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2014 & 2017 Walk-in Coolers and Freezers Standards Evaluation: Final Report

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1 EXECUTIVE SUMMARY

In this evaluation, two related groups of standards will be discussed.

In June 2014, the Department of Energy (DOE) published a final rule for Walk-in Coolers and Walk-in Freezers (referred to here as WiCF) in which DOE adopted amended energy conservation standards for the main components of these appliances: refrigeration systems (ten different equipment classes), panels (three different equipment classes), and doors (six different equipment classes). The June 2014 Final Rule took effect August 4, 2014, and compliance was required beginning June 5, 2017 (for standards that were not vacated, as discussed below). Following the publication of the June 2014 Final Rule, manufacturers and trade organizations filed petitions in the U.S. Appeals Court for the Fifth Circuit for reconsideration. In response, the Court vacated six of the standards: two for multiplex condensing refrigeration systems, and four for low-temperature dedicated condensing refrigeration systems.

In response to the vacated standards, DOE established an ASRAC Working Group[1] to propose standards to replace the six vacated standards, which led to the July 2017 Final Rule. The Working Group provided recommendations, which DOE generally followed in its proposed standard. On July 10, 2017, DOE published the Final Rule for walk-ins for the vacated standards. The scope of the standard included low and medium-temperature unit coolers, and low-temperature dedicated condensing systems. The July 2017 Final rule took effect September 8, 2017, and compliance is required beginning July 10, 2020.

As part of its codes and standards program, NEEA supported this standard's development and adoption. NEEA provided comments on the test procedure and 2014 standard. A NEEA staff member served on the ASRAC Working Group that provided terms which DOE adopted for the 2017 standard. 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 WiCF standard, and to quantitatively assess the savings from the standard due to the combined efforts of NEEA and the energy efficiency organizations. An efficiency organization is one whose goal is to seek policies that promote energy efficiency in buildings and appliances. TRC reviewed the DOE docket for the 2014 and 2017 standard, including the Notice of Proposed Rulemakings, Final Rules, Technical Support Documents; and ASRAC Working Group presentations, meetings, and final term sheet for the 2017 standard. TRC also interviewed nine stakeholders active in the adoption of the process: two NEEA staff members, three staff members from other efficiency organizations, three manufacturers, and one

[1] DOE's Appliance and Equipment Standards Program created the Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) to aid in DOE's process of establishing energy efficiency standards for certain appliances and commercial equipment. For more information see: https://www.energy.gov/eere/buildings/appliance-standards-and-rulemaking-federal-advisory-committee

other stakeholder. All interviewees were involved in the 2014 standard and/or the 2017 standard, and several served as ASRAC Working Group members.

For the qualitative assessment of the 2014 standard, TRC found that NEEA engaged in several activities prescribed in the codes and standards logic model, particularly through comments submitted in the public review process. For the quantitative assessment of the 2014 standard, TRC found that the efficiency organizations activities led to 12% of the total energy savings from the standard. Three quarters of these savings came from comments from the efficiency organizations recommending that DOE regulate WiCF equipment through component-based standards, instead of a performance standard for the entire system.

For the qualitative assessment of the 2017 standard, TRC found that NEEA engaged in several activities prescribed in the codes and standards logic model, and participated in the ASRAC Working Group. For the quantitative assessment of the 2017 standard, TRC found that the efficiency organizations activities led to 20% of the savings, from working with manufacturers in the ASRAC Working Group to improve the engineering analysis and negotiating with manufacturers on efficiency levels.

2 INTRODUCTION

In June 2014, DOE published a final rule for Walk-in Coolers and Walk-in Freezers (referred to here as WiCF) in which DOE adopted amended energy conservation standards for the main components of walk-in coolers and walk-in freezers: refrigeration systems, panels, and doors. These standards are expressed in terms of annual walk-in energy factor (AWEF) for the walk-in refrigeration systems, R-value for walk-in panels, and maximum energy consumption for walk-in doors.

Following the publication of the June 2014 Final Rule, manufacturers and trade organizations filed petitions for reconsideration. In response, the U.S. Court of Appeals for the Fifth Circuit vacated six of the standards: two for multiplex condensing refrigeration systems, and four for low-temperature dedicated condensing refrigeration systems. DOE established an ASRAC Working Group to propose standards to replace the six vacated standards. ASRAC approved the Working Group's recommendations in a term sheet,[2] and DOE's proposed standard generally followed the recommendations.

On July 10, 2017, DOE published the Final Rule for walk-ins for the vacated standards. The scope of the standard included low and medium-temperature unit coolers (previously referred to as multiplex condensing refrigeration systems), and low-temperature dedicated condensing systems. The July 2017 Final rule took effect September 8, 2017, and compliance is required beginning July 10, 2020. DOE used the same test procedure for both standards, which was published December 28, 2016.

As part of its codes and standards program, NEEA supported the development and adoption of both WiCF standards.

2.1 Study Purpose

The scope of TRC's evaluation was to investigate the barriers to adoption for the WiCF standards, 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 WiCF standards, which TRC developed based on the NEEA Standards Development Logic Model; and

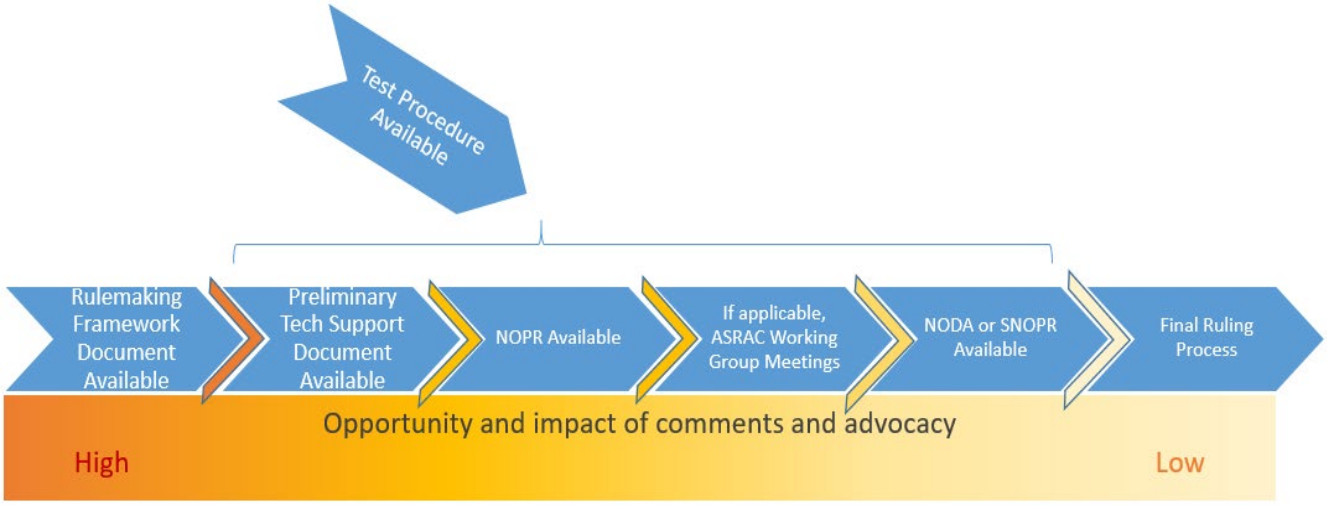
[2] A term sheet is the document which represents the outcome of the ASRAC meetings, with terms agreed upon by the ASRAC working group members through negotiation. The terms can recommend efficiency levels, engineering analysis issues, and the test procedure. The ASRAC working group provides the term sheet to the DOE, which usually adopts some or all of these terms in its rulemaking.

2. A quantitative assessment of the savings from the standards 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. In addition, for this standard, the DOE created a working group through the Appliance Standards Rulemaking Federal Advisory Committee (ASRAC)[3] to negotiate new efficiency levels for the refrigeration systems. 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 documents that impact energy savings, including providing comments and data on the:

[3] 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."

1. Test procedure, which details how a project must be tested for compliance with the standard
2. Inputs and analysis methodologies 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 on 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.

Figure 2 summarizes the items in TRC's literature review for each standard evaluation. Note that the test procedure applies to both the 2014 and 2017 standard, since both use the same test procedure.

Figure 2. Items in Literature Review for 2014 Standard, 2017 Standard, and Test Procedure

Literature Review Item	2014 Standard	2017 Standard	Test Procedure
DOE docketed comments from stakeholders, including manufacturers, energy efficiency organizations, and other interested parties	X	X	X
DOE Notice of Proposed Rulemaking (NOPR)	X	X	
DOE Final Rule	X	X	X
DOE Preliminary Technical Support Documents (TSDs)	X	X	
DOE Final TSDs		X	
Docketed meeting presentation documents from the ASRAC Working group		X	
Meeting transcripts from the ASRAC Working group		X	
Final ASRAC term sheet		X	

Figure 3 summarizes the materials reviewed by meeting date from the ASRAC Working Group as part of the 2017 standard literature review.

Figure 3. ASRAC Working Group Materials Reviewed by Meeting

Meeting Date	Docketed Meeting Presentation Documents	Meeting Transcripts
September 11, 2015	X	
September 30 & October 1, 2015	X	X
October 15 & 16, 2015	X	X
November 3 & 4, 2015	X	X
November 20, 2015	X	X
December 3 & 4, 2015	X	X
December 14 & 15, 2015	X	X

TRC conducted phone interviews with staff at various organizations that were active in the adoption of this standard. All interviewees were involved in the 2014 standard and/or the 2017 standard. This included:

- Two NEEA staff members: one that led NEEA's support of this standard for the 2014 standard and the second that led its support for the 2017 standard, including participation in the ASRAC working group;
- Staff members from energy efficiency organizations that played a prominent role in supporting this standard's development. TRC interviewed staff from three of the efficiency organizations;
- Three manufacturers in phone interviews and emails.
- One utility representative in a phone interview

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 4. Number of Targeted and Completed Interviews by Stakeholder Category

Stakeholder Category	**Target Interviews**	**Candidates Contacted**	**Completed Interviews**
NEEA C&S Staff	1-2	2	2

Energy Efficiency Organizations	3-5	4	3
Manufacturers and Trade Organizations	3-5	6	3*
(OPTIONAL - Pending need) Other Stakeholders	1-2	1	1
(OPTIONAL - Pending need) DOE staff or consultants	1-2	0	0
Total	**7-16**	**13**	**9**

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

Several manufacturers and trade organization representatives did not respond to a request. Of the nine completed interviews, five stakeholders were involved in both standards, three were involved in only the 2014 standard development, and one was involved in only the 2017 standard development.

3.2 Limitations of Data Collection Efforts and Analysis

One overarching limitation was that the DOE began development of the WiCF standard years ago, with stakeholder comments submitted as early as 2009. Several stakeholders interviewed also reported difficulty recalling aspects of the standard development, given the time lag.

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.

Based on TRC's review of the dockets, 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 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. For each WiCF standard, TRC used the results of the literature review and interviews to understand the barriers to the adoption of the standard, activities that all organizations conducted to address these barriers – including comments and activities conducted through the ASRAC working group, and the outcome of these activities – such as changes in DOE's rulemaking or ASRAC working group terms.

For each WiCF standard, 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. Sections 5.1 and 6.1 provides detail on TRC's methodology for the quantitative analysis for the 2014 and 2017 WiCF standards, respectively.

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 NEEA logic model, TRC identified logic model activities and outputs with a "Y" if NEEA engaged in the activity or produced the output and "N" if NEEA did not. The figure provides a rationale for whether NEEA addressed each objective, and describes where some activities may not have been relevant or necessary for this standard.

For the 2014 standard, NEEA's primary influence came from submitting comments to DOE during the standard development process. Comments from NEEA – all of which were submitted jointly with other efficiency organizations – included the following recommendations for DOE:

1. Move from a performance-based approach of the entire walk-in cooler/freezer equipment to prescriptive requirements at the component level. For the envelope, NEEA and other organizations recommended that DOE use a metric based on the overall heat gain of the envelope.
2. Use the Annual Walk-in Energy Factor (AWEF) metric for the cooling system instead of annual Energy Efficiency Ratio (EER) metric as proposed by manufacturers.
3. Include carbon dioxide (CO2) emissions in cost-benefit analyses.
4. Adopt Trial Standard Level (TSL) 4 the highest economically justified efficiency levels.

DOE largely adopted these recommendations in the 2014 standard.

For the 2017 standard, NEEA's primary influence came from one of its C&S staff members serving as an ASRAC Working Group member. NEEA worked jointly with four other energy efficiency organizations: Natural Resources Defense Council (NRDC), Appliance Standards Awareness Project (ASAP), California Investor Owned Utilities (CA IOUs), and American Council for an Energy Efficient Economy (ACEEE). Collectively, they served as a counterpoint to manufacturers' proposals for engineering analysis assumptions, efficiency levels, and other topics,3 and negotiated with manufacturers to create a standard that was agreeable to both energy efficiency organizations and manufacturers.

Overall, NEEA was successful at conducting most 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 or other efficiency organizations (including the CA IOUs) were generally able to provide data.

Figure 5. Assessment of NEEA's Activities on the WiCF 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 participated in ASRAC working group in which they directly negotiated with manufacturers.	NEEA attended public meetings at all stages of rulemakings 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 advocate caucus. There was a uniform position from all 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 EFFICIENCY ORGANIZATIONS IN 2014 STANDARD

This section describes the influence that the efficiency organizations had on the 2014 WiCF standard.

5.1 Description of Calculation of Energy Savings from 2014 Standard

TRC estimated the energy efficiency organizations' influence using an analysis framework described below. Sections 5.3 and 5.4 provides a description of TRC's rationale for our rankings and estimates of percentages. This section includes an example calculation, and the inputs are shown in *red italic text*.

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. Within each barrier, TRC identified sub-barriers. Based on the importance of each sub-barrier, TRC assigned a weighting factor to each so that their sum would total 100%:
   i. Manufacturer Opposition to More Stringent Standard: 30% total
      i. Opposition to proposed refrigeration system efficiency levels: 18%
      ii. Opposition to proposed envelope (panels, doors) efficiency levels: 12%
   ii. Lack of Data Availability and Accuracy: 60% total
      i. *Originally regulated WiCF through performance approach of entire system: 47%*
      ii. Debate over metric for refrigeration equipment and inclusion of hot gas defrost as design option: 5%
      iii. Lack of shipment data: 4%
      iv. Debate over panel and door lifetimes: 4%
   iii. Lack of Accurate Test Procedure: 10%

b. **Identified and estimated the significance of each efficiency stakeholder activity to overcome each barrier.** As one example activity – which was the activity that generated the greatest energy savings – the energy efficiency organizations commented that the DOE should regulate walk-ins at the component level and circulated a document to other stakeholders to obtain their buy-in for this approach. TRC found that this activity had a high significance in reducing the barrier, "Lack of Data Availability and Accuracy". TRC estimated the significance as 40% for addressing this barrier, based on the following scale:

   Low = 10%, Medium = 20%, and *High = 40%*

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 sub-barrier, "Originally regulated WiCF through performance approach of entire system" as 47% of significance across all barriers. Consequently, TRC estimated that the significance of this energy efficiency organizations activity relative to all activities was 47% x 40% = 19%.

d. **Estimated the role of efficiency organizations in each activity relative to all participants to support DOE (i.e. all, primary, major contributor, 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%): Efficiency organizations led efforts to provide comments to DOE.

Major Support (30%): Efficiency organizations were one of a few stakeholders; efficiency organizations did not lead efforts but contributed significantly.

Minor Support (10%): Efficiency organizations were one of many stakeholders but did not contribute significantly.

Using the example activity of comments to regulate WiCF at the component level, efficiency organizations provided the Primary Support to the DOE. For this example, activity, the final estimated significance for this energy efficiency activity is 19% (calculated in step c) x 50% = 9%.

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 Results of Energy Savings from 2014 Standard Activities

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5.2.1 Estimate of Savings from 2014 Standard Activities

TRC estimates the efficiency organizations' influence for the 2014 standard development process is 12%. Figure 4 presents results. TRC provides a supporting rationale for each input in the sections below the figure.

Figure 6. Impact Analysis of Efficiency Organizations' Contributions to 2014 WiCF 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 for refrigeration systems was not acceptable to the industry.	Original standard proposal in DOE NOPR for panels and doors was not acceptable to the industry.	Originally regulated Walk-ins at whole system level, even though equipment is custom-built, often with different manufacturers responsible for different components, and which was challenging for compliance and enforcement.	Debate over refrigeration metric; and DOE had included hot gas defrost as a technology that does not improve rated performance of refrigeration equipment.	Shipping costs assumed by DOE too high and DOE did not have any shipments data.	DOE faced comments from manufacturers stating that component lifetimes were significantly lower than assumed.	Under Test Procedure NOPR: - Manufacturers could use units indoors designed for outdoors; - Confusion whether packaged dedicated systems are covered; - Unit coolers connected to remote condensing units could be treated differently based on connected equipment	
Significance for energy savings	**Medium**	**Medium**	**Very High**	**Low**	**Low**	**Low**	**Low**	
a. Significance of barrier (%)	**18%**	**12%**	**47%**	**5%**	**4%**	**4%**	**10%**	**100%**
	Activities to Address Barrier 1		**Activities to Address Barrier 2**				**Activities to Address Barrier 3**	
Activities Conducted by all EE Organizations	EE organizations commented that refrigeration system standard should be higher than proposed.	EE organizations commented in support of DOE's proposed level for panels and doors.	ASAP originally proposed the idea that the original manufacturers of each component should be responsible for compliance. Submitted comments to DOE and participated in public meetings recommending DOE regulate walk-ins at component level. Circulated a document proposing IOUs' recommendation to other stakeholders to get buy-in.	Manufacturers suggested Energy Efficiency Ratio (EER). EE organizations commented that DOE should continue to use Annual Walk-in Energy Factor (AWEF) since it enabled product differentiation and simplified enforcement, and that DOE should include hot gas defrost as a design option.	Submitted written comments to DOE and participated in public meetings. EE organizations suggested using shipments data from the industry organization NAFEM.	Contacted end-users of walk-in doors and obtained data regarding lifetime. Submitted comments and participated in public meetings to support DOE's assumptions regarding door lifetimes.	Submitted comments on Test Procedure and Standard NOPR to: - Prevent manufacturers from allowing units designed and certified for indoor conditions to be used outdoors; - Revise definitions to clarify that packaged dedicated systems are included and covered by the test procedure; - Revise test procedure so all unit coolers connected to remote condensing units treated the same	

Results - i.e., DOE response	DOE ultimately adopted a higher standard. Several refrigeration standards were vacated through lawsuit, but some were maintained	DOE maintained their standards for most envelope and door components.	Agreed with EE organizations' approach and eventually adopted standards at the component level and that the original manufacturer of each components should be responsible for compliance.	DOE maintained its use of AWEF as refrigeration system metric. DOE also included hot gas defrost as a design option for multiplex condensing systems, but not for dedicated condensing systems due to its lack of effectiveness in improving efficiency; average efficiency improvement: 0.64 AWEF.	DOE interviewed manufacturers, obtained data from NAFEM and other sources, and revised shipping rates to be 1 to 2 orders of magnitude lower.	DOE slightly lowered assumed component lifetimes between the NOPR and Final Rule	DOE: - Required that dedicated condensing units not designated for outdoor use will be labeled ''indoor use only", but maintains indoor units have similarly stringent efficiency requirements - Renamed the ''packaged dedicated systems'' category as ''single-package dedicated refrigeration systems" to reduce confusion - Developed a separate approach addressing certification issues for manufacturers who sell condensing units and/or unit coolers as separate products	
Effectiveness of activity for addressing barrier	**Low**	**Low**	**High**	**Medium**	**Medium**	**High**	**Low**	
b. Significance for each barrier (%)	**10%**	**10%**	**40%**	**20%**	**20%**	**40%**	**10%**	
c. Significance across <u>all</u> barriers: axb (%)	**2%**	**1%**	**19%**	**1%**	**1%**	**2%**	**1%**	
EE organizations' role	**Major**	**Major**	**Primary**	**Primary**	**Minor**	**Major**	**Major**	
d. EEs' Relative Role in activity (%)	**30%**	**30%**	**50%**	**50%**	**15%**	**30%**	**30%**	
e. Significance of EE activity relative to total savings, cxd (%)	**0.5%**	**0.4%**	**9%**	**0.5%**	**0.1%**	**0.5%**	**0.3%**	**11.7%**

5.2.2 Timing of Savings from 2014 Standard

For the 2014 standard, savings should start in 2017, since the requirements take effect June 5, 2017. Savings from the efficiency organizations are 12% annually. In other words, there is no difference in the percent of savings from the efficiency organizations for the 30-year timeframe identified by DOE: it is 12% for each year, from 2017 through 2047.

5.3 Rationale for Weighting Significance of Barriers from 2014 Standard

This section provides TRC's rationale for ranking each barrier in Figure 5. For each subsection, TRC summarizes the barrier, provides the rank of that barrier as shown in the row "Significance for energy savings" in Figure 5, and provides supporting evidence for that ranking.

The NEEA Standards Development Logic Model was the primary source of barriers to the adoption of the WiCF standards assessed by TRC. Because this is the general logic model that applies to all of NEEA's standards development efforts, TRC assessed only those barriers that were relevant to this list of barriers based on the specific challenges faced by 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.

5.3.1 Barrier 1: Manufacturer opposition to regulation or more stringent standard

Significance for energy savings: Medium

To summarize why TRC ranked this barrier as medium:

- There was considerable debate over the efficiency levels for the refrigeration system standards. However, six of the refrigeration system standards were vacated so did not produce any energy savings in the 2014 WiCF standard. (These were resolved in the 2017 standard.) Consequently, the refrigeration system efficiency levels only had a medium impact on savings for the 2014 standard.

- There was low to moderate debate over the efficiency levels for the door and panel components.

The description below provides more detail.

There was significant manufacturer opposition to the proposed standard in the Notice of Proposed Rulemaking (NOPR). Manufacturers opposed the initial DOE stringency proposal that

TSL[4] 4 be the target for each of panels, doors, and the refrigeration system. Multiple manufacturers, including ThermoKool, U.S. Cooler, and Lennox commented that the proposed standard level was infeasible and urged DOE to adopt a lower TSL.

DOE reformulated its TSLs between the NOPR and Final Rule. Under the newly formulated TSLs in the Final Rule, TSL 3 represented maximum technology ("max tech")[5] and TSL 1 was roughly equivalent to TSL 4 in the NOPR for the refrigeration equipment. DOE adopted Final Rule TSL 2 for all equipment classes, which was higher than the NOPR for refrigeration equipment but roughly equivalent to the NOPR TSL for panel and door components.

TRC ranked this barrier as medium for both the refrigeration system TSL and for the panel/door TSL, in terms of energy savings from this standard. Manufacturers strongly opposed proposed refrigeration system efficiency levels, but much of resistance to this barrier was resolved in the 2017 standard (as described in Section 6). The energy savings for refrigeration systems from the 2014 standard was moderate. For the door and panel components, interviewees and the docket indicated that there was low-to-moderate debate over efficiency levels. The door/panel efficiency levels did not represent as large of a barrier as the refrigeration system efficiency levels.

5.3.2 Barrier 2: Lack of appropriate model, data availability and accuracy

This barrier includes:

1. The frameworks (or structure of the models) that DOE used to approximate energy use from these appliances, costs to implement different TSLs, savings from different TSL, and other analysis; and

2. The inputs for these frameworks.

The first sub-barrier discussed below, "Originally regulated WiCF through performance approach of entire system", falls into category 1: frameworks. As described under that sub-barrier, DOE initially used a regulation framework that did not accurately reflect the market and was not acceptable to industry. DOE needed to address this fundamental barrier in its regulatory framework to move forward with the standard.

The remaining sub-barriers in this section fall into category 2: inputs. DOE makes numerous assumptions in the engineering analysis that ultimately shape the energy savings values.

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[4] TSLs (Trial Standard Levels) consist of a set of candidate efficiency levels for appliances and equipment for which standards are being considered. TSLs combine specific efficiency levels for each equipment class and range from low to maximum efficiency. The DOE standards process seeks to find a TSL that reflects an appropriate balance of efficiency and cost to achieve that level.

[5] When DOE adopts a standard for a type or class of covered product, it must determine the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible for such product. (42 U.S.C. 6295(p)(1) and 6316(a)) Accordingly, DOE determined the maximum technologically feasible ("max-tech") improvements in energy efficiency for WiCF refrigeration systems.

Assumptions are wide-ranging and consist of such different factors as the small general contractor markup, to individual component costs, to consumer discount rates, and many other factors. In the sections below, TRC describes those modelling and engineering analysis assumptions that efficiency organizations commented on that resulted in energy savings. One reason that TRC ranked all of these engineering assumptions with a Low significance is because there were many other assumptions and inputs that stakeholders debated. Note that this report only discusses the inputs for which efficiency organizations provided comments, and that led to energy savings.

Sub-barrier: The original DOE approach regulated WiCF through performance of entire system

Significance for energy savings: Very High

Manufacturers and energy efficiency organizations both noted that walk-in equipment is custom-built, often with different manufacturers responsible for different components, therefore presenting a challenge to enforce. Some manufacturers wanted separate standards for the envelope and the refrigeration system, while other manufacturers wanted the option of rating the entire refrigeration system. Thus, a major barrier was manufacturers' concern regarding how the equipment would be regulated and who the responsible entity would be for meeting the standard. All interviewees noted that this was a major barrier that DOE needed to overcome for the standard to move forward. As described in Section 5.4.2, due in part to recommendations from the efficiency advocates, the DOE ultimately adopted standards at the component level so that the original manufacturer of each component was responsible for compliance, which overcame this barrier..

Sub-barrier: The debate over refrigeration metric and inclusion of hot gas defrost as design option

Significance for energy savings: Low

The industry test procedure available at the time, AHRI 1250-2009, used AWEF as the metric for refrigeration equipment. Manufacturers recommended using the Energy Efficiency Ratio (EER) instead. With EER, fan energy is in both the nominator and denominator, so a fan that runs continuously at full load is not penalized. The AWEF does not include fan energy in the numerator, so increases the impact of evaporator fan savings on the rating. While this has a significant impact on energy savings, the debate over the AWEF and EER metric largely occurred at the AHRI 1250-2009 standard proceeding (in which NEEA did not participate[6]). In addition, hot gas defrost was a subject of discussion, but not heavily debated until the 2017 standard. Consequently, TRC identified this sub-barrier as low.

[6] Other energy efficiency organizations participated in the AHRI 1250-2009 development. But because NEEA did not participate, and NEEA will ultimately use this report to estimate savings from its efforts, TRC does not include energy savings from efficiency organizations' work on the AHRI 1250-2009 standard.

Sub-barrier: Lack of shipment data

Significance for energy savings: Low

Interviewees noted this was a low point of contention and doesn't affect the cost-effectiveness analysis results (though it does impact the national impact results).

Sub-barrier: Debate over door lifetimes

Significance for energy savings: Low

Though equipment lifetimes generally have a large impact on cost-effectiveness results, comments from the efficiency organizations focused only on door lifetimes, and not the other components. Also, data from efficiency organizations mostly just confirmed what DOE was already assuming.

5.3.3 Barrier 3: Lack of accurate test procedure

Significance for energy savings: Low

Because DOE used an existing industry standard test procedure, AHRI 1250-2009, for many aspects of its test procedure, TRC ranked this barrier as Low. But there were a few issues that stakeholders debated in the test procedure development, as described below.

Though energy efficiency organizations didn't move the DOE away from the accepted tested procedure, they did identify several issues with the test procedure, including: that it allowed manufacturers to test equipment in a way that was not representative of how it would be used in the field or that in some cases it allowed manufacturers to avoid testing equipment. This included using equipment designed, tested, and certified for outdoor use for indoor applications. In addition, the efficiency organizations argued that the test procedure definitions led to confusion over whether packaged dedicated systems are included.

Energy efficiency organizations also noted that the test procedure did not adequately account for the fact that the condensing unit and the unit cooler are often manufactured by different manufacturers. This would make compliance difficult for unit cooler manufacturers since they would be responsible for – but not in control of – the efficiency of connected equipment.

5.4 Rationale for Weighting Significance of Activities from 2014 Standard

This section describes TRC's rationale for weighting the significance of each activity that the efficiency organizations conducted. For each activity, TRC provides the results from the following rows in Figure 5:

- Effectiveness of activity for addressing barrier,
- EE organizations' role, and
- Significance of EE activity relative to total savings,

and provides supporting evidence for each result.

5.4.1 Activities to Address Barrier 1 (Manufacturer Opposition to More Stringent Standard): Efficiency Organizations Engaged Manufacturers in Information Exchange and Negotiation

Effectiveness of activity for addressing barrier: Low

In response to the NOPR, the efficiency organizations submitted comments and participated in public meetings and expressed support for the proposed efficiency level for the panels and doors. They also urged DOE to adopt a higher efficiency level for the refrigeration standards on the basis that higher efficiency levels were cost-effective. Following the 2014 Final Rule, standards for four out of the six refrigeration system equipment classes were vacated. The vacated standards represent about 38% of the energy savings resulting from the 2014 standard, or 47% of the energy savings from just the refrigeration standards. Because only half of the savings from the refrigeration system classes were maintained, TRC ranked the efficiency organizations' effectiveness as low as related to refrigeration systems efficiency.

TRC considered attributing negative savings to the efficiency organizations because they urged DOE to adopt higher refrigeration efficiency levels. However, TRC reviewed the petition filed by the manufacturers, the ASRAC meeting notes, and spoke with multiple efficiency organizations and manufacturers to investigate why manufacturers filed the lawsuit. TRC found that the driving issue for why the standards were vacated was more due to errors in DOE's underlying analyses than the efficiency levels.

The docket and interviews indicated that the debate over efficiency levels for panels and doors was primarily between DOE and manufacturers. The efficiency organizations provided comments in support of the DOE's proposed efficiency levels but had less of a role than their comments for the refrigeration system levels. Consequently, TRC ranked the efficiency organization's effectiveness as low as related to panels and doors.

EE organizations' role: Major

TRC identified the efficiency organizations as providing major support to the DOE for each activity, since they were the primary stakeholder providing comments in support of the higher efficiency levels.

Significance of EE activity relative to total savings: 0.5% from refrigeration efficiency levels and 0.4% for door/ panel efficiency levels.

5.4.2 Activities to Address Barrier 2 (Lack of Data Availability and Accuracy): Efficiency Organizations Provide Comments and Data

Commented on Component-Level Standards

Effectiveness of activity for addressing barrier: High

The efficiency organizations recommended that DOE regulate walk-ins at a component level through written comments to DOE and participation in public meetings. Even more importantly,

following the publication of the Framework[7], the efficiency organizations circulated a document proposing IOUs' recommendation that walk-ins be regulated in terms of the efficiency of their components to other stakeholders. A review of the docket highlighted that in response to the Framework document, seven different organizations, three of which were efficiency organizations, commented similarly about having separate standards for different components. Once stakeholders were generally in agreement to have separate standards for envelope and refrigeration system, the efficiency organizations proposed separate standards for subcomponents (i.e., separating envelope into panels and doors). ASAP originally proposed the idea that the original manufacturers of each component should be responsible for compliance.

DOE agreed with the efficiency organizations' approach and eventually adopted standards at the component level and that the original manufacturer of each component should be responsible for compliance.

Because of these factors, TRC ranked the efficiency organizations' effectiveness as High.

Role of Efficiency Organizations: TRC identified the efficiency organizations as being the primary proponent to the DOE for this activity. The efficiency organizations initially proposed the idea and circulated it to the various stakeholders to gain their support.

Savings from Activity: 9% of savings.

Commented on Refrigeration Metric and Hot Gas Defrost Assumptions

Activity and its Significance: The industry test procedure AHRI 1250-2009 used AWEF as the metric for refrigeration equipment. However, manufacturers recommended using EER as the metric. The efficiency organizations commented that DOE should use Factor AWEF since it enabled product differentiation, including for products that included strategies to reduce fan energy (through greater fan efficacy or operation of fans at part load when possible). Efficiency organizations also commented that AWEF simplified compliance and enforcement compared with EER.

DOE had included hot gas defrost as a technology that does not improve rated performance of refrigeration equipment. The efficiency organizations commented that DOE should include hot gas defrost as a design option that would increase the efficiency. After the efficiency organizations' comments, DOE included hot gas defrost as a design option for multiplex condensing systems, but not for dedicated condensing systems due to its lack of effectiveness in improving efficiency. The average efficiency improvement due to the hot gas defrost design option was determined to be 0.64 AWEF.

[7] The Framework Document is a publication towards the beginning of the appliance standards rulemaking process that outlines the scope of the rulemaking and explains the methodology and inputs of analyses that DOE will conduct during the rulemaking. The Framework Document also solicits data and comments from stakeholders.

TRC ranked the significance of these collective activities as medium. DOE used the AWEF metric, although hot gas defrost was a design option that is only applicable to certain equipment classes.

EE organizations' role: Primary

The efficiency organizations were the primary proponent of using AWEF and including hot gas defrost as a design option.

Significance of EE activity relative to total savings: 0.5% of savings.

Commented on Shipping Costs and Shipments Assumptions

Effectiveness of activity for addressing barrier: Medium

Energy efficiency organizations submitted written comments to DOE and participated in public meetings. Energy efficiency organizations suggested using shipments data from the industry organization, North American Association of Food Equipment Manufacturers (NAFEM). Accordingly, DOE conducted additional research, interviewed manufacturers, and obtained data from NAFEM and used that in combination with other data to revise shipments and equipment class/size distributions. DOE revised shipping rates to be one to two orders of magnitude lower than previously thought.

TRC ranked the significance of this activity as medium, as the recommendation to use industry data ended up supporting the position of the efficiency organizations. Based on shipments data the DOE received due to efficiency organizations' comments, the total number of refrigeration system shipments decreased by 22% between the Preliminary Analysis and the Final Rule. However, in the two equipment classes that accounted for 93% of the refrigeration system energy savings, the shipments actually increased by 23%. Therefore, the total savings accounted for is higher due to the shipments data.

EE organizations' role: Minor

The efficiency organizations pointed DOE to a reputable data source and recommended that DOE investigate shipping costs. However, because the efficiency organizations were not the creators of the data, their role was minor.

Significance of EE activity relative to total savings: 0.1% of savings.

Commented on Component Lifetime Assumptions

Effectiveness of activity for addressing barrier: High

In the NOPR, DOE assumed that the lifetime of doors was 14 years. Manufacturers commented that this grossly overestimated lifetime of this equipment, and reported that the lifetime was typically three to ten years. In response, efficiency organizations contacted end-users of walk-in doors and obtained data regarding lifetimes, which indicated that equipment lifetime was typically fifteen years, with a lower range for freight doors. DOE ultimately reduced their

assumed lifetime for this equipment, but not as much as they would have without the efficiency organizations' comments.

Figure 5 summarizes the lifetime assumptions in the NOPR, claimed by manufacturers (ThermoKool, Bally, Danfoss, Hillphoenix, and Nor-Lake), claimed by one of the efficiency organizations (CA IOUs), and in the Final Rule.

Figure 7. Lifetime Assumptions (years) for WiCF Doors by Data Source

	NOPR	Comments					Final Rule	
Component		Thermo-Kool	Bally	Danfoss, Hillphoenix, APC, IB	Nor-Lake	CA IOUs	Small	All other sizes
Display Door	14	-	-	-	-	-	12	12
Freight Door	14	-	-	-	5 - 7	8 - 9	12	6
Passage Door	14	-	-	-	8 - 10	-	12	6
Doors, unspecified	-	3 - 5	4 - 6	3	-	15	-	-

TRC ranked the efficiency organizations' effectiveness as high for this activity because it enabled DOE to reduce the assumed lifetimes only slightly compared to the NOPR. In the absence of efficiency organizations' comments, DOE may have reduced equipment lifetimes significantly.

EE organizations' role: Major

The efficiency organizations collected data from primary sources and provided it to DOE and is therefore a major contributor.

Significance of EE activity relative to total savings: 0.5% of savings.

5.4.3 Activities to Address Barrier 3 (Lack of Accurate Test Procedure): Efficiency Organizations Provide Comments and Data

Effectiveness of activity for addressing barrier: Low

Efficiency organizations submitted comments and participated in public meetings regarding the test procedure. Their overall goal was reducing ambiguity in the test procedure in terms of how tests are conducted and how results are applied, and ensuring that the test procedure reflected field conditions as accurately as possible.

Efficiency organizations submitted comments to the DOE to create definitions, labeling, and/or marketing restrictions to prevent manufacturers from allowing units designed, tested, and certified for indoor conditions to be used for outdoor applications. ASAP and NEEA noted that outdoor units have certain design options (e.g., floating head pressure control, variable- speed condenser fans, ambient sub- cooling) that allow them to perform more efficiently in outdoor environments. They argued that a test procedure that would permit a ‘‘loophole’’ allowing units designed and tested for indoor conditions to be used for outdoor applications would result in lost energy savings. ASAP and NEEA recommended the creation of a definition that prevents these loopholes. The CA IOUs commented that indoor units should be labeled for ‘‘indoor use only’’ to help contractors, building inspectors, and building owners verify that the equipment complies with standards. The CA IOUs also explained that since indoor units have less stringent AWEF requirements and are not designed to adjust to the wide fluctuations in outdoor temperature, they are generally less costly to purchase. They speculated that this price difference could lead to increased energy consumption, incentivizing customers to buy less efficient, more affordable indoor units for outdoor applications. ASAP and NEEA also encouraged DOE to consider whether labeling requirements and/or marketing restrictions could help prevent equipment certified for indoor use from being used in outdoor applications. Manufacturers commented contrarily, claiming that there are units that can be used both indoors and outdoors, that some contractors retrofit an indoor unit for outdoor use, and that it is not possible for DOE to control how the market uses equipment.

Efficiency organizations also recommended that DOE revise definitions to clarify that the industry test procedure (AHRI 1250-2009) covers packaged dedicated systems. Manufacturers argued that packaged systems should be exempt from the scope of the WICF standards because there is no test procedure for them.

In addition, efficiency organizations recommended that DOE revise the test procedure so that all unit coolers connected to remote condensing units are treated the same, whether they are connected to a dedicated, shared, or multiplex remote condensing unit. CA IOUs asserted that the AHRI 1250 test was inadequate because it requires a unit cooler for testing a dedicated condensing unit, which is a less reliable rating method due to the lack of a viable enforcement mechanism.

Overall, these activities had low significance in reducing the barrier. Regarding the issue of including packaged dedicated systems, DOE reported that their intention was to cover these systems under the WiCF rulemaking, so DOE may have ended at the same result even in the absence of the efficiency organizations’ comments. The additional language to cover packaged dedicated systems was a clarification, not an increase in scope. Regarding equal treatment of unit coolers regardless of the type of remote condensing units, the result would likely have occurred since DOE largely referenced AHRI 1250.

EE organizations' role: Major

Because the efficiency organizations were the primary stakeholders submitting comments of this nature, TRC considered their role as major.

Savings from Activity: 0.3% of savings.

6 INFLUENCE OF EFFICIENCY ORGANIZATIONS IN ASRAC WORKING GROUP AND 2017 STANDARD

Manufacturers and trade organizations filed a legal proceeding after the DOE published the 2014 WiCF Final Rule, stating that the engineering analysis for the refrigeration system standards was flawed and consequently the efficiency levels for that equipment too high; a court vacated six of the refrigeration system standards. To overcome this contention, the DOE developed an ASRAC Working Group[8], which was tasked with negotiating the standards that were vacated – including adjusting the engineering analysis and developing proposed efficiency levels.

Figure 7 shows the ASRAC Working Group members.

Figure 8. ASRAC Working Group Members

ASRAC WiCF Working Group Member (Organization)	Organization Type
Ashley Armstrong (U.S. Department of Energy)	Government
Lane Burt (Natural Resources Defense Council)	Efficiency org.
Mary Dane (Traulsen)	Manufacturer
Cyril Fowble (Lennox International, Inc.)	Manufacturer
Sean Gouw (CA Investor-Owned Utilities)	Utility and Efficiency org.*
Andrew Haala (Hussmann Corp)	Manufacturer
Armin Hauer (ebm-papst, Inc.)	Manufacturer
John Koon (Manitowoc Company)	Manufacturer
Joanna Mauer (Appliance Standards Awareness Project)	Efficiency org.
Charlie McCrudden (Air Conditioning Contractors of America)	Manufacturer
Louis Starr (Northwest Energy Efficiency Alliance)	Efficiency org.
Michael Straub (Rheem Manufacturing)	Manufacturer
Wayne Warner (Emerson Climate Technologies)	Manufacturer

*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 eight manufacturers, four efficiency organizations, and one DOE staff member. In general, the Working Group members from efficiency organizations provided comments in Working Group meetings regarding engineering analysis assumptions, and negotiated with the manufacturers to develop efficiency levels for each equipment class that would be acceptable to all parties.

[8] DOE's Appliance and Equipment Standards Program created the Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) to aid in DOE's process of establishing energy efficiency standards for certain appliances and commercial equipment. For more information see: https://www.energy.gov/eere/buildings/appliance-standards-and-rulemaking-federal-advisory-committee

6.1 Description of Calculation of Energy Savings from 2017 Standard

To estimate the percent of energy savings from energy efficiency organizations' activities for the 2017 WiCF standard, TRC estimated the energy efficiency organizations' influence using an analysis framework described below. Note that the efficiency organizations conducted most of their activities for the standard as part of their ASRAC Working Group participation, apart from their comments on the test procedure. The test procedure comments were the same as those described for the 2014 WiCF standard since one test procedure governed both.

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: 45%,
    ii. Lack of Data Availability and Accuracy: 45% total
        i. Inaccurate assumptions and lack of data for design options: 20%
        ii. Inaccurate assumptions for duty cycle: 20%
        iii. Lack of analysis on refrigerant R-448A compared to R-407A and resistance to using R-407A for analysis: 5%
    iii. Lack of Accurate Test Procedure: 10%

b. **Identified and estimated the significance of each efficiency stakeholder activity to overcome each barrier.** As one example activity, the energy efficiency organizations negotiated with manufacturers to establish an efficiency level for refrigeration equipment that was acceptable to industry but higher than what manufacturers proposed. TRC found that this activity had a high significance in reducing the barrier, "Manufacturer Opposition to More Stringent Standard". TRC estimated the significance as 40% for addressing this barrier, based on the following scale:

    Low = 10%, Medium = 20%, and High = 40%

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 negotiations on the efficiency level in addressing the "Manufacturer Opposition to more Stringent Standard" barrier as 45% of significance across all barriers. Consequently, TRC estimated that the significance of this energy efficiency organizations activity relative to all activities was 45% x 40% = 18%.

d. **Estimated the role of efficiency organizations in each activity relative to all participants to support DOE (i.e. all, primary, major contributor, minor).** TRC estimated efficiency organizations' role to support DOE and address each barrier and applied a weighting to the significance of their activities. The efficiency organizations played a major role in improving the engineering analysis – which the manufacturers cited as flawed in their legal proceedings that led to vacating the standard – and negotiating efficiency levels with manufacturers. Consequently, for the 2017 WiCF standard, TRC assumed that the maximum role played by the energy efficiency

organizations for comments affecting these documents and analysis was 80%, as described below:

Primary Support (80%): Efficiency organizations led efforts to negotiate with manufacturers, or conducted or presented analysis.

Major Support (30%): Efficiency organizations were primary stakeholder to provide comments to DOE.

Minor Support (10%): Efficiency organizations were one of many stakeholders but did not contribute significantly.

Using the example activity of negotiating efficiency levels, efficiency organizations served as the Primary role. For this example, activity, the final estimated significance for this energy efficiency activity is 18% (calculated in step c) x 80% = 14%.

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.

6.2 Results of Energy Savings from 2017 Standard Activities

TRC estimates the efficiency organizations' influence for the 2017 standard development process is 20%. Figure 8 presents results. TRC provides a supporting rationale for each input below this figure.

6.2.1 Estimate of Savings from 2017 Standard Activities

TRC estimates the efficiency organizations' influence for the 2017 standard development process is 20%. Figure 8 presents results. TRC provides a supporting rationale for each input below this figure.

Figure 9. Impact Assessment of Energy Efficiency Organizations' Activities for 2017 WiCF 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	Manufacturers pushed for lower refrigeration efficiency standards.	Inaccurate energy savings attributed to condenser sizing design option. Lack of data on evaporator fan blades for design option.	Inaccurate assumptions impacting energy use model, including duty cycle (operating hours).	No analysis on refrigerant R-448A compared to R-407A. Resistance in accepting R-407A analysis from one ASRAC member since their constituency only uses R-448A.	Under Test Procedure NOPR: - Manufacturers could use units indoors designed for outdoors; - Confusion whether packaged dedicated systems are covered; - Unit coolers connected to remote condensing units could be treated differently based on connected equipment	
Significance for energy savings	**High**	**Medium**	**Medium**	**Low**	**Low**	
a. Significance of barrier (%)	**45%**	**20%**	**20%**	**5%**	**10%**	**100%**
	Activities to Address Barrier 1	**Activities to Address Barrier 2**			**Activities to Address Barrier 3**	
Activities Conducted by all EE Organizations	Efficiency organizations conducted their own research, defended max tech efficiency standards, and negotiated with manufacturers in ASRAC working group.	Through participation in ASRAC, efficiency organizations pushed DOE to optimize condensing unit in analysis for both coil face area and air side heat transfer, and submitted data on evaporator fan blade performance improvements.	Efficiency organizations submitted field-measured test data from a refrigeration manufacturer.	Efficiency organizations presented analysis that compared performance of units with refrigerants R-407A and R-448A, which concluded that performance is similar.	Submitted comments on Test Procedure and Standards NOPR to: - Prevent manufacturers from allowing units designed and certified for indoor conditions to be used outdoors; - Revise definitions to clarify that packaged dedicated systems are included and covered by the test procedure; - Revise test procedure so all unit coolers connected to remote condensing units treated the same	

Results - i.e., DOE response	ASRAC working group unanimously adopted efficiency levels between original stances of manufacturers and EE organizations, which DOE adopted.	DOE optimized condenser sizing in engineering analysis and revised associated costs and energy savings. DOE also incorporated efficiency organization data into analysis which increased AWEF and dropped incremental cost for this design option.	DOE revised duty cycle assumptions based on efficiency organization data and reasoning. By lowering the duty cycle hours, the energy savings from design options increased.	DOE's analysis assumes the use of R-407A but a manufacturer would be permitted to use any acceptable refrigerant in its equipment to meet the proposed standard, enabling adoptability of the standard	DOE: - Required that dedicated condensing units not designated for outdoor use will be labeled ''indoor use only", but maintains indoor units have similarly stringent efficiency requirements - Renamed the ''packaged dedicated systems'' category as ''single-package dedicated refrigeration systems" to reduce confusion - Developed a separate approach addressing certification issues for manufacturers who sell condensing units and/or unit coolers as separate products	
Effectiveness of activity for addressing barrier	**High**	**Medium**	**Medium**	**Medium**	**Low**	
b. Significance for each barrier (%)	**40%**	**20%**	**20%**	**20%**	**10%**	
c. Significance across all barriers: axb (%)	**18%**	**4%**	**4%**	**1%**	**1%**	
EE organizations' role	**Primary**	**Primary**	**Major**	**Major**	**Minor**	
d. EEs' Relative Role in activity (%)	**80%**	**80%**	**50%**	**50%**	**30%**	
e. Significance of EE activity relative to total savings, cxd (%)	**14.4%**	**3.2%**	**2.0%**	**0.5%**	**0.3%**	**20.4%**

6.2.2 Timing of Savings from 2017 Standard

For the 2017 standard, savings should start in 2020, since the requirements take effect July 10, 2020. Savings from the efficiency organizations are 20% annually. In other words, there is no difference in the percent of savings from the efficiency organizations for the 30-year timeframe identified by DOE: it is 20% for each year, from 2020 through 205

The remainder of this section describes TRC's rationale for our rankings and weightings in Figure 8.

6.3 Rationale for Weighting Significance of Barriers from 2017 Standard

6.3.1 Barrier 1: Manufacturer opposition to regulation or more stringent standard

Significance for energy savings: High

As illustrated by the legal proceeding, some manufacturers raised fierce opposition to the refrigeration system efficiency standards that DOE passed as part of the 2014 WiCF standard. The contention was strong enough that DOE established an ASRAC Working Group to negotiate standards to replace those vacated by the lawsuit.

Because of the high level of disagreement that the Working Group needed overcome to develop an efficiency level that was agreement to all parties, TRC ranked this barrier as high.

6.3.2 Barrier 2: Lack of appropriate model, data availability and accuracy

The legal proceeding filed by several manufacturers noted both the efficiency levels but also flawed underlying analysis as the basis for the lawsuit. Consequently, the ASRAC Working Group needed to first work together to improve the engineering analysis before they could negotiate efficiency levels. Because reaching agreement on the underlying analysis was a critical part of the negotiations, TRC assigned 45% of the total weight to Barrier 2: Lack of data availability and accuracy – spread out over several sub-barriers, each with separate Significance ratings (see below).

Sub-barrier: Condenser sizing and evaporator fan blade design options

Significance for energy savings: Medium

Manufacturers and energy efficiency organizations both questioned the accuracy of the baseline model and DOE's engineering analysis. The starting point of the engineering analysis was generally based on the 2014 Final Rule, which DOE acknowledged contained some errors. Manufacturers and efficiency organizations had a significant amount of discussion and analysis to reach an agreement for many aspects of the engineering analysis. One such aspect was on the condenser sizing and evaporator fan blade design options. These design options have a small incremental impact on the potential AWEF rating and has a medium impact on overall energy savings when adopted; consequently, TRC ranked this sub-barrier as medium.

Sub-barrier: Duty cycle assumptions

Significance for energy savings: Medium

Some design options save energy primarily when the unit is in partial-load operation. Therefore, the length of time at which a unit is assumed to be at full-load operation and partial-load operation impact the energy savings potential associated with each design option and therefore each efficiency level. This barrier has an overall energy impact of medium because it only impacts the energy savings of some design options. Therefore, TRC ranked this sub-barrier as medium.

Sub-barrier: Refrigerant assumptions

Significance for energy savings: Low

While DOE does not require the use of any particular refrigerant, DOE's analysis was based on the refrigerant R-407A. One ASRAC Working Group member reported that they used refrigerant R-448. It was not clear how a system's efficiency performance might vary under the two refrigerants. Because it was only one manufacturer that raised this issue, TRC considered this a low barrier.

6.3.3 Barrier 3: Lack of accurate test procedure

Significance for energy savings: Low

The barriers to test procedure appropriateness that the efficiency organizations addressed were the same in both the 2014 and 2017 WiCF standard, because the same test procedure governs both standards. Section 5.1.3 describes sub-barriers for Barrier 3: Lack of appropriate test procedure, which are the same for the 2014 and 2017 WiCF Standards.

6.4 Rationale for Weighting Significance of Activities from 2017 Standard

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

6.4.1 Activities to Address Barrier 1 (Manufacturer Opposition to More Stringent Standard): Efficiency Organizations Directly Negotiate with the Manufacturers

Effectiveness of activity for addressing barrier: High

During the ASRAC Working Group meetings, after agreeing upon the engineering analysis approach and assumptions, members worked together to arrive at an efficiency standard that was acceptable to all parties. In the last several ASRAC Working Group meetings, efficiency organizations and manufacturers negotiated efficiency levels to adopt for each equipment class. Based on TRC's review of the ASRAC meeting transcripts and presentations from those meetings, manufacturers wanted to adopt TSL 3, whereas efficiency organizations pushed to adopt max tech, which was generally TSL 7. The DOE reconfigured the TSLs somewhat during the negotiation process and following the negotiation process, but in general, the efficiency organizations sought max tech, while manufacturers sought a lower standard level. In addition to the specific level, efficiency organizations and manufacturers also differed in how to specify the minimum AWEF. The efficiency organizations recommended that the minimum AWEF standard

should vary with equipment capacity to maximize potential energy savings, whereas manufacturers recommended that the minimum AWEF should be a single number across all equipment capacities. Through negotiations, the efficiency organizations and manufacturers reached a compromise on both fronts: They eventually agreed upon minimum AWEF values somewhere between TSL 3 and max tech for each equipment class. The minimum AWEF values vary by capacity up to a certain capacity, above which the minimum AWEF is flat.

Based on TRC's interviews of participants in the ASRC Working Group, multiple efficiency organizations reported that as a group they were a significant contribution to the final negotiated efficiency level. They noted that they were strong on getting to max tech levels, and that in their absence, the efficiency standard would have ended up where the manufacturers had recommended. In an interview with one manufacturer who participated in the ASRAC Working Group, he noted that the efficiency organizations' role was only moderate because DOE was driven to adopt higher standards anyways. However, the same manufacturer noted that having a voice advocating for higher efficiency standards was important.

TRC ranked the effectiveness of the efficiency organizations as high for this activity because they were able to negotiate standard levels that were significantly above the levels recommended by manufacturers.

EE organizations' role: Primary

TRC identified the efficiency organizations as playing a primary role in this activity, because they negotiated directly with manufacturers.

Significance of EE activity relative to total savings: 14.4% of savings.

6.4.2 Activities to Address Barrier 2 (Lack of Data Availability and Accuracy): Efficiency Organizations Provide Comments and Data

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

Commented on Condenser Sizing and Evaporator Fan Blade Design Options

Effectiveness of activity for addressing barrier: Medium

Through participation in ASRAC, efficiency organizations pushed DOE to optimize condensing units in the engineering analysis for both coil face area and air side heat transfer. During the negotiation process, DOE's initial analysis results indicated that increasing the condenser size did not actually decrease the unit energy use, due to a trade-off between compressor energy and condenser fan energy. Efficiency organizations pushed DOE to consider a realistic scenario in which the increased condenser size as a design option did reduce energy use. Although the AWEF increase from this design option was modest (0.02 to 0.34 depending upon equipment class), the analysis showed that higher energy savings were possible with this design option.

Efficiency organizations also conducted activities related to the evaporator fan blade performance design option. The efficiency organizations submitted data from a report by the Florida Solar Energy Center showing that it was possible to achieve fan efficiency improvements

between 17 and 25%. The incremental AWEF increase due to this design option was generally higher and came at a lower cost in the 2017 analysis compared to the 2014 analysis. The incremental AWEF increase ranged from 0.04 to 0.12 at a cost ranging from $5 to $82 in the 2014 analysis compared to an incremental AWEF increase ranging from 0.02 to 0.16 at a cost ranging from $5 to $51 in the 2017 analysis. These data enabled DOE to improve its assumption on evaporator fan as a design option, which overall supported the case that higher efficiency levels could be met cost effectively.

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

EE organizations' role: Primary

TRC identified the efficiency organizations as being the primary proponent to the DOE for this activity.

Significance of EE activity relative to total savings: 3.2% of savings.

Commented on Duty Cycle Assumptions

Effectiveness of activity for addressing barrier: Medium

DOE presented its initial energy use analysis assumptions in early ASRAC Working Group meetings. DOE noted an assumed daily runtime of 16 hours for coolers and 18 hours for freezers. The efficiency organizations noted that the assumed full-load runtime was too high, and therefore did not give adequate energy savings benefits to various design options. Efficiency organizations collected and presented field data on duty cycles from two different sources. Driven by the efficiency organizations' findings, DOE ultimately revised its daily runtime assumptions to 13.3 hours for coolers (down from 16 hours) and 15 hours for freezers (down from 18 hours).

Because the efficiency organizations collected and presented data that led to changes in assumptions, TRC ranked the efficiency organizations' effectiveness as Medium for addressing the barrier, Lack of data availability and accuracy.

EE organizations' role: Major

TRC identified the efficiency organizations as being a major contributor to the DOE for this activity.

Significance of EE activity relative to total savings: 2.0% of savings.

Commented on Refrigerant Assumptions

Effectiveness of activity for addressing barrier: Medium

As described above, DOE's analysis was based on the refrigerant R-407A, but one ASRAC Working Group member used refrigerant R-448. Efficiency organizations presented analysis to

the ASRAC Working Group that compared performance of units with refrigerants R-407A and R-448A, which concluded that performance is similar.

TRC ranked the efficiency organizations' effectiveness as Medium for addressing the barrier, Lack of data availability and accuracy.

EE organizations' role: Major

TRC identified the efficiency organizations as being a major contributor to the DOE for this activity since they were the main type of stakeholder to provide analysis.

Significance of EE activity relative to total savings: 0.5% of savings.

6.4.3 Activities to Address Barrier 3 (Lack of accurate test procedure): Efficiency Organizations Provide Comments and Data

Significance of EE activity relative to total savings: 0.3% of savings.

Section 5.1.3 describes the efficiency organizations activities to address barriers to an inaccurate test procedure. Because it was the same test procedure for the 2014 and 2017 WiCF standards, the efficiency organizations' activities were the same.

7 ADDITIONAL ACTIVITIES THAT MAY GENERATE FUTURE ENERGY SAVINGS

TRC notes two other activities that the efficiency organizations conducted during the WiCF standard development that may lead to future energy savings.

In response to the NOPR, the efficiency organizations commented on the use of the social cost of carbon (SCC). They expressed support for the derivation and application of the SCC values. In contrast, some manufacturers questioned the scientific and economic basis of the SCC values. DOE continued to account for the SCC, consistent with direction from the Office of Management and Budget. One interviewee noted that the discussion on proper accounting of the SCC goes beyond the WiCF rulemaking, with similar discussions occurring across multiple rulemakings. The Final Rule for the WICF standards state that these efficiency levels were cost effective without including SCC. However, by including the SCC in these standards, DOE set a precedent to incorporate this in other standards, where the SCC may push the efficiency level to be cost effective.

One of the terms from ASRAC term sheet developed by the Working Group recommended that DOE initiate a new test procedure rulemaking to address several items related to WiCF refrigeration systems, including incorporation of off-cycle power consumption, a method to separately rate variable-capacity condensing units, and a method to measure defrost energy consumption. During interviews, efficiency organizations reported that some of them (including NEEA staff) have been involved in the AHRI 1250 development and that the AHRI 1250 committee has incorporated ASRAC's recommendations into the next version of the AHRI 1250 standard.

Because savings from other standards that could be affected by SCC or the future AHRI 1250 test procedure are outside the scope of this evaluation, TRC did not attempt to estimate savings from these efforts. But we note that there is likely spillover in energy savings from the efficiency organizations' efforts in the 2017 WiCF standard development through their ASRAC work.

8 CONCLUSIONS

Based on the data collection, TRC's impact assessment was that efficiency organizations had a low-to-moderate influence on the 2014 WiCF standard and a moderate influence on the 2017 WiCF standard. The main influence of the efficiency organizations in the 2014 standard was submitting comments and garnering stakeholder support for DOE to regulate WiCF at the component level. TRC estimates that the efficiency organizations contributed 12% of savings from the 2014 standard.

The main influence of the efficiency organizations in the 2017 standard was participating in an ASRAC working group, in which they negotiated with manufacturers to reach agreement on an acceptable engineering analysis, and used that framework to negotiate with manufacturers on an efficiency level for refrigeration standards that was higher than what manufacturers had proposed but still acceptable to industry. TRC estimates that the efficiency organizations contributed 20% of savings from the 2017 standard.