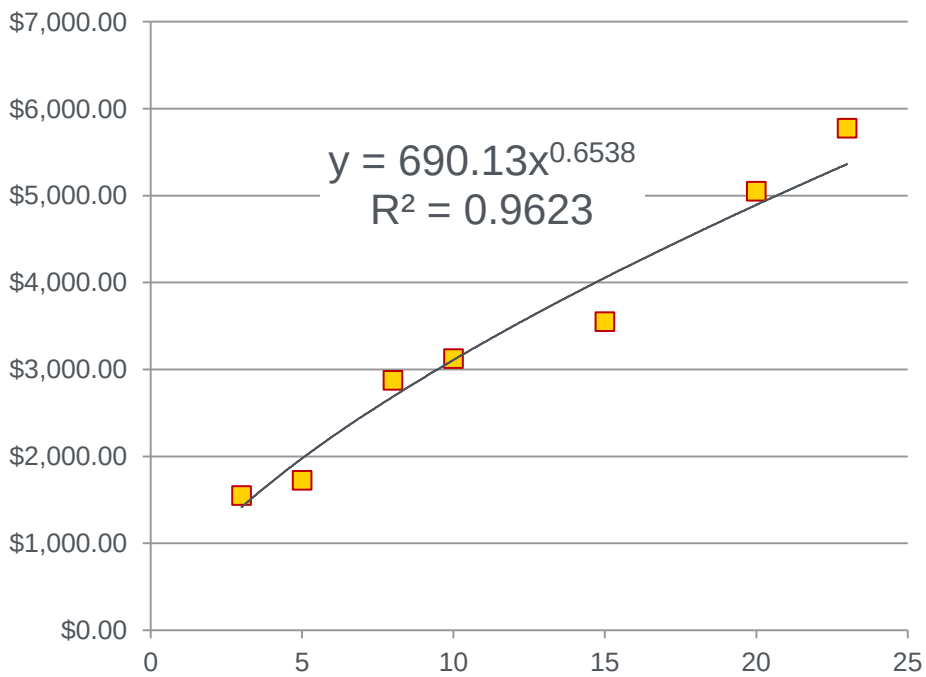
- Economic evaluation from the end-user perspective.
- Results are expressed as LCC savings (baseline minus the standard level).
- Simple payback period (PBP) is also calculated and reported in this analysis.



Installation Cost (Showing Air-Cooled)

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

- DOE calculated installation cost as a function of capacity in tons from RS Means CostWorks data for cooling type, but had no information on installation costs by efficiency level.
- DOE assumed that installation cost would not vary with efficiency level.



Tons	kBtu/hr	Base Installation Cost
3	36	$ 1,415
5	60	$ 1,977
5.4	64.8	$ 2,079
12.7	152.4	$ 3,636
20	240	$ 4,893
23	276	$ 5,361

Installation Cost (Cont.)

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

DOE requests comments on whether computer room air conditioner installation cost increases as a function of increased efficiency. If so, how should the increase in cost be estimated or derived?

(Issue #13)

Repair Cost

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

- From 2011 RS Means data, DOE calculated a cost curve showing one-time baseline repair costs as a percentage of original equipment cost for different equipment capacities.
- To estimate baseline repair cost for each capacity analyzed, DOE then multiplied the calculated percentage from the cost curve at each capacity times the original equipment cost from the current analysis.
- The one-time baseline repair cost was then converted to a baseline average annual repair cost.
- For higher-efficiency levels, DOE scaled the material portion of the baseline repair cost by the relative equipment price at each higher level, then added baseline repair labor expense to get total repair cost.

Maintenance Cost

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

- DOE based its estimates on 2011 RS Means maintenance data.
- Annualized maintenance costs were estimated at $84/yr for units up to 240 kBtu/hr, $102/yr for larger units
- Maintenance costs include cleaning evaporator coils, lubricating motors, cleaning condenser coils, checking and refilling refrigerant as necessary, and similar activities. Such costs are almost entirely attributable to labor expenses, and were assumed not to vary with efficiency level.

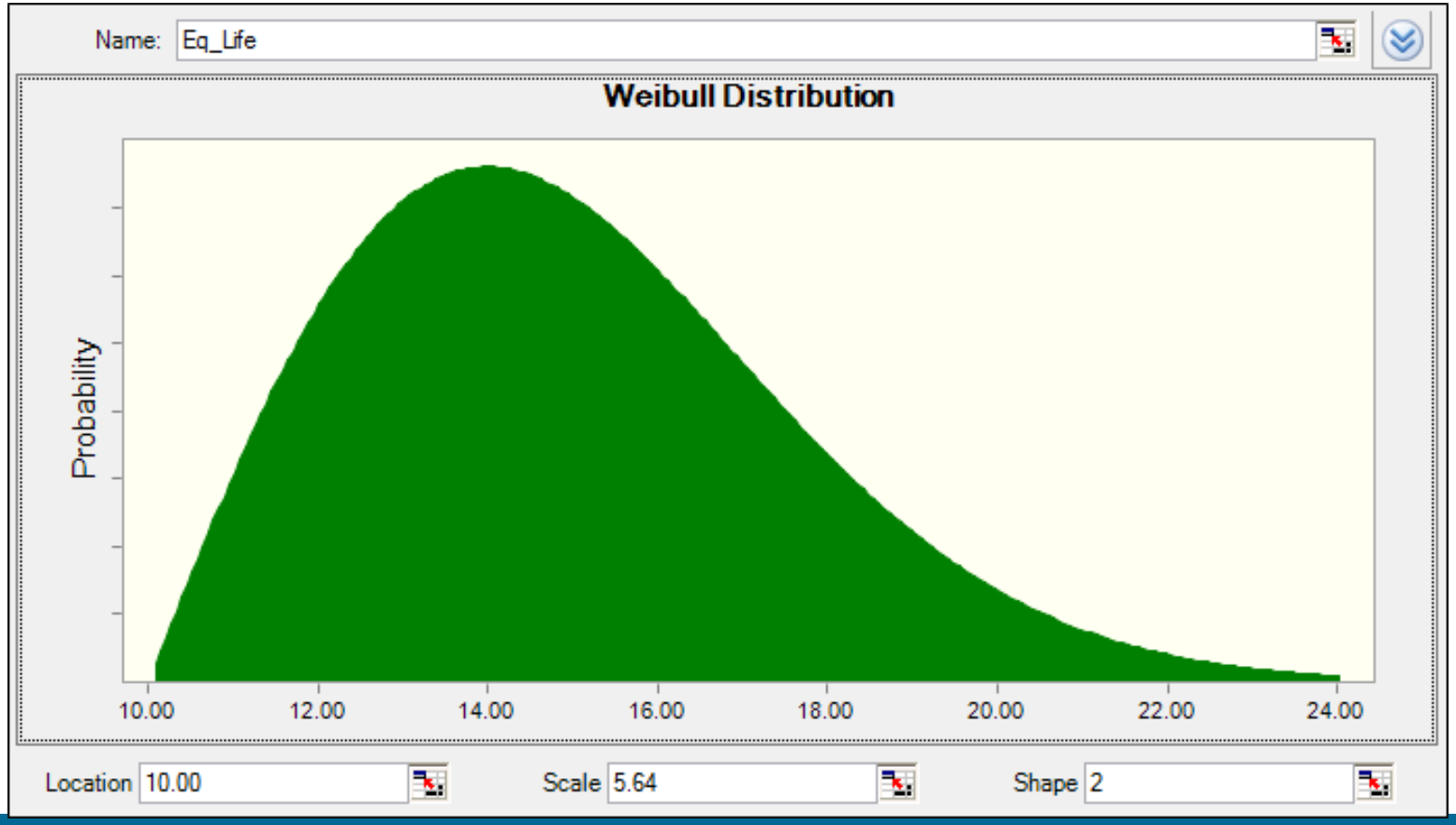
Discount rates

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

- Discount rates represent how future monetary expenditures or benefits are "discounted" to the present and indicate how much value a consumer places on a dollar in the future compared to one in the present.
- Discount rates were sampled for three classes of customers: (1) private companies; (2) State and local government (including education); and (3) Federal government.
- Commercial discount rates: based on capital asset planning model (weighted cost of equity and debt).
- Source of underlying data for private companies was 938 companies in health care, education, and finance and services on the Damodaran Online website.
- For State and local government, a 10-yr. AA municipal bond rate was used.
- For the Federal government, 1971-2010 geometric average of long-term (>10 yr) U.S. government securities was used.

Lifetime of Equipment

- Based on a survey of the available literature (7 sources), DOE concluded that a range of 10-25 years with an average of 15 years was appropriate.
- Lifetimes were assumed to follow a Weibull probability distribution:



LCC-PBP Analysis Results

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

- **In general, LCC savings were strongly negative above the ASHRAE level (indicating increased life-cycle costs to the consumer).**
- **Exceptions – positive LCC savings seen:**
  - For smallest air-cooled units at Levels 1 and 2 (PBPs >8 years)
  - For medium and large air-cooled units (PBPs were <4 years)
  - For smallest water-cooled and glycol-cooled units (PBPs were negative)
  - For medium and large water-cooled and glycol-units (PBPs were either negative or else > 9 years)
- **Payback periods were generally longer than equipment lifetimes.**
- **In cases where paybacks were negative for one of two reasons**:
  - There are reduced first costs for higher efficiency levels with some equipment classes.
  - Repair and maintenance cost increases outweigh energy costs savings resulting in net increases in operating costs (compared with the baseline ASHRAE standard level).

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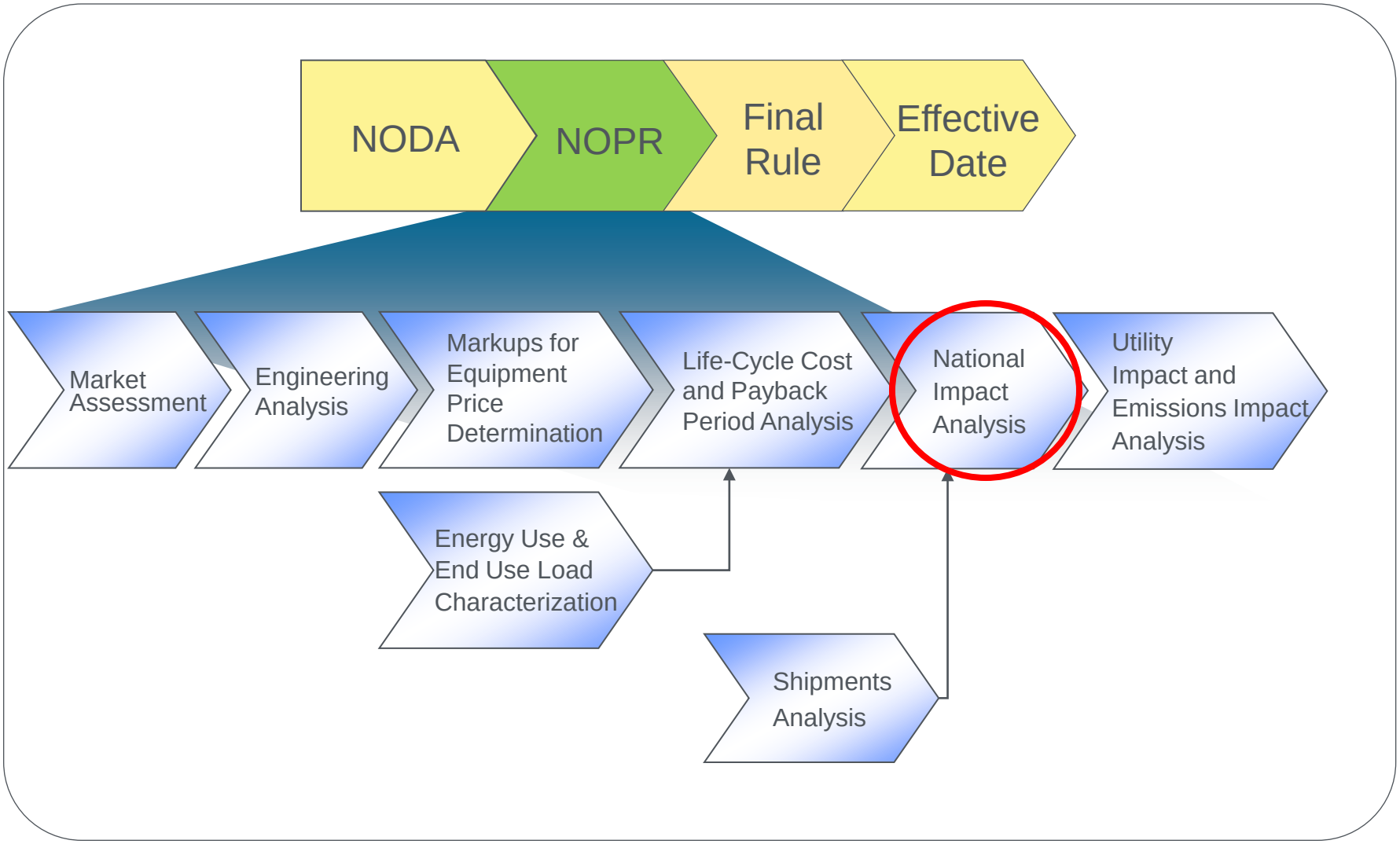
NOPR
Rulemaking Stage



National Impact Analysis

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

- Purpose
  - To estimate the National Energy Savings (NES) from adoption of standards at the ASHRAE Standard 90.1-2010 efficiency levels and also at more-stringent levels.
  - To estimate the national economic impact on the nation in terms of national Net Present Value (NPV) from adoption of computer room air conditioner standards higher than the ASHRAE Standard 90.1-2010 efficiency levels.

- Components
  - Shipment Analysis;
  - National Energy Savings Calculations; and
  - National Net Present Value Calculations.

Shipments Analysis

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

- Purpose
  - To estimate shipments of equipment over time.
- Methodology
  - Obtained historical and forecasted shipments (2000-2020) for Australia.
  - Used the ratio of number of business establishments in Australia and US to inflate the Australia shipments to the US.
  - Estimated future shipments by extrapolating the historical trend.
  - Disaggregated shipments into product classes first using Australia market shares to allocate shipments to six broad product classes and then using market information of models in the US to further disaggregate into all product classes.
  - DOE did not distinguish between upflow and downflow units.

CRAC Shipments

Year	Air-cooled <65	Air-Cooled 65-240	Air-cooled >240	Water-cooled <65	Water-cooled 65-240	Water-cooled >240	Water-cooled <65 FE	Water-cooled 65-240 FE	Water-cooled >240 FE	Glycol cooled <65	Glycol cooled 65-240	Glycol cooled >240	Glycol cooled <65 FE	Glycol cooled 65-240 FE	Glycol cooled >240 FE
2012	671	-	-	74	-	-	46	-	-	69	-	-	69	-	-
2013	691	7,499	1,677	76	1,233	470	47	1,036	180	71	1,233	387	71	1,431	345
2014	711	7,722	1,727	79	1,270	484	49	1,067	185	73	1,270	398	73	1,473	356
2015	732	7,951	1,778	81	1,308	498	50	1,098	190	75	1,308	410	75	1,517	366
2016	754	8,186	1,831	83	1,346	513	52	1,131	196	78	1,346	422	78	1,562	377
2017	776	8,427	1,885	86	1,386	528	53	1,164	202	80	1,386	435	80	1,608	388
2018	799	8,674	1,940	88	1,427	543	55	1,198	208	82	1,427	447	82	1,655	399
2019	823	8,933	1,998	91	1,469	559	56	1,234	214	85	1,469	461	85	1,704	411
2020	847	9,192	2,056	94	1,512	576	58	1,270	220	87	1,512	474	87	1,754	423
2021	847	9,198	2,057	94	1,513	576	58	1,271	220	87	1,513	474	87	1,755	424
2022	866	9,401	2,103	96	1,546	589	59	1,299	225	89	1,546	485	89	1,794	433
2023	885	9,604	2,148	98	1,580	602	61	1,327	230	91	1,580	495	91	1,832	442
2024	903	9,807	2,194	100	1,613	614	62	1,355	235	93	1,613	506	93	1,871	452
2025	922	10,009	2,239	102	1,646	627	63	1,383	240	95	1,646	516	95	1,910	461
2026	941	10,212	2,284	104	1,680	640	64	1,411	245	97	1,680	527	97	1,948	470
2027	959	10,415	2,330	106	1,713	652	66	1,439	249	99	1,713	537	99	1,987	480
2028	978	10,618	2,375	108	1,746	665	67	1,467	254	101	1,746	548	101	2,026	489
2029	997	10,821	2,420	110	1,780	678	68	1,495	259	103	1,780	558	103	2,064	498
2030	1,015	11,023	2,466	112	1,813	690	70	1,523	264	104	1,813	569	104	2,103	508
2031	1,034	11,226	2,511	114	1,846	703	71	1,551	269	106	1,846	579	106	2,142	517
2032	1,053	11,429	2,557	116	1,880	716	72	1,579	274	108	1,880	590	108	2,181	526
2033	1,071	11,632	2,602	118	1,913	729	73	1,607	279	110	1,913	600	110	2,219	536
2034	1,090	11,835	2,647	120	1,947	741	75	1,635	283	112	1,947	610	112	2,258	545
2035	1,109	12,038	2,693	122	1,980	754	76	1,663	288	114	1,980	621	114	2,297	554
2036	1,127	12,240	2,738	125	2,013	767	77	1,691	293	116	2,013	631	116	2,335	564
2037	1,146	12,443	2,783	127	2,047	779	79	1,719	298	118	2,047	642	118	2,374	573
2038	1,165	12,646	2,829	129	2,080	792	80	1,747	303	120	2,080	652	120	2,413	582
2039	1,183	12,849	2,874	131	2,113	805	81	1,775	308	122	2,113	663	122	2,451	592
2040	1,202	13,052	2,919	133	2,147	817	82	1,803	313	124	2,147	673	124	2,490	601
2041	1,221	13,254	2,965	135	2,180	830	84	1,831	317	126	2,180	684	126	2,529	610
2042	-	13,457	3,010	-	2,213	843	-	1,859	322	-	2,213	694	-	2,567	620
Cumulative	28,518	315,793	70,636	3,152	51,940	19,780	1,954	43,628	7,563	2,935	51,940	16,288	2,935	60,250	14,542

NES and NPV Methodology

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

- National Energy Savings (NES) calculated for a period of 30 years from the earliest possible standard compliance date (depends on effective date in ASHRAE and size of product).
  - 2012 to 2041 for CRACs <65 kBtu/h
  - 2013 to 2042 for larger CRACs
- National NPV for CRACs calculated from 2012-2055 or 2013-2056, which covers *life-cycle* installation and operational expenses for all equipment shipments between 2012 and 2041 or 2013 and 2042.
  - Assumes a 15 year product lifetime.
- Both NES and NPV analyses take into account a four-year to five-year delay for DOE to set standards more stringent than the efficiency levels in ASHRAE Standard 90.1-2010.
  - Amended energy conservation standards at the ASHRAE efficiency levels would be implemented in 2012 or 2013.
  - Amended energy conservation standards at more-stringent efficiency levels than those in ASHRAE Standard 90.1-2010 would be implemented in 2017.

NES and NPV Methodology – Cont'd

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

- Used national average customer prices, annual energy use, energy prices, and annual repair and maintenance expenditures from LCC analysis.
  - These inputs were based on downflow units but are assumed to represent upflow units as well. The SCOPs for upflow units were adjusted upward by 0.11 (based on ASHRAE) prior to developing efficiency distributions to allow for this approach.
- Streams of energy use and total costs calculated over analysis time periods with all costs (expenditures) discounted to the present.
- Used a constant price assumption for the default national impact analysis (NIA) forecast, as discussed in the LCC analysis

NES and NPV Methodology – Cont'd

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

- Analysis used a distribution of shipments mapped to each of the efficiency levels considered (*i.e.*, those efficiency levels include a level below-ASHRAE (baseline), the ASHRAE level, and up to 4 higher efficiency levels) based on mapping the market assessment data for available models to the analyzed efficiency levels.

Example Distribution of Efficiencies for Air-Cooled CRACs <65,000 btu/h

	Energy Efficiency Level					
	2.00 SCOP (Baseline)	2.20 SCOP (ASHRAE)	2.40 SCOP	2.60 SCOP	2.80 SCOP	3.00 SCOP (Max-Tech)
Base Case	2%	9%	20%	45%	18%	5%

- Amended energy conservation standards assumed to "roll up" less-efficient equipment to standard level, but not to affect projected shipments at higher efficiency levels.
- Once an amended standard is in place, new equipment enters the market according to the new efficiency mix.

NIA Issues for Comment

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

DOE seeks comment on whether there would be a rebound effect in computer room air conditioner equipment energy use as a result of improvements in the efficiency of such units.

(Issue #14)

DOE seeks comment on whether shipments of computer room air conditioners would change with higher standard levels.

(Issue #15)

DOE seeks comment on the NES-forecasted base-case distribution of efficiencies and DOE's prediction of how amended energy conservation standards would affect the distribution of efficiencies in the standards case.

(Issue #16)

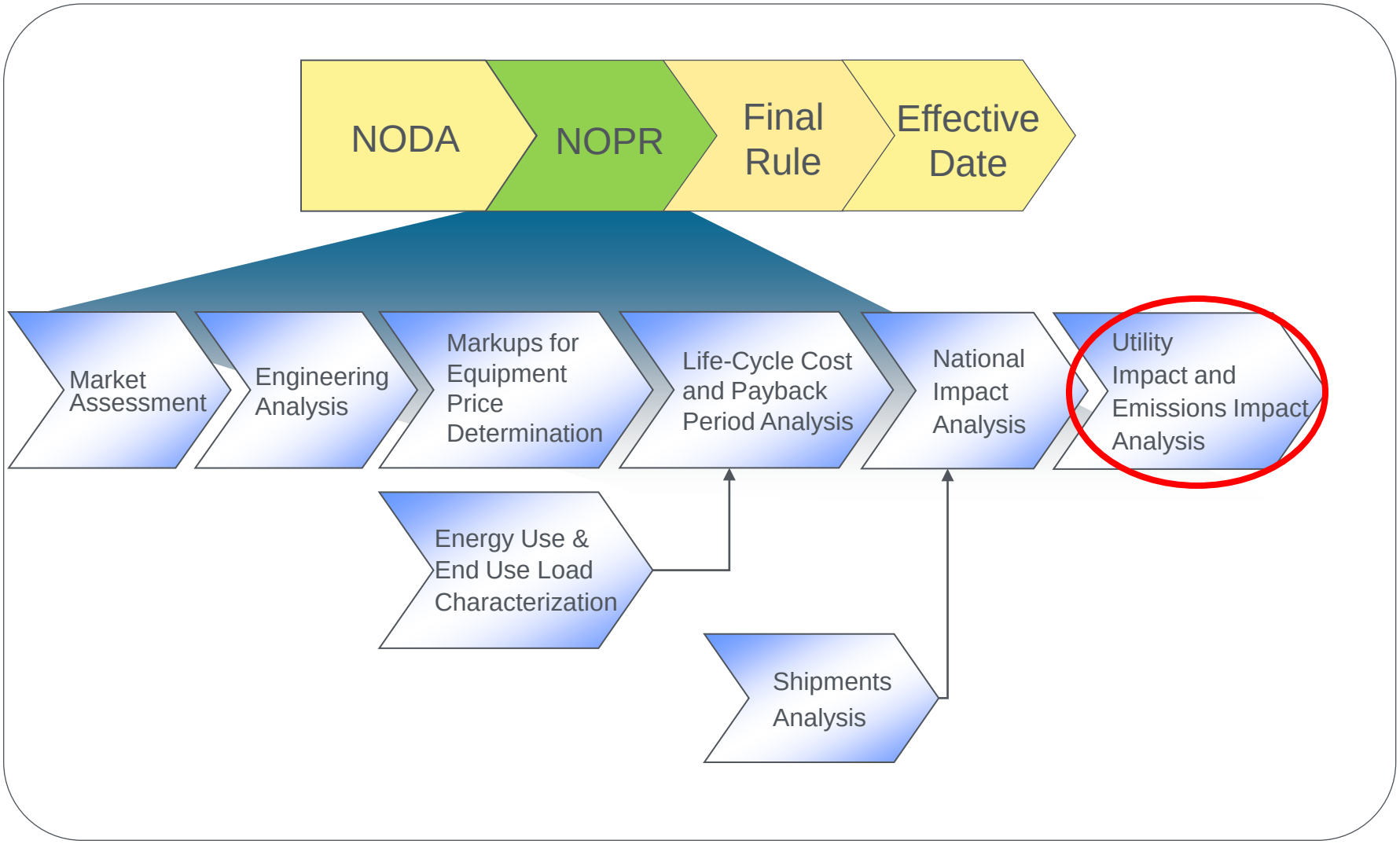
NIA Results

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

- Cumulative NES results showed savings of 0.01 quad for establishing amended energy conservation standards at efficiency levels in ASHRAE Standard 90.1-2010.
  - Cumulative NES savings ranged from 0.07 to 0.98 quads for establishing amended energy conservation standards at efficiency levels higher than ASHRAE Standard 90.1-2010.

- Cumulative NPV savings ranged from -$2.25 to +$0.01 billion (2011$) for establishing amended energy conservation standards at efficiency levels higher than ASHRAE Standard 90.1-2010 using both 3-percent and 7-percent discount rates.

NOPR
Rulemaking Stage



Utility Impact Analysis

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

- Purpose
  - Assess the overall impacts on domestic energy supplies that would result from the adoption of energy conservation standards.
- Method
  - DOE used NEMS-BT, a variant of the NEMS (National Energy Modeling System) developed and used by DOE/Energy Information Administration (EIA) for their *Annual Energy Outlo*ok (*AEO*) report, as the basis of the Utility Impact Analysis.
  - Outputs of the utility impact analysis include forecasts of electricity sales and avoided capacity resulting from a comparison of base and standards cases.
  - DOE modeled the energy savings impacts from amended energy conservation standards using NEMS-BT to generate forecasts that deviate from the *AEO* reference case.

Emissions Impact Analysis

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

- Purpose
  - Estimate national environmental impacts from new energy efficiency standards for products covered under this rule.
- Methodology
  - For emissions from power plants, DOE used the environmental impacts predicted from the NEMS-BT modeling analysis used for the Utility Impacts Analysis. The following emissions are assessed:
    - Carbon dioxide (CO2)
      - NEMS-BT calculates quantities of CO2 emissions from power plants under standards.
    - Sulfur dioxide (SO2)
      - Clean Air Act amendments of 1990 cap SO2 emissions.
      - NEMS-BT does not show any measurable impact from standards.
    - Nitrogen oxides (NOx)
      - Clean Air Interstate Rule (assumed in effect in *AEO2011* NEMS) caps NOx emissions in 28 eastern States and DC.
      - NEMS-BT calculates quantities of U.S. emissions of NOx from power plants in 22 "non-capped" States.
      - For the 28 "capped" States and DC, NEMS-BT does not show any measurable impact from standards.
    - Mercury (Hg)
      - *AEO2011* NEMS does not include EPA's recent Mercury and Air Toxics Standard.
      - NEMS-BT calculates quantities of Hg emissions from power plants under standards.

Emissions Impact Analysis

Monetization of Emissions Reductions

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

- To value avoided CO2 emissions, 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 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 interagency estimates of the potential global benefits resulting from reduced CO2 emissions in 2010 are $5.00, $22.70, $37.20, and $68.80 per metric ton in 2011 dollars.
  - For emission reductions that occur in later years, these values grow in real terms over time.
- DOE also estimated the potential monetary benefit of reduced NOx emissions resulting from the considered standard levels.

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Sampling Plans for all ASHRAE Equipment

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

Test the Minimum Number of Units of a Basic Model Specified in Sections 429.11 and 429.43 Using the Applicable DOE Test Procedure

(Maximum Number of Units is at the Discretion of the Manufacturer)

Determine which Federal Conservation Standards Apply to the Product

431.77, 431.87, 431.97, 431.110,

Calculate the Product Specific Certification Statistics

Sample Mean (x)

Determine Minimum and Maximum Rating Values

Compare Mean to Energy Conservation Standard Per Regulations

Generate Certified Rating Between Minimum and Maximum Values

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Closing Remarks and Comments

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

- Closing Remarks
  - At this time, DOE welcomes any additional remarks or questions from interested parties on the NOPR for certain ASHRAE Equipment.

- DOE specifically invites comment on:
  - The proposed test procedure amendments;
  - The proposed energy conservation standard levels (*i.e.*, the efficiency levels specified by ASHRAE Standard 90.1-2010) for the products in this NOPR.

Closing Remarks and Comments

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- In all correspondence, include all of the following:
  - Energy Conservation Standards for ASHRAE Equipment
  - Docket Number: EERE-2011-BT-STD-0029
  - Regulatory Identification Number (RIN):1904-AC47

- Contact Information

Email: ASHRAE90.1-2011-STD-0029@ee.doe.gov

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Comment period closes: Monday, April 2, 2012