New Fan Efficiency Requirements in ANSI/ASHRAE/IES 90.1-2019

AMCA *insite* ™ Webinar | AMCA International | www.amca.org

Introductions & Guidelines

- Participation Guidelines:
  - Audience will be muted during the webinar.
  - Questions can be submitted anytime via the GoToWebinar platform and will be addressed at the end of the presentation.
  - Reminder: This webinar is being recorded!
  - A survey will be sent to all participants within 24 hours of the webinar.

Q & A

To submit questions:

- From the attendee panel on the side of the screen, select the “Questions” drop down option.
- Type your question in the box, starting with the name of the presenter for whom your question is directed.
- Click “Send”.

COPYRIGHT MATERIALS

Fan Sizing/ Selection & Energy Regulation

Purpose and Learning Objectives

The purpose of this presentation is to inform participants about two fan-efficiency metrics, Fan Efficiency Grade (FEG) and Fan Energy Index (FEI), how they work for sizing and selection fans and how they are used on energy codes and standards.

Fan Sizing/ Selection & Energy Regulation

Purpose and Learning Objectives

At the end of this presentation you will be able to:

1. Explain how FEI is replacing FEG in model energy codes and standards, including ASHRAE 90.1-2019 and ASHRAE 189.1-2020.
2. Compare ASHRAE 90.1 fan-efficiency provision with that of the India Building Code
3. Apply FEI and FEG for sizing and selecting fans for Constant Speed (CS) and Variable Air Volume (VAV) systems.
4. Describe how to find FEI and FEG ratings from manufacturers.

Presenter and Moderator: Michael Ivanovich

Senior Director, Global Affairs AMCA International

- Joined AMCA July 2011
- Voting member of ASHRAE 90.1 Mechanical Subcommittee
- Represents AMCA on codes, standards and regulations
- Coordinates advocacy in N. America, Asia, Europe, and Middle East

Presenter:
Tim Mathson

Principal Engineer, AMCA International

- Joined AMCA 2019
- 30 years as a fan designer/engineer at Greenheck
- Chaired AMCA 208 Committee, Fan Engineering Committee
- Member of ASHRAE Technical Committee TC 5.1

Agenda

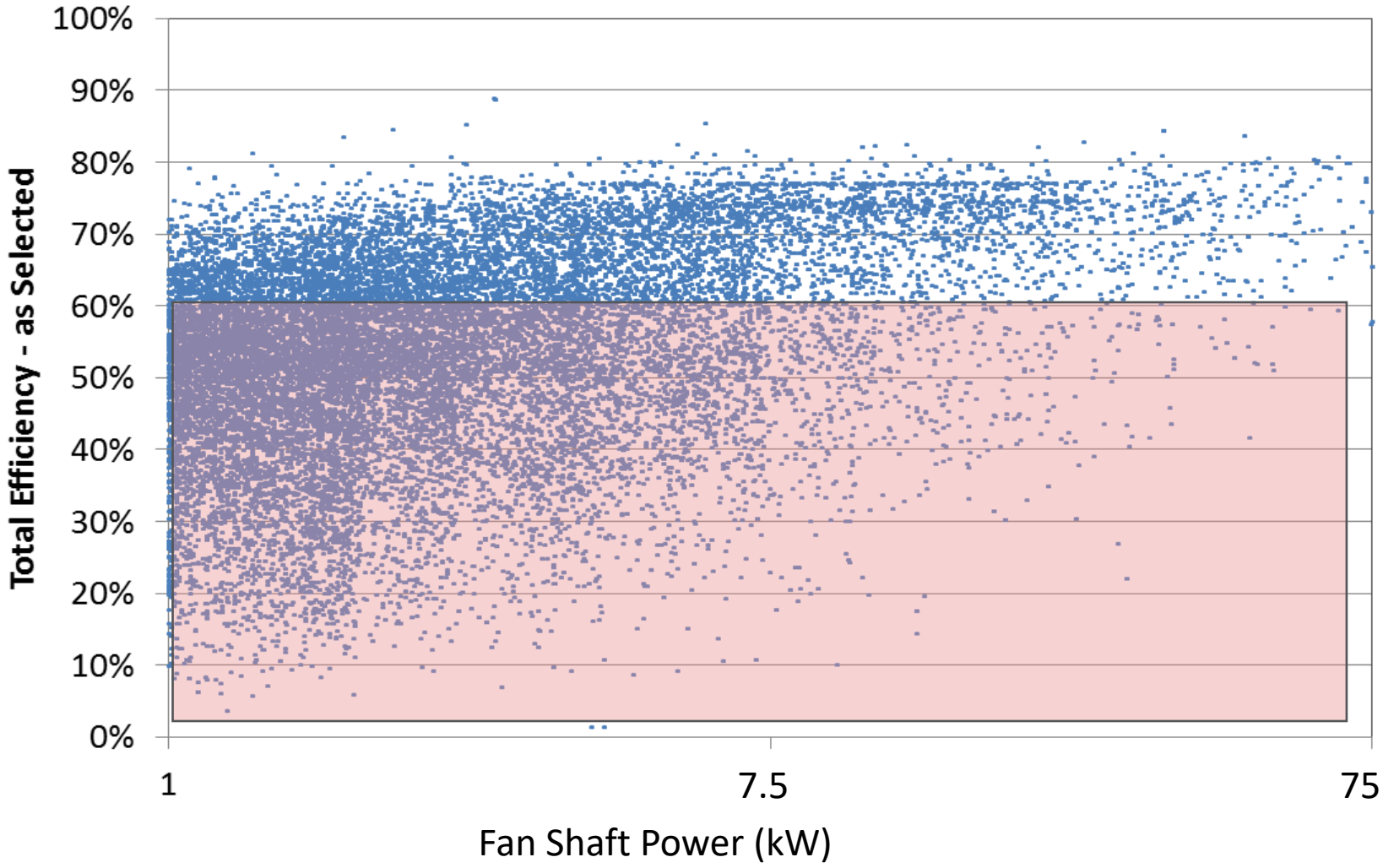
1. Overview of Metrics for Commercial & Industrial Fan Efficiency
2. Introducing the Fan Efficiency Grade (FEG)
3. Introducing the Fan Energy Index (FEI)
4. India Building Code: Fan Efficiency Provisions
5. Comparison of India Building Code to ASHRAE Standards
6. AMCA Certified Ratings, Resources, Conclusion/Summary

Overview of Metrics for Commercial and Industrial Fan Efficiency

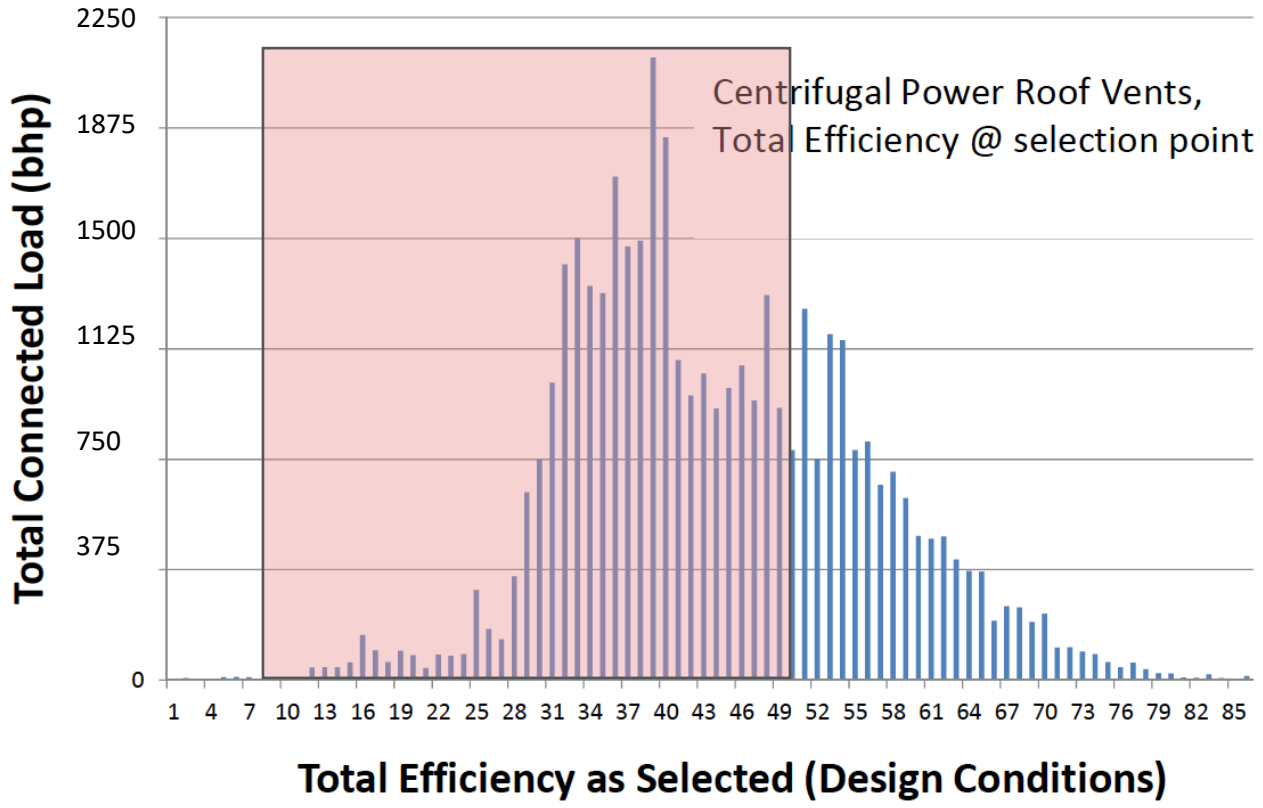
Michael Ivanovich

Specifying Efficient Fans Seems to be a Problem

Company X:
2012 Fan Sales
45,000 fans



Another View: AMCA 2012 Database



A lot of fans have poor selections -they are not properly sized for running conditions

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

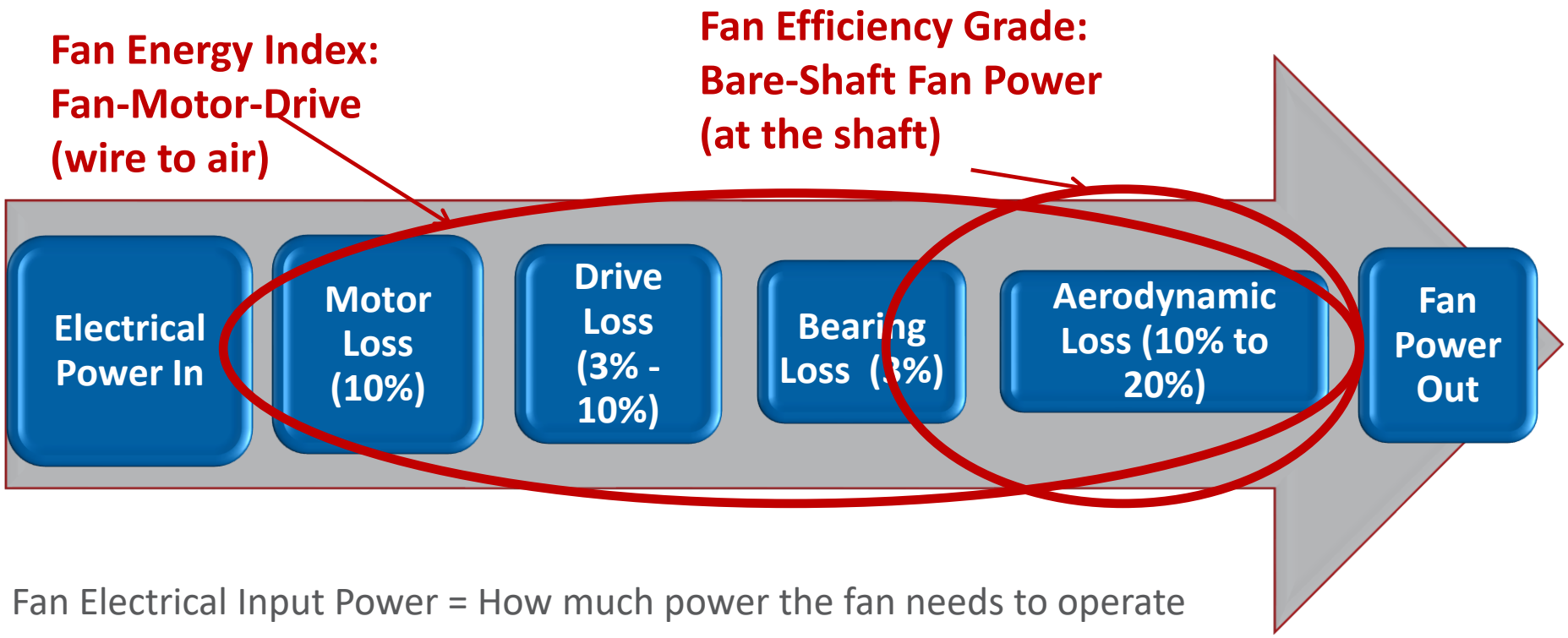
AMCA's Fan Efficiency Metrics

- 2010: Fan Efficiency Grade (FEG)
  - **Peak** efficiency based on fan total efficiency
  - Fan only, no motor or drive efficiency losses are considered
  - Sizing/selection window applied by designer to ensure efficient selection
  - AMCA Standard 205-2010, Energy Efficiency Classification for Fans
  - First ASHRAE 90.1 reference: 2013

AMCA's Fan Efficiency Metrics

- 2018: Fan Motor Efficiency Grade (FEI)
  - **NOT peak** efficiency; can be static or total efficiency, depending on how fan is rated
  - Wire-to-Air – motor-driven fan efficiency
  - No sizing/selection window needed
  - AMCA Standard 208-2018, Calculation of the Fan Energy Index
  - First ASHRAE 90.1 reference: 2019

Fan-Only vs. Wire-to-Air



Fan Electrical Input Power = How much power the fan needs to operate

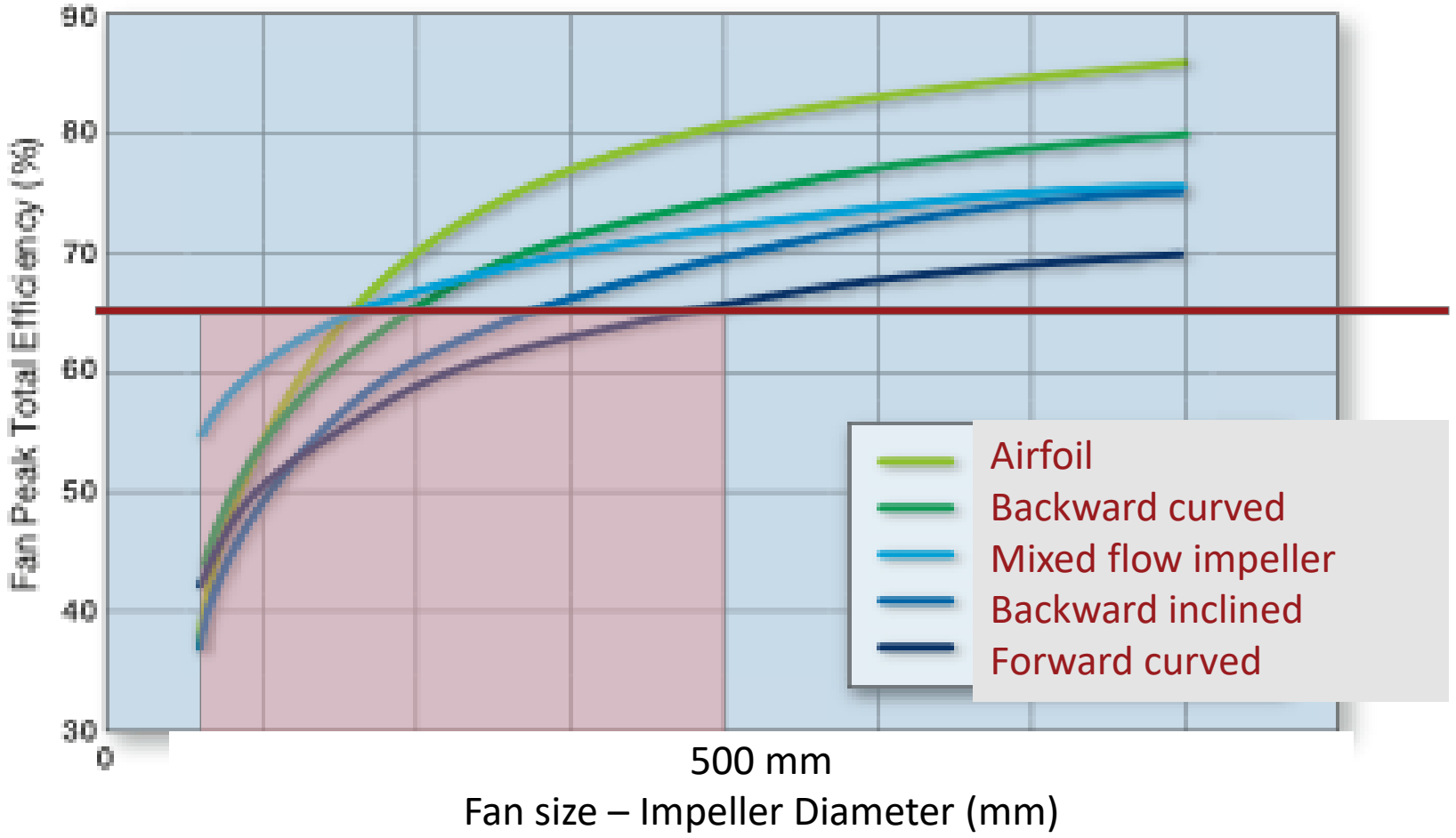
Introducing the Fan Efficiency Grade (FEG)

Michael Ivanovich

Fan Facts

- Fans are a mature market
- Niche products for specific applications
- Multiple fan types, sizes, prices can meet application requirements
- Some types of fans more efficient than others
- Early thinking (ASHRAE 90.1) was a minimum of 65% efficiency
- But that approach wouldn’t work, so what then?

Rise and Fall of the “65%-Threshold” Concept



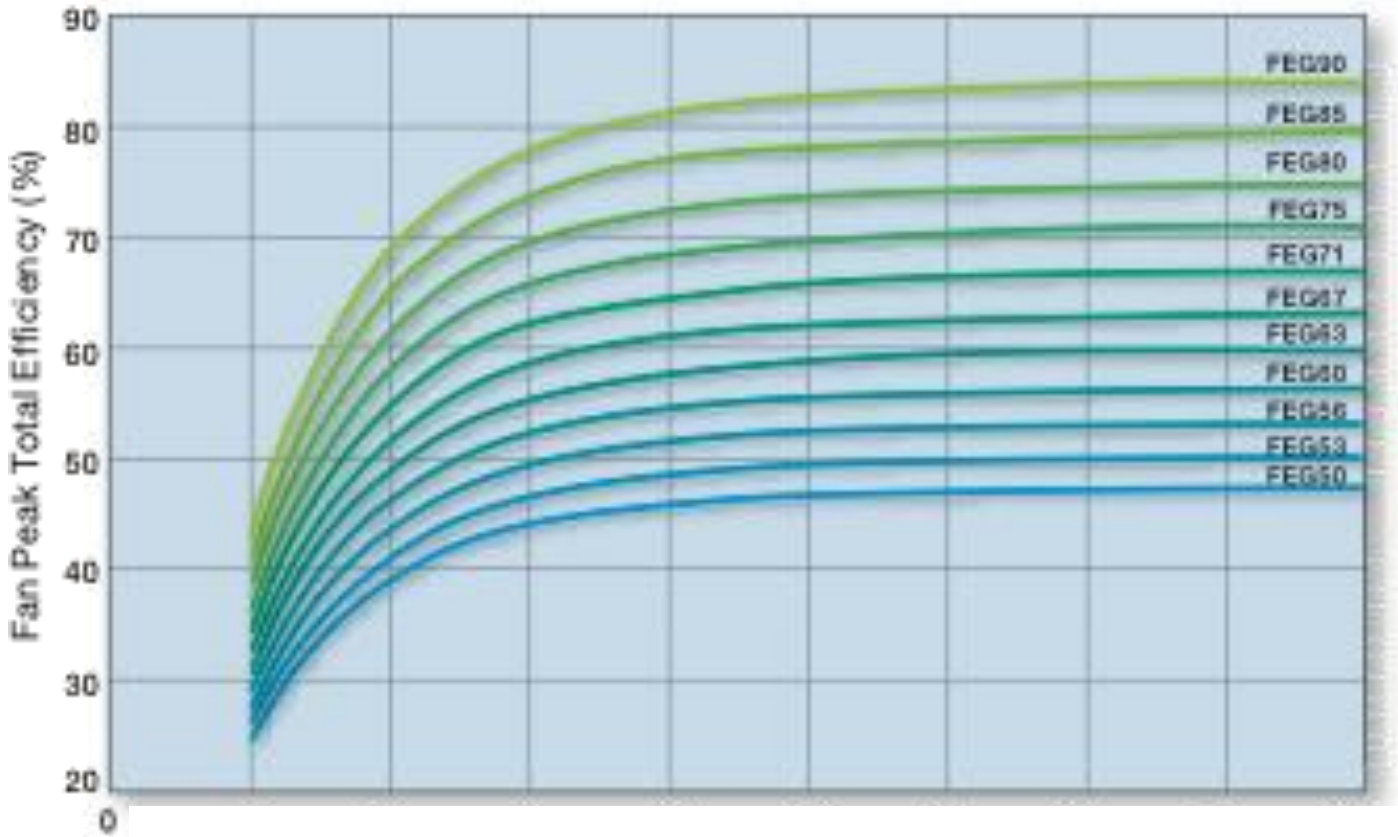
Single-Efficiency Threshold Does Not Work

- For fans of same model, efficiency varies with impeller diameter
- Bearing losses, manufacturing tolerances etc.
- So, for all types of fans, 65% minimum efficiency eliminates too many ”small” fans
- A method was needed to compensate for impeller size

Fan Efficiency Grade (FEG)

- Bare-shaft fan; no motor or drive
- Peak total efficiency for all types of fans
- Curves based on fan data from manufacturers worldwide
- Curves define index or category for fans for all sizes of particular model

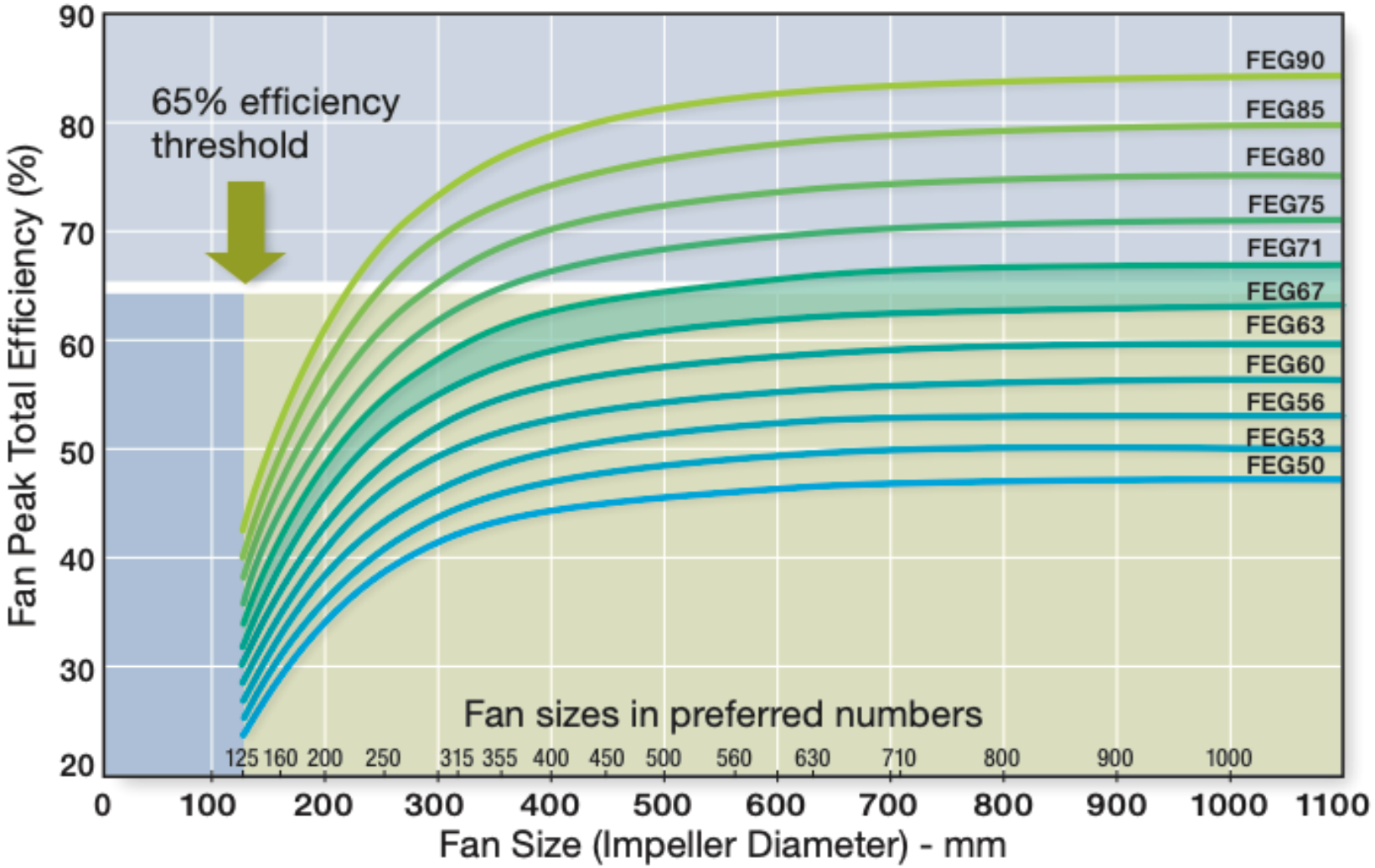
AMCA Standard 205-2010 (2012, 2019): Fan Efficiency Grades (FEG)



Fan size – Impeller Diameter (mm)

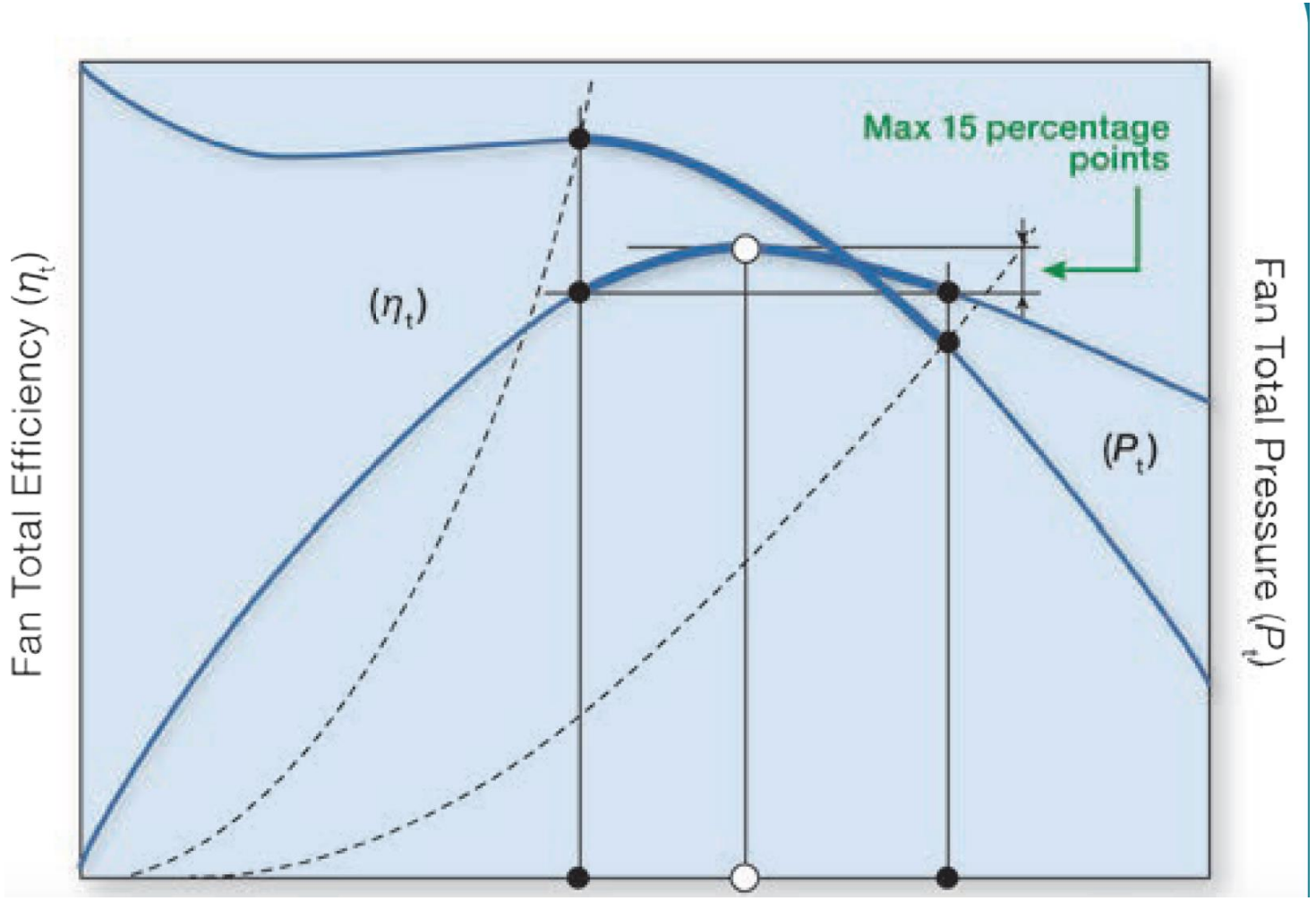
FEG bands constant through fan sizes

AMCA Standard 205 vs 65% Efficiency Threshold



ASHRAE 90.1
2013, 2016

Sizing/Selection Window Needed for FEG-Rated Fans



ASHRAE 90.1-2013, 2016
15 percentage points

ASHRAE 189.1-2014, 2017
10 percentage points

India Building Code 2016
10 percentage points

Example of FEG-based Fan Selection

- Airfoil fan
- Manufacturer sizing/selection program outputs fan diameters 460 mm to 920 mm
- FEG 85 for all sizes

Efficiency Varies with Size for a Duty Point

This is why the 15- percentage point window needed for FEG

Fan Size (mm)	Fan Speed (rpm)	Fan Power (kW)	Actual Total Efficiency (%)	FEG
460	3,238	8.8	40.1	85
510	2,561	7.2	49.5	85
560	1,983	6.0	59.0	85
610	1,579	5.0	69.1	85
685	1,289	4.6	75.8	85
770	1,033	4.3	82.5	85
920	778	4.5	78.7	85

Introducing the Fan Energy Index (FEI)

Tim Mathson

Why Change from FEG?

- Origin of FEI is a now-stalled USA federal regulation
- Problems with Fan Efficiency Grade (FEG)
  - Not wire-to-air
    - Bare-shaft fan only
    - No inclusion of motors, drives
  - Peak total efficiency only
    - Needed a selection window applied by designers

      "Fans must be selected to operate within 10 percentage points of peak total efficiency"
    - Cannot apply such a window for an equipment/appliance regulation

FEI Fixes FEG Problems

- FEI fixes all these issues:
  - Wire to air – covers fan, transmission, motor, speed control
  - Considers off-peak fan efficiency
  - Static or total pressure, as appropriate
  - Includes fans testable to:
    - Most commercial/industrial fans: AMCA 210 / ISO 5801
    - Jet fans: AMCA 250 / ISO 13350
    - Induced flow fans: AMCA 260

Benefits of FEI

Clarity

- FEI includes effect of losses from fans, motors, and drives
- FEI rating allows instant identification of compliance

Flexibility

- Fan selections allow variety of fan types, sizes, motors, and drives
- Facilitates consideration of budget, acoustics, form factor, etc.

Simplicity

- Intuitive metric that directly reflects power consumed by the fan

Greater energy savings

- Net result is greater energy savings and lower lifecycle cost

Wire-to-Air Metric

FEI – Fan Energy Index

Defined in AMCA Standard 208-2018:

$$FEI = \frac{Reference\ Fan\ Electrical\ Input\ Power}{Actual\ Fan\ Electrical\ Input\ Power}$$

$$FEI = \frac{FEP_{ref}}{FEP}$$

- FEP_{ref} and FEP calculated at the same airflow and pressure
- FEI is a relative measure of power required for a given duty point – relative to the *Reference Fan*

The Reference Fan

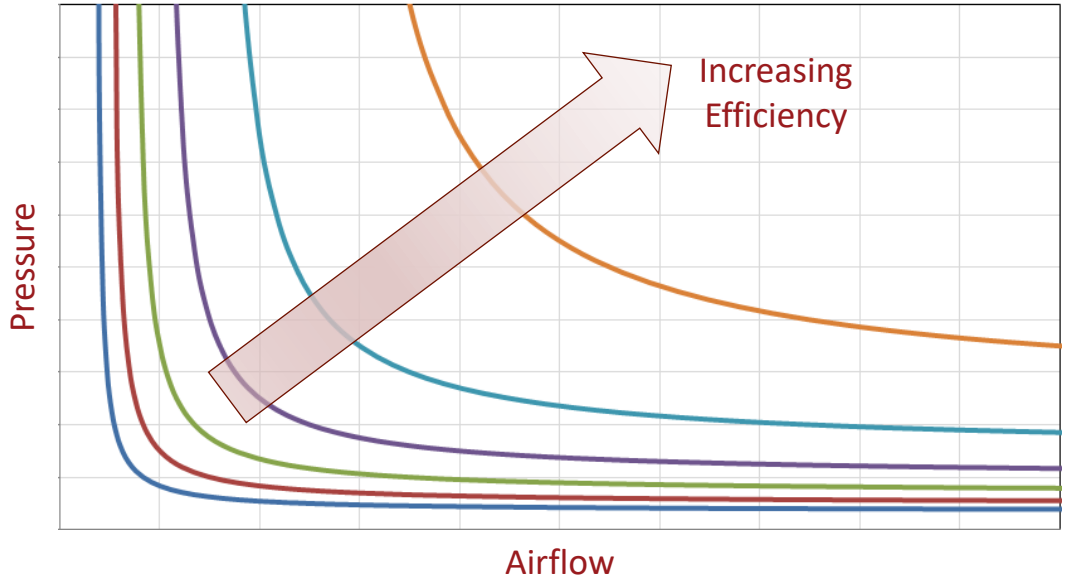
Think of the Reference fan as a "*Reasonably Efficient Fan*"…

- Established by DOE and the fan industry
- Later documented in AMCA 208

Empirical function of fan efficiency vs. airflow and pressure:

1. Independent of:
   - Fan type
   - Fan size
   - Motor type
   - Belt or direct drive

2. Fixed in time

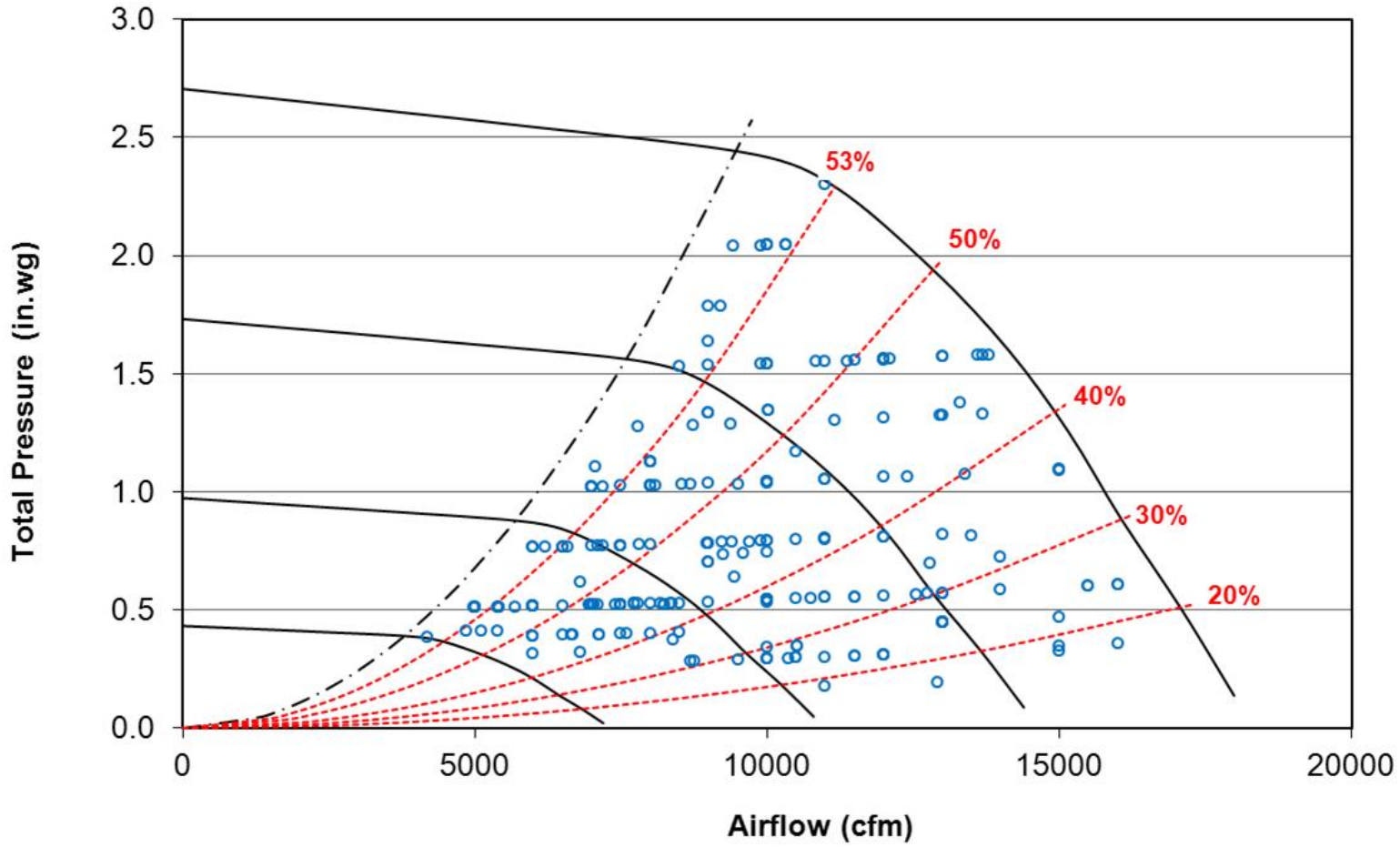


Fan Selection

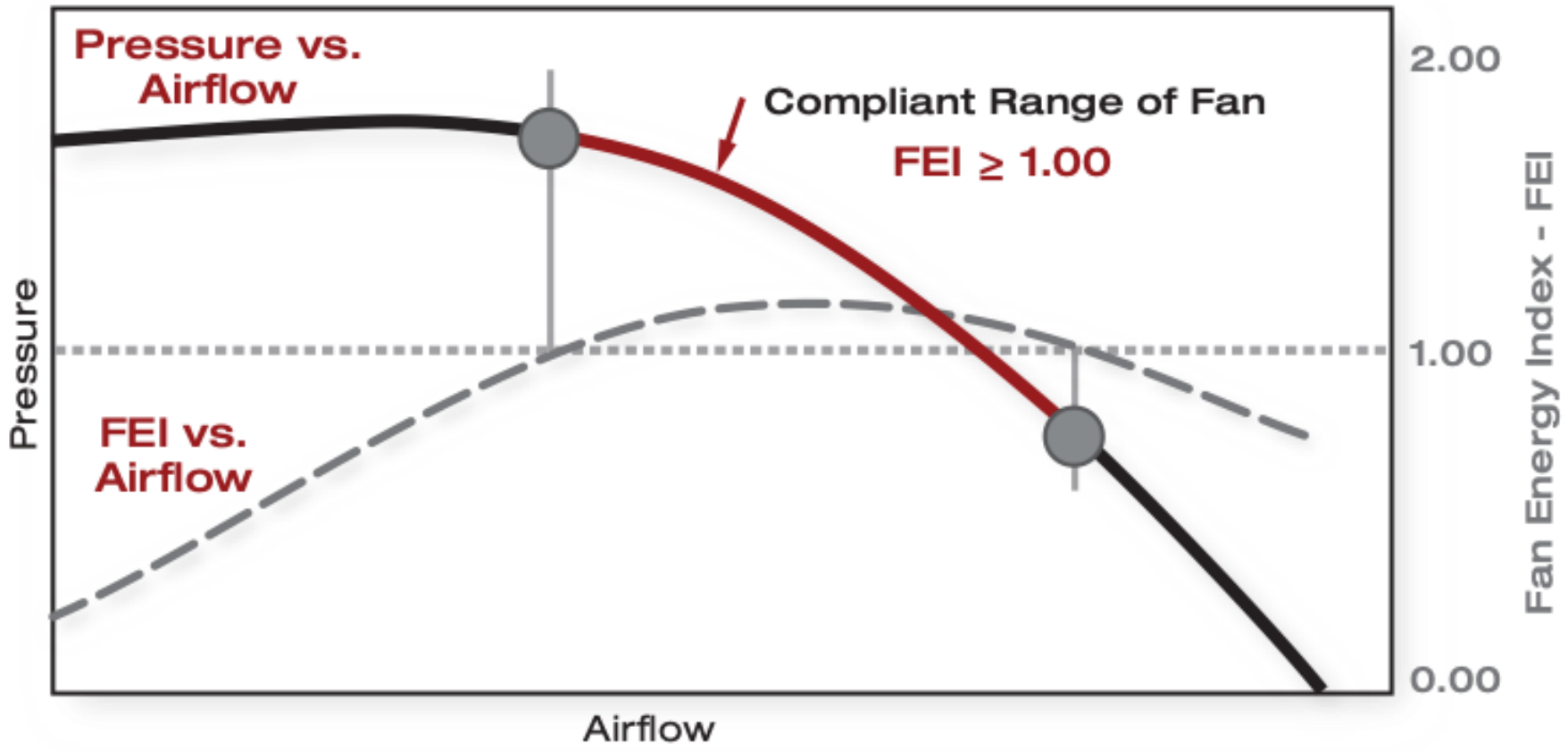
- Fan efficiency is highly dependent on where the fan is operating on the fan curve.
- Fans are typically selected to provide airflow at a designated duty point.
  - Airflow
  - Pressure
  - Air Density (sea level vs. high elevation)
- Turns out, help is needed for selecting fans.

Square Inline Fan – Size 30

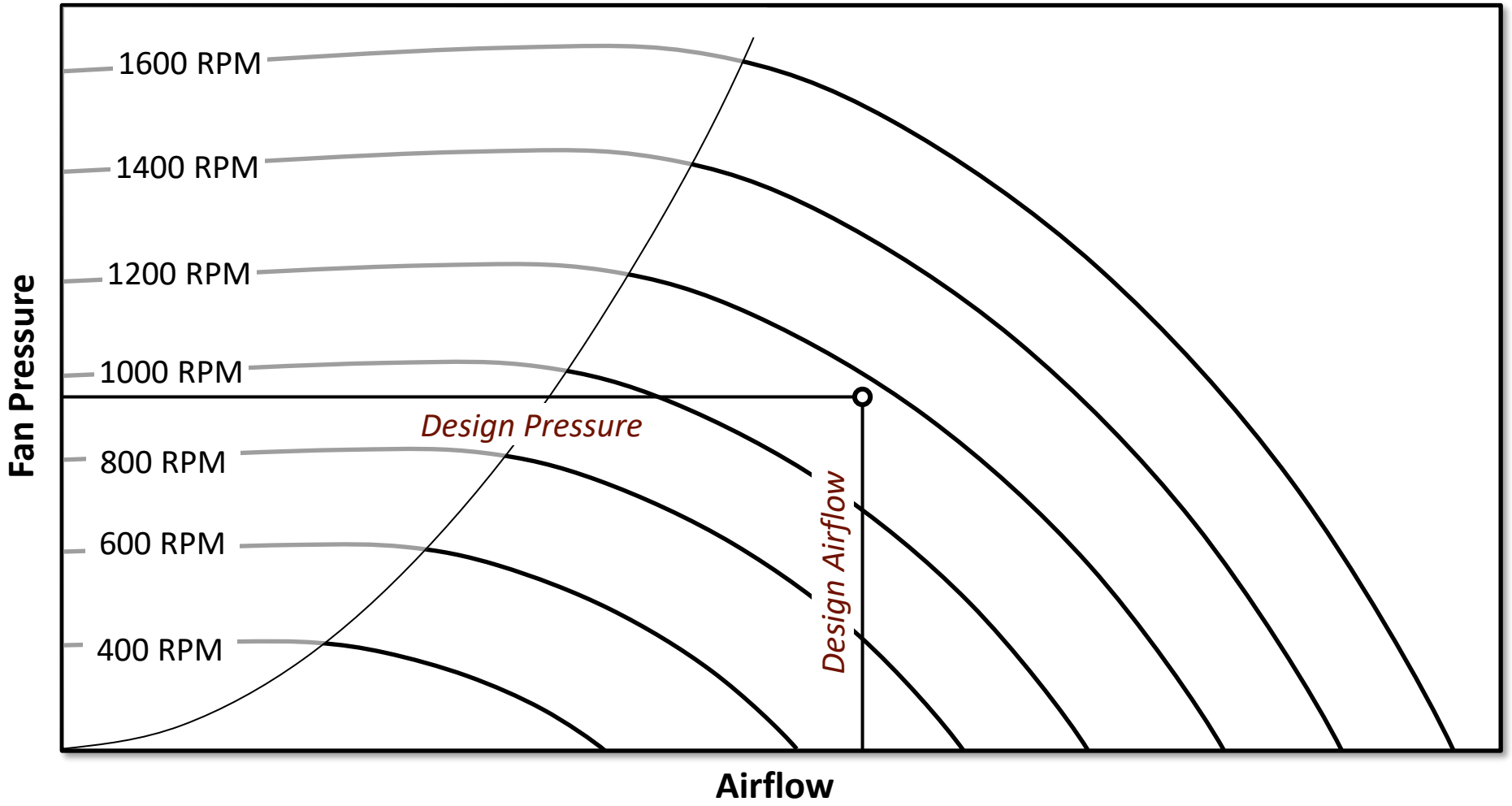
295 Actual Fan Selections



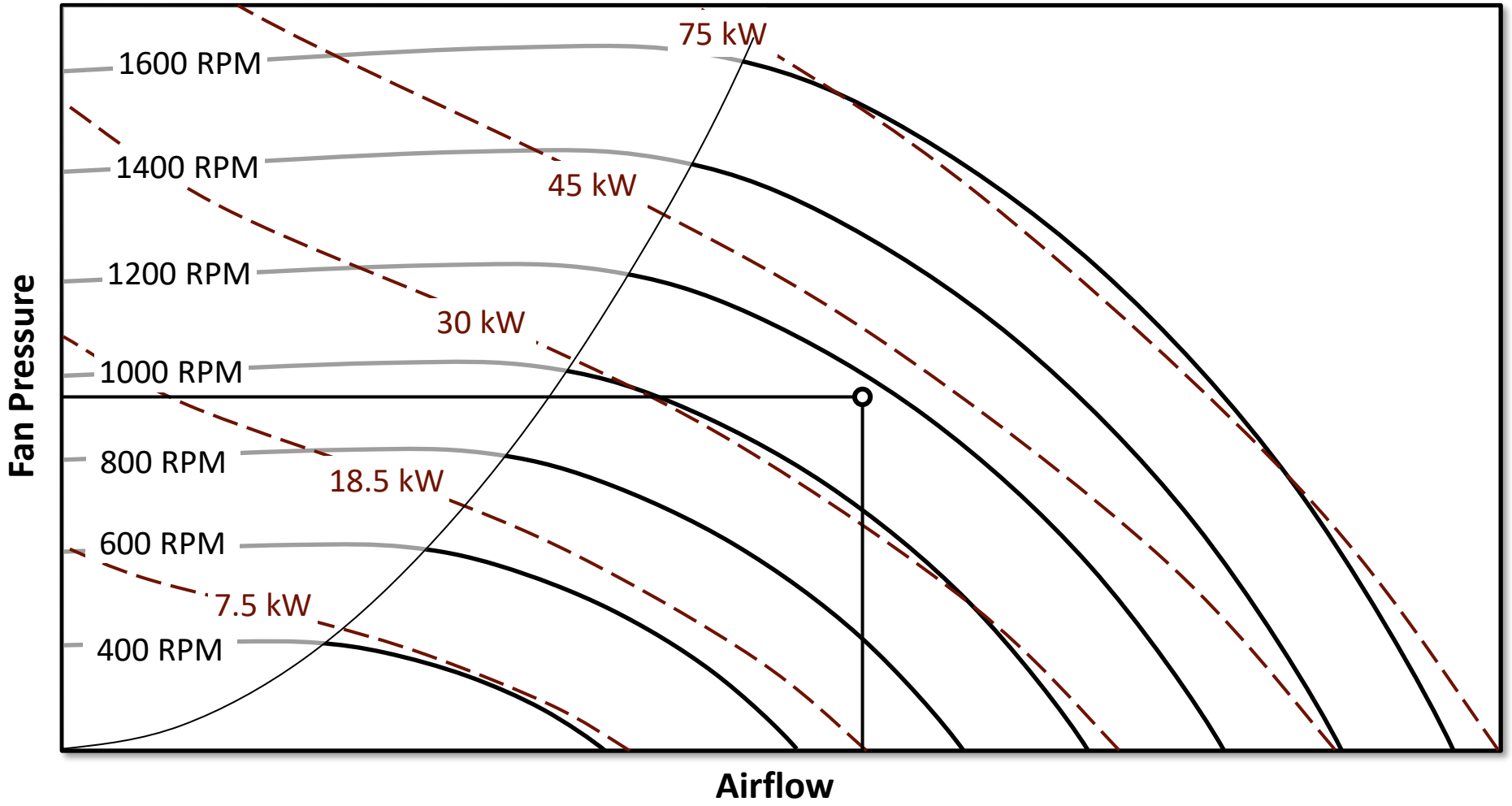
FEI ≥ 1.00 Defines Compliant Range for Selection



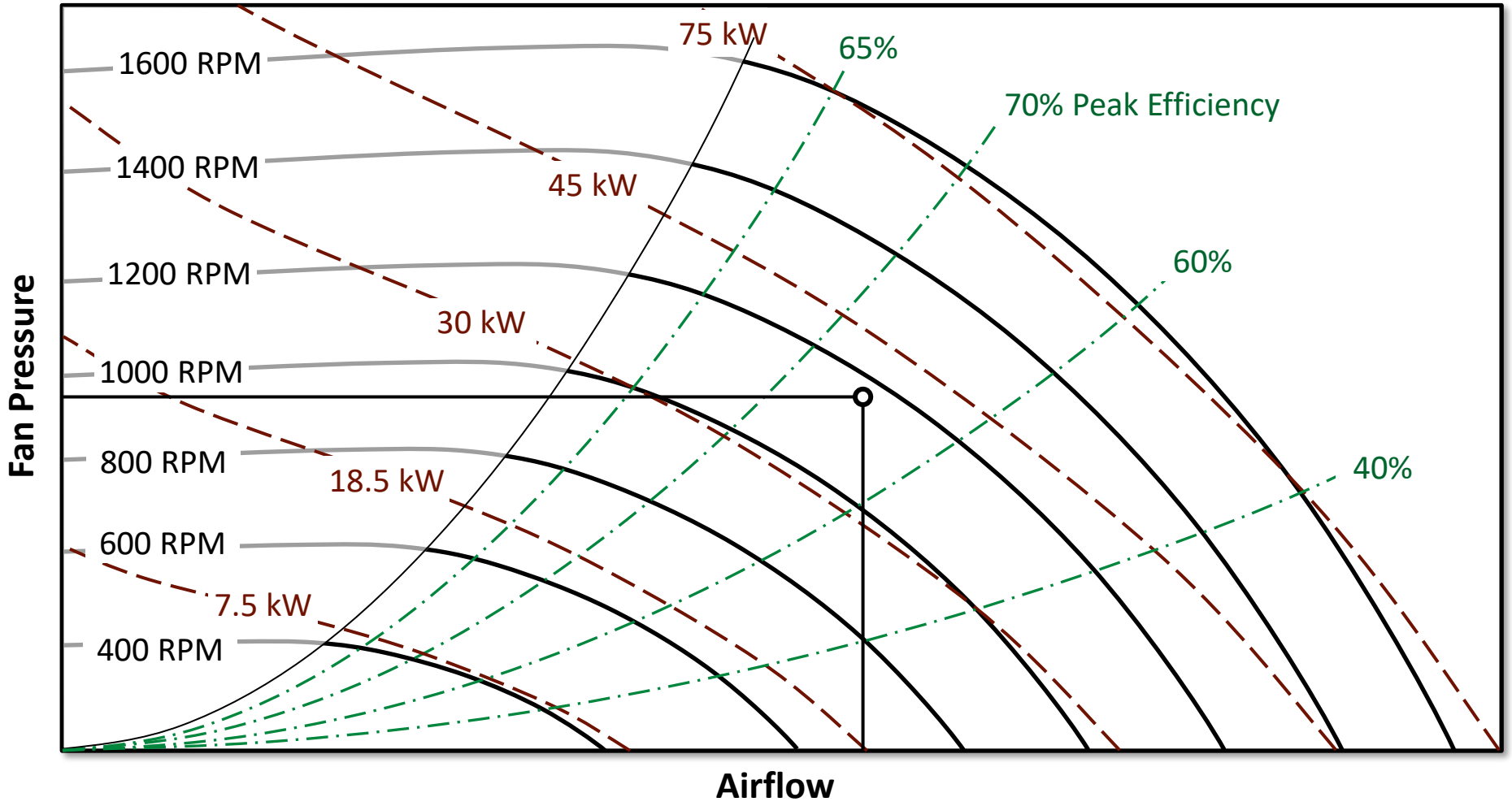
Fan Selection Using Multiple Speed Fan Curves



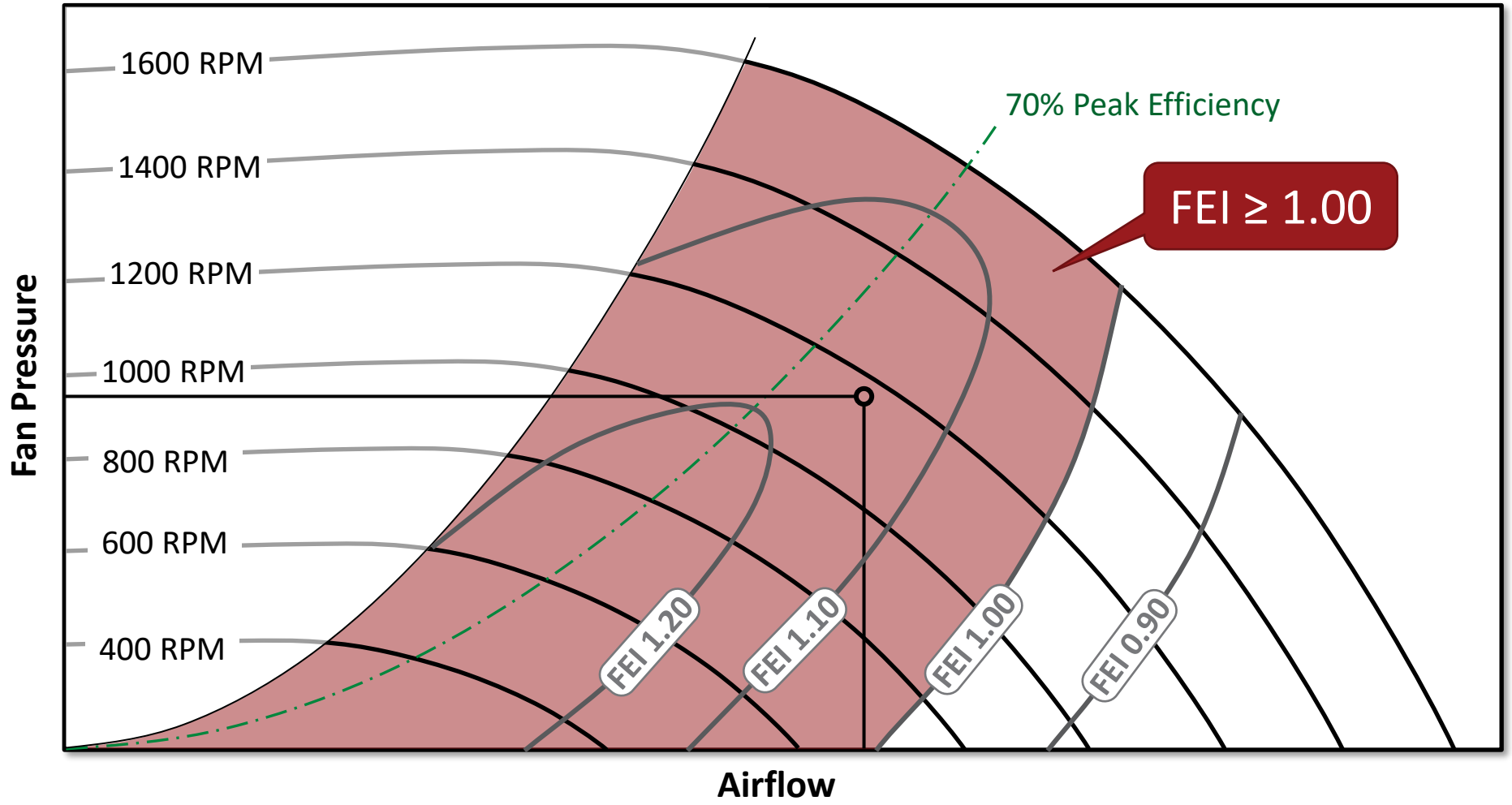
Fan Selection Using Multiple Speed Fan Curves



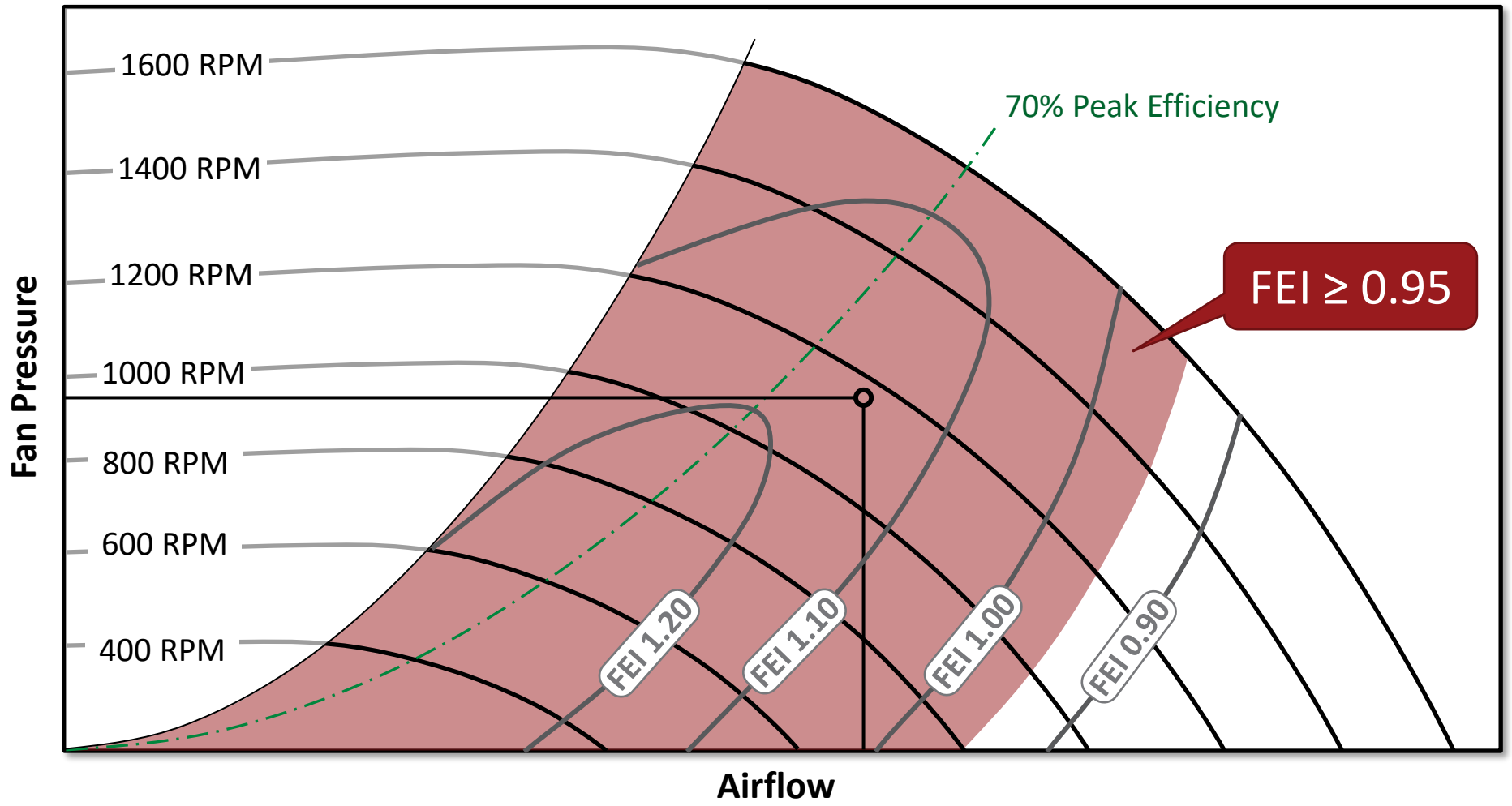
Fan Selection Using Multiple Speed Fan Curves



Fan Selection Using Multiple Speed Fan Curves



Fan Selection Using Multiple Speed Fan Curves



FEI Improves Fan Selections

- Enables comparisons of:
  - Different fan types
  - Different fan sizes
  - Different motor and drive combinations

All at the same design duty point!

FEI Examples – Stand Alone Fans

Utility set:

- 10,000 cfm (4.7 m^3/s)
- 2.0” wg (500 Pa) static pressure
- Sea level (standard atmospheric pressure)

Sidewall prop fan:

- 20,000 cfm (9.4 m^3/s)
- 0.25” wg (62.5 Pa) static pressure
- Sea level (standard atmospheric pressure)

…apologies for the inch-pound units for following examples…

Utility Set

10,000 cfm at 2.0-in Ps
(4.7 m^3 / s at 500 Pa)

Product Type

Model: BCV Look Up...

Air Performance Settings

Altitude above sea level	0 ft
Fan inlet pressure	0.000 in WC
Fan inlet temperature	70 F
Design temperature	70 F
Relative humidity	
Inlet density	0.0750 lb/ft³

Selection Criteria | Performance Modifiers

Volumetric flow: 10000 cfm

Static pressure: 2.000 in WC

Drive method: 60 Hz Belt Drive

Size: 90 600

Outlet velocity:

Speed:

Power:

Show Available Products | Add Available Products to Results

Model	Size	Cl	Dia (%)	Width (%)	% of Peak	Drive Type	RPM	Max RPM	Std Pwr (BHP)	Op Pwr (BHP)	Out Vel (FPM)	Stat Eff (%)	Tot Eff (%)	In LwA	Out LwA	Rel Cost	FEI	FEP (KW)
BCV	200	II	100	100	24.42	BD	2,323	2,490	10.52	10.52	4348	29.98	47.61	99	N/A	0.41	0.81	8.88
BCV	222	II	100	100	34.34	BD	1,761	2,238	8.00	8.00	3509	39.43	54.53	94	N/A	0.55	0.95	6.77
BCV	245	I	100	100	45.33	BD	1,392	1,577	6.50	6.50	2899	48.50	61.18	90	N/A	0.50	1.07	5.59
BCV	270	I	100	100	56.72	BD	1,110	1,397	5.42	5.42	2387	58.13	68.43	88	N/A	0.61	1.20	4.71
BCV	300	I	100	100	71.14	BD	892	1,257	4.72	4.72	1934	66.81	74.59	86	N/A	0.74	1.31	4.11
BCV	330	I	100	100	83.61	BD	748	1,143	4.35	4.35	1597	72.49	78.25	84	N/A	0.85	1.38	3.79
BCV	365	I	100	100	96.58	BD	618	995	4.10	4.10	1305	76.87	80.95	76	N/A	1	1.43	3.58
BCV	402	I	100	100	99.91	BD	551	903	4.20	4.20	1074	75.05	77.75	76	N/A	1.73	1.39	3.67

Transfer to Fanulator

AMCA Licensed for Sound and Air Performance and Fan Efficiency Grade (FEG).
Power rating (BHP) does not include belt drive losses.

Item Details... | Reports... | Curves...

Sidewall Prop Fan

- 20,000 cfm at 0.25-in. static pressure (9.4 m^3/s at 62.5 Pa)

Model	Drive	Volume	SP	Power	Motor	RPM	Max (Fan)	OVEL	TSPD	SE	TE	Pts From	FEG	FEI	UnitWT
		CFM	inwc	HP	HP		RPM	fpm	fpm			PeakTE			lbs
36XLWH	Belt	20000	.25	3.51	5.00	825	895	2715	7883	24%	68%	0%	71	1.05	195
42XLWH	Belt	20000	.25	2.66	3.00	555	870	2006	6175	32%	64%	0%	67	1.37	246
48XLWH	Belt	20000	.25	2.11	3.00	432	650	1558	5471	40%	65%	3%	71	1.70	294
54XLWH	Belt	20000	.25	1.98	2.00	330	611	1234	4686	43%	59%	9%	71	1.81	313
60XLWH	Belt	20000	.25	1.90	2.00	259	550	1001	4085	45%	56%	15%	75	1.88	338
42XMWH	Belt	20000	.25	2.56	3.00	653	821	2006	7265	33%	66%	3%	71	1.42	245
48XMWH	Belt	20000	.25	1.96	2.00	491	726	1558	6218	43%	70%	0%	71	1.82	269
54XMWH	Belt	20000	.25	1.86	2.00	356	558	1234	5056	46%	63%	7%	71	1.92	320
60XMWH	Belt	20000	.25	1.46	1.50	299	530	1001	4716	58%	73%	2%	80	2.40	305

Sidewall Prop Fan

- 10,000 cfm at 0.25” static pressure (9.4 m^3/s at 62.5 Pa)

Model	Drive	Volume	SP	Power	Motor	RPM	Max (Fan)	OVEL	TSPD	SE	TE	Pts From	FEG	FEI	UnitWT
		CFM	inwc	HP	HP		RPM	fpm	fpm			PeakTE			lbs
24XLWH	Belt	10000	.25	2.16	3.00	1380	1398	2993	8806	20%	64%	1%	67	0.88	147
30XLWH	Belt	10000	.25	1.34	1.50	768	1061	1939	6132	32%	62%	1%	67	1.38	118
36XLWH	Belt	10000	.25	1.07	1.50	550	895	1357	5255	40%	59%	9%	71	1.70	142
42XLWH	Belt	10000	.25	1.16	1.50	421	870	1003	4684	37%	47%	17%	67	1.58	188
48XLWH	Belt	10000	.25	1.32	1.50	373	650	779	4723	33%	37%	30%	71	1.40	228
54XLWH	Belt	10000	.25	1.30	1.50	283	611	617	4019	33%	36%	32%	71	1.41	272
60XLWH	Belt	10000	.25	1.61	2.00	247	550	500	3896	26%	28%	43%	75	1.16	338
30XMWH	Belt	10000	.25	1.24	1.50	988	1175	1939	7889	35%	67%	1%	71	1.49	121
36XMWH	Belt	10000	.25	.919	1	627	948	1357	5991	47%	69%	3%	-	1.95	142
42XMWH	Belt	10000	.25	.861	1	444	821	1003	4940	50%	63%	6%	-	2.07	188
48XMWH	Belt	10000	.25	1.05	1.50	394	726	779	4989	41%	47%	22%	71	1.73	234
54XMWH	Belt	10000	.25	1.13	1.50	296	558	617	4203	38%	42%	28%	71	1.62	279
60XMWH	Belt	10000	.25	1.03	1.50	261	530	500	4116	42%	45%	30%	80	1.77	305

Benefits of FEI

Clarity

- FEI includes effect of losses from fans, motors, and drives
- FEI rating allows instant identification of compliance

Flexibility

- Fan selections allow variety of fan types, sizes, motors, and drives
- Facilitates consideration of budget, acoustics, form factor, etc.

Simplicity

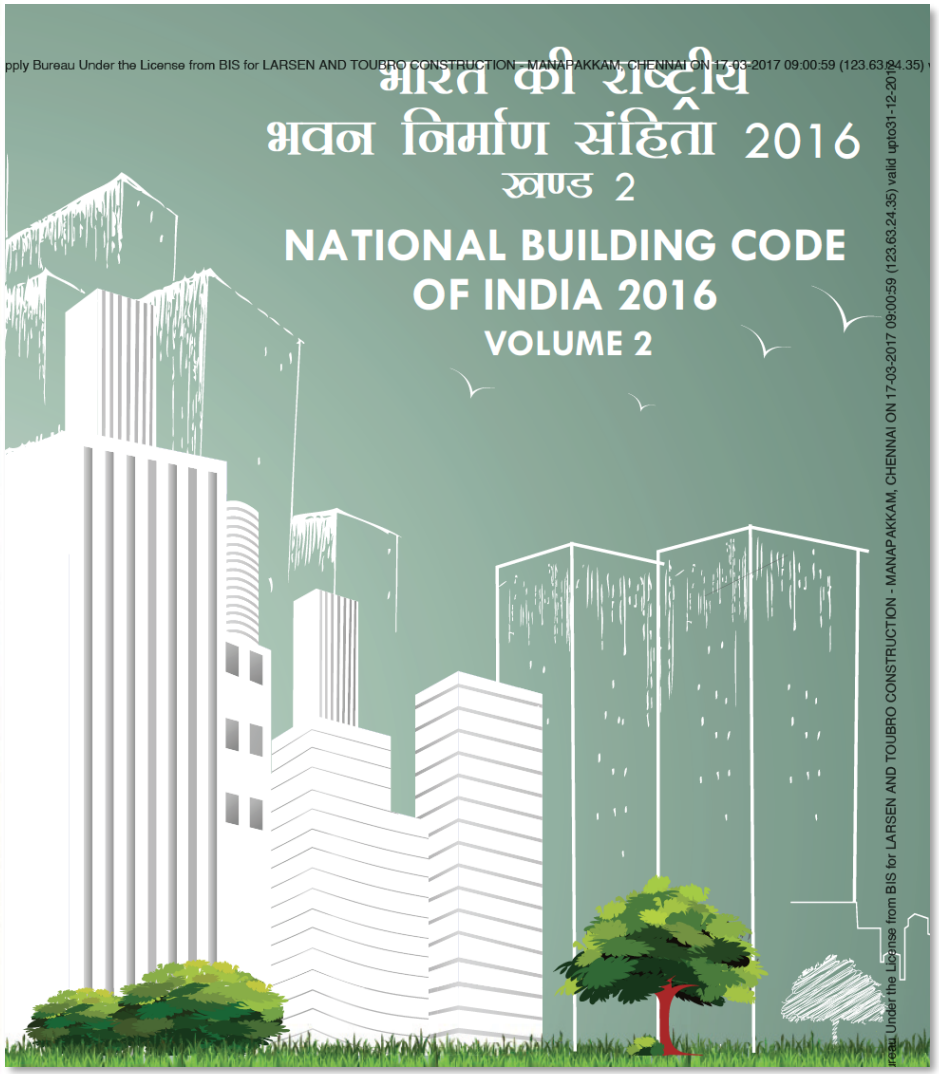
- Intuitive metric that directly reflects power consumed by the fan

Greater energy savings

- Net result is greater energy savings and lower lifecycle cost

India Building Code

Michael Ivanovich



भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS

MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG, NEW DELHI 110002
Phone: + 91 11 23230131, 23233375, 23239402 Extn 4402; Fax: + 91 11 23235529

DRAFT IN WIDE CIRCULATION

DOCUMENT DESPATCH ADVICE

Reference	Date
CED 46/T-16	31 July 2016

TECHNICAL COMMITTEE:
NATIONAL BUILDING CODE SECTIONAL COMMITTEE, CED 46

Download at: www.asiaamca.org/download/National_Building_Code_of_India_2016_Vol_2.zip

Significant Modifications

m. Ventilation has now taken the centre-stage for sustainability in design, construction and operation of buildings.

n. Installation practices for the air conditioning, heating and mechanical ventilation system have been modified to suite the vast options of components now available.

Fan Efficiency Provisions

- 11.7 Selection of Fans for Mechanical Ventilation

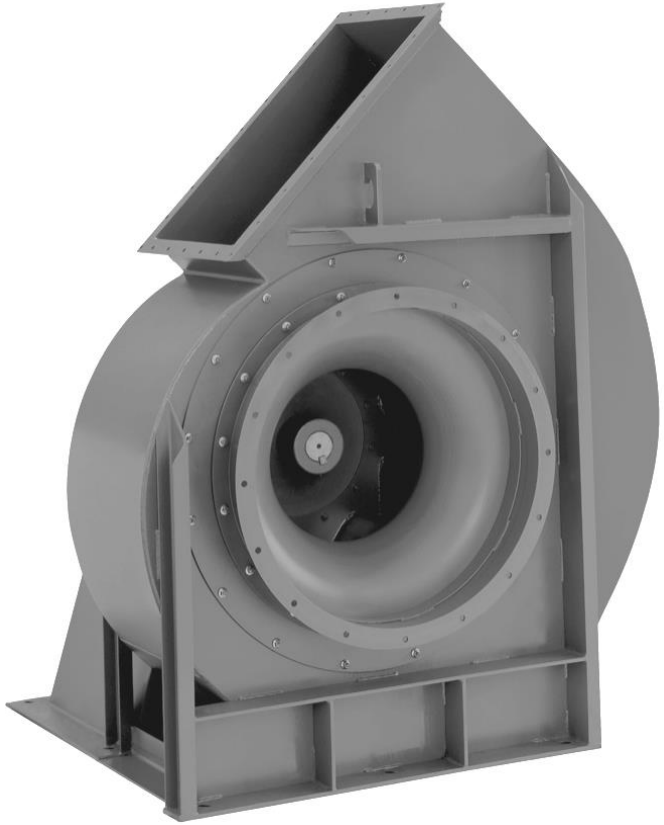
  A fan should be selected so that its efficiency at the required point of operation is the highest possible from a range of selections. This will not only ensure minimum motor power and low energy cost but will also normally result in the quietest operation.

- 11.7.1 Fan Efficiency Requirement
  - Recommends not using tube axial fans as supply fans
  - Prefers use of vane axial fans over tube axial fans
  - Requires mechanical ventilation fans to meet a specific FEG minimum ratings:

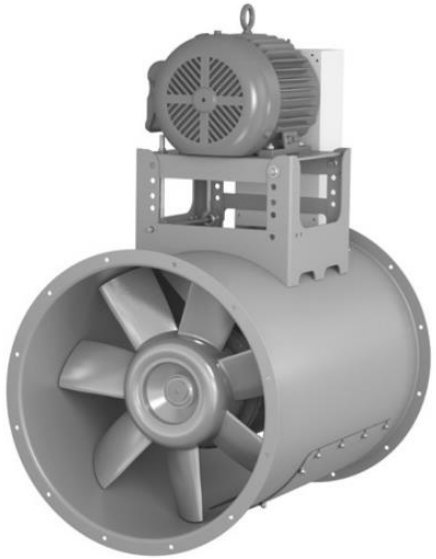
    a) For tube axial fans requiring a shaft power of 2.5 kW or more, the fan efficiency grade shall be FEG 60 or more.

    b) For centrifugal and vane axial fans requiring a shaft power of 2.5 kW or more, the fan efficiency grade shall be FEG 71 or more.

Vane Axial vs Tube Axial



Centrifugal Fan



Tube Axial Fan

Vane Axial Fan

Vane Axial Fan
(reverse, showing vanes in red)

Picture courtesy of Twin City Fan

Fan Efficiency Provisions

- 11.7.1 Fan Efficiency Requirement
  - Sets the sizing/selection window at “10 percentage points of the peak value.”

    The operating total efficiency at the selected point of operation for a given application shall be within 10 percentage points of the peak value.

- Small thing:
  - Operating total efficiency at the selected point of operation must be within 10 percentage points of the **fan’s peak total pressure**

Fan Efficiency Provisions

- 7.2.3.9 Air Handling Units…7.2.3.9.2 Fan
- For AHUs requiring a shaft power of 2.5 kW or greater (see Section 11.7.1)

…For example, for a fan of size 800 mm with a peak total efficiency of 75 percent (FEG 80), the operating total efficiency shall be between 65 and 75 percent.

Some Other Provisions Impacting Fan Efficiency

- 7.2.8 Ductwork, Air Distribution and Fan-System Interface
  - AWESOME guidance – on inlet, outlet, and cabinet conditions
- 11.3, 11.4 – Car Park and Tunnel Ventilation
- 12.2.2 Energy Efficient Installation of Ventilation Fans
  - THANK YOU for covering system effect so thoroughly
- 15.4 Readiness for Commissioning

FEI and FEG in ASHRAE Standards

Tim Mathson

ASHRAE 90.1-2013,2016 Language

- FEG ≥ 67, based on AMCA Standard 205
- FEG selected at selected to operate with 15 percentage points of peak total efficiency
- Covered
  - Standalone fans (including PRVs) ≥ 5.00 HP (4.1 kW)
  - Embedded fans and fan arrays > 5.0 HP (4.1 kW)
- Exempt
  - Fans embedded in equipment that is regulated or 3rd party-certified for air performance or energy performance
  - Fans intended to operate only during emergency conditions
  - Powered roof and wall ventilators
  - Fans listed in Section 6.4.1.1 (minimum efficiency tables)
  - Fans not in scope of AMCA 205

ASHRAE 189.1-2014, 2017 Language

- Decreases sizing/selection window to 10 percentage points from peak total efficiency
- No other changes

`ASHRAE 90.1-2019 Language

- FEI ≥ 1.00; FEI ≥ 0.95 for VAV
- FEI calculated at “fan system design conditions”
- Covered
  - Standalone fans (including PRVs) ≥ 1.00 HP (0.89 kW)
  - Embedded fans and fan arrays > 5.0 HP (4.1 kW)
- Exempt
  - Fans embedded in equipment that is regulated or 3rd party-certified for air performance or energy performance
  - Reversible tunnel ventilation fans and ceiling fans
  - Fans for high temperatures, explosive atmospheres, or emergency conditions
  - Fans listed in Section 6.4.1.1 (minimum efficiency tables)
  - Fans not in scope of AMCA 208

ASHRAE 189.1-2020 Language

- FEI ≥ 1.10 for covered fans
- Level does not change for constant or variable speed
- No other changes

Comparison of India Building Code with ASHRAE Standards

Publication	Fan Efficiency Metric	Minimum Requirement	Sizing/Selection Window*	Minimum Motor Size
ASHRAE 90.1** 2013, 2016	FEG	67	15 ppts	4.1 kW
ASHRAE 189.1 2014, 2017	FEG	67	10 ppts	4.1 kW
India Building Code	FEG	70 - centrifugal, vane axial 60 - tube axial	10 ppts	2.5 kW
ASHRAE 90.1** 2019	FEI	1.00 - CV 0.95 - VAV	Not applicable	0.89 kW (electrical input power)
ASHRAE 189.1 2020	FEI	1.10 – CV & VAV	Not applicable	0.89 kW (electrical input power)

* Units for sizing/selection window is percentage points from peak total efficiency

** ASHRAE 90.1 provisions have a lot of detail for exemptions, fan arrays, etc. that carry over to 189.1

Conclusion, Summary, Resources

Michael Ivanovich

Conclusions and Summary

- FEI replaces FEG effective ASHRAE 90.1-2019, ASHRAE 189.1-2020
- FEI is an extended-motor-driven-system metric
  - Wire-to-air
  - Covers motors and drives, not just the fan
  - Part-load and full-load
- Calculated using fans rated in static or total pressure
- Leads to better selections
  - Fans running more efficiently over more operating points
- Must comply with India Building Code using FEG and sizing/selection window
- But might be able to get a better selection using FEI and selecting FEG-compliant fan

Conclusions and Summary

- India Building Code has provisions not found in ASHRAE standards
  - Inlet and outlet conditions
  - System effect
  - Monitoring
  - Acoustics
- AMCA is working with others on 90.1 Mechanical Subcommittee to bring system effect into 90.1
- India's other provisions may be of interest to ASHRAE 90.1, as well

- THANK YOU!

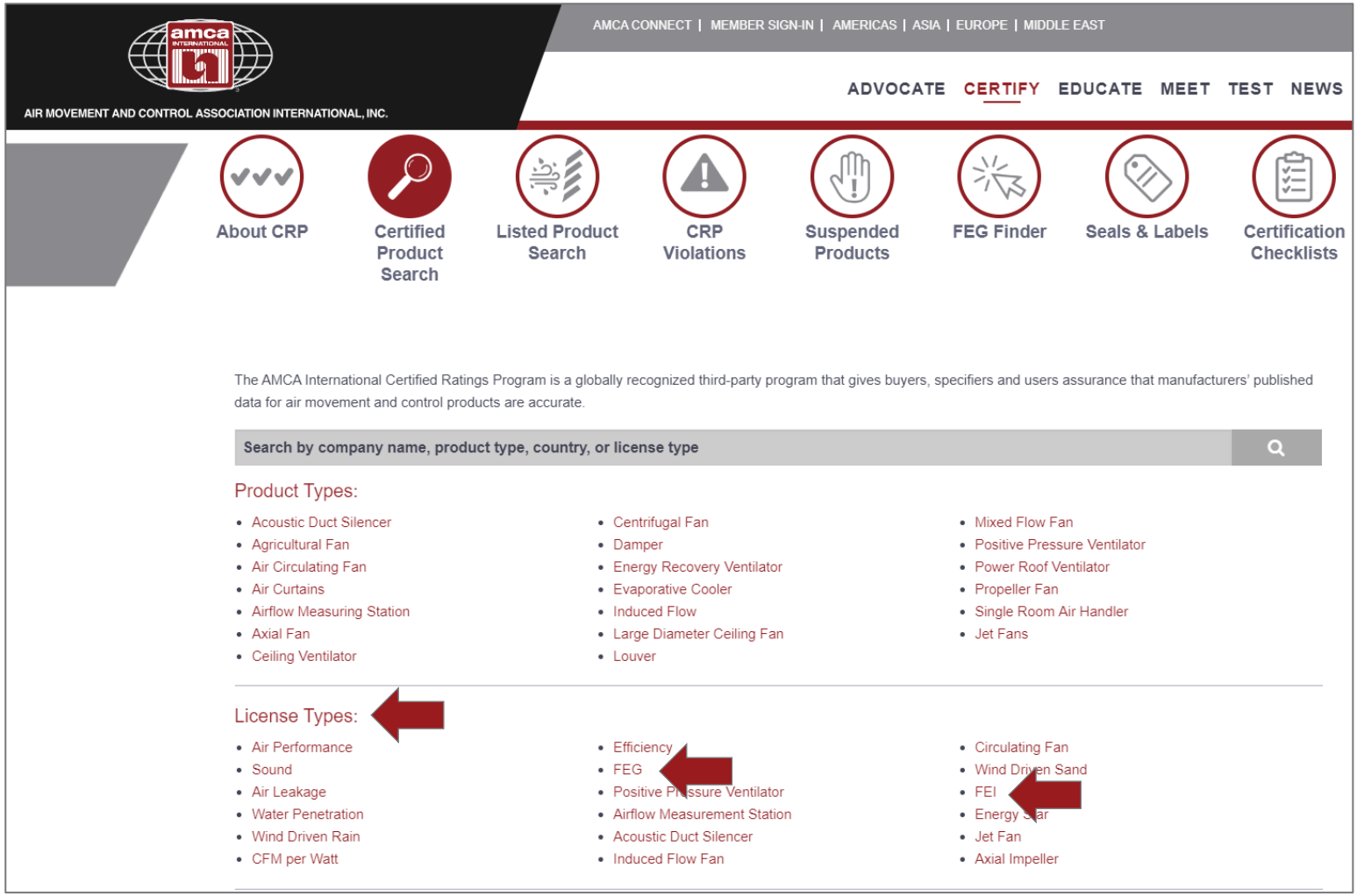
AMCA Certified Ratings Program (CRP)

amca WORLDWIDE CERTIFIED RATINGS
SOUND AND AIR PERFORMANCE
FEG FAN EFFICIENCY GRADE CERTIFIED
AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC.®
www.amca.org

amca WORLDWIDE CERTIFIED RATINGS
SOUND AND AIR PERFORMANCE
FEI FAN ENERGY INDEX
AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC.®
www.amca.org

AMCA Certified FEI and FEG Ratings

- AMCA certifying fans and manufacturer software for FEI
- Check for FEI & FEG certifications at **www.amca.org/certify**
  - Click on “Certified Product Search” and search by “license type”
- FEI Ratings found using manufacturer’s sizing/selection software
- FEG ratings in software and catalogues



Resources

- **AMCA International**: *www.amca.org*
- **AMCA Certified FEI ratings**: *www.amca.org/certify*
- **ANSI/AMCA Publications & Standards:** *www.amca.org/store* (available for purchase)

  > 208-18: Calculation of the Fan Energy Index

- **AMCA microsite for FEI training, technical papers, PowerPoints, and regulatory status**: *www.amca.org/fei*
- **ASHRAE 90.1-2019:** *www.ashrae.org/bookstore*

Questions?

THANK YOU!

Contact:
Michael Ivanovich
mivanovich@amca.org

Sizing/Selection Example

- ASHRAE 90.1-2019:
  - FEI ≥ 1.00 at fan system design conditions (duty point)
  - FEI ≥ 0.95 for VAV

  - **Air flow rate**: 18,000 cfm (8.50 m^3/s)
  - **Air pressure (static):** 5.4 in. w.g. (1,345 pascal)
  - **Air density:** Standard (sea level)

  - For constant flow, duty point is at 100% flow
  - For VAV, hypothetical duty points are:
    - **40% flow:** 7,200 cfm (4.25 m^3/s)
    - **70% flow:** 12,800 cfm (5.95 m^3/s)
    - **100% flow:** 18,000 cfm (8.50 m^3/s)

Example Constant Flow

FEI ≥ 1.00

Impeller diameter in (mm)	Fan Impeller Type (all double width)	FEI @ 100% Flow
18 (464)	Airfoil	0.90
20 (508)	Airfoil	1.05
22 (565)	Airfoil	1.13
24 (622)	Airfoil	1.23
27 (686)	Airfoil	1.21
18 (464)	Backward inclined	0.82
20 (508)	Backward inclined	0.93
22 (565)	Backward inclined	1.05
24 (622)	Backward inclined	1.16
27 (686)	Backward inclined	1.17

Example VAV

FEI ≥ 0.95

Impeller diameter in (mm)	Fan Impeller Type (all double width)	FEI @ 40% Flow	FEI @ 70% Flow	FEI @ 100% Flow
18 (464)	Airfoil	1.05	0.89	0.90
20 (508)	Airfoil	1.17	1.06	1.05
22 (565)	Airfoil	1.21	1.15	1.13
24 (622)	Airfoil	1.24	1.25	1.23
27 (686)	Airfoil	1.20	1.23	1.21
16 (406)	Backward inclined	1.05	0.83	OVERSPEED
18 (464)	Backward inclined	1.02	0.90	0.82
20 (508)	Backward inclined	1.11	0.94	0.93
22 (565)	Backward inclined	1.21	1.12	1.05
24 (622)	Backward inclined	1.22	1.18	1.16
27 (686)	Backward inclined	1.19	1.20	1.17

Guidance for VAV Systems

- Because slowing a fan's rotational speed generally increases the FEI rating:
  - Best duty point for VAV is hottest day of year, needing 100% airflow.
  - Select fan to have an acceptable FEI rating at the 100% flow rate.
  - This will ensure fan is compliant at loads below 100% flow rate.
- If the fan meets the FEI requirement at the peak condition:
  - Fan likely to meet the FEI requirement at lower flow conditions.
- Ensure fan will avoid surge and overspeed at all operating points.

What is the right selection?

- All fans with FEI ≥ 1.00 (CS) or 0.95 (VAV) are compliant
- Free to consider other decision criteria:
  - Form factor
  - Weight
  - Budget
  - Energy cost
  - Acoustics
  - Availability

Changes to slides

- 3 “directed”
- 8 reordered build
- 10 labels
- 18 legend
- 25 need to rework the builds on this slide (I did not do this)
- 37, 38 hp to kW
- 56 rewording
- 58 reformat