AMCA ASET Webinar Series

Fan Energy Index - Changing Our Industry

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Michael Ivanovich

Senior Director, Global Affairs
AMCA International

Webinar Moderator

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Introductions & Guidelines

- Today's Presenters:
  - Michael Ivanovich
  - Tim Mathson
  - Mark Bublitz
- Participation Guidelines:
  - Audience will be muted during the presentations
  - 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!
  - To earn PDH credit for today, please stay clicked onto the webinar.
  - A post-webinar evaluation will be emailed to everyone and must be completed to qualify for today's PDH credit.

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FEI- Changing Our Industry

Purpose and Learning Objectives

The purpose of this webinar is to inform AMCA members and industry professionals on the Fan Energy Index (FEI) Metric that is replacing Fan Efficiency Grade (FEG) in energy codes, standards, and regulations.

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

1. Describe the characteristics of the Fan Energy Index and how they represent fan efficiency.
2. Outline how Fan Energy Index is defined in AMCA Standard 208, Calculation of the Fan Energy Index for fan ratings.
3. Identify how FEI can be applied in VAV and constant-speed air systems.
4. Explain how FEI is replacing FEG in model energy codes and standards, including ASHRAE 90.1-2019.

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Webinar Outline

- Tim: Benefits of Fan Energy Index (FEI)
- Tim: How FEI is calculated by manufacturers from test data
- Mike: How FEI is applied in Constant Speed air systems
- Mike: How FEI is applied in VAV systems
- Mike: AMCA-certified FEI ratings
- Mark: Status and timeline of FEI in Codes, Standards, Regulations
- Mark: Conclusions and Wrap-up
- All: Questions?

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Tim Mathson

Principal Engineer, AMCA International

FEI Technical Overview & Practical Application

- Joined AMCA July 29, 2019
- 30-yrs fan designer/engineer at Greenheck
- Chaired AMCA 208 Committee, Fan Engineering Committee

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FEI – Fan Energy Index

- **Introduction to FEI**
- **Benefits of FEI**
  - Reflects energy consumption
  - Establishes compliant range of operation
  - Provides comparison tool for fan selection
- **Aspects of FEI calculation**

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FEI – Fan Energy Index

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

- Both calculated at the same output power…duty point
- FEI is a relative measure of power required for a given duty point – relative to the *Reference Fan*

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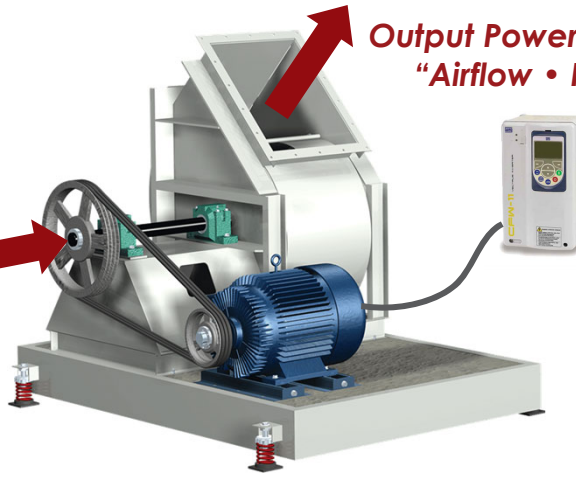
Wire-to-Air Metric



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Wire-to-Air Metric

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Fan Energy Index Establishes a Compliant Range of Operation

- Codes: ***minimum FEI requirement at the duty point***
  - USA: FEI ≥ 1.00
- Duty point:
  - Airflow,
  - Total or static pressure, depending on fan type
  - Air density
- FEI emphasizes proper fan sizing and selection

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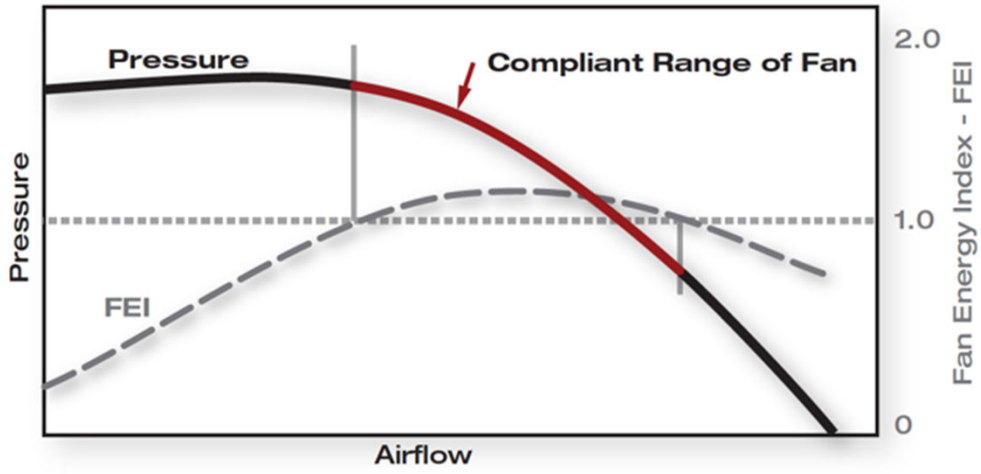
Compliant Range (FEI ≥ 1.00)

For a fan at a single fan speed



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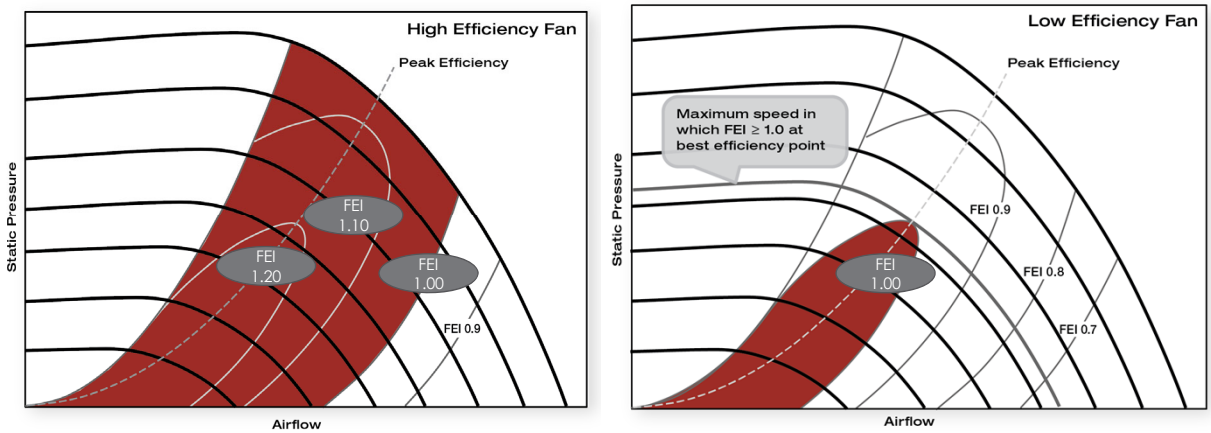
Compliant Range (FEI ≥ 1.00)

For a fan at multiple speeds



EFFICIENT FAN

INEFFICIENT FAN

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Comparison of Fan Selections – A vs. B

For a given duty point, $FEP_{ref}[A] = FEP_{ref}[B]$

$$FEI\ [A] = \frac{FEP_{ref}\ [A]}{FEP_{act}\ [A]} \qquad FEI\ [B] = \frac{FEP_{ref}\ [B]}{FEP_{act}\ [B]}$$

Higher FEI means lower power consumed

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Comparison of Fan Sizes

Duty Point 10,000 cfm at 3" P_t (4.72 m^3/s at 750 Pa)

Fan Size	Fan Speed (rpm)	Fan Shaft Power (bhp / kW)	FanTotal Efficiency (%)	FEP_{act} (kW)	FEP_{ref} (kW)	FEI	
18	3,238	11.8 / 8.80	40.1	10.0	7.14	0.71	
20	2,561	9.56 / 7.13	49.5	8.16	7.14	0.87	
22	1,983	8.02 / 5.98	59.0	6.88	7.14	1.04	Compliant
24	1,579	6.84 / 5.10	69.1	5.91	7.14	1.21	
27	1,289	6.24 / 4.66	75.8	5.41	7.14	1.32	
30	1,033	5.67 / 4.23	82.5	4.93	7.14	1.45	Best
36	778	6.01 / 4.48	78.7	5.22	7.14	1.37	

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FEI Distinguishes Static and Total Pressure

Static Pressure Basis

- Unducted fans
  - PRV's
  - Unhoused centrifugal fans

Total Pressure Basis

- Ducted fans
  - Housed centrifugal
  - Inline centrifugal
  - Tube Axial and Vane Axial
- Useful outlet velocity pressure
  - Lab exhaust
  - Air circulator

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FEI Calculation – Wire-to-Air

- Measured electrical input power

- Measured shaft input power
  - Regulated 3 phase motors – AMCA 207
  - Tested motors and/or speed controllers – various standards
  - Default motor and drive losses

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Benefits of FEI

Clarity
- FEI covers fans, motors, and drives --- "fan system" efficiency rating
- FEI rating allows instant identification of compliance

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

Simplicity
- Intuitive metric that directly reflects power consumed by the fan

Greater energy savings
- Benefits above mean greater energy savings and lower lifecycle cost

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Michael Ivanovich

Senior Director, Global Affairs, AMCA International

Application of FEI in Constant Speed Air Systems and VAV Systems; FEI-Certified Ratings

- 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

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How FEI Can Be Used by Engineers

- Fan selections based on engineer's selected duty point
- You'll hear FEI described as an "operating point metric"
- Design Point of Operation = Duty Point = Selection Criteria
  - **Airflow** at most important design point
  - **Static or total pressure** (depending on fan type)
  - **Air density** of the installation location (altitude an important factor)

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Example:

- **FEI requirement is FEI ≥ 1.00 at engineer's selected duty point:**
  - **Air flow rate**: 18,000 cfm (8.50 m^3/s)
  - **Air pressure:** 5.4 in. w.g. (1,345 pascal)
  - **Air density:** standard (sea level)

  - For constant flow, duty point is at 100% flow
  - For VAV:
    - **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)

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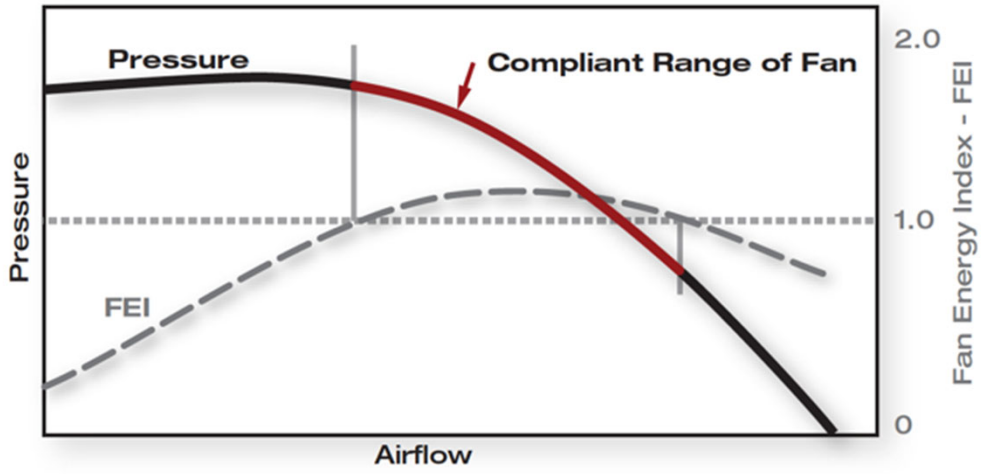
Remember: Compliant Range (FEI ≥ 1.00)

For a fan at a single fan speed



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Example Constant Flow

Manufacturer's software output

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

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Example Constant Flow

Impeller diameter in (mm)	Fan Impeller Type (all double width)	FEI @ 100% Flow
18 (464)	Airfoil	0.90
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27 (686)	Backward inclined	1.17

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What is the right selection?

- All fans with FEI ≥ 1.00 are compliant with requirement
- Free to consider other decision criteria:
  - Form factor
  - Weight
  - Budget
  - Energy cost
  - Acoustics
  - Availability

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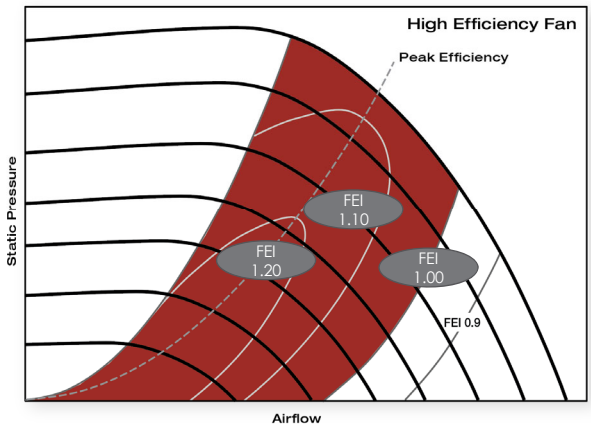
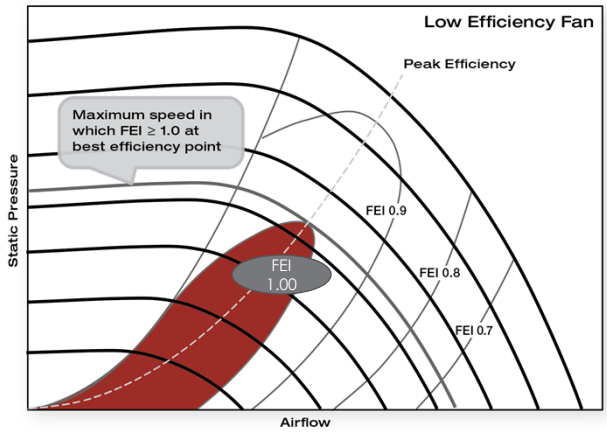
Remember:
Compliant Bubbles (FEI ≥ 1.00) for Centrifugal Fan with Speed Control



EFFICIENT FAN



INEFFICIENT FAN

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Example VAV

For VAV, 3 design points:

- 100% Flow
- 70% Flow
- 40% Flow

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

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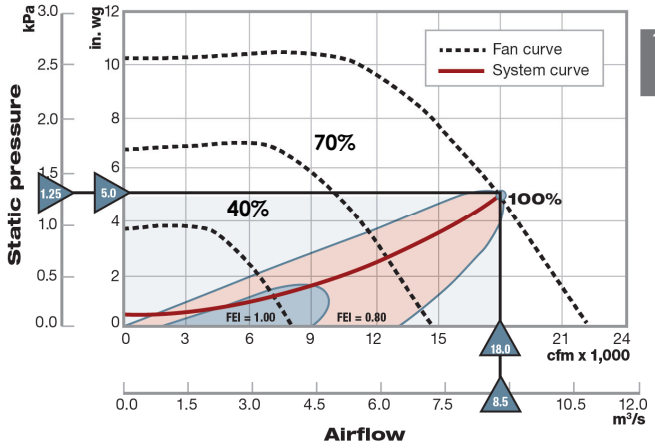
18-in. Backward-Inclined Fan is Non-Compliant at 70% and100% Flow



18 (464)	Backward inclined	40% 1.02	70% 0.90	100% 0.82

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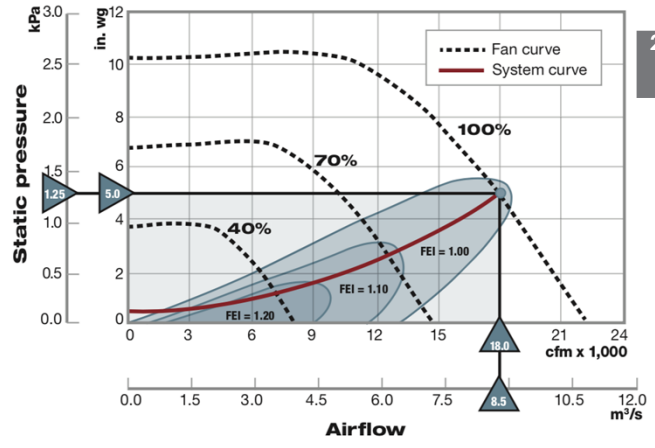
22-in. Backward Inclined Fan is Compliant at 40%, 70% and 100%



22 (565)	Backward inclined	40% 1.21	70% 1.05	100% 1.05

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Which Selection is Best?

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
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What is the right selection?

- All fans with FEI $\geq$ 1.00 are compliant with requirement
- Free to consider other decision criteria:
  - Form factor
  - Weight
  - Budget
  - Energy cost
  - Acoustics
  - Availability

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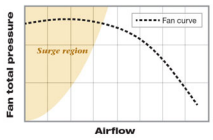
Structural Considerations

Avoid!

- Fans too large that would operate in the surge region



- Fans too small would have to operate at speeds to fast
  - Wastes energy and noisy
  - Possible structural problems with fan

Do!

- Select largest impeller not in surge
  - Or go one size smaller to cover unexpected higher static pressure
- Follow manufacturer guidance on overspeed conditions

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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

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Guidance for VAV Systems

- If the fan meets the FEI requirement at the peak condition, it likely will meet the FEI requirement at lower flow conditions
- Ensure fan will avoid surge and overspeed at all operating points

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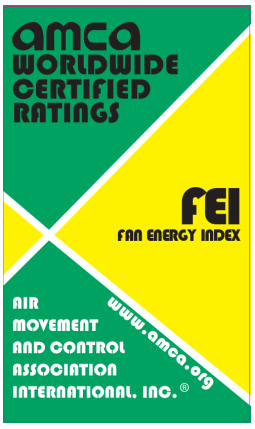
AMCA Certified Ratings Program: FEI

- AMCA certifying fans and manufacturer software for FEI
- FEG certifications will continue
- Check for FEI certifications at www.amca.org/certify
- Expect surge in summer / fall 2019
- Industry awaiting finished codes and standards



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Mark Bublitz

Chair, AMCA Fan Regulation Committee

FEI Advocacy & Current Regulatory Developments and Initiatives

- Current member of AMCA Board of Directors
- Chair of AMCA Engineering Standards Committee
- Member of ASHRAE, ASME

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FEI in Codes, Standards & Regulations

- Model energy **standard** → ASHRAE 90.1
- Model energy **code** → International Energy Conservation Code (IECC)
- Model high-performance building (green) building **standard/code** → ASHRAE 189.1 / International Green Construction Code (IGCC)
- **State** building energy **codes** → California Title 24; states that adopt ASHRAE 90.1 or IECC
- **Federal** appliance **regulations** → U.S. Dept. of Energy
- **State** appliance **regulations** → California, NY, CO, etc.

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FEI in Codes, Standards & Regulations

Publication	Publication Type	Edition	Status	Expected Completion	Effective Date
ASHRAE 90.1	Model Standard	2019	Awaiting ANSI	August 2019	Upon publication, but needs to be adopted to have affect
ASHRAE 189.1	Model Standard	2020	Awaiting Public Review	June 2020	Upon publication, but needs to be adopted to have affect
IECC	Model Code	2021	Awaiting Final Action Hearing	November 2019	Upon publication, but needs to be adopted to have affect
Connecticut Energy Code	State Code	2020	Awaiting first hearing on IECC-2018, July 10	August 2019. May move FEI into 2018!	October 2020.
Florida Energy Code	State Code	2020	Passed first hearing	2020	
Calif. Title 24	State Code	2022	Just Starting	2021	2022

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FEI as a Regulatory Metric

- Replacing Fan Efficiency Grade (FEG) in model codes and standards
  - **Approved** for ASHRAE 90.1-2019
    - FEI $\geq$ 1.00; 0.95 for VAV
  - Proposed for ASHRAE 189.1-2020
    - Addendum is through subcommittee and full committee
    - Awaiting publication for public review
    - **FEI $\geq$ 1.10**
  - Proposed for International Energy Conservation Code (IECC)-2021
    - Will be finalized in October 2019
    - Equivalent to ASHRAE 90.1

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ASHRAE 90.1-2019 →→ Sneak Peek

- **Requirement**
  - FEI ≥ 1.00 ; 0.95 for VAV, at engineer's selected duty point
  - Promotes use of variable speed fans and compensates for drive losses
- **Covered**
  - Standalone fans (including PRVs) FEI ≥ 1.0 HP or FEI ≥ 0.89 kW
  - Embedded fans and fan arrays FEI ≥ 5 HP or FEI ≥ 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
  - Fans for high temperatures, explosive atmospheres, or emergency conditions
  - Ceiling fans (because of existing federal standard)

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Changes from ASHRAE 2013 and 2016

- Gone:
  - Fan Energy Grade
  - Sizing/selection window of 15 percentage from peak total efficiency
  - Exemption for powered roof ventilators
- Changed:
  - Lower limit of fan size changed from 5 HP to 1 HP
  - FEI is an operating point metric
  - FEI includes motors and drives, if sold with fan
  - FEI recognizes static pressure AND total pressure; not just total

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Conclusions

- Fan Energy Index (FEI) *evolves the Fan Efficiency Grade metric* by absorbing the sizing/selection window; including motors and drives; and recognizing static, as well as, total pressure fan ratings.
- Hence, FEI emphasizes *right-sizing fans*, covers *low-pressure fans*, and eases *compliance and enforcement*.
- *FEI saves more energy*, enables direct calculation of energy savings, and leads to ratings that reflect the actual energy efficiency of the fan system.

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Resources

- AMCA International: **www.amca.org**
- AMCA certifying FEI ratings: **www.amca.org/certify**
- AMCA 208 standard (free for 2019): **www.amca.org/store**
- AMCA microsite for FEI training, technical papers, PowerPoints, and regulatory status: **www.amca.org/fei**

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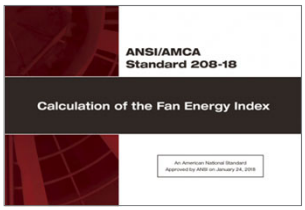
FEI Online Education Modules

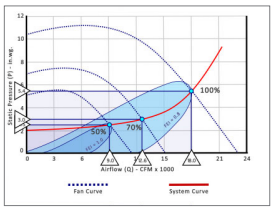
AMCA Introduction to Fan Energy Index (FEI) for Stand-Alone Fans- *FEI 101*

- Self-guided, introductory online course
- Suitable for non-engineers
- Discounted price for AMCA Members
- 1.5 PDH eligible



AMCA Calculating Fan Energy Index (FEI) for Stand-Alone Fans- *FEI 201*

- Self-guided, advanced online course; includes *FEI 101*
- Designed for engineering professionals
- Discounted price for AMCA Members
- 3.5 PDH eligible if taken alone; 5 PDH for 101 & 201 courses



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Attendees will receive an email at the address provided on your registration, listing the total RCEP credit hours awarded and a link to a printable certificate of completion.

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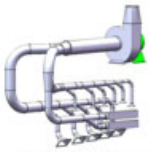
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Questions?

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- Type your question in the box on the right side of your screen & press your Enter key.
- Start your question by naming the presenter who your question is for.

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NEXT PROGRAM!

Join us for our next ASET Webinar:

- Wednesday, October 31
- 1:00-2:00 p.m. CST
- **TOPIC: *Update on Codes, Standards, and Certifications for Louvers and Fire/Smoke Dampers***

- Registration details to be announced soon!
- Promoted in association with *ASHRAE Journal*

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