AHRI Proposal for Embedded Fans in Commercial HVACR and Water Heating Equipment

Discussion with the California Energy Commission

Tuesday, November 28, 2017
Overview of AHRI Proposal
Fan Overview

Embedded Fan Definitions

• **Embedded Fan:** A fan included as a component in a residential, commercial, or industrial heating, ventilation, air-conditioning (HVACR) or water heating equipment where the fan is:
  • Permanently mounted in the equipment
  • Used to support heat transfer, combustion or other mechanisms within the equipment
  • Tested as part of equipment certification according to ANSI, ASHRAE, AHRI, DOE or other performance standards; and labeled for such use if sold as a fan assembly only for use within an exempt product.

• **Replacement Embedded Fan:**
  • An impeller, blade or wheel sold with or without a motor, with or without shaft and bearings, designed and marketed as a replacement for an existing part in an Embedded Fan, including cross-reference(s) to the original fan part and a label stating that this part is for replacement purposes only.
  • Complete Embedded Fan assemblies including cross-reference(s) to the original blower part and a label stating that this part is for replacement purposes only.
AHRI Recommendation
Proposal and Rationale

Proposal
• Limit scope of proposed regulations on commercial and industrial fans to stand-alone fans only
• Exclude all fans embedded in HVACR and water heating equipment
  • Fans embedded in equipment
  • Replacement embedded fans

Rationale
• Vast majority of embedded fans already covered by California and Federal standards
• Very little energy can be saved through additional standards
• As with most component regulations, no overall energy savings at product level as other components are modified such that overall efficiency meets market requirements
• Costs will increase to consumers due to fan development and equipment testing and certification requirements
  • Small shipment volumes of products potentially affected by commercial and industrial fan standards raise effective cost per fan
• Like-for-like replacement fan components critical for repairs on existing HVACR equipment
## AHRI Recommendation

Embedded Fans Already Covered by California Standards

<table>
<thead>
<tr>
<th>Product</th>
<th>Fan Application</th>
<th>Standard Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Unitary Air Conditioner and Heat Pump</td>
<td>Panel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supply</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exhaust</td>
<td></td>
</tr>
<tr>
<td>Central Station Air Handling Unit</td>
<td>Supply, Exhaust</td>
<td></td>
</tr>
<tr>
<td>Air Cooled Chiller</td>
<td>Panel</td>
<td></td>
</tr>
</tbody>
</table>

- Federal Standard, CA Title 20, CA Title 24, 110.2 (b)
- CA Fan Limit, Title 24, 140.4 (c), 140.9 (a - 4 and 5)
- CA Equipment Limit, Title 24, 110.2 (d and g)
AHRI Methodology Summary
Changes to DOE NODA 3 Analysis

• National Impact Analysis:
  • Changes in Base Case Shipments
    • Air-Cooled Chillers
    • Central Station Air-handling Units
    • Commercial Unitary Packaged Air-conditioners and Heat Pumps
  • Life Cycle Cost Inputs
    • LCC Input sheet in NIA did not correspond to DOE NODA 3 spreadsheet. AHRI modified to “OEM, Reference” from the “LCC Results” sheet of the LCC model to reflect that all analyzed Panel Fans are used in OEM applications
    • CA adjustment: 12% of national market seems reasonable

• Life Cycle Cost:
  • Equipment Costs
    • AMCA database does not adequately capture OEM fans market. Should not be used as a proxy for annual shipments
    • Total industry costs not volume dependent
    • Lead to updated OEM panel, unhoused centrifugal and house centrifugal numbers
  • CA Electric Rates and TDV
    • AHRI has updated the DOE analysis of estimated end user economics based on:
      • Average California May 2017 commercial electricity prices of $0.1438 per kWh.
      • 20% increase in average California commercial electricity prices to approximate possible TDV pricing
Potential Energy Savings – Total U.S.
DOE Analysis Leaves Inaccurate Perception of Energy Saving Potential

<table>
<thead>
<tr>
<th>Category</th>
<th>Total US 30 Year Quads</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVACR + WH Categories</td>
<td></td>
</tr>
<tr>
<td>Panel</td>
<td>0.60</td>
</tr>
<tr>
<td>Housed Centrifugal</td>
<td>1.59</td>
</tr>
<tr>
<td>Unhoused Centrifugal</td>
<td>0.76</td>
</tr>
<tr>
<td>Sub-Total</td>
<td>2.95</td>
</tr>
<tr>
<td>Other</td>
<td>4.28</td>
</tr>
<tr>
<td>Total Fans</td>
<td>7.23</td>
</tr>
</tbody>
</table>

Source: DOE cif_noda3_nia.xlsm

DOE projected savings *not* corrected for embedded fan percentages.
## Potential Energy Savings – Total U.S.

Actual Potential Savings Much Less

<table>
<thead>
<tr>
<th>Category</th>
<th>Total US 30 Year Quads - DOE</th>
<th>Total US US 30 Year Quads - AHRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embedded HVACR + WH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panel</td>
<td>0.60</td>
<td>0.00</td>
</tr>
<tr>
<td>Housed Centrifugal</td>
<td>1.59</td>
<td>0.20</td>
</tr>
<tr>
<td>Unhoused Centrifugal</td>
<td>0.76</td>
<td>0.13</td>
</tr>
<tr>
<td>Total Embedded</td>
<td>2.95</td>
<td>0.33</td>
</tr>
</tbody>
</table>

Source: DOE cif_noda3_nia.xlsm, AHRI analysis

AHRI projected savings are due to equipment standards only and exclude potential effects of building standards.
Potential Energy Savings - California
Actual Potential Savings Much Less (Continued)

<table>
<thead>
<tr>
<th>Category</th>
<th>California 30 Year Quads - DOE</th>
<th>California 30 Year Quads - AHRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embedded HVACR + WH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panel</td>
<td>0.072</td>
<td>0.000</td>
</tr>
<tr>
<td>Housed Centrifugal</td>
<td>0.191</td>
<td>0.024</td>
</tr>
<tr>
<td>Unhoused Centrifugal</td>
<td>0.091</td>
<td>0.016</td>
</tr>
<tr>
<td>Total Embedded</td>
<td>0.354</td>
<td>0.040</td>
</tr>
</tbody>
</table>

Source: DOE cif_noda3_nia.xlsm, AHRI analysis 12% California factor

AHRI projected savings are *before* effects from CA Title 24 building fan limits. *After building fan limits, likely savings approach zero.*
Embedded Fan Overview

Centrifugal Fans
Panel Fans
Commercial Water Heating and Boiler Fans
Centrifugal Fans
Embedded Fan Examples – Simple Rooftop Unit (~90% of Market)

Panel Fans
Supply Fan
No Return or Exhaust Fan

Source: Carrier Corporation
Centrifugal Fans

Embedded Fan Examples – Large Rooftop Unit (~10% of Market)

- Heating and Cooling Coils
- Panel Fans
- Economizer Unit
- Supply Fans

Source: Ingersoll Rand, Inc.
Centrifugal Fans
Embedded Fan Examples – Central Station Air Handling Unit

Source: Dunham-Bush Americas
Centrifugal Fans
Corrections to the Analysis

• Incorrect shipment data
  • Overstated central station air handling unit shipments
  • Overstated percentage of commercial unitary units with return/exhaust fans
    • Exhaust/return air fans used with economizers common in large/complex rooftop units and rare in small ones

• No consideration for existing Title 24 fan power limits
  • DOE analyses are national and generally exclude building code effects

• Insufficient consideration of speed control for supply fan motors
  • Now common in central station air handling units and large commercial unitary rooftops
  • Required under CA Title 24 140.4(m) and 140.9, (a - 5)
  • Results in significant reduction in fan motor power vs systems with a single speed fan

• No consideration of market forces for fans not covered by prescriptive standards
  • Design reviews required in CA
  • Building process for large rooftop and central station air handlers promotes cost/energy use analysis in designs
Centrifugal Fans

DOE Relied on Incorrect Data from Current Industrial Report

Source: US Department of Commerce, Current Industrial Report MA35M and MA333M
## Centrifugal Fans

Projected 30 Year Energy Savings (Quads)

Corrected for shipment data only, does not include effects of Title 24 or other building standards or of variable speed drives.

<table>
<thead>
<tr>
<th>Fan Type</th>
<th>Corrected Savings</th>
<th>Embedded %</th>
<th>Embedded Savings - US</th>
<th>Embedded Savings - CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrifugal Housed</td>
<td>0.39</td>
<td>51%</td>
<td>0.20</td>
<td>0.024</td>
</tr>
<tr>
<td>Centrifugal Unhoused</td>
<td>0.21</td>
<td>64%</td>
<td>0.13</td>
<td>0.016</td>
</tr>
<tr>
<td>Total</td>
<td>0.60</td>
<td>55%</td>
<td>0.33</td>
<td>0.040</td>
</tr>
</tbody>
</table>
Panel Fans
Embedded Fan Examples – Remote Condenser, Refrigeration

Source: Heatcraft Worldwide Refrigeration
Panel Fans

Embedded Fan Examples – Air-Cooled Chiller

Source: Carrier Corporation
Panel Fans
Corrections to the Analysis

• Incorrect product characterization
  • DOE analysis assumes Air Cooled Chillers are independent products
  • Virtually all are integrated with compressor units and all meet ASHRAE 90.1 chiller standards and Title 24, Table 110.2-D
  • Remote air cooled condensing units common in commercial refrigeration (covered by Title 24, Table 120.6-C), not in air conditioning for mild climates
  • Changing fans will result in rebalancing product design, not energy savings

• Incorrect, offsetting shipment data
  • Overstates average number of fans per condensing unit (14 vs. 8 estimated by manufacturers). DOE fan estimates equivalent to 200 tons, overstates average size of air-cooled chillers.
  • DOE underestimates number of chillers (12,579 vs. CIR average of 26,000)

• Incorrect energy usage
  • DOE uses average energy consumption and cost, not OEM,
    • 50% less energy used by OEM panel fans
    • 30% lower savings at EL 5 (5.4% vs 7.6%)
Panel Fans
Projected 30 Year Energy Savings (Quads)

<table>
<thead>
<tr>
<th>Fan Type</th>
<th>Corrected Savings</th>
<th>Embedded HVAC %</th>
<th>Embedded Savings - US</th>
<th>Embedded Savings - CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>0.1</td>
<td>65%</td>
<td>0.065</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Corrected for shipment and OEM Fan Usage data only, does not include effects of Title 24 integrated chiller standards or other building standards or of variable speed motors requirements.

Total actual savings likely to be 0 quads.
Fan Overview
Embedded Fan Examples – Commercial Boiler Fan Assembly

Source: Lochinvar, LLC, Beckett Corporation, images not to same scale
Commercial Water Heating and Boiler Fans

Virtually No Fans over 1HP

• Fan energy included in commercial water heater standards
• Fan energy not included in commercial boiler or commercial water supply boiler standards
• Extremely limited savings opportunity
  • Small markets
  • Few fans over 1HP
  • Fans integral to product designs, difficult to replace or redesign
  • Replacing embedded fans would require complete retesting and recertification for safety and other purposes
Consumer Economics
Consumer Economics

Overview

• Consumer economics based on DOE LCC model from fan rulemaking.
• Absence of detailed data for individual Monte Carlo tests makes analysis difficult, so conclusions should be taken with caution. However, no other data exists.
• All but one DOE assumption accepted despite vehement industry protests:
  • Ability to substitute fan with 2” increase in diameter without any increase in cost to total package
  • No accounting for extra curb or duct changes in replacement scenarios if exterior dimensions of outside equipment change
  • Probable under-estimation of conversion costs
    • Additional refrigeration cycle, heating, performance, acoustical, safety, and seismic testing
    • Engineering to accommodate larger fans to account for wind, seismic and structural loads
  • Discrepancy between discount rates in LCC analysis and in conversion cost annualization
  • DOE incremental markups
• Conversion costs adjusted for actual shipment volumes, not fans in AMCA database.
Consumer Economics
Centrifugal Fans

<table>
<thead>
<tr>
<th>Housed OEM Centrifugal Fans (per fan)</th>
<th>DOE Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incremental Consumer Price</td>
<td>$291</td>
</tr>
<tr>
<td>Lifetime Operating Cost Savings</td>
<td>$606</td>
</tr>
<tr>
<td>Life Cycle Cost Savings</td>
<td>$315</td>
</tr>
</tbody>
</table>

| Conversion Costs Adjusted for Shipments<sup>1</sup> | $336         |
| Adjusted Life Cycle Cost Savings          | ($21)        |

- Assumes energy savings from fan. No actual savings in most instances:
  - No savings in supply or panel fans in new unitary equipment or chillers due to equipment efficiency standards
  - No savings for any fan in new construction
  - Repair fans in practice must be OEM original equipment for testing, safety or physical reasons
- Without savings, consumer change in LCC would be ($627) or 29% price increase

<sup>1</sup> Based on national shipments, CA only would vastly increase costs
Unhoused Centrifugal Cost Issues

- Yellow = 1st Year Energy Savings
  - $5-10 per year per most EL classes
  - If so, why are we considering regulation?
- Green and blue = 1st cost
  - 0.5-1.8% per most EL classes
  - Vastly understates BT Frame Vs. Airfoil ECM
  - Where are cabinet and conversion costs?

### Centrifugal Unhoused ($2015)

<table>
<thead>
<tr>
<th></th>
<th>1st Cost</th>
<th>1st Year's Energy Cost</th>
<th>1st Year's Energy Savings</th>
<th>Extra 1st Cost</th>
<th>% Extra Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regs</td>
<td>4088</td>
<td>3099</td>
<td>$ -</td>
<td>$ -</td>
<td>0.0%</td>
</tr>
<tr>
<td>1</td>
<td>4114</td>
<td>3091</td>
<td>$  8</td>
<td>$  26</td>
<td>1.3%</td>
</tr>
<tr>
<td>2</td>
<td>4124</td>
<td>3089</td>
<td>$ 10</td>
<td>$  36</td>
<td>1.8%</td>
</tr>
<tr>
<td>3</td>
<td>4134</td>
<td>3084</td>
<td>$ 14</td>
<td>$  46</td>
<td>2.3%</td>
</tr>
<tr>
<td>4</td>
<td>4151</td>
<td>3076</td>
<td>$ 23</td>
<td>$  63</td>
<td>3.1%</td>
</tr>
<tr>
<td>5</td>
<td>4171</td>
<td>3067</td>
<td>$ 32</td>
<td>$  83</td>
<td>4.1%</td>
</tr>
<tr>
<td>6</td>
<td>4323</td>
<td>2886</td>
<td>$ 213</td>
<td>$ 234</td>
<td>11.6%</td>
</tr>
</tbody>
</table>
### Consumer Economics

**Panel Fans**

<table>
<thead>
<tr>
<th>Housed OEM Panel Fans (per fan)</th>
<th>DOE Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incremental Consumer Price</td>
<td>$106</td>
</tr>
<tr>
<td>Lifetime Operating Cost Savings</td>
<td>$228</td>
</tr>
<tr>
<td>Life Cycle Cost Savings</td>
<td>$122</td>
</tr>
</tbody>
</table>

| Conversion Costs Adjusted for Shipments¹       | $122           |
| Adjusted Life Cycle Cost Savings               | ($0)           |

- Assumes energy savings from fan. No actual savings in most instances:
  - No savings in panel fans in new unitary equipment or chillers due to equipment efficiency standards
  - Repair fans in practice must be OEM original equipment for testing, equipment performance or physical reasons
  - Without savings, consumer change in LCC would be ($228) or 14% price increase

¹ Based on national shipments, CA only would vastly increase costs
Thank you!

Questions?

Connect with us!

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AND @AHRIengage

/AHRIcommunications

/AHRIconnect

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