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Commercial Unitary Air Conditioners Standard Evaluation: Final Report

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1 Executive Summary – Commercial Unitary Air Conditioners

On September 30, 2014, the United States Department of Energy (DOE) published a Notice of Proposed Rulemaking (NOPR) for small, large, and very large commercial unitary air conditioners (CUACs) and commercial unitary heat pumps (CUHPs). The Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) developed a Working Group to support the rulemaking. The Working Group met six times between April and June 16, 2015 and submitted a term sheet to ASRAC on June 15, 2015, which recommended two efficiency levels: one that aligned with ASHRAE 90.1-2013 standards to effect in 2018, and the second with more stringent efficiency levels to take effect in 2023. The DOE incorporated the Working Group's recommended efficiency levels and these compliance dates in the Final Rule, which was published on January 15, 2016.

As part of its codes and standards program, the Northwest Energy Efficiency Alliance (NEEA) supported this standard's development and adoption. A NEEA staff member served on the ASRAC Working Group. He and other staff members from efficiency organizations negotiated with manufacturers to determine the recommended efficiency levels—particularly the efficiency levels of the second tier that will take effect in 2023. NEEA and other efficiency organizations also provided comments that affected the analysis, which affected the candidate efficiency levels that the Working Group recommended and that DOE then promulgated.

NEEA contracted TRC to conduct an independent evaluation to qualitatively assess NEEA's influence in the establishment of the CUAC standard and to quantitatively assess the savings from the standard due to the combined efforts of NEEA and the energy efficiency organizations. TRC reviewed the DOE docket for the standard, including the Notice of Proposed Rulemaking, Final Rule, Technical Support Document; and ASRAC Working Group presentations, meetings, and final term sheet. TRC also interviewed stakeholders active in the adoption of the process including one NEEA staff member, three staff members from other efficiency organizations, and four manufacturers. All interviewees served as ASRAC Working Group members.

For the qualitative assessment, TRC found that NEEA engaged in several activities prescribed in the codes and standards logic model, particularly through the NEEA staff member's participation in the ASRAC Working Group.

For the quantitative assessment, TRC estimates that 19% of the total savings that will result from the CUAC standard were due to efforts of NEEA and the efficiency organizations. The majority of those savings, 15% came from their negotiations of the second tier of efficiency levels. Through these negotiations, the efficiency organizations worked with manufacturers to develop efficiency levels that industry accepted, but that were higher than what manufacturers proposed. TRC estimated that an additional 5% came from public and written comments that the efficiency organizations provided. These comments included recommending higher external static pressure (ESP) assumptions, suggesting shorter equipment lifetimes for repaired equipment, supporting DOE in its original assumption to include fan energy use in non-cooling modes, and recommending adjustments to assumptions of high efficiency equipment shipments. Combining these two categories of contributions, leads TRC to the conclusion that 19% of the total savings from the CUAC standard were due to efforts of NEEA and the efficiency organizations.

2 INTRODUCTION

On February 1, 2013, the U.S. Department of Energy (DOE) published a request for information and notice of document availability for small, large, and very large, air cooled commercial package air conditioning equipment (CUACs), commercial unitary heat pumps (CUHPs), and commercial warm air furnaces (CWAFs) to solicit information to help DOE determine whether standards more stringent than those already in place would result in significant additional energy savings. On September 30, 2014, DOE published a Notice of Proposed Rulemaking (NOPR) for small, large, and very large CUACs and CUHPs. The Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) developed a Working Group to support the rulemaking. The Working Group met six times between April and June 16, 2015 and submitted a term sheet to ASRAC on June 15, 2015. This term sheet included two sets of efficiency levels for CUAC and CUHP: the initial efficiency levels that aligned with ASHRAE 90.1-2013 standards and would take effect on January 1, 2018 and higher efficiency levels that would take effect on January 1, 2023. The Working Group also recommended efficiency levels for CWAF equipment that would take effect on January 1, 2023, and recommended changes to the next version of the test procedure. The DOE incorporated the Working Group's recommended efficiency levels and these compliance dates in the Final Rule, which was published on January 15, 2016. As part of its codes and standards program, the Northwest Energy Efficiency Association (NEEA) supported this standard's development and adoption.

2.1 Study Purpose

The scope of TRC's evaluation was to investigate the barriers to adoption for this standard, the activities that NEEA conducted, the activities that other energy efficiency organizations conducted, and the effectiveness of these activities. Based on the results, TRC provided two assessments:

1. A qualitative assessment of NEEA's influence in the establishment of the CUAC standard, which TRC developed based on the NEEA Standards Development Logic Model; and

2. A quantitative assessment of the savings from the standard due to all energy efficiency organizations, including NEEA.

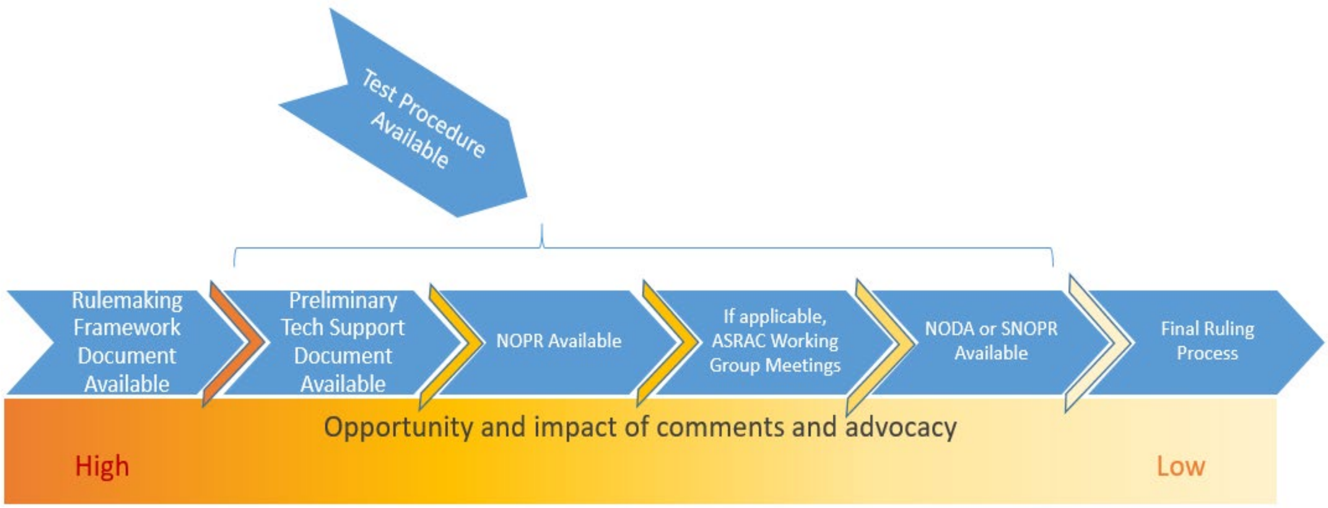
2.2 Description of DOE Adoption Process

As background, TRC provides the following description of the DOE federal standard adoption process. The DOE is the government agency responsible for developing and adopting national appliance energy standards. During the standard development process, the DOE seeks input from stakeholders, including comments regarding the feasibility of the proposed standard and its impact on consumers, manufacturers, and other stakeholders. Stakeholders can provide input during public meetings and comment periods, both of which occur after the public release of rulemaking documents. The DOE must address stakeholder comments and demonstrate that the benefit of a new or revised standard will exceed any burden that it may impose—e.g., that the energy savings (in dollars) from the new standard will exceed costs for implementation.

The CUAC standard process included the creation of a working group ASRAC. According to the DOE website, "The Appliance and Equipment Standards Program established the ASRAC in an effort to further improve the DOE process of establishing energy efficiency standards for certain appliances and commercial equipment. ASRAC will allow DOE to use negotiated rulemaking as a means to engage all interested parties, gather data, and attempt to reach consensus on establishing energy efficiency standards. Rules drafted by negotiation may be more pragmatic and implemented at earlier dates than under a more traditional rulemaking process."

TRC developed Figure 1 to illustrate the general DOE standard development process and opportunities for stakeholder input.

Figure 1. DOE Standard Development Process and Opportunities for Stakeholders' Influence



There are multiple opportunities for stakeholders to influence the final standard and supporting document that impact energy savings, including providing comments and data on the:

1. Test procedure, which details how a project must be tested for compliance with the standard

2. Inputs and analysis used to evaluate each efficiency level considered for the standard, including engineering analysis to determine cost effectiveness, market availability and pricing data, and design options that could affect efficiency

3. Efficiency levels proposed for each equipment class

In addition, stakeholders may participate in the ASRAC Working Group, which may discuss the above items and provide recommendations to the DOE one or more of those topics.

3 Methodology

This section provides an overview of the data collection activities and analysis methodology for this evaluation.

3.1 Data Collection Approach

To collect data for this evaluation, TRC:

1. Reviewed literature—primarily from the DOE docket for this appliance standard, and
2. Gathered feedback from stakeholders involved in the rulemaking process for this standard, primarily through telephone interviews.

TRC's literature review included:

- DOE docketed comments from stakeholders, including manufacturers, energy efficiency organizations, and other interested parties
- DOE Notice of Proposed Rulemaking (NOPR)
- DOE Supplemental NOPR (SNOPR)
- DOE Final Rule for the energy conservation standard and test standard
- DOE Preliminary and Final Technical Support Documents (TSDs)
- Select meeting presentation documents from the ASRAC Working group including:
  - June 1st, 2015
  - June 10th, 2015
- Select meeting notes from the ASRAC Working group including:
  - June 9th, 2015
  - June 10th, 2015
- The final term sheet recommended by the ASRAC Working Group

TRC conducted phone interviews with staff at various organizations that were active in the adoption of this standard. All interviewees participated in the ASRAC Working Group. This included:

- The NEEA staff member that led NEEA's support of this standard,
- Staff members from energy efficiency organizations that played a prominent role in supporting this standard's development. TRC interviewed staff from the following

organizations: Appliance Standard Awareness Program (ASAP), Natural Resources Defense Council (NRDC), and a California Investor Owned Utility (IOUs)

- CUAC manufacturers and industry representative in phone interviews. TRC collected feedback from Rheem, Trane, UTC Carrier, and Goodman.

Figure 2 summarizes the interview dispositions. As shown in this figure, TRC met the total number of target interviews. TRC did not contact DOE or DOE consultants for this standard because their input was not critical to analysis.

Figure 2. Number of Targeted and Completed Interviews by Stakeholder Category

Stakeholder Category	Target Interviews	Candidates Contacted	Completed Interviews
NEEA C&S Staff	1-2	1	1
Energy Efficiency Organizations	3-5	5	3
Manufacturers and Trade Organizations	3-5	6	4*
(OPTIONAL - Pending need) Other Stakeholders	1-2	1	0
(OPTIONAL - Pending need and NEEA approval) DOE staff or consultants	1-2 limited interviews	0	0
Total	**7-16**	**13**	**8**

**One was a partial response, provided in an email.*

Some candidates did not provide an interview, for the following reasons:

- Some manufacturers did not respond to a request.
- One energy efficiency organization representative has since retired.
- One energy efficiency organization representative reported that he was not involved enough in the process, and recommended we speak with another efficiency organization representative (who was already in our sample).

3.2 Limitations of Data Collection Efforts and Analysis

One overarching limitation was that the DOE began development of this standard in 2013, so stakeholders (including NEEA) conducted most of their efforts in 2014 (when the NOPR was released) and earlier. To help address recall issues, TRC sent interviewees their organization's docketed comments, a summary of the adoption timeline, and a summary of the ASRAC Working Group term sheet prior to the interview. TRC acknowledges that this may have introduced some bias into interviewees' responses. Due to the time lag, TRC also had difficulty reaching some individuals who played a key role because they no longer worked for an organization.

Based on TRC's careful review of docket's detail, ASRAC meeting presentations and transcripts, and from information collected through interviews with participants in the process, we believe that our quantitative and qualitative assessments accurately portray the proceedings and that the conclusions regarding efficiency organizations' influence are reasonable.

3.3 Methodology to Assess NEEA's Influence

To assess NEEA's influence on the development and adoption of this standard, TRC compared the proposed activities from NEEA Standards Development Logic Model with activities that NEEA conducted based on interviews and the literature review. TRC first identified barriers to the adoption of this standard, and then we identified influential activities that addressed the barrier in which NEEA participated. Finally, TRC identified NEEA's role and contribution for each activity and output.

3.4 Methodology to Estimate Energy Savings from All Efficiency Stakeholders

To estimate savings from all energy efficiency organizations' efforts in support of the standard, TRC first developed a qualitative assessment of the impact of energy efficiency organizations' efforts. TRC used the results of the literature review and interviews to understand the barriers to the adoption of the CUAC standard, activities that all organizations conducted to address these barriers—including comments and data provided to the DOE and the outcome of these activities —such as reduced manufacturer opposition or changes in DOE's rulemaking.

TRC then translated this qualitative assessment into a quantitative framework to approximate the significance of energy efficiency organizations' activities as a percentage of energy savings resulting from activities during the development and rulemaking process. To develop the quantitative analysis, TRC used the following methodology:

A. **Estimated savings from efficiency level negotiations conducted through the ASRAC Working Group.** Efficiency organizations and manufacturers negotiated the standard levels during the ASRAC Working Group. From the Working Group meeting presentation and minutes, TRC was able to determine the difference between the total savings from the manufacturers' proposal, the efficiency organizations proposal, and the Final Rule. TRC took the difference manufacturers' proposal savings and the savings in the Final Rule to determine the percent savings that can be attributed to the efficiency organizations participation in the ASRAC Working Group. Because TRC was able to estimate savings directly associated with participation in the ASRAC Working Group, our analysis tracked savings from this separately from other activities.

B. **Estimated savings from all other comments, including comments on the engineering analysis, and previous studies that supported analysis.** For all other activities, TRC could not calculate savings directly associated to those activities. Consequently, TRC determined the role and significance of efficiency organizations' activities on the energy savings from the development and rulemaking process. TRC considered all activities conducted by the efficiency organizations (except the efficiency level negotiations calculated in (A) and estimated the influence of these activities in overcoming barriers to adoption.

TRC added savings from the ASRAC Working Group (A) with the savings from all other comments (B) for total savings from the energy efficiency organizations.

4 NEEA Effectiveness Assessment Results

Figure 3 summarizes the results of TRC's assessment of NEEA's efforts. TRC developed this figure using the NEEA logic model as an assessment framework. Note that NEEA has one logic model for all codes and standards activities. NEEA adapts its activities to suit the specific needs for each particular standard; therefore, not all barriers or activities are relevant for every standard.

Using the assessment criteria from the NEEA logic model, TRC used information from the analysis to identify whether NEEA met each criterion. TRC identified logic model activities and outputs with a "Y" if NEEA accomplished the activity or output and "N" if NEEA did not. The figure provides a rationale for whether NEEA accomplished each objective, and it also describes where some activities may not have been relevant or necessary for this standard.

NEEA's primary influence came from Louis Starr serving as an ASRAC Working Group member. NEEA worked jointly with five other energy efficiency organizations: NRDC, ASAP, CA IOUs, American Council for an Energy Efficient Economy (ACEEE), Northwest Power and Conservation Council. Collectively, they served as a counterpoint to manufacturers' proposals for engineering analysis assumptions, efficiency levels, and other topics, and they negotiated with manufacturers to create a CUAC standard that was agreeable to both energy efficiency organizations and manufacturers. Although Andrew deLaski of ASAP led the majority of negotiations for the efficiency organizations, Louis Starr of NEEA actively participated in Working Group meetings.

Manufacturers interviewed noted that NEEA and ASAP were active and effective in the Working Group discussions. TRC's review of ASRAC meeting notes supports that the NEEA staff member participated in ASRAC meetings, but the ASAP staff member led the negotiations for the energy efficiency organizations.

In addition to its ASRAC Working Group participation, NEEA submitted comments to the DOE during the CUAC rulemaking process. Initially in the standard development process NEEA submitted comments individually. These comments covered issues including:

1. Urging DOE to use both the Integrated Energy Efficiency Rating (IEER) and Energy Efficiency Rating (EER) in lieu of just replacing EER with IEER.

2. Encouraging the use of regional efficiency standards due to regional climate differences. Including a comment that the current test procedure uses external static pressure that is too low, which in turn underestimates fan energy use.

3. Encouraging DOE to review actual equipment lifetime for determining lifecycle cost of equipment as the current method under values useful life.

As the standard development progressed, NEEA partnered with the five energy efficiency organizations mentioned above to submit joint comments. These comments covered issues including:

1. Supporting DOE's use of IEER.

2. Urging DOE to evaluate efficiency levels between EL3 and EL4.
3. Encouraging DOE to ensure that technology options are properly ordered in developing cost-efficiency curves.
4. Encouraging DOE to consider microchannel heat exchangers for small/medium equipment in engineering analysis.
5. Agreeing with DOE's approach for energy use analysis—specifically, the inclusion of supply fan savings outside of cooling mode.
6. Stating DOE overestimated the impact of higher efficiency levels on shipments.
7. Encouraging DOE to attempt to capture price trends of technologies that can improve the efficiency of commercial air conditions and heat pumps. Specifically, encouraging DOE to use component-based price learning that was being used in the preliminary TSD for ceiling fans.
8. Encouraging DOE to require reporting of EER values at each of the four IEER test points and include this in the Certification Compliance Database. This is useful for utilities and other efficiency program administrators.

Section 5.2.4 has more information about comments 2, 3, 5, 8 and 9, which resulted in energy savings.

Overall, NEEA was successful at conducting the majority of its planned activities from the logic model. There were two activities that NEEA did not conduct for this standard: conducting primary research and providing savings and economic analysis based on Northwest data. However, there was not a high need for these data or analysis for this standard since manufacturers were generally able to provide data.

Figure 3. Assessment of NEEA's Activities on the CUAC Standard

Barrier (NEEA logic model)	Manufacturer opposition			Lack of data with which to conduct the necessary analyses in a rulemaking		Lack of common interest among certain stakeholders	Insufficient funding/staff for US DOE to run standards processes
Proposed Activity (NEEA logic model)	Negotiation with manufacturers.	Attend public meetings held by DOE.	Analyze and critique organizations, manufacturers and rulemaking documents.	Conduct primary research to create data for standards and test procedures.	Provide savings and economic analyses based on Northwest data.	Collaboration with other organizations under the umbrella of ASAP.	Encourage utilities to provide data and political support for standards.
Accomplished by NEEA? (TRC)	Y	Y	Y	N	N	Y	Y
Rationale/ explanation (TRC)	NEEA did not negotiate with manufacturers directly on proposed CUAC standard. However, NEEA, manufacturers, and others participated in ASRAC-formed Working Group that developed the CUAC standard. During the Working Group meetings, efficiency organizations, including NEEA negotiated with manufactures on the CUAC standard.	Yes. NEEA attended several public meetings for this standard, including all ASRAC Working Group Meetings.	NEEA submitted sole comments and joint comments on standard development. NEEA attended and actively participated in all public DOE hearings.	NEEA did not collect or provide primary data.	NEEA did not provide savings data for the Northwest.	NEEA submitted joint comments, and held on-going communication and meetings. NEEA participated in the ASRAC Working Group energy efficiency caucus sessions. There was a uniform position from all energy efficiency organizations.	NEEA worked jointly with CA IOUs, who provided data in the support of the standard.
Outputs (NEEA logic model)	Consensus-based proposals to submit to DOE or better general understanding of manufacturer positions and concerns	NEEA adds valuable information at each stage of the rulemaking process.		NEEA adds valuable information at each stage of the rulemaking process.	NEEA information/ analysis referenced in rulemaking proceedings/ documentation	NEEA adds valuable information at each stage of the rulemaking process. NEEA information/ analysis referenced in rulemaking proceedings/ documentation	Utilities are present at hearings/ publicly support new standards.
Accomplished by NEEA? (TRC)	Y	Y		N	N	Y	Y
Rationale/ explanation (TRC)	Participated in ASRAC Working Group efficiency caucus.	NEEA provided comments in support of DOE and other efficiency organizations.		NEEA did not complete any primary research for this standard.	NEEA did not provide any research for the docket.	DOE rulemaking documentation references NEEA joint comments. NEEA active during public stakeholder hearings.	NEEA worked jointly with CA IOUs on the ASRAC Working Group.

5 Influence of All Energy Efficiency Organizations

As documented in the Final Rule, manufacturers and other stakeholders raised significant comments after DOE released the NOPR and SNOPR. To overcome this contention, the DOE developed the ASRAC Working Group, which was tasked with negotiating key parts of the standard—including adjusting the engineering analysis and developing proposed efficiency levels.

Figure 4 shows the ASRAC Working Group members.

Figure 4. ASRAC Working Group Members

ASRAC CUAC Working Group Member (Organization)	Organization Type
John Cymbalsky (U.S. Department of Energy)	Government
Marshall Hunt (CA IOUs: Pacific Gas & Electric Company, San Diego Gas & Electric Company, Southern California Edison, and Southern California Gas Company)	Utility and Efficiency org.*
Andrew deLaski (Appliance Standards Awareness Project)	Efficiency org.
Louis Starr (Northwest Energy Efficiency Alliance)	Efficiency org.
Meg Waltner (Natural Resources Defense Council)	Efficiency org.
Harvey Sachs (American Council for an Energy Efficient Economy)	Efficiency org.
Jill Hootman (Trane)	Manufacturer
John Hurst (Lennox)	Manufacturer
Karen Meyers (Rheem Manufacturing Company)	Manufacturer
Charlie McCrudden (Air Conditioning Contractors of America)	Manufacturer
Paul Doppel (Mitsubishi Electric)	Manufacturer
Robert Whitwell (United Technologies Corporation (Carrier))	Manufacturer
Russell Tharp (Goodman Manufacturing)	Manufacturer
Sami Zendah (Emerson Climate Technologies)	Manufacturer
Mark Tezigni (Sheet Metal and Air Conditioning Contractors	Manufacturer
Nick Mislak (Air-Conditioning, Heating, and Refrigeration Institute)	Manufacturer
Michael Shows (Underwriters Laboratories)	Other

*TRC classified the California IOU contributors as an efficiency organization, because they developed and advocated for proposals (did not just provide data) and generally worked with the efficiency organizations on those proposals.

The Working Group included five efficiency organizations and ten manufacturers. In general, the Working Group members from efficiency organizations:

A. Negotiated with the manufacturers to develop efficiency levels for each equipment class that would be acceptable to all parties, and

B. Provided comments in Working Group meetings regarding engineering analysis assumptions.

TRC calculated the influence of the first activity (negotiations on efficiency levels) in section 5.1 and from the second activity (comments on engineering analysis) in section 5.2.

5.1 Energy Savings from Efficiency Level Negotiations in ASRAC Working Group

Throughout most of the ASRAC Working Group meetings, the efficiency organizations and manufacturers had different opinions on where the efficiency levels should be set. Several manufacturers suggested that DOE adopt the ASHRAE 90.1-2013 standards for this equipment, while efficiency organizations for higher efficiency levels. To overcome this challenge, manufacturers proposed that the Working Group recommend two tiers for efficiency levels:

1. The first tier, effective 2018, that would align with ASHRAE 90.1-2013 standards, and
2. A second tier, effective at some point in the future, at higher efficiency levels.

The docket and interviews with ASRAC Working Group members indicate that there was little disagreement over the efficiency level or timing of the first tier. Almost all of the negotiations between the efficiency organizations and manufacturers was to agree on the efficiency levels in the second tier and (to a lesser extent) when those would take effect.

The original NOPR had proposed Trial Standard Level[1] 3, which would have resulted in 11.8 quads of energy savings. Based on a review of June 9 and June 10, 2015 Working Group meeting transcripts, after adjusting the calculations from the original NOPR to account for changes in engineering analysis and other input assumptions:

- The manufacturers proposed Efficiency Level (EL) 2.5 by 2024, which would result in 12.6 quads[2] of energy savings by 2080.
- The efficiency organizations proposed EL 4 by 2022, which would result in 18.2 quads of energy savings by 2080.

Led by the ASAP representative, the efficiency organizations proposed that the Working Group "split the difference" and compromise with total energy savings in the middle of the two proposals. Furthermore, the efficiency organizations proposed that manufacturers finalize the

[1] The Trial Standard Level (TSL) combines specific efficiency levels for each equipment class. In the NOPR, DOE analyzed the benefits and burdens of eight TSLs, which includes six equipment classes.

[2] Note that all quad values represent full fuel cycle (FFC) savings. FFC refers to the energy use associated with the complete fuel production. This includes extraction, processing, and delivery.

efficiency levels for each equipment class to reach those total energy savings. While both parties made concessions, the efficiency organizations set firm quad savings target for the standard.[3]

The manufacturers agreed to this proposal, and the ASRAC Working Group ultimately recommended a mix of EL2.5 and EL3 depending on equipment class, with total savings of 14.8 quads. In addition, the Working Group arrived at the midpoint for the year when the second tier would take effect: 2023. DOE adopted this proposal in its Final Rule.

Interview results and ASRAC meeting note transcripts support that the efficiency organizations were the primary entities pushing back on manufacturers on their proposed efficiency levels; because it went to ASRAC negotiations, efficiency organizations primarily negotiated with manufacturers, rather than DOE. Consequently, TRC assigns all of the incremental savings from the second tier EL that was adopted, compared to the second tier EL that the manufacturers proposed, to the efficiency organizations.

TRC calculated the savings from efficiency organizations as follows:

(Savings from adopted standard – Savings from standard proposed by manufacturers) / Savings from adopted standard

= (14.8 quads – 12.6 quads) / 14.8 quads = 15% of savings

TRC assigned the savings from these negotiations beginning in 2023, when the second tier EL begins.

5.2 Energy Savings from Comments on Baseline Model and Previous Studies that Support the Analysis

5.2.1 Description of Calculation of Energy Savings from Comments

To estimate the percent of energy savings from all other activities (except the efficiency level negotiations), TRC estimated the energy efficiency organizations' influence using an analysis framework described below.

a. **Identified and estimated the relative significance of the barriers** to adoption of the standard. TRC identified three barriers that were significant for standard development. Based on the importance of each barrier, TRC assigned a weighting factor to each so that their sum would total 100%:
    i. Manufacturer Opposition to More Stringent Standard (High: 60%),
    ii. Lack of Data Availability and Accuracy (Medium: 30%), and
    iii. Lack of Accurate Test Procedure (Low: 10%).

[3] One efficiency organization stated, "Our group will not take any further cuts beyond what I'm going to describe for you now...You tell us the best way to get there". From the ASRAC Working Group meeting minutes from June 10, 2015

b. **Identified and estimated the significance of each efficiency stakeholder activity to overcome each barrier.** As one example activity, the energy efficiency organizations provided comments that the external static pressure was too low in the model. TRC found that this activity had a low significance in reducing the barrier, “Lack of Data Availability and Accuracy”. TRC estimated the significance as 10% for addressing this barrier, based on the following scale:

   None = 0%, Extremely Low = 2%, Very Low = 5%, Low = 10%, Medium = 30%, and High = 60%

c. **Estimated the effectiveness of each efficiency stakeholder activity relative to all efficiency stakeholder activities to overcome all barriers**. Following our example activity, TRC rated the change in external static pressure as 10% of significance in addressing the “Lack of Data Availability and Accuracy” barrier, and TRC rated this barrier as 30% of significance for all barriers. Consequently, TRC estimated that the significance of this energy efficiency organizations activity relative to all activities was 30% x 10% = 3%.

d. **Estimated the role of efficiency organizations in each activity relative to all participants to support DOE (i.e. all, primary, major contributor, minor, very minor).** TRC estimated efficiency organizations’ role to support DOE and address each barrier and applied a weighting to the significance of their activities. Because DOE (including its consultants) did the majority of the work to develop the draft test procedure, NOPR, and draft engineering analysis, TRC assumed that the maximum role played by the energy efficiency organizations for comments affecting these documents and analysis was 50%, as described below:

   Primary Support (50%): Led efforts to provide comments to DOE.

   Major Support (30%): One of a few stakeholders; did not lead efforts but contributed significantly.

   Minor Support (10%): One of many stakeholders but did not contribute significantly.

   Using the example activity of higher external static pressure, efficiency organizations provided the Primary Support to the DOE. For this example activity, the final estimated significance for this energy efficiency activity is 30% x 10% x 50% = 1.5%.

e. **Estimated the total impact of efficiency organizations’ activities.** For each activity, TRC estimated the significance of each activity to overcome all barriers (step c) and multiplied this by the relative role of the organizations (step d). TRC then summed the significance of all activities.

5.2.2 Results of Energy Savings from Comments

TRC estimates the efficiency organizations’ influence for this part of the standard development process is 5%. Figure 5 presents results. TRC provides a supporting rationale for each input below this figure.

Figure 5. Impact Assessment of Energy Efficiency Organizations' Activities for CUAC Standard

Barrier, based on NEEA logic model	1. Manufacturer Opposition to More Stringent Standard	2. Lack of Data Availability and Accuracy					3. Lack of Accurate Test Procedure		Total
Sub-barrier specific to standard	Original standard proposal in DOE NOPR was not acceptable to the industry. This prompted the DOE to create the ASRAC Working Group.	External Static Pressure (ESP) assumptions underrepresented field conditions, and NOPR did not consider conversion curbs.	Model assumptions included a mean lifetime for repaired equipment that was too high.	Manufacturers argued to exclude fan energy use from non-cooling periods.	Model overestimated the impact of higher efficiency levels on shipments.	Lack of data for engineering analysis assumptions.	IEER testing procedure included ESP values that were too low.	IEER test procedure included high temperature testing point that was too low.	
Significance for energy savings	**High**	**Medium**					**Low**		
a. Significance of barrier (%)	**60%**	**30%**					**10%**		**100%**
Activities Conducted by all EE Organizations	**Activities to Address Barrier 1**	**Activities to Address Barrier 2**					**Activities to Address Barrier 3**		
	Participated in ASRAC Working Group meetings and separate Advocate Caucus meetings. Worked with manufacturers to negotiate a two-tier system including the timing and the efficiency levels that was acceptable to industry. For ASRAC negotiations, set firm quad savings target of 14.8 quads for the standard. Manufacturers were able to identify how they would reach those firm targets.	Advocated for higher ESP assumptions in the Working Group and recommended appropriate ESP to use in the analysis. Supported minor support to DOE in its analysis of penetration of conversion curbs in high efficiency units and energy impacts.	Provided comments that mean lifetime for repaired equipment was too high.	ASAP supported DOE in retaining fan energy use during all modes of operation in the analysis, helping DOE to maintain methodology in NOPR.	Commented that DOE's model overestimated the impact of higher efficiency levels on shipments.	Funded studies used by DOE (and consultants) in Technical Support Document: 1.5% of total TSD references were advocate studies.	Provided comment that ESP ratings are low in four test points, resulting in lower fan energy consumption and artificially inflated IEER ratings.	Commented that high temperature testing point should be higher to reflect operating conditions in hot climates.	
Results - i.e., DOE response	ASRAC Working Group unanimously adopted Term #4, which recommended two tiers of efficiency levels and timelines for each. Phase 1 includes ASHRAE 90.1 levels. DOE adopted recommendations from Working Group, including efficiency levels and timelines.	DOE increased the ESP in analysis for this standard. DOE assumed a fraction of market would require conversion curbs, further increasing ESP for those units.	DOE updated assumptions that the mean lifetime for repaired equipment is equal to one half the mean lifetime of new equipment.	DOE retained fan energy use in all modes of operation.	DOE adopted similar but more transparent modeling approach than what was in NOPR.	DOE developed engineering analysis based on studies, including those from stakeholders.	DOE plans to initiate an additional test procedure rulemaking focused on revising the IEER metric. This may include changes to the high temperature set point and to ESP assumption - both for assumed value and to include ESP of fans in non-cooling modes.		

Barrier, based on NEEA logic model	1. Manufacturer Opposition to More Stringent Standard	2. Lack of Data Availability and Accuracy					3. Lack of Accurate Test Procedure	Total
Effectiveness of activity for addressing barrier	High	Low	Low	Very Low	Very Low	Extremely low	None - potential savings from future test procedures	
b. Significance for each barrier (%)	Accounted for separately	10%	10%	5%	5%	1.0%	0%	
c. Significance across all barriers: a x b (%)		3%	3%	2%	2%	0.3%		
EE organizations' role		Primary	Primary	Primary	Primary	Minor		
d. EEs' Relative Role in activity (%)		50%	50%	50%	50%	10%		
e. Significance of EE activity relative to total savings, c x d (%)		1.5%	1.5%	0.8%	0.8%	0.03%		5%

The remainder of this section describes TRC's rationale for our rankings and weightings in Figure 5.

5.2.3 Rationale for Weighting Significance of Barriers

To identify barriers, TRC began with the barriers in the NEEA Standards Development Logic Model. Because this is the general logic model that applies to all of NEEA's standards development efforts, TRC revised this list of barriers based on the specific challenges of this standard. TRC identified two of the barriers in the NEEA logic model for standards rulemaking as applicable to this standard—Manufacturer Opposition, and Lack of Data—and added a third barrier based on the specifics of this standard: lack of accurate test procedure and metric.

Barrier 1: Manufacturer opposition to regulation or more stringent standard

Significance: High

Rationale and Findings: There was significant manufacturer opposition to the proposed standard in the NOPR. In the NOPR, DOE proposed adoption of TSL 3 based on an IEER. Manufacturers urged DOE to adopted ASHRAE 90.1-2013 efficiency levels (i.e. TSL 1) and/or consider additional efficiency levels between EL2 and EL3. Manufacturers further questioned DOE's interpretation of the statutory lead time requirements for amending the standards.

American Heating and Refrigeration Institute (AHRI) and ACEEE submitted a joint letter to the ASRAC requesting a negotiated rule making for CUAC and CUHP. ASRAC developed a Working Group to support the rulemaking, which consisted of manufacturers, efficiency organizations, and other stakeholders. The Working Group was able to negotiate efficiency levels and timing that industry would accept: ASHRAE 90.1-2013 standards to take effect on January 1, 2018 and higher efficiency levels that would take effect on January 1, 2023. The Working Group also recommended efficiency levels for CWAF equipment that would take effect on January 1, 2023. The DOE incorporated the Working Group's recommended efficiency levels and these compliance dates in the Final Rule, which was published on January 15, 2016.

Several interviewees noted that the ASRAC Working Group process allowed the manufacturers and efficiency organizations to come to a consensus on the engineering analysis, the efficiency levels, and the timeline for implementation. This includes manufacturers who critiqued the initial proposal in the NORP. One interviewee said that this process helps prevent potential future lawsuits from the manufacturers.

Because of the high level of contention regarding the NOPR, TRC ranked this barrier as high.

Barrier 2: Lack of data availability and accuracy

Significance: Medium

Rationale and Findings: Manufacturers and energy efficiency organizations both questioned the accuracy of the baseline model and DOE's engineering analysis.

Manufacturers argued that a number of inputs in the model were incorrect and overstated, including cost of equipment, cost of compliance, overestimation of energy savings, employment and shipping data, and equipment lifetime. As a result, manufacturers believed savings and benefits of the proposed NOPR standard were overestimated. Energy efficiency organizations also raised concerns that the model did not accurately represent field conditions, all modes of equipment operation, and equipment lifetime.

The stakeholders' concern over the analysis assumptions was an important barrier, but not as significant as the barrier regarding manufacturer opposition to the efficiency levels.

Barrier 3: Lack of accurate test procedure

Significance: Low

Rationale and Findings: There was discussion between both the manufacturers and energy efficiency organizations regarding the test procedure. Stakeholders raised issues including the ability of the test procedure to accurately capture total fan energy use, including external static pressure assumptions and operation of the fan in modes other than mechanical cooling and heating.

TRC ranked this barrier as low. The DOE had a test procedure in place for the negotiations, and the discussions regarding the test procedure were not as contentious as discussions regarding the efficiency levels or engineering analysis. In particular, the manufacturers did not push back heavily on the test procedure, so this was a low barrier to the adoption of the standard.

5.2.4 Rationale for Weighting Significance of Activities

This section describes TRC's rationale for weighting the significance of each activity that the efficiency organizations conducted.

Activities to Address Barrier 1: Manufacturer Opposition to More Stringent Standard

The efficiency organizations participated in the ASRAC Working Group, which negotiated efficiency levels. TRC calculates this separately in section 5.1.

Activities to Address Barrier 2: Lack of Data Availability and Accuracy

The efficiency organizations conducted five activities that affected the final DOE analysis, which in turn affected savings. TRC calculated the significance of each activity separately.

The majority of these activities were comments on analysis. In interviews, some manufacturers reported that the majority of the changes to the model and analysis were due to manufacturer comments only. They reported that the energy efficiency organizations were not as involved in the technical details but were generally concerned with increasing efficiency levels as high as possible, even if these levels were "unrealistic".

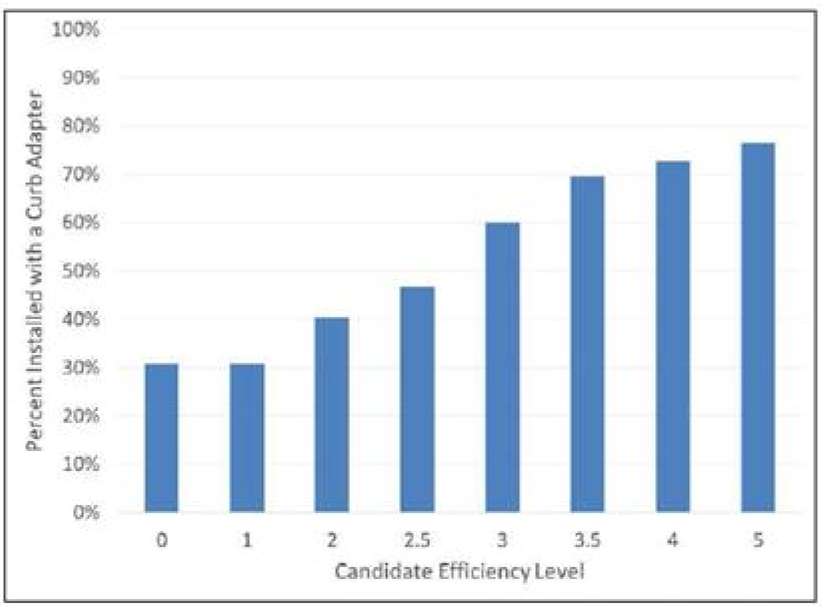
Commented on ESP and Conversion Curb Assumptions

Activity: The efficiency organizations commented that the DOE analysis assumed ESP values that were too low to represent field conditions. They advocated for higher ESP assumptions as part of the ASRAC Working Group. The Final Rule describes that DOE increased the ESP assumptions. The NOPR does not explicitly identify DOE's initial ESP assumption, but the

NOPR refers to AHRI 340/360-2007 as for its ESP assumption. Based on Table 5 in the AHRI standard, TRC identified that the ESP ranges from 0.20" to 0.75", based on unit capacity. In the Final Rule, the ESP ranges from 0.75" to 1.25".

The DOE did not consider conversion curbs in the NOPR. When an owner replaces an existing unit, conversion curbs (or curb adapters) may be required if the new unit cannot be fitted onto the existing curb. A curb adapter provides an interface between an HVAC rooftop unit and the rooftop ports that feed the heating and air conditioning to and from the building. The rooftop ports are built into a raised external assembly called a curb. Many of these rooftop HVAC curbs were originally set into the roof to accommodate old HVAC units. Conversion curbs impact energy consumption because they further increase ESP, which increases fan energy use. DOE did considerable research (as documented in the TSD) to determine the percentage of the market that requires a conversion curb and how it varies with efficiency level, and ASRAC Working Group members also debated these assumptions in meetings. For each equipment class, DOE developed a chart similar to the one in Figure 6, which shows that the higher efficiency units have higher rates of conversion curbs (and therefore higher energy use due to the higher ESP). In the Final Rule, the analysis assumes that a certain percentage of units require the use of a conversion curb, and those units have an additional 0.2" of ESP required in addition to the ESP in the DFR (0.75" to 1.25").

Figure 6. Example of DOE's Conversion Curb Adoption Rate Analysis (Source: CUAC Technical Support Document)



<u>Significance of Activity</u>: For the ESP assumptions, the higher ESP values recommended by the efficiency organizations provided a more accurate estimate of energy consumption in the field. However, TRC believes the revised ESP assumptions had little impact on the energy savings from the standard for the following reason: based on a review of the TSD, it appears that the new ESP assumptions affected each candidate efficiency level approximately equally. Because energy savings come from incremental differences between candidate efficiency levels, TRC estimates this increase in ESP (which bumped up energy use for all candidate efficiency levels

equally) did not impact energy savings from the standard. In other words, this study is only interested in incremental differences in energy between candidate efficiency levels. The energy savings at each efficiency level did not change as a result of the ESP change.

TRC believes that the conversion curb assumptions had a significant impact on the analysis. If the DOE had assumed that the rates of conversion curbs on high-efficiency units were high, the high-efficiency units would have appeared less cost-effective, which would have likely driven the Working Group to recommend slightly lower efficiency levels. However, the DOE primarily led the effort to develop conversion curb assumptions, not the efficiency organizations.

Finally, the ESP and conversion curb assumptions were just two of several changes that the DOE made to its analysis. Other changes made to the energy analysis between the NOPR and DFR included:

- Reduced ventilation rates
- Assumed that a fraction of units would have faulty economizers
- Modified part-load performance curve of condenser unit
- Modified assumption used for sizing equipment based on building load

Because of these factors, TRC ranked the efficiency organizations' influence as Low for addressing the barrier, Lack of data availability and accuracy.

<u>Role of Efficiency Organizations</u>: TRC identified the efficiency organizations as being the primary supporter to the DOE for this activity. As noted above, the efficiency organizations made several comments about ESP assumptions, which were identified in the docket and which several interviewees recalled. The DOE took the lead role in the conversion curb assumptions.

<u>Savings from Activity</u>: 2% (1.5% before rounding) of savings.

Commented on Equipment Lifetime Assumptions

<u>Activity</u>: In the original NOPR, DOE assumed that a repaired unit had the same lifetime as new equipment. Some efficiency organizations (the California IOUs and ASAP) and one manufacturer (Carrier) commented that while replacing a failed part with a new part returns a unit to service, it does not reset that lifetime after a repair, and, therefore, does not expect repaired units to last as long as new equipment.

In the Final Rule, DOE updated assumptions so that the mean lifetime for repaired equipment is equal to one half the mean lifetime of new equipment.

<u>Significance</u>: TRC determined that the significance of this activity was low, because we believe it had only a small effect on cost effectiveness calculations and overall adoptability of the standard.

Role of Efficiency Organizations: TRC identified the efficiency organizations as being the primary supporter to the DOE for this activity since two efficiency organizations and one manufacturer made this comment.

Savings from Activity: 2% (1.5% before rounding) of savings.

Comments on Inclusion of Fan Energy use in Non-Cooling Modes

Activity**:** ASAP supported DOE's inclusion of fan energy use during all modes of operation as proposed in the original NOPR analysis. Manufacturers commented that it was inappropriate to incorporate energy savings attributed to fan operations during modes of operation other than cooling. The ASRAC Working Group discussed the issue and agreed to keep the fan energy use as originally calculated in the NOPR. DOE maintained the NOPR fan energy use approach in the Direct Final Rule energy use calculations.

Significance of Activity: TRC ranked the relative effectiveness as very low because there was no change in fan energy use assumptions compared with the NOPR, but efficiency organizations allowed DOE to maintain its methodology.

Role of Efficiency Organizations: Efficiency organizations were the primary supporter of DOE for this issue.

Savings from Activity: 1% (0.8% before rounding) of savings

Commented on DOE's Impact of Higher Efficiency Level Shipments

Activity: ASAP commented that DOE's model overestimated the impact of higher efficiency levels on shipments. This includes the model's failure to capture complex factors affecting purchase and repair decisions such as manufacturer's leases, no upfront costs, and the phasing out of R-22 refrigerant.

DOE noted the difficulty in modeling shipments due to the need to simultaneously estimate multiple parameters. Because of this, and lack of additional data, DOE adopted a simpler and more transparent modeling approach. However, the Final Rule does not indicate that the results changed.

Significance: TRC ranked the relative effectiveness as very low because the changes may have made the calculations more acceptable to stakeholders but had very little impact on the results.

Role of Efficiency Organizations: The efficiency organizations played the primary role in commenting on this issue, so TRC identified them as Primary Support.

Savings from Activity: 1% (0.8%) before rounding.

Provided Data for Analysis through Past Studies

DOE required various data to develop its energy savings, cost analysis, market assessment, and other analysis. DOE relied on existing information from a variety of sources, including data from federal agencies, manufacturers and trade organizations, national laboratories, and energy efficiency organizations. TRC reviewed the Final Rule Technical Support Document and developed the following summary of DOE's use of studies from energy efficiency organizations. DOE used:

1. Data from a Pacific Gas and Electric (PG&E) study on California's potential for achieve energy efficiency to determine the effect of rebate programs on market penetration of efficient technologies.

2. Data from a Southern California Edison (SCE) customer decision study was used to estimate the effects of tax credits on consumer purchases.

3. Data from a Northwest Power and Conservation Council study on commercial roof top units.

4. Data from a retro commissioning evaluation funded by Portland Energy Conservation, Inc. (PECI) in conjunction with the Institute for Market Transformation (IMT) and PG&E.

Significance of Activity: Of the 279 referenced studies, four (or about 1%) were funded by energy efficiency organizations. As such, TRC determined the relative effectiveness to address this barrier as extremely low.

Role of Efficiency Organizations: The efficiency organizations played a minor role in overcoming this barrier.

Savings from Activity: 0% (0.03% before rounding)

Activities to Address Barrier 3: Lack of Accurate Test Procedure

The energy efficiency organizations commented that the ESP values in the test procedure were too low in four test points, resulting in lower fan energy consumption and artificially inflated IEER ratings. They also commented that the test procedure included a high temperature testing point rating, 95 °F that was too low to reflect operating conditions in hot climates, and they recommended a dry bulb test point of 105 or 115 °F.

The test procedure was not updated during these proceedings. Term #2 of the ASRAC Working Group term sheet recommended that DOE initiate a rulemaking to amend the test procedures for CUACs and CUHPs focused on revising the IEER metric. However, this affects future standards. Consequently, TRC found that this activity did not result in savings from this standard.

5.3 Total Savings and Timing of Savings

TRC estimates that savings from efficiency organizations' comments and supporting data, equal to 4.5% of annual savings, began the year that the standard first took effect: 2018.

TRC assumed that savings from the efficiency level negotiations, equal to 14.9% of annual savings, will begin the year that the second-tier efficiency requirement takes effect: 2023. Combining the savings from the efficiency organizations' activities providing comments and supporting data, 4.5%, and their work to negotiate the efficiency levels, 14.9%, TRC calculates total savings from efficiency organizations' activities as 19.4% (rounded to 19%) beginning in 2023.

Figure 7 provides TRC's estimate of the percent of annual savings from the standard due to efficiency organizations' activities. Note that the DOE provides energy savings (in quads) through 2080, with a different estimate of energy savings for each year. To estimate energy savings from the efficiency organizations, the percentages in Figure 7 should be multiplied by an annual estimate of savings for each year (rather than totaling savings for 2018 to 2080 and reapportioning those savings for 2018 to 2047).

Figure 7. Yearly Savings from CUAC Standard from Efficiency Organization Activities

Year	% of Annual Savings from Standard due to EE Organizations
2018	4.5%
2019	4.5%
2020	4.5%
2021	4.5%
2022	4.5%
2023	19.4%
2024	19.4%
2025	19.4%
2026	19.4%
2027	19.4%
2028	19.4%
2029	19.4%
2030	19.4%
2031	19.4%
2032	19.4%
2033	19.4%
2034	19.4%
2035	19.4%
2036	19.4%
2037	19.4%
2038	19.4%
2039	19.4%
2040	19.4%
2041	19.4%
2042	19.4%
2043	19.4%
2044	19.4%
2045	19.4%
2046	19.4%
2047	19.4%

6 Conclusions

Based on the data collection, TRC's impact assessment was that efficiency organizations had a moderate influence on this standard. The main influence of the efficiency organizations was negotiating the second tier of efficiency levels for CUAC. Manufacturers and energy efficiency organizations both reported that, while it is a long process, the ASRAC Working Group negotiations were about meeting in the middle and it allowed for a standard that is acceptable by all stakeholders. TRC estimated that the efficiency organizations' work to negotiate the efficiency levels led to 15% (14.9% before rounding) of the savings from the standard.

In addition, the efficiency organizations made comments and supported DOE for several issues related to analysis assumptions. These included comments on ESP assumptions, lifetime of repaired equipment, shipments of efficient units, and including fan energy of equipment in non-cooling modes. As a very minor impact, the efficiency organizations had funded or conducted studies that the DOE used in its analysis, although the vast majority of studies used by DOE came from other sources. Overall, TRC found that the efficiency organizations' comments led to 5% (4.5% before rounding) of savings from the standard.

Combining these two categories of contributions, leads TRC to the conclusion that 19% of the total savings from the CUAC standard were due to efforts of NEEA and the efficiency organizations.