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Seminar 29: Fan Energy Savings and System Efficiency Increase by Using the Fan Energy Index

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GREENHECK
Building Value in Air.

Fan Energy Index Defined

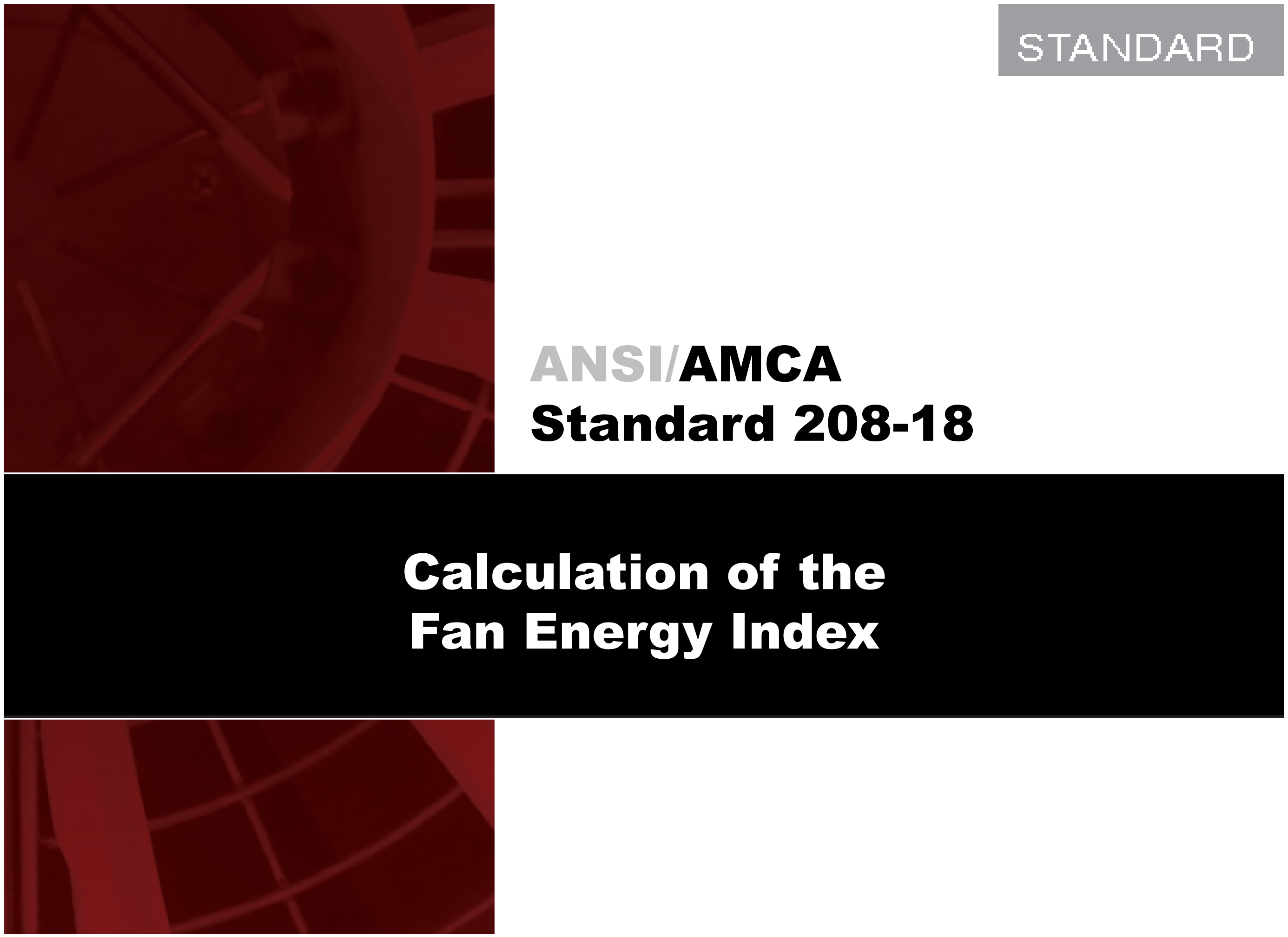
Learning Objectives

1. Identify shortcomings of existing measures of fan efficiency.
2. Understand how the Fan Energy Index is derived for each fan type and each configuration.
3. Describe the role of fan selection in determining energy consumed by a fan during its lifetime.
4. Describe how the relative electrical power consumption difference of different fans for a given duty point becomes obvious through the FEI metric.
5. Define the fan selection process with FEI and fan labelling when the design flow and pressure is known at the point of sale.
6. Explain how fan distributors and OEM fan suppliers support power-saving fan selection through the FEI metric when the design point is unknown.

Fan Energy Index Defined

- New AMCA Standard 208
- Shortcomings of other fan efficiency metrics
- Definition of FEI
- Impact of FEI in Energy Savings

AMCA Standard 208-2018



STANDARD

ANSI/AMCA
Standard 208-18

Calculation of the
Fan Energy Index

AMCA 208 Purpose

This standard defines the calculation method for the fan energy index, which is an energy efficiency metric for fans inclusive of motors and drives. This metric provides a standardized and consistent basis to compare fan energy performance across fan types and sizes at a given fan duty point.

It can be used by fan specifiers to understand and communicate the fan efficiency design intent. It can also be used by legislative or regulatory bodies to define the energy efficiency requirements of fans.

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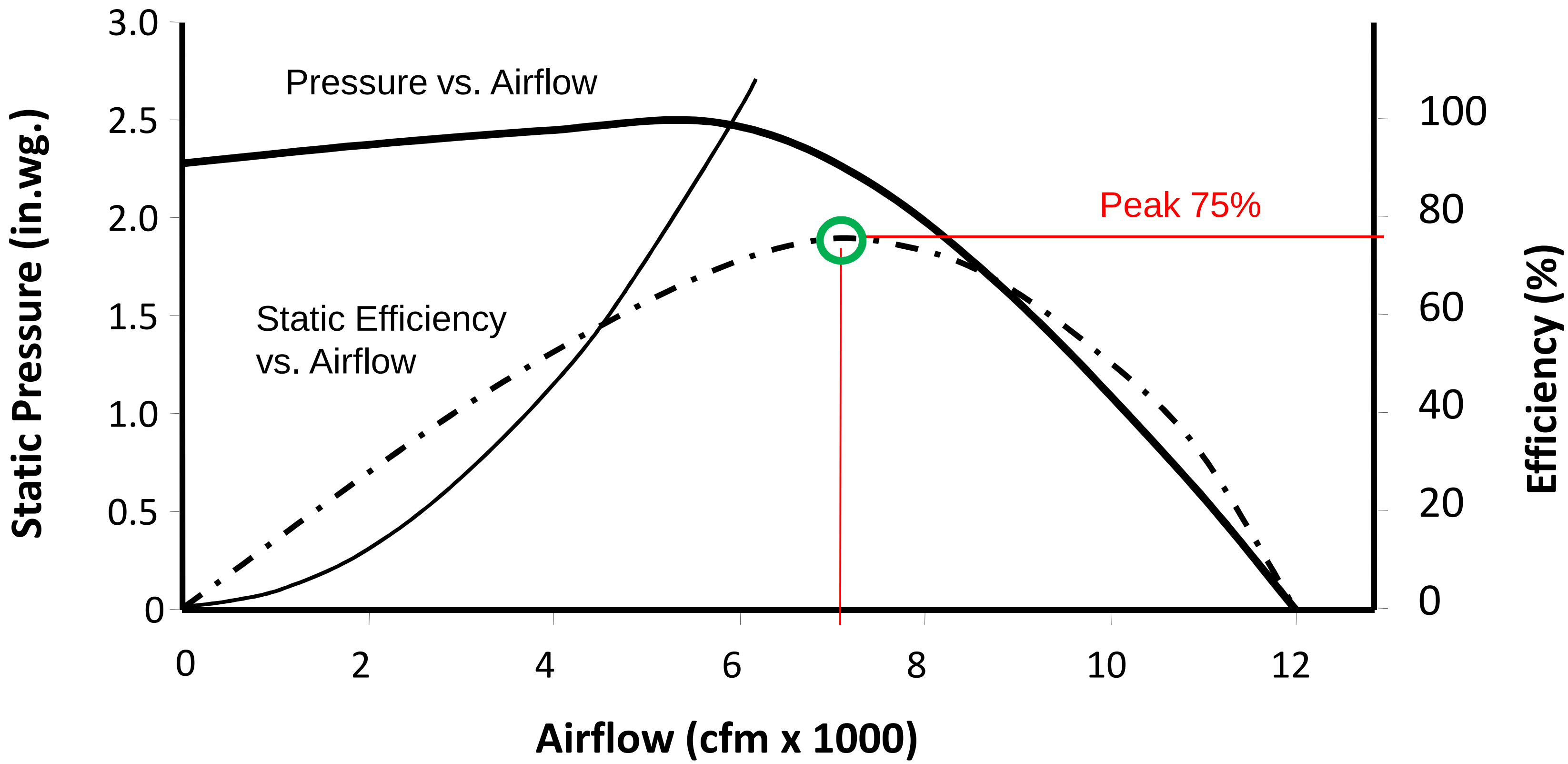
Need for a New Metric –
Regulation and unintended consequences

Existing Metrics:

- FEG – ASHRAE 90.1, 189.1, IGCC, IECC
- FMEG – ISO 12759, EU327 in Europe

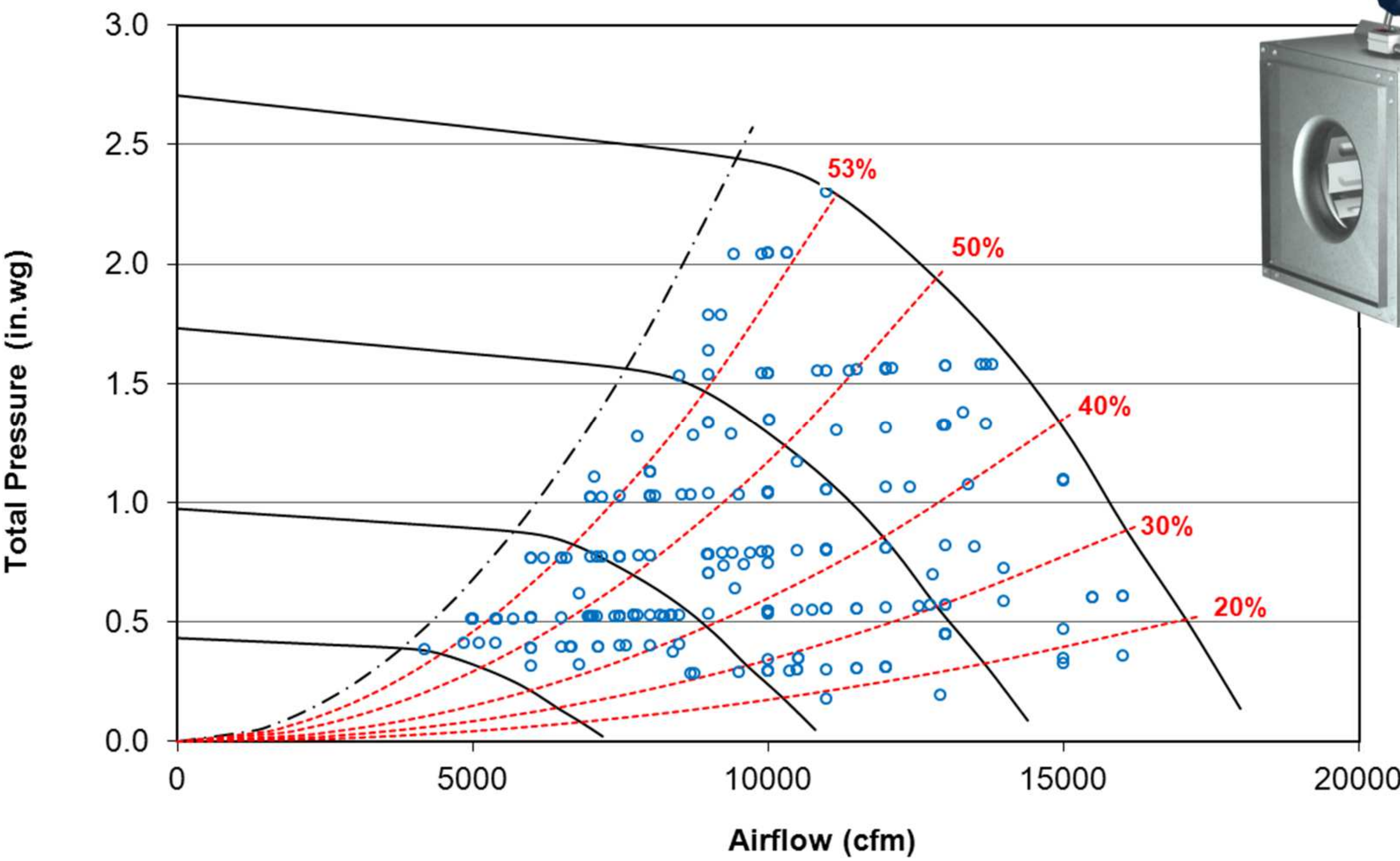
Peak Efficiency Metrics

Unintended Consequences
Fan efficiency is not constant!

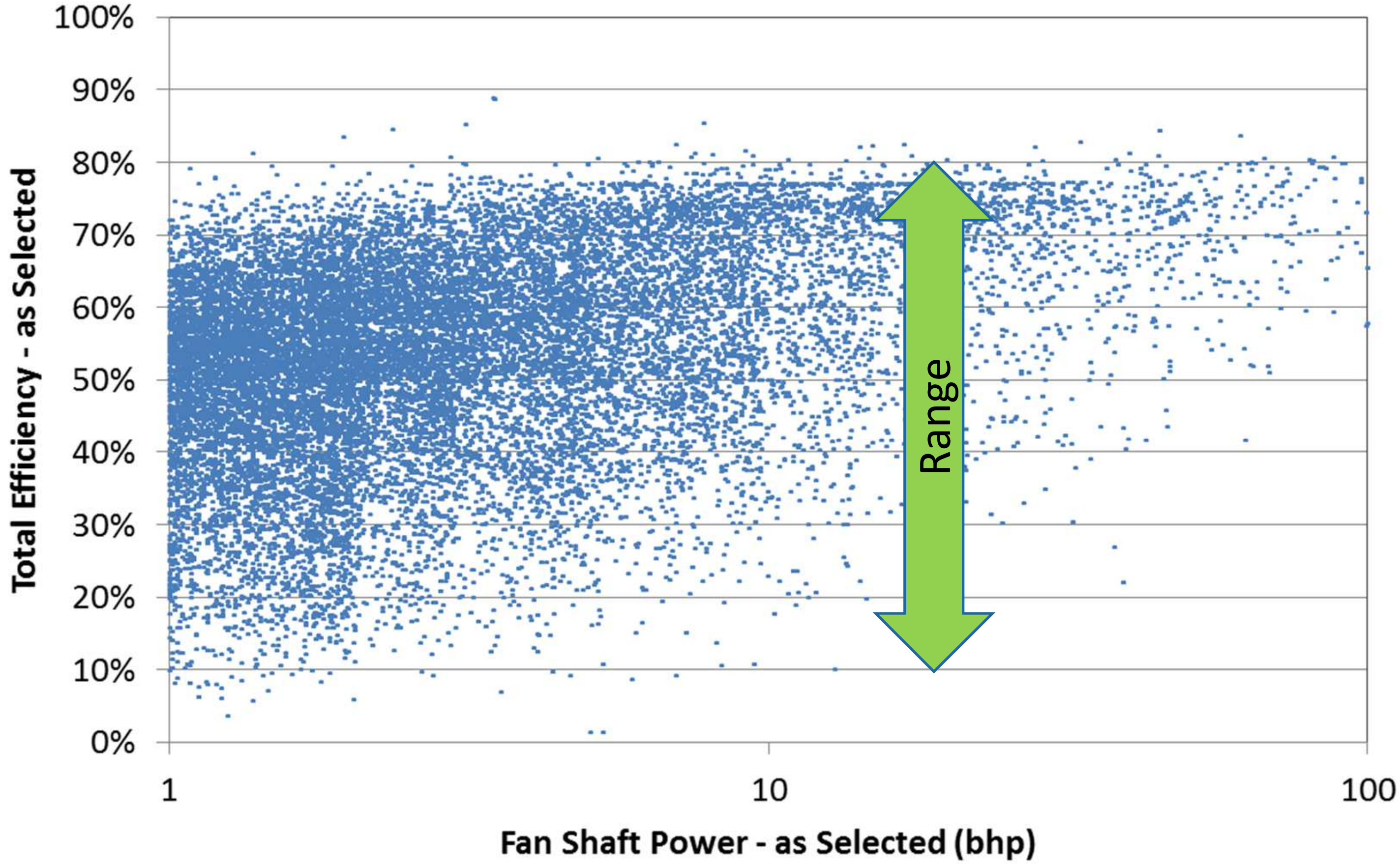


30” Square Inline Fan
2012 Sales - Fan selections

295 Fans with Motors ≥ 1 hp

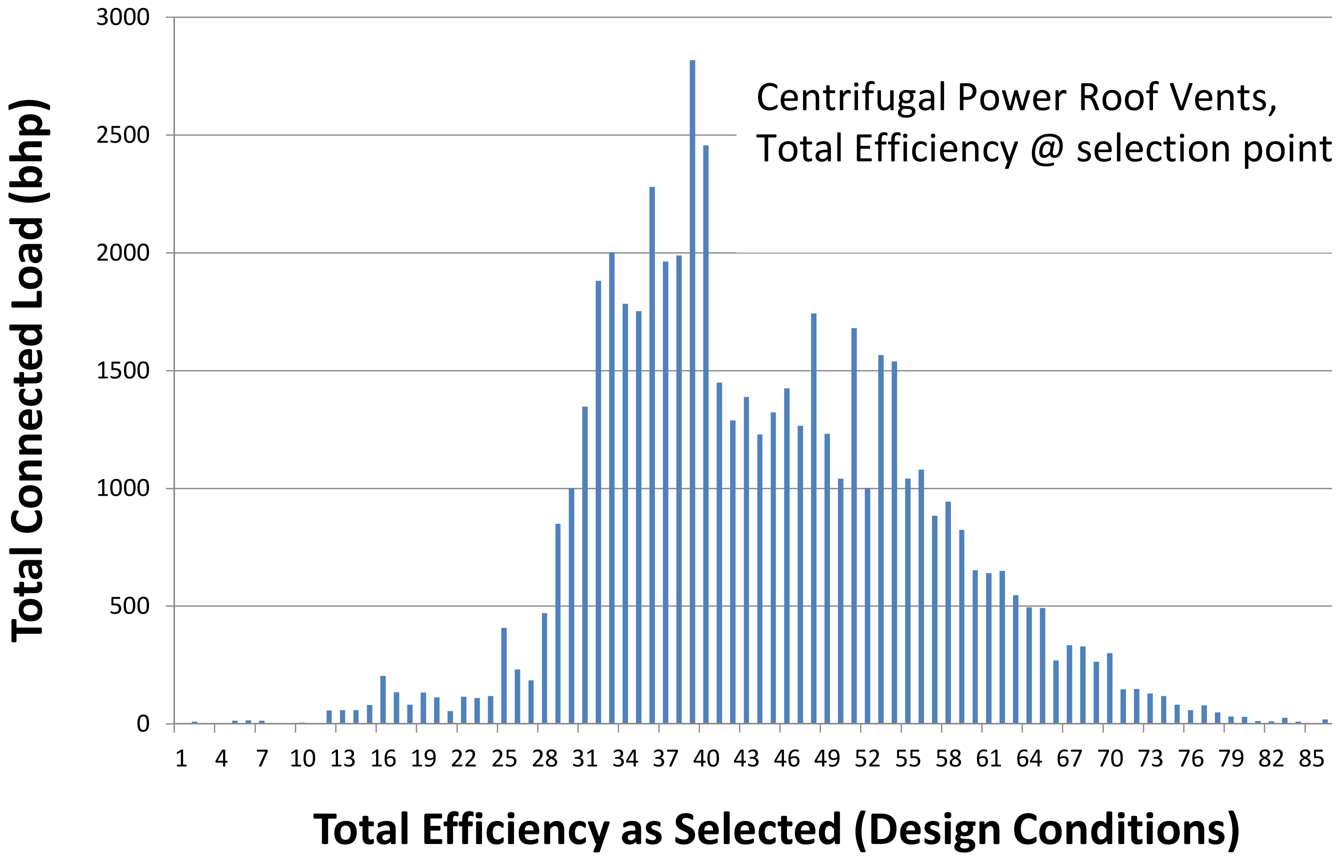


All Fan Products
2012 Sales - fan selections



45,000 fans
220,000 bhp

AMCA Database
Fan efficiency varies widely with selection!



Based on AMCA database of 1.3 million fan selections, 45% of USA market

Unintended consequences

- What if, in the process of increasing the peak efficiency of a fan, we increase the cost of the product? In a price sensitive market, this increased cost could result in more smaller fan selections with efficiency further from peak.

- A peak efficiency metric would eliminate certain fans from the market, even though they may consume less power as applied than another fan that remained on the market.

Clean Sheet Metric

- **FEG & FMEG – Based on peak fan efficiency**

  "How good is the fan?"

- **FEI – Based on fan input power as applied**

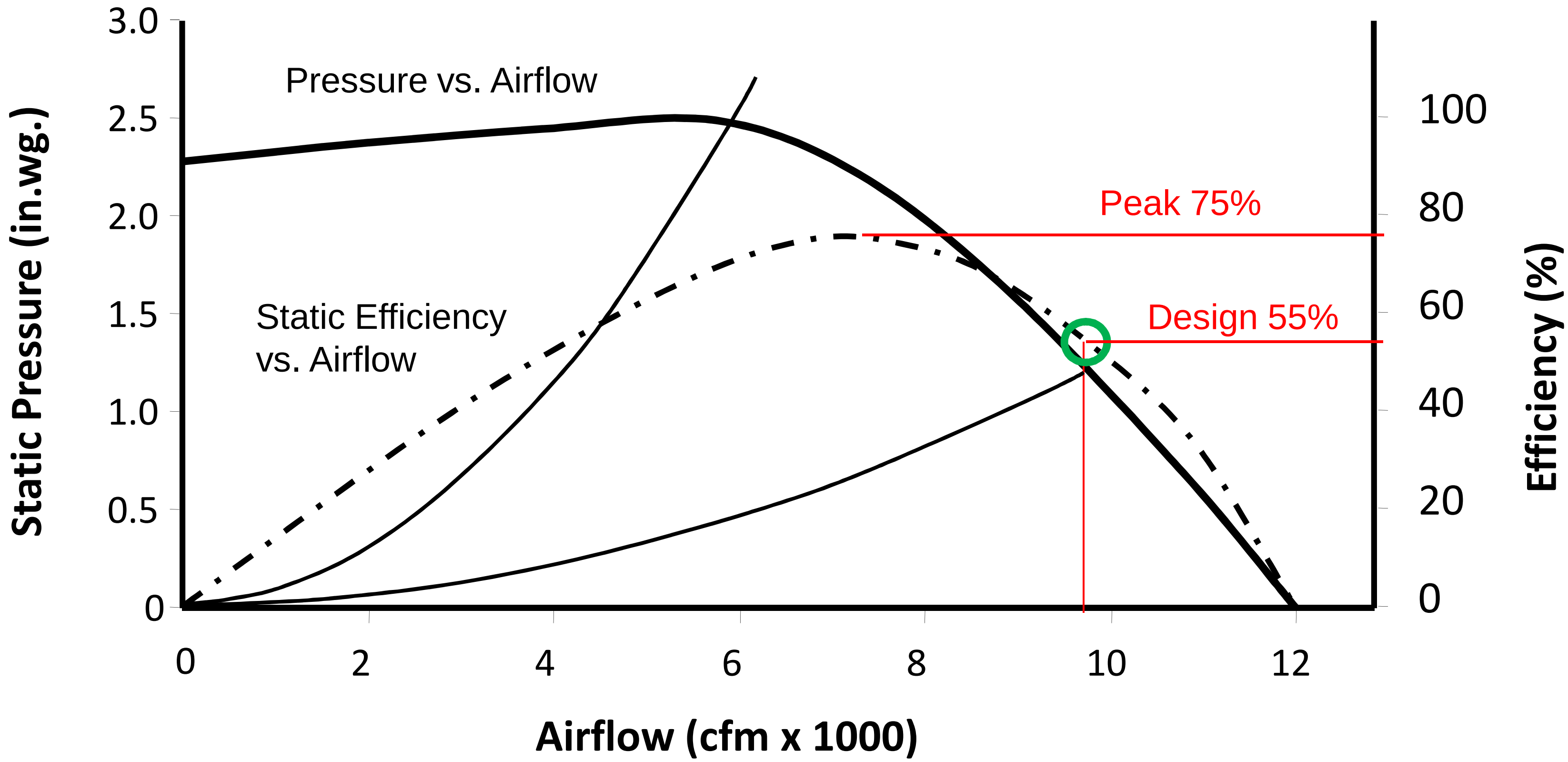
  "How good is the fan for its application?"

Fan selection process is key to energy savings!

The market will demand more efficient fans!

FEI

FEI is not just evaluated at the peak efficiency, but is evaluated at every point on a fan curve. In this way, a regulatory body or specifying engineer can establish a minimum requirement at a much more important duty point – the design airflow and pressure.



Index related to a reference fan

Concept:

$$\text{FEI} = \frac{\text{Fan Overall Efficiency (W2A)}}{\text{Reference Fan Overall Efficiency}}$$

This is true in all cases <u>except</u> at free air (efficiency=0)

FEI Definition:

$$\text{FEI} = \frac{\text{FEP}_{\text{ref}}}{\text{FEP}_{\text{act}}} = \frac{\text{Reference Fan Electrical Input Power}}{\text{Actual Fan Electrical Input Power}}$$

Index related to a reference fan

$$\text{FEI} = \frac{\text{FEP}_{\text{ref}}}{\text{FEP}_{\text{act}}} = \frac{\text{Reference Fan Electrical Input Power}}{\text{Actual Fan Electrical Input Power}}$$

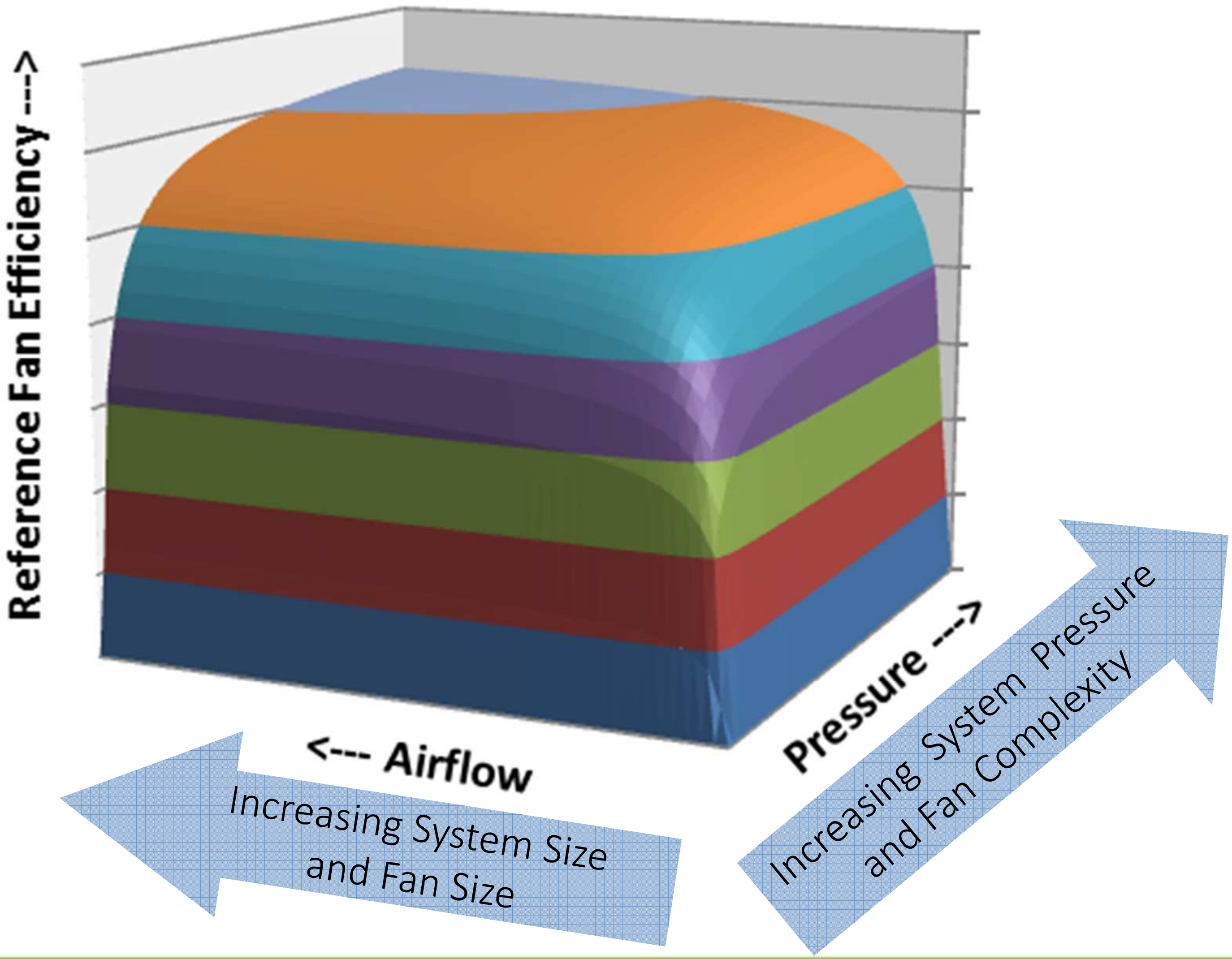
Reference Fan:

$$\text{FEP}_{\text{ref}} = \text{H}_{\text{i,ref}} \left(\frac{1}{\eta_{\text{trans,ref}}}\right) \left(\frac{1}{\eta_{\text{mtr,ref}}}\right) \left(\frac{1}{\eta_{\text{ctrl,ref}}}\right)$$

Assumptions:

- Ref Fan Efficiency
- Belt Driven
- 4 Pole PE Motor
- Constant Speed

Reference Fan Efficiency



Actual Fan Electrical Input Power, FEP_{act}

$$FEI = \frac{FEP_{ref}}{FEP_{act}} = \frac{\text{Reference Fan Electrical Input Power}}{\text{Actual Fan Electrical Input Power}}$$

Wire-to-Air fan test (AMCA 210):

$$FEP_{act} = \text{measured wire to air}$$

Shaft-to-Air fan test (combined with AMCA 207):

$$FEP_{act} = H_{i,act}\left(\frac{1}{\eta_{trans,act}}\right)\left(\frac{1}{\eta_{mtr,act}}\right)\left(\frac{1}{\eta_{ctrl,act}}\right)$$

Improve Fan Efficiency

Use Direct Drive

Use Better Motor

Use Better Controller

Test Requirements and Pressure Basis

Table A.2 - Fan Types, Test Configurations, and FEI Pressure Basis

The following fan categories are used to define consistent test standards, test procedures, and the pressure used for FEI calculation. These categories do not imply that all fans within a category must be regulated by code bodies or that they must be assigned the same minimum FEI requirements.

Fan Category	Housing Type	Impeller Type	Test Standard	Test Config/ Installation Type	FEI Pressure Basis	Notes
Centrifugal Housed	SW or DW Scroll (not inline)	AF, BC, BI, MF, FC, Radial, Radial Tipped	AMCA 210, ISO 5801	B or D	Total	1
				A or C	Static	
Centrifugal Inline	Square, Rect, Cylindrical	AF, BC, BI, MF, FC	AMCA 210, ISO 5801	B or D	Total	1
				A or C	Static	
Centrifugal Unhoused	None	AF, BC, BI, MF	AMCA 210, ISO 5801	A	Static	2
Centrifugal PRV Exhaust	Spun Alum, Upblast, Hooded, Wall Housing	AF, BC, BI, MF, FC	AMCA 210, ISO 5801	A or C	Static	3
Centrifugal PRV Supply	Hooded or otherwise enclosed	AF, BC, BI, MF, FC	AMCA 210, ISO 5801	B or D	Total	3

Test Requirements and Pressure Basis

Table A.2 - continued

Fan Category	Housing Type	Impeller Type	Test Standard	Test Config/ Installation Type	FEI Pressure Basis	Notes
Axial Inline	Cylindrical (Tube Axial or Vane Axial)	Propeller	AMCA 210, ISO 5801	B or D	Total	1
				A or C	Static	
Axial Panel	Panel, Ring	Propeller	AMCA 210, ISO 5801	A	Static	
Axial PRV	Sup & Ex, Spun Alum, Upblast, Hooded, Wall Housing	Propeller	AMCA 210, ISO 5801	A or C	Static	
Laboratory Exhaust	High Velocity Discharge	Any	AMCA 210, ISO 5801	A or C	Total	4
	Induced Flow	Any	AMCA 260	A or C	Total	4,5
Jet Fan	Unidirectional, Reversible	Propeller or AF, BC, BI	AMCA 250, ISO 13350	E	Total	4,6
Circulating	Cylindrical, Panel, Unhoused	Propeller	AMCA 230	E	Total	4,7

Embedded fans and appurtenances

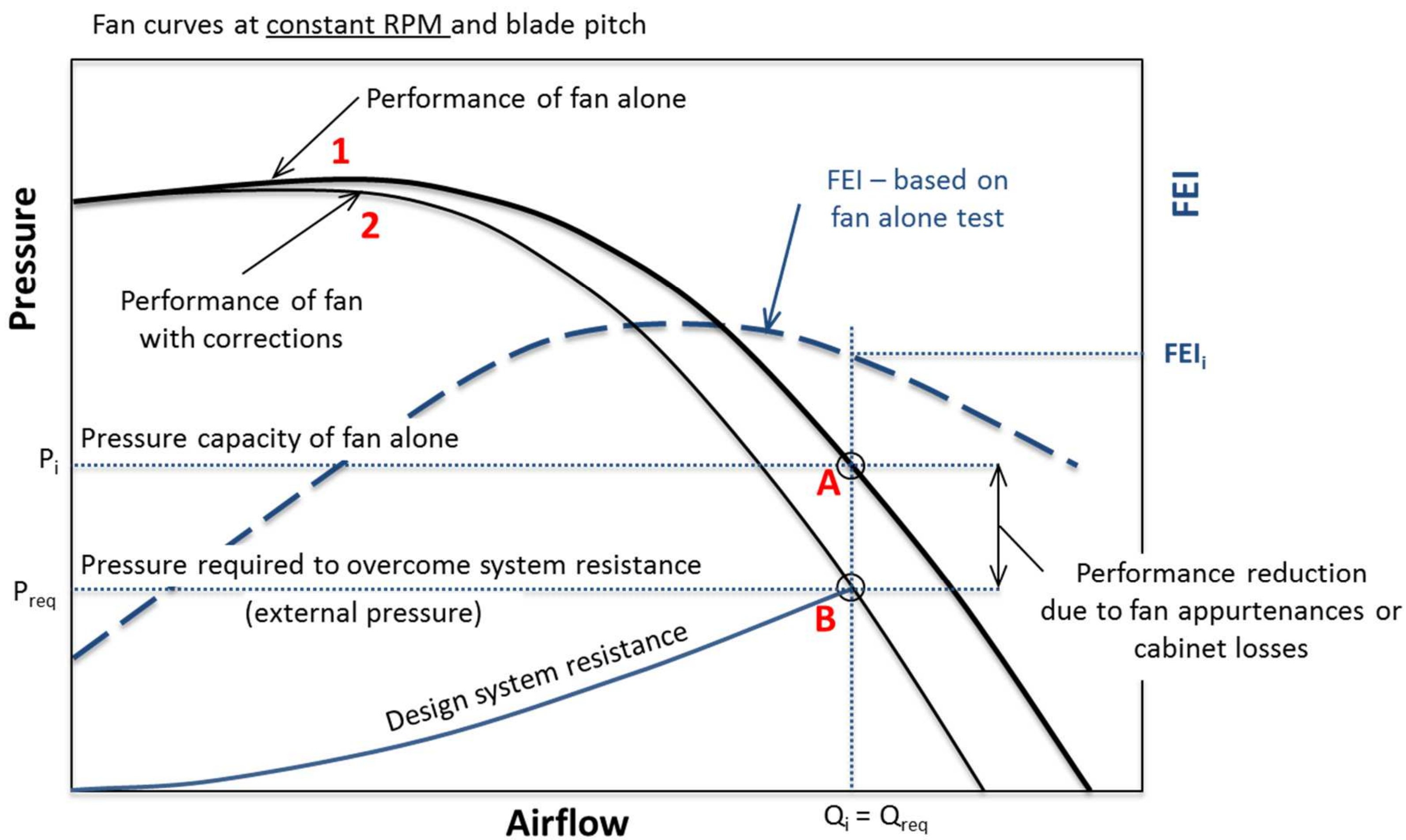


Figure 1

Annex C
Fan Arrays (informative)

C.1 General

Any number of fans can be used in a fan array configuration where the total required airflow is divided among each of the fans. In order to ensure a consistent calculation of FEI regardless of the number of fans used, **a fan array is treated as a single fan moving the total required airflow through the array.**

Fan Array Definition (paraphrased):

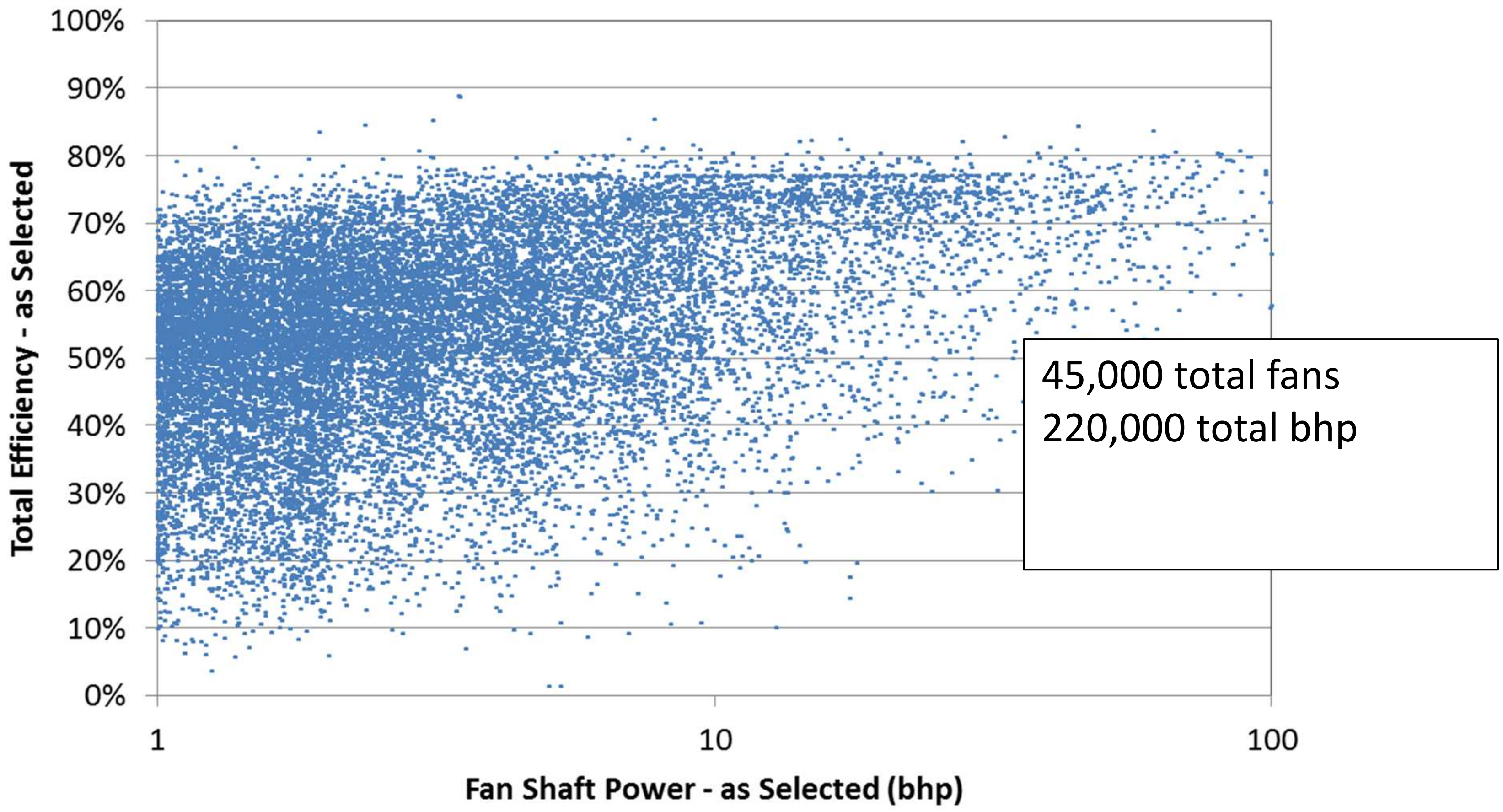
Multiple fans in parallel having common inlet and outlet plenums within an air handler.

Annex C includes a clear example of fan array calculations.

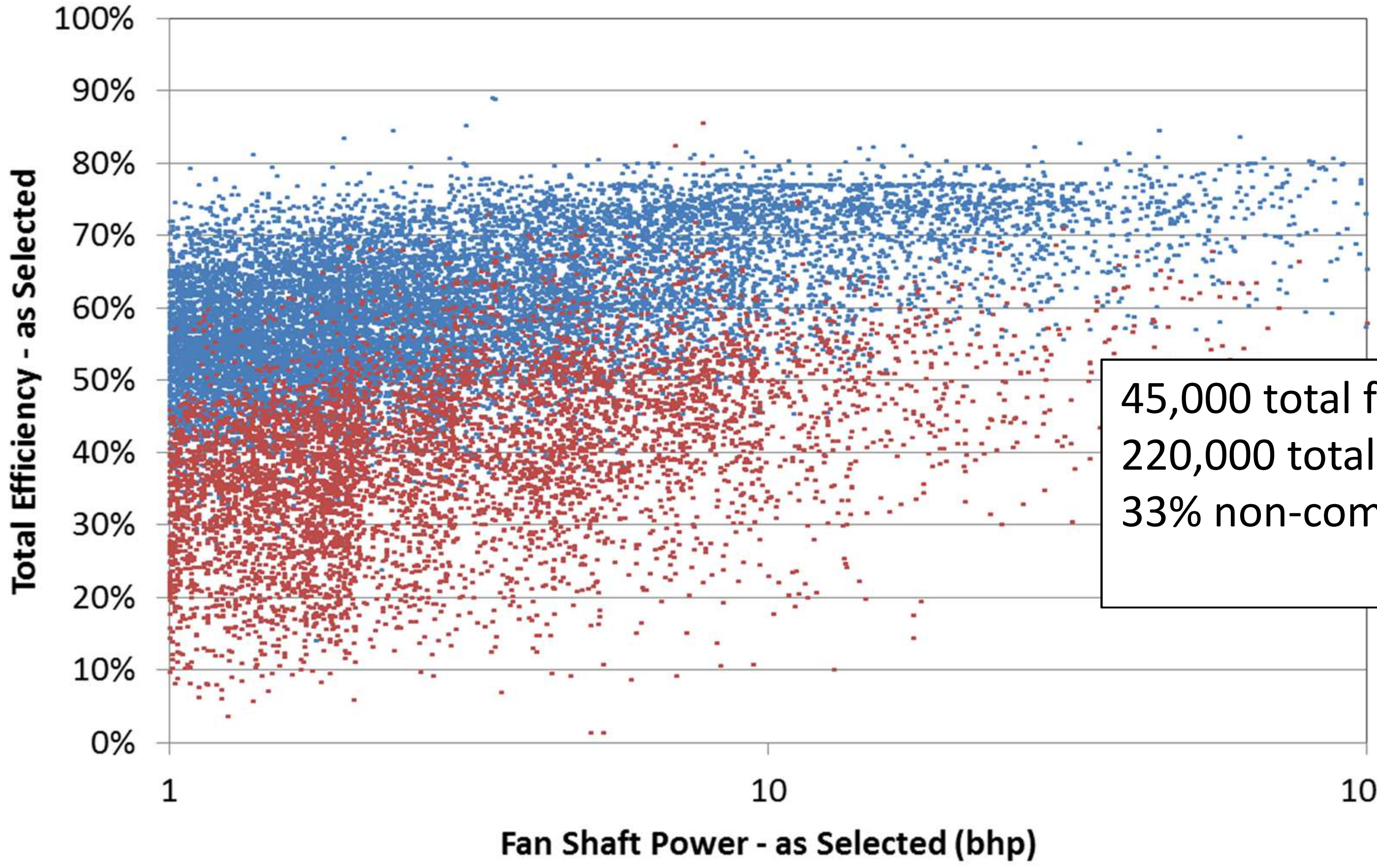
Impact

Minimum FEI of 1.0 is a reasonable starting point

Impact -
2012 Sales – fan selections

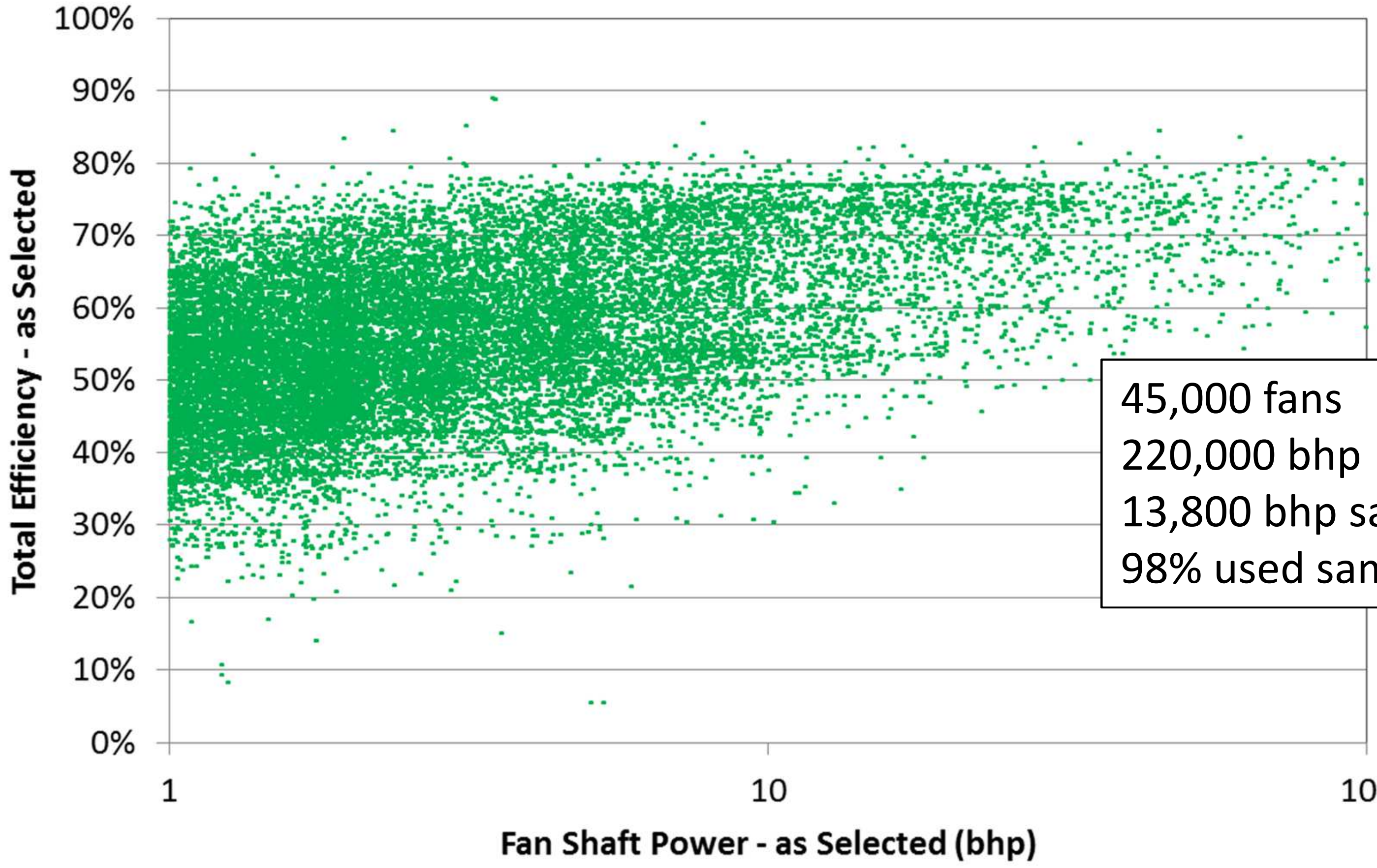


Impact – FEI = 1.0
2012 Sales – fan selections



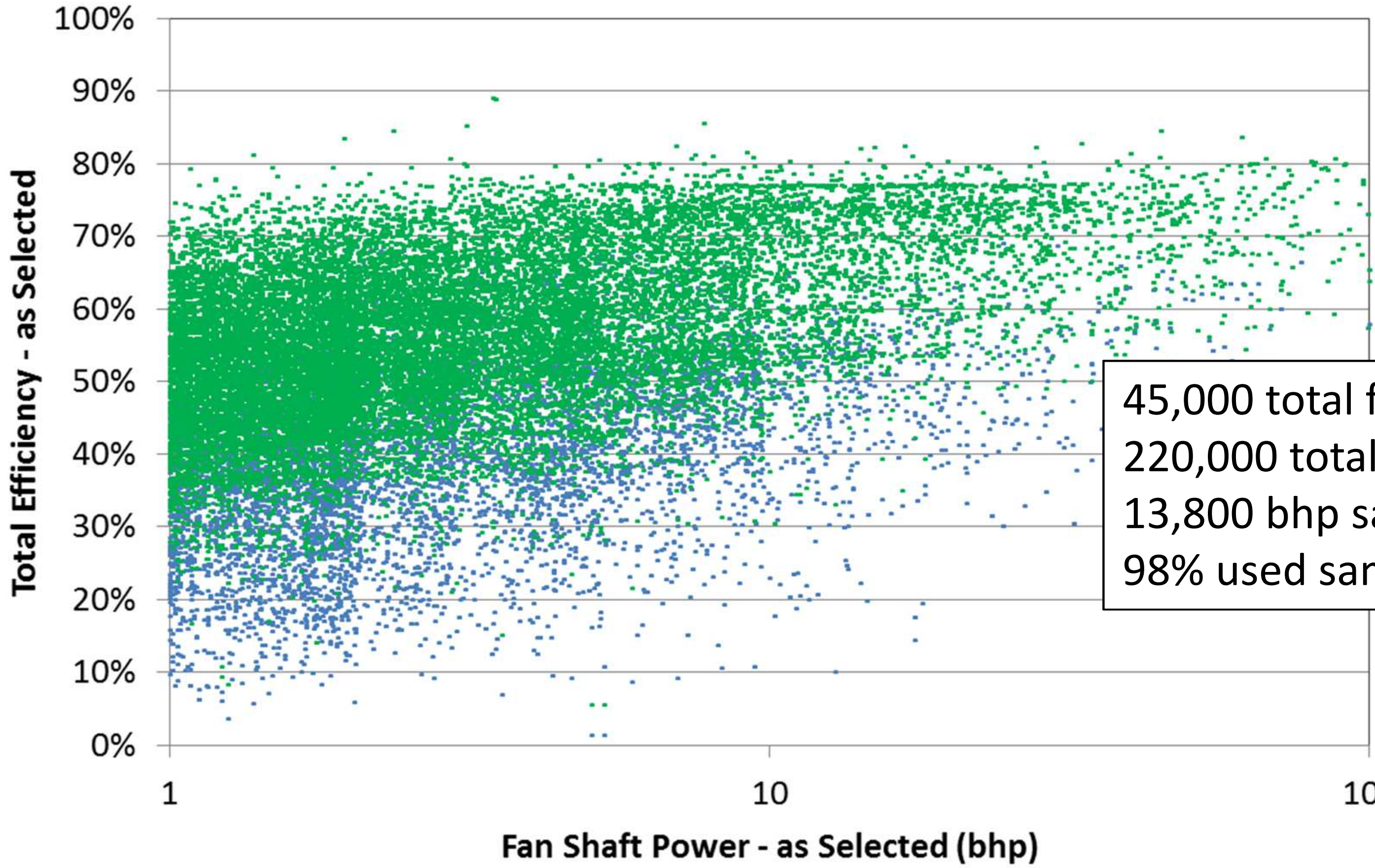
45,000 total fans
220,000 total bhp
33% non-compliant

Impact - 2012 fan selections



45,000 fans
220,000 bhp
13,800 bhp saved (6%)
98% used same model

Impact -
2012 fan selections



45,000 total fans
220,000 total bhp
13,800 bhp saved (6%)
98% used same model

Conclusions

- Existing fan efficiency metrics are not suitable for ensuring energy savings.
- Fan selection is ultimately more important than peak efficiency in determining fan power consumed.
- FEI will encourage more efficient fan designs, use of more efficient motors, and direct drives.

Bibliography

ASHRAE. 2016
Standard 51 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating

AMCA International. 2017
Standard 207 - Fan System Efficiency and Fan System Input Power

AMCA International. 2018
Standard 208 - Calculation of the Fan Energy Index

Questions

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