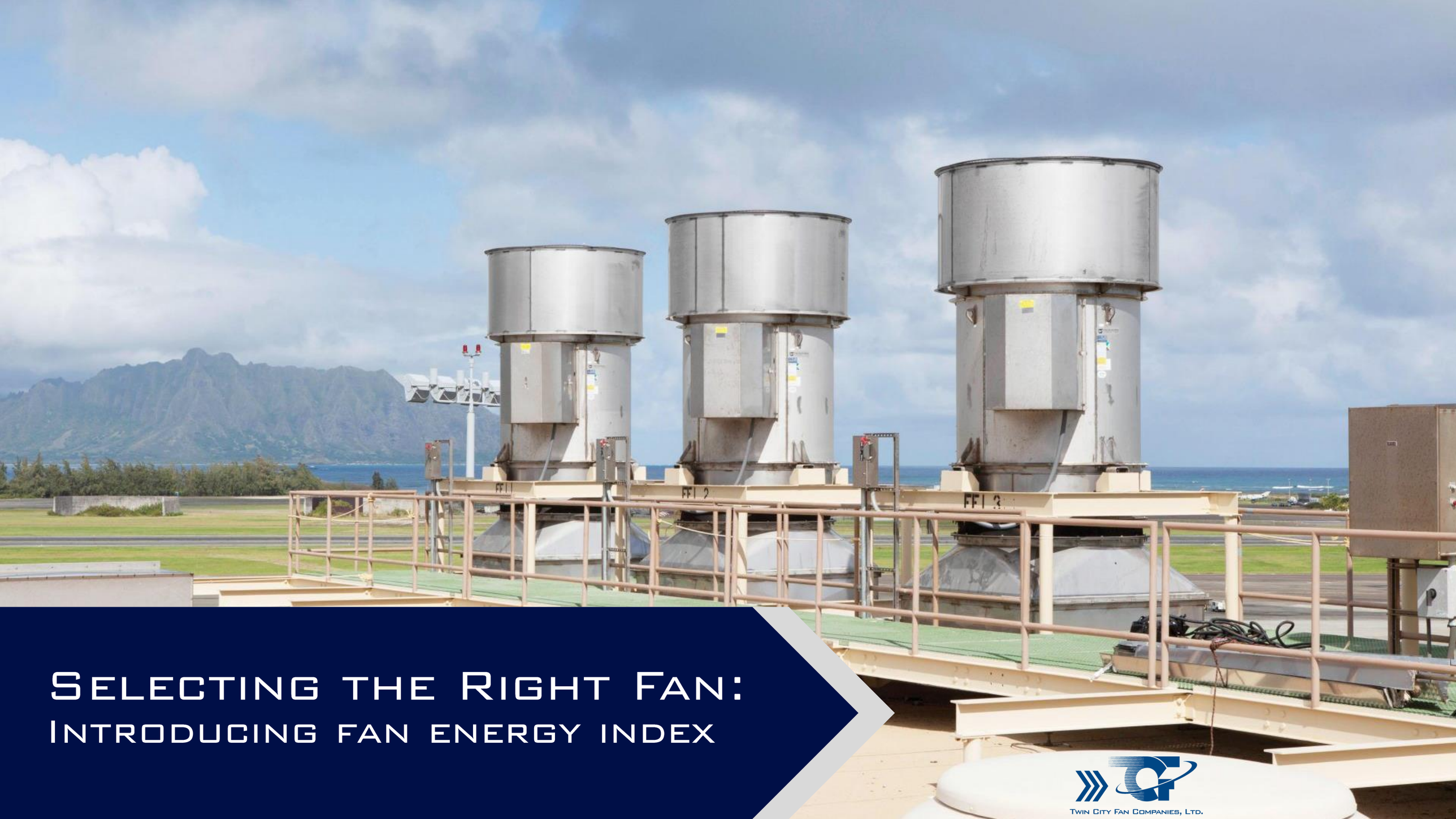


Selecting the Right Fan:
Introducing fan energy index

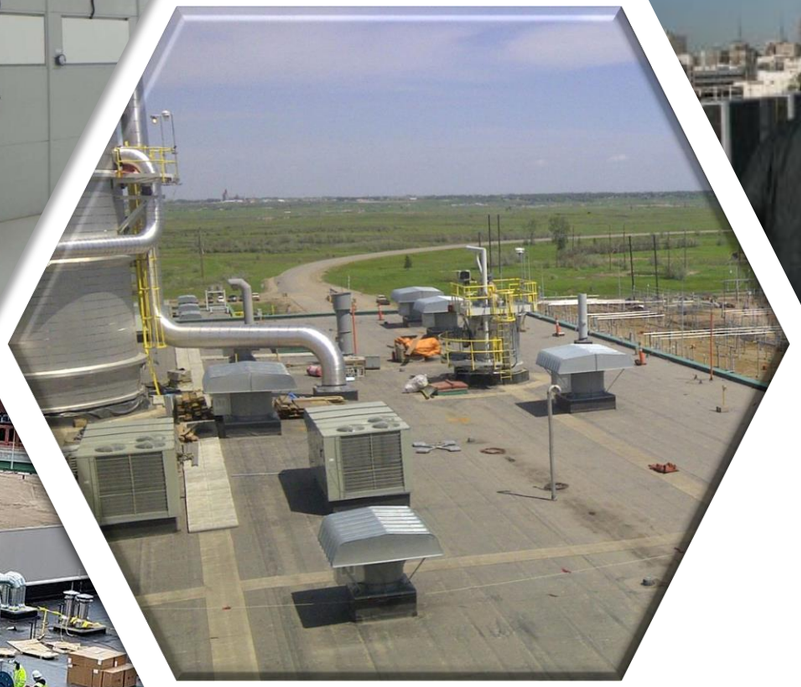
Twin City Fan Companies, Ltd.

Three Takeaways

1. We have a choice -
   - Increasing safety requirements
   - Energy efficiency is more important than ever
2. Regulations are here and more are coming.
3. Every system is different and important. Rely on the experts with your questions.

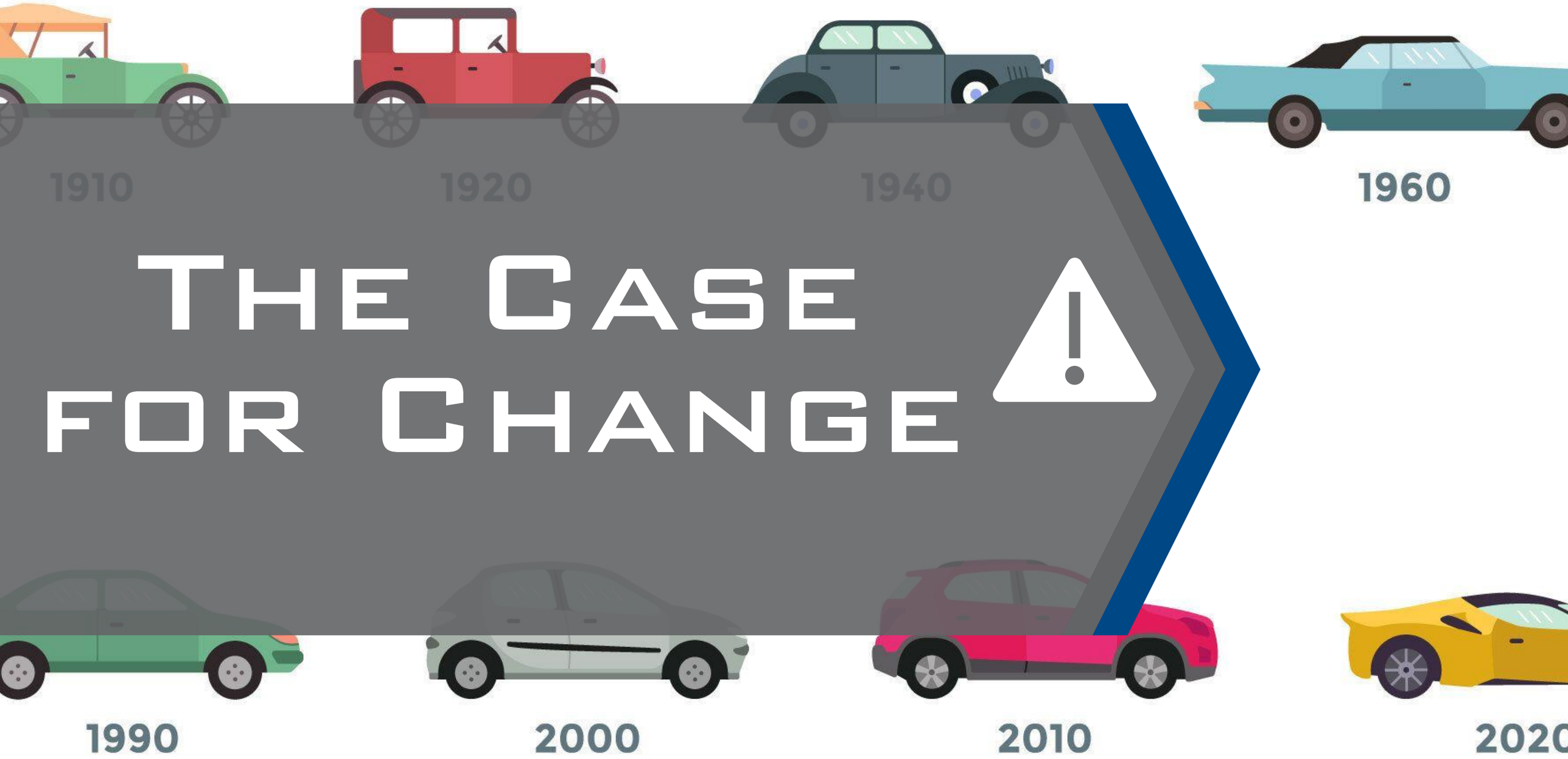
Learning Outcomes

Where Are Fans?



Heart of a System

System

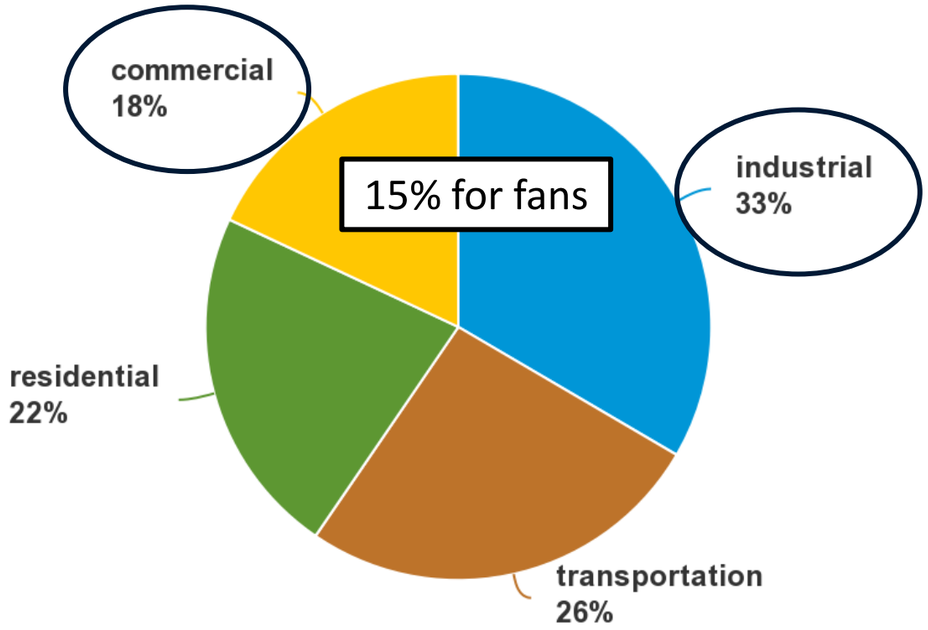


The Case for Change

Energy Consumption

Share of total U.S. energy consumption by end-use sectors, 2020

Total = 92.94 quadrillion British thermal units

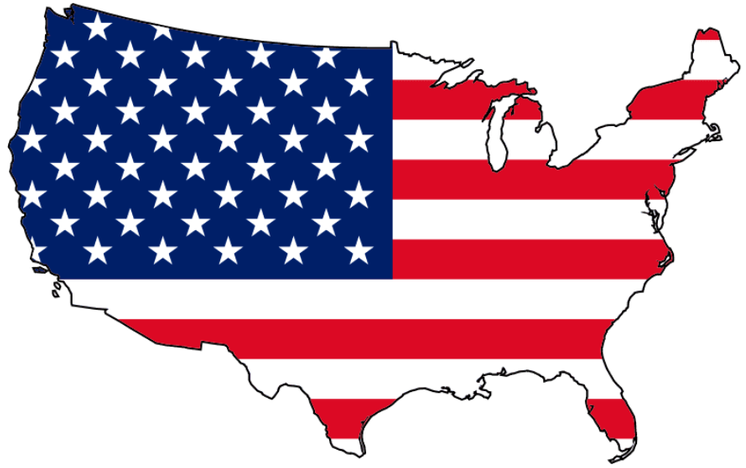


"Commercial and industrial buildings account for approximately 51% of total U.S. energy use."

-U.S. Energy Information Administration, April 2021

Energy Consumption

The yearly consumption of commercial and industrial fans



7.6%

2020 US Energy Consumption

27,238,916,784,001 kWh

What can FEI do? 1% Reduction!

Extra households to power

25.6M Households

- Based on average household consumption of 10,649 kWh / year

Savings

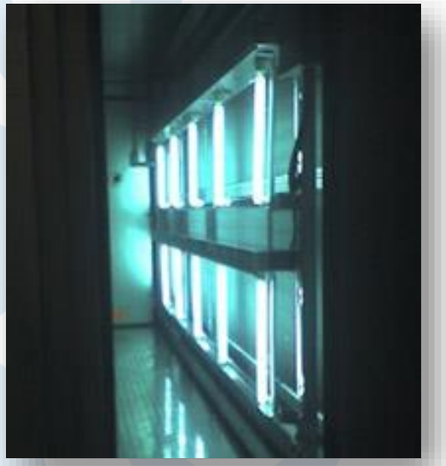
$34.2 Billion

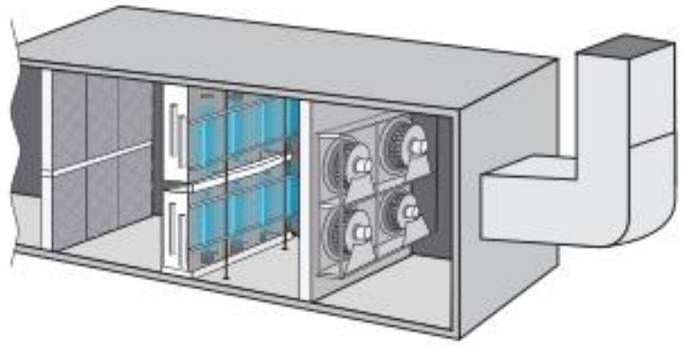
- Based on average US Electricity Rate of 12.55 cents / kWh

Safety – Pandemic

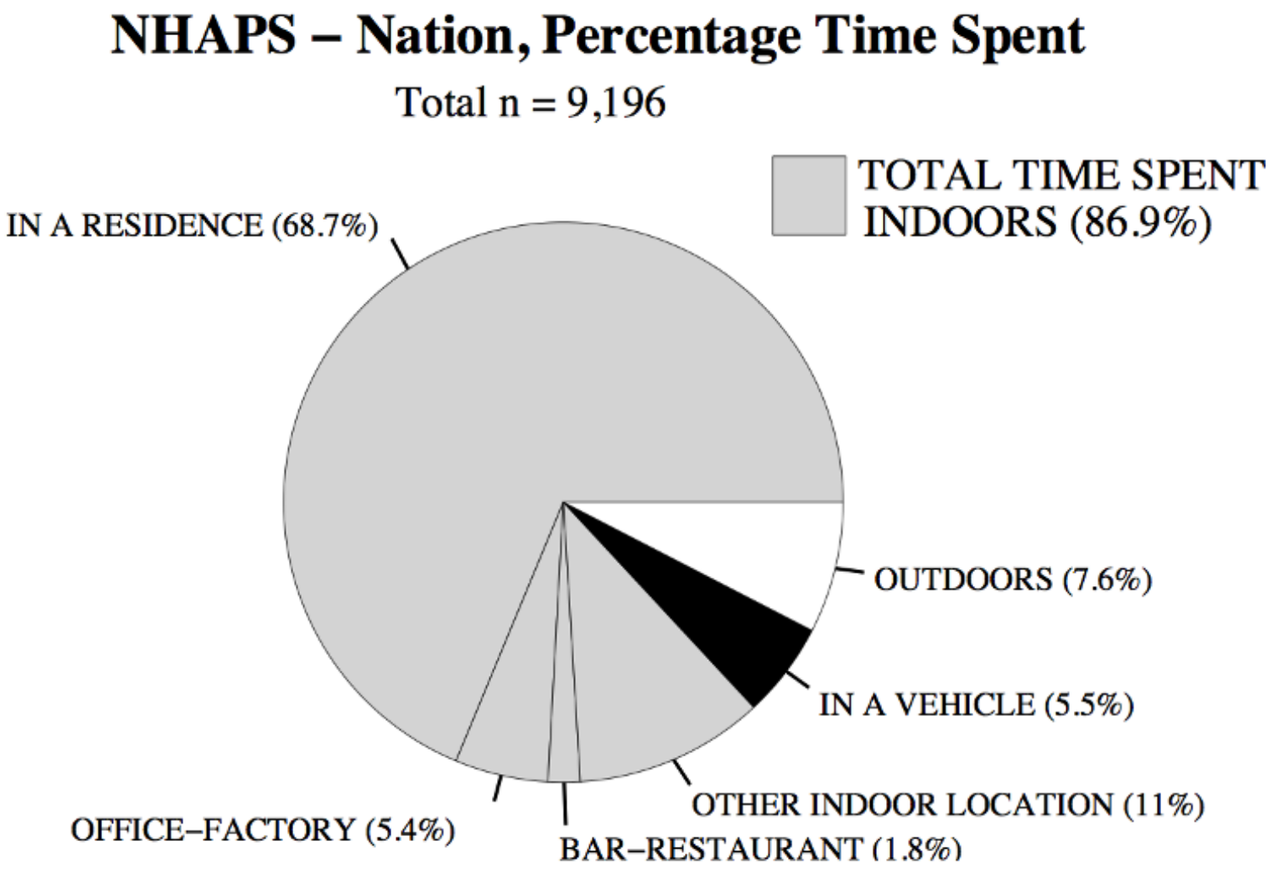
ASHRAE Recommendations for COVID-19

24/7 operation - ASHRAE 62.1 Airflow Recommendations
MERV 13 Filtration
Ultraviolet Germicidal Disinfection
Portable Room Cleaners with HEPA Filter
Increase Outside Air





Safety



National Human Activity Pattern Survey

- Funded by Environmental Protection Agency (EPA)

Indoor Air Quality

Estimated percentage of buildings with complaints related to indoor air quality

Real Consequences

U.S. indirect costs, including missed work and lost productivity

Asthma: $5 Billion / Year

Allergic Rhinitis: $9.7 Billion / Year

- Asthma and Allergy Foundation of America, 2021

Environmental Litigation

Dangerous indoor air quality and sick building syndrome are a **growing** focus of law for lawyers in the areas of personal injury, real estate, construction, homeowner associations and business.

The Case for Change

Fan Regulation

Historical Regulation

AMCA

OSHA

NFPA

Miami-Dade Regulation

OSHPD Regulation

FEG

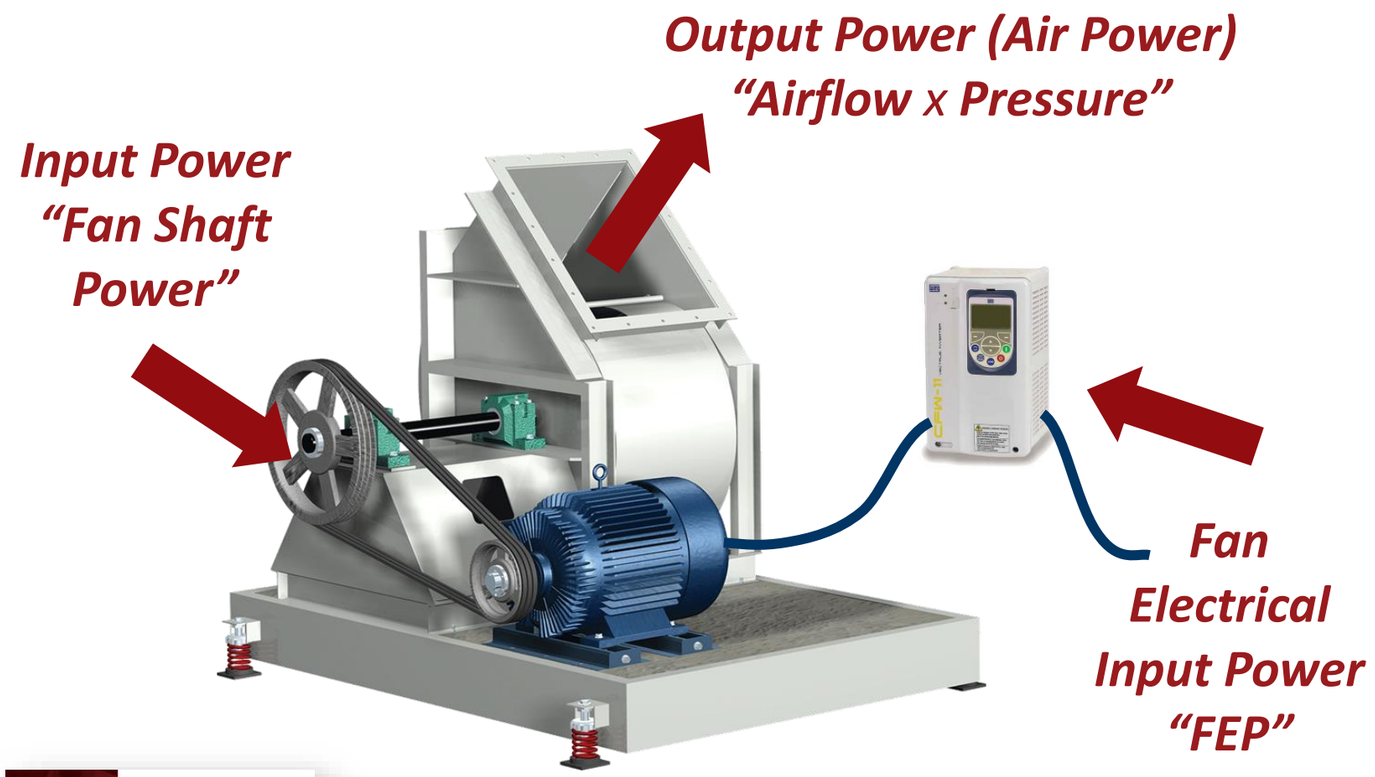
U.S. GREEN BUILDING COUNCIL
LEED CERTIFIED
USGBC

INTERNATIONAL WELL BUILDING INSTITUTE
WELL
TM

Durable And Maintainable Design
Energy Efficiency
Indoor Environmental Quality
Eco Friendly Materials Use
Water Efficiency
Waste Reduction
SUSTAINABLE
GREEN BUILDING

FEI vs. FEG

Wire-to-Air Metric



Fan Energy Index (FEI)

True 'application-based metric'
Not a 'product-based metric' like FEG.

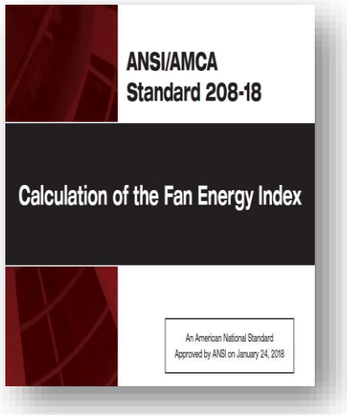
It optimizes system design with proper fan selection.

FEI is a relative measure of power required to satisfy a given duty point – relative to the *Reference Fan*

Reference Fan Power is a 'Virtual Fan Power' and also a function of duty point (Flow x Pressure)

Forces system designers to minimize Pressure

Total Pressure, Pt ~ H (Power) / Q (flow rate)

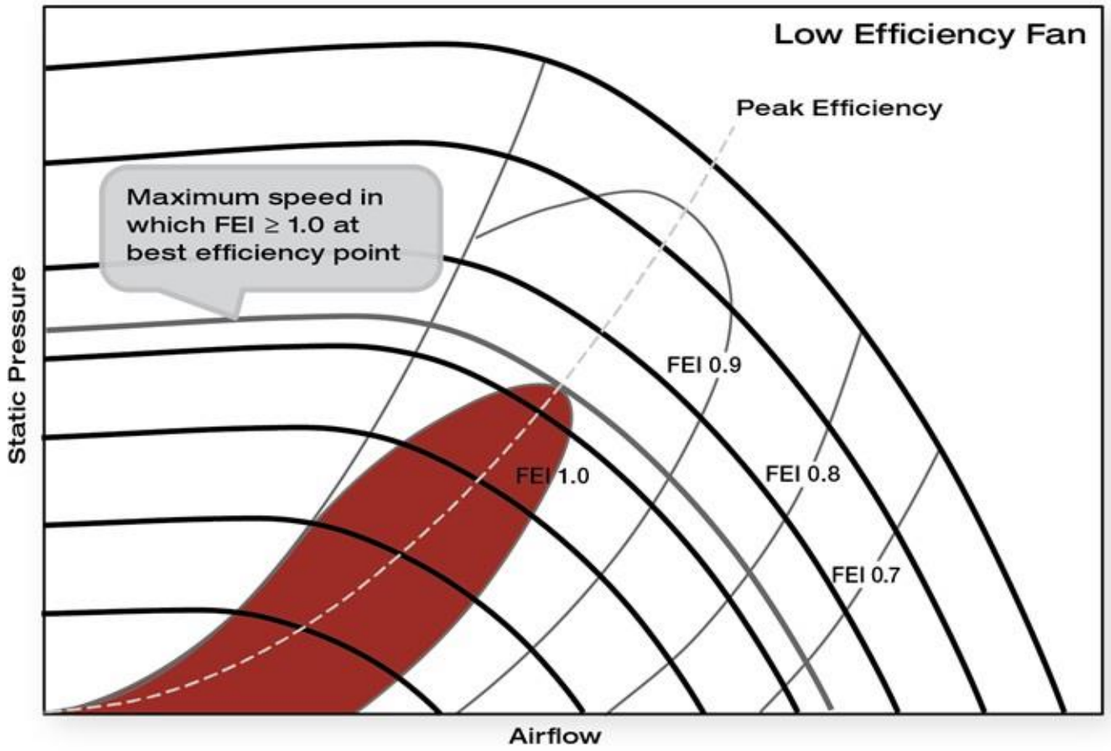


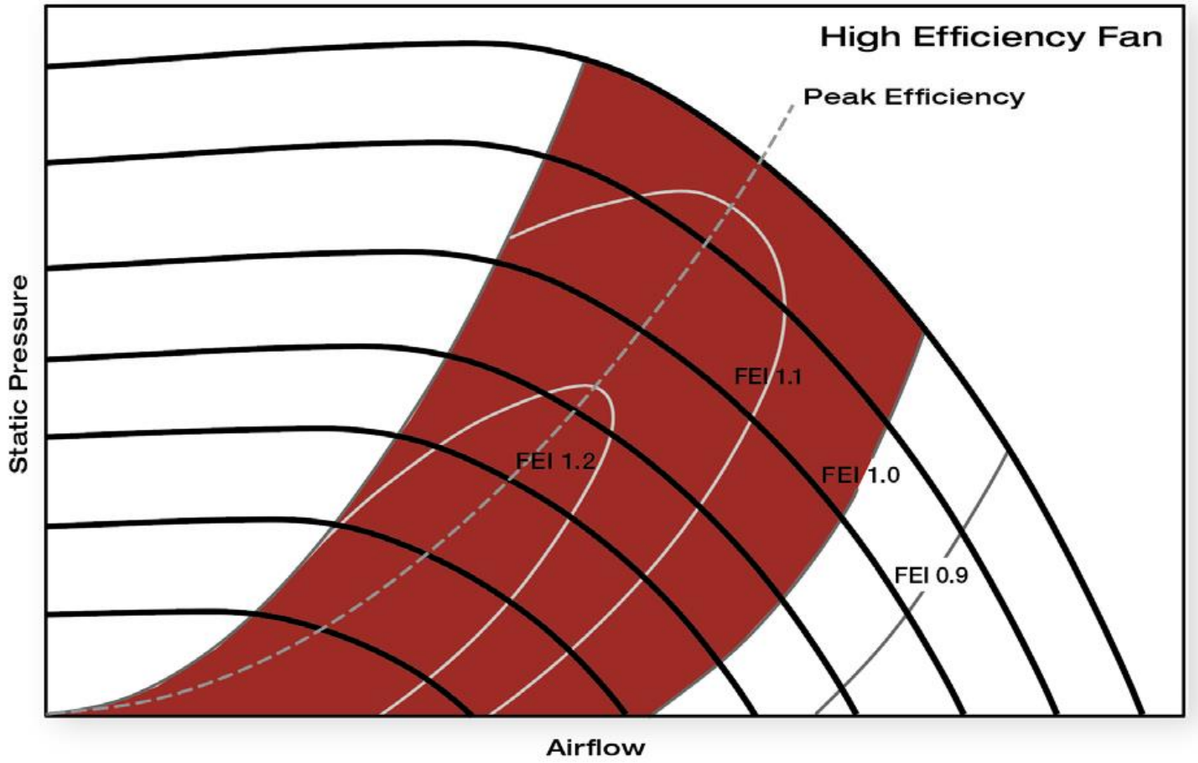
$$FEI = \frac{\text{Reference Fan Electrical Input Power}}{\text{Rated Fan Electrical Input Power}}$$

Going Inside the Numbers

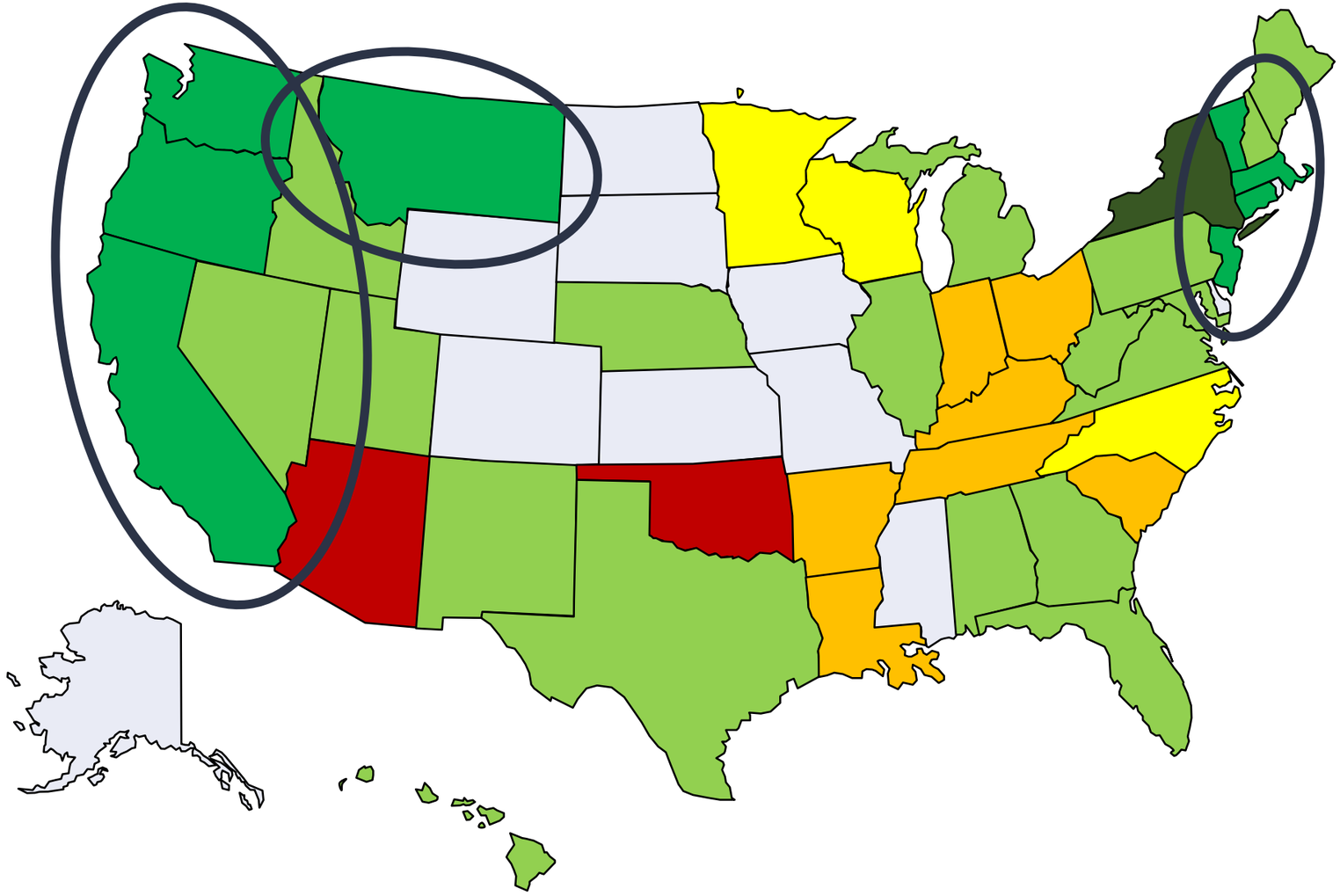
- FEI higher = good
- FEI lower = bad

Low Efficiency vs. High Efficiency





ASHRAE 90.1 Adoption



- ASHRAE 90.1-2019 *(FEI included)*
- ASHRAE 90.1-2016
- ASHRAE 90.1-2013
- ASHRAE 90.1-2010
- ASHRAE 90.1-2007
- Older than ASHRAE 90.1-2007
- No Statewide Code

- As of April 2023

Proposed Dept. of Energy (DOE) FEI

Table I-1 Proposed Energy Conservation Standards for GFBs

Equipment Class	With or Without Motor Controller	Fan Energy Index (FEI)*
Axial Inline	Without	1.18 * A
Axial Panel	Without	1.48 * A
Axial Power Roof Ventilator	Without	0.85 * A
Centrifugal Housed	Without	1.31 * A
Centrifugal Unhoused	Without	1.35 * A
Centrifugal Inline	Without	1.28 * A
Radial Housed	Without	1.17 * A
Centrifugal Power Roof Ventilator - Exhaust	Without	1.00 * A
Centrifugal Power Roof Ventilator - Supply	Without	1.19 * A
Axial Inline	With	1.18 * A* B
Axial Panel	With	1.48 * A* B
Axial Power Roof Ventilator	With	0.85 * A* B
Centrifugal Housed	With	1.31 * A* B
Centrifugal Unhoused	With	1.35 * A* B
Centrifugal Inline	With	1.28 * A* B
Radial Housed	With	1.17 * A* B
Centrifugal Power Roof Ventilator - Exhaust	With	1.00 * A* B
Centrifugal Power Roof Ventilator - Supply	With	1.19 * A* B

*A is a constant representing an adjustment in FEI for motor hp, which can be found in Table I-2. B is a constant representing an adjustment in FEI for motor controllers, which can be found in Table I-2

Fans OUT of Scope

- Safety fans as defined in Section 1602(d) of the Title 20 Efficiency Regulation Article
- Ceiling fans
- Circulating fans
- Induced flow fans
- Jet fans
- Cross-flow fans
- Embedded fans as defined in ANSI/AMCA 214-21 (CA Title 20)
  - **3.25.4 Embedded Fan:** A fan that is part of a manufactured assembly where the assembly includes functions other than air movement.
  - **Note: DOE Test Procedure (TP) defines embedded fan per Table III-7 (next slide). …different**
  - **CA in 45-day public comment period for compliance to Department of Energy Test Procedure.**
  - **https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=22-AAER-01**
- Fans mounted in or on motor vehicles or other mobile equipment
- Fans that create a vacuum of 30 in. water gauge or greater
- Air curtains unit as defined in Section 1602(d) of the Article
- Fans that are designed and marketed to operate at or above 482°F (250°C)

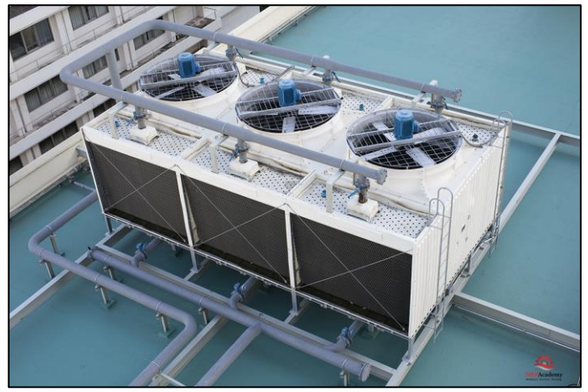
Fans OUT of Scope

Table III-7—Embedded Fans Excluded From the Scope of the Test Procedure
Fans embedded in:
DX-DOASes subject to any DOE test procedures in appendix B to subpart F of part 431.*
Single-phase central air conditioners and heat pumps rated with a certified cooling capacity less than 65,000 British thermal units per hour ("Btu/h"), that are subject to DOE's energy conservation standard at 10 CFR 430.32(c).
Three-phase, air-cooled, small commercial packaged air-conditioning and heating equipment rated with a certified cooling capacity less than 65,000 Btu/h, that are subject to DOE's energy conservation standard at 10 CFR 431.97(b).
Transport refrigeration (*i.e.,* Trailer refrigeration, Self-powered truck refrigeration, Vehicle-powered truck refrigeration, Marine/Rail container refrigerant), and fans exclusively powered by combustion engines.
Vacuum cleaners.

Air-Cooled Steam Condensers

Air-Cooled Coolers

Evaporative Condensers

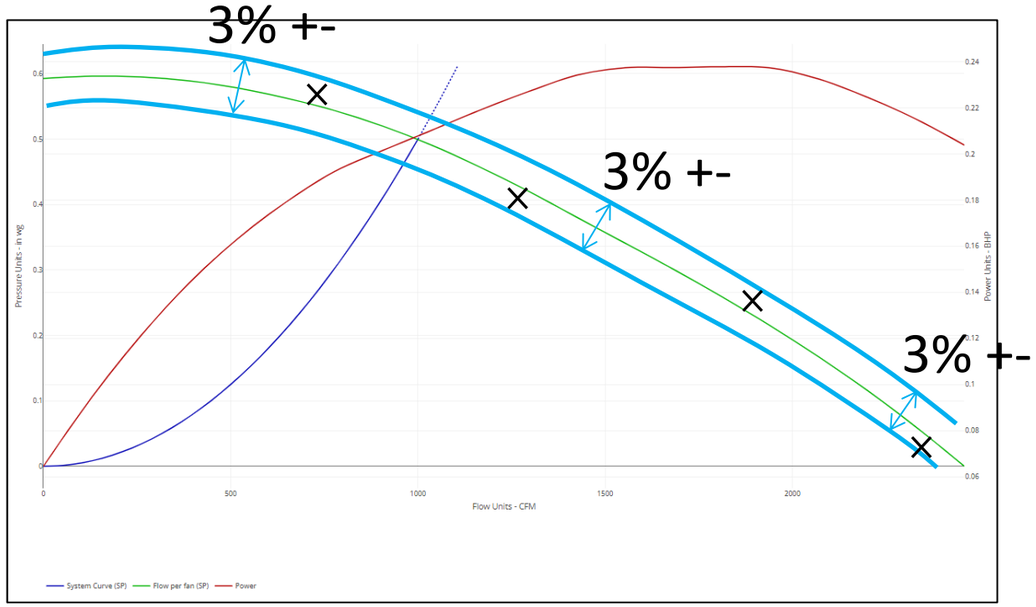


Evaporative Cooling Towers

Fan Energy Index in Codes, Standards & Regulations

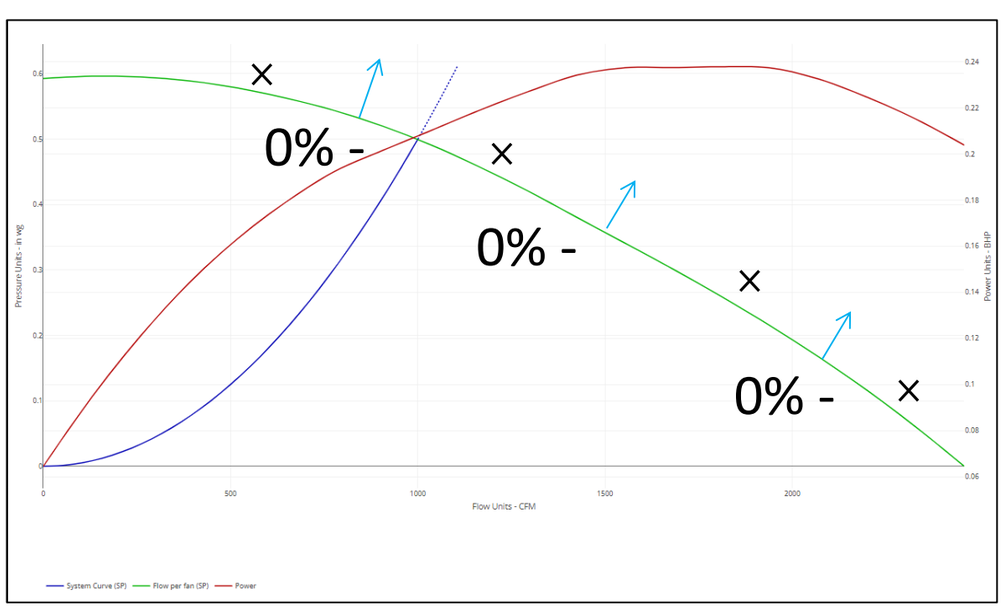
Publication	Publication Type	Edition	Status	Expected Completion	Effective Enforcement Date
US DOE	Energy Standard NOPR	2024	Final Draft Jan 2024	Final Early 2025	Final + 5 years = ~Early 2030
US DOE	Test Procedure NOPR	2023	Draft 2023 (~AMCA 214)	Late 2023	~~November 2023~~ Pushed to April 2024
California Energy Commission (CEC Title 20)	FEI >=1 Product compliance	2022	Complete	Published	~~November 2023~~ Pushed to April 2024
California Energy Commission (CEC Title 24)	State Code	2022	Under review by CA Bldg. Stds Commission	Aug 2022	January 1, 2023
IGCC (International Green Construction Code)	Model Code	2021	Complete	Published	Published, but needs to be enforced to have effect
IECC (International Energy Conservation Code)	Model Code	2021	Complete	Published	Published, but needs to be enforced to have effect
ASHRAE 189.1	Model Standard	2020	Complete	Published	Published, but needs to be enforced to have effect
Oregon Energy Efficiency Specialty Code	State Code	2020	Took Effect	Complete	
Florida Building Code	State Code	2020	Took Effect	Complete	
ASHRAE 90.1	Model Standard	2019	Complete	Published	Published, but needs to be enforced to have effect

AMCA 210 vs. DOE Test Procedure



Historical AMCA 210

(Accounting for any variance in manufacturing)



DOE Test Procedure

(No variance allowed)

Labeling Updates

Fan Energy Index (FEI)..... ≥ 1.00 Efficiency Boundaries

A. Max. Airflow (CFM)..... 3496.3

B. Max. Fan Speed (RPM)..... 5206*

C. Max. Pressure (in. water gauge) 14.9891

D. Type of Pressure (static or total).....Total

Note: Operation outside of these boundaries will result in an energy inefficient operation.

- -

Regulated fans with an FEI value less than 1.0 are not intended for sale or intended to be offered by the manufacturer for sale in California, based on CA Title 20 requirements.

* The values shown are used for CA Title 20 requirements and may not represent the performance for the application of this fan. Go to *www.tcf.com* to find the product catalog for more information. Operating the fans at maximum capacity could result in the fans failing and put the user or others at risk of injury or death.

Serial No.: 23-256485-003 500029235

Enforcement of CA Title 20

§ 429.120 Maximum civil penalty.

Any person who knowingly violates any provision of § 429.102(a) may be subject to assessment of a civil penalty of no more than $560 for each violation. As to § 429.102(a)(1) with respect to failure to certify, and as to § 429.102(a)(2), (5) through (9), each unit of a covered product or covered equipment distributed in violation of such paragraph shall constitute a separate violation. For violations of § 429.102(a)(1), (3), and (4), each day of noncompliance shall constitute a separate violation for each basic model at issue.

[76 FR 12451, Mar. 7, 2011, as amended at 81 FR 41794, June 28, 2016; 81 FR 96351, Dec. 30, 2016; 83 FR 1291, Jan. 11, 2018; 83 FR 66083, Dec. 26, 2018; 85 FR 830, Jan. 8, 2020; 86 FR 2955, Jan. 14, 2021; 87 FR 1063, Jan. 10, 2022; 88 FR 2193, Jan. 13, 2023; 89 FR 1028, Jan. 9, 2024]

FEI is a Metric.

The intent is to change behavior.

Best Practices

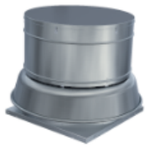
Roof Ventilation

Roof Ventilation

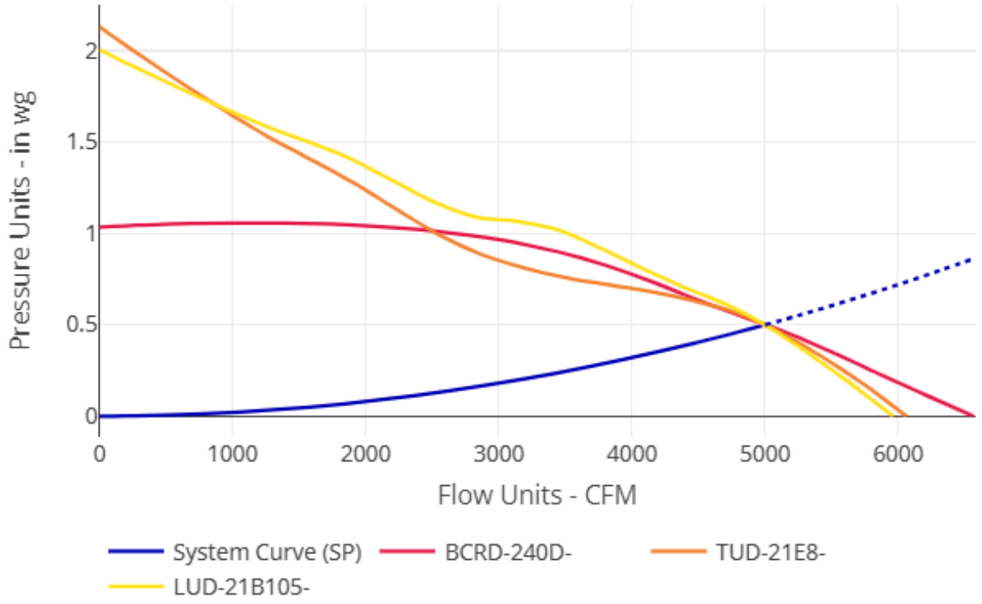
5,000 CFM at 5” w.c. Static Pressure

Roof Ventilation

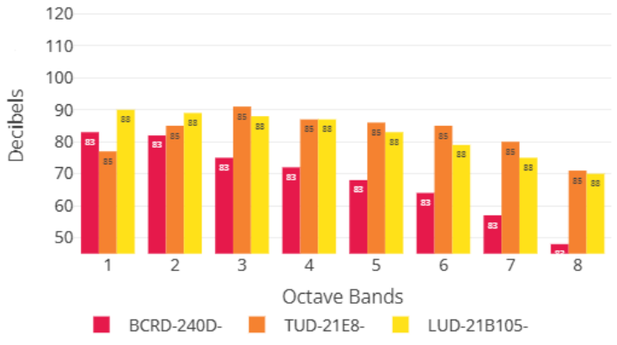
Fan Product Comparison



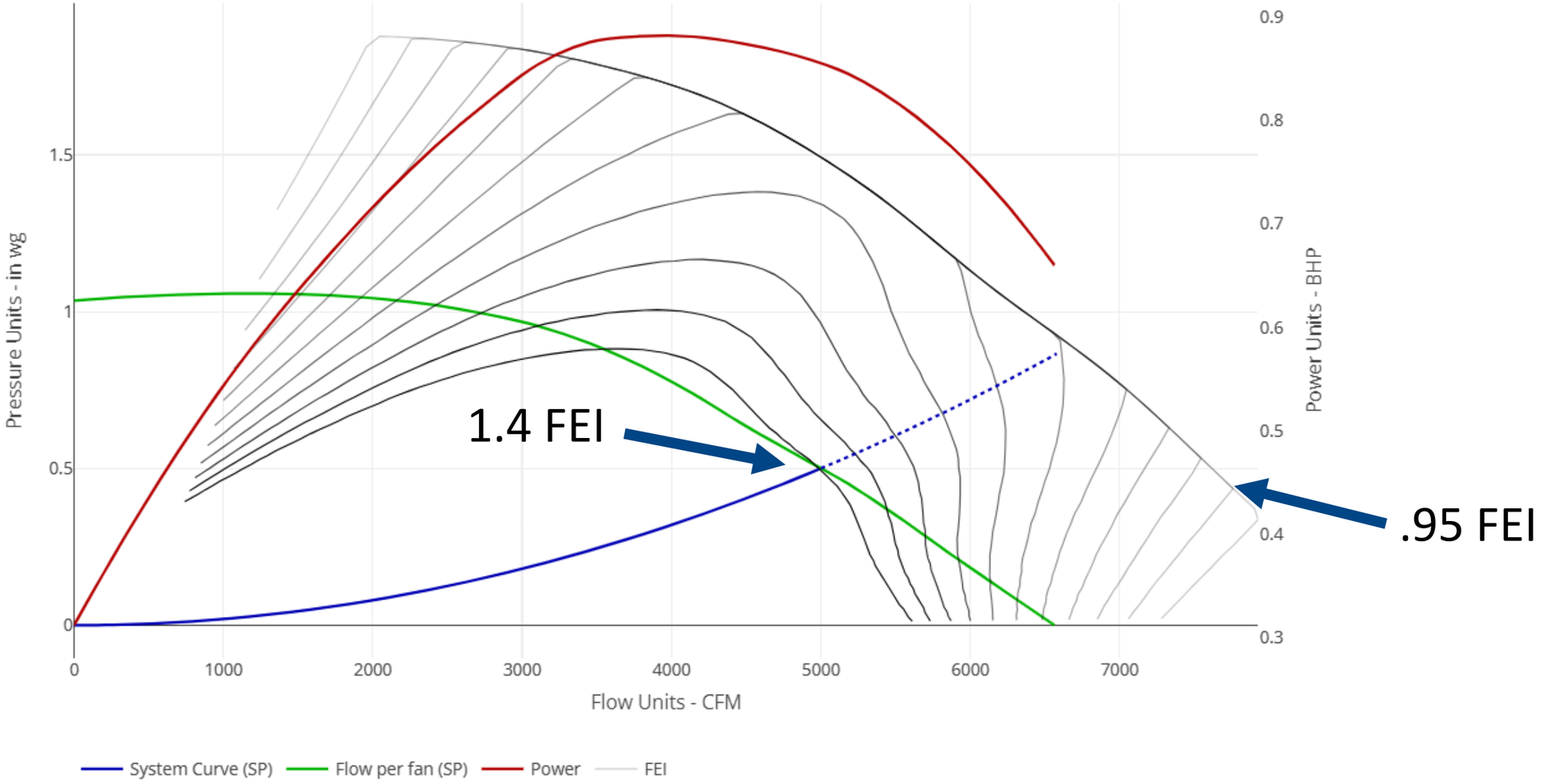
	BCRD-240D	TUD-21E8	LUD-21B105
Performance			
Volumetric Flow (CFM)	5000	5000	5000
Static Pressure (in wg)	0.500	0.500	0.500
Total Pressure (in wg)	0.550	0.756	0.756
Operating Power (BHP)	0.86	1.41	1.08
RPM	652	1701	1694
Static Efficiency %	46.0	27.9	36.5
% of Peak Static Pressure	47.3	70.1	46.7
Fan Energy Index (FEI)	1.40	0.97	1.24
Sound			
Inlet LwA	74	91	88
Inlet Sones	12.6	31	28
Pricing			
Budget Price Index	2.0	3.1	1.7



Sound Graph



Roof Ventilation



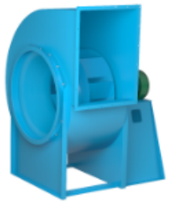
Mid-Run Ducted Fan

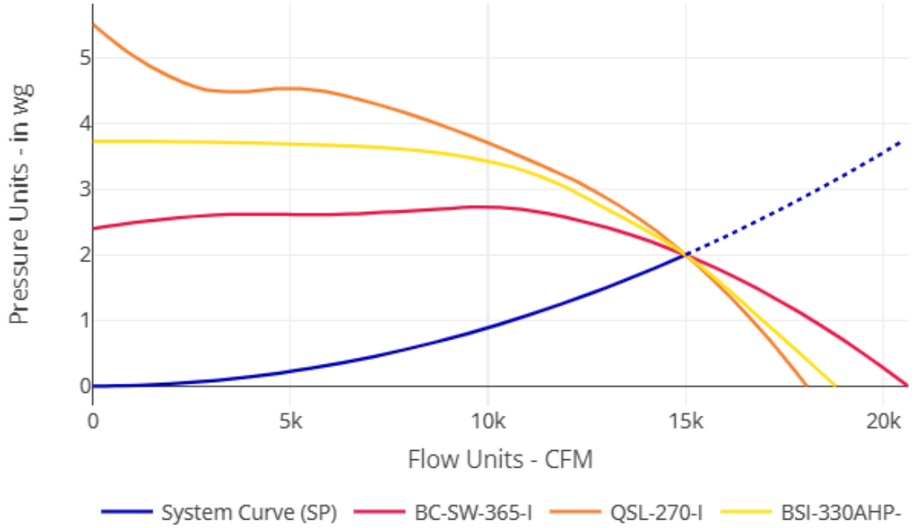
Mid-Run Ducted Fan

15,000 CFM at 2” w.c. Static Pressure

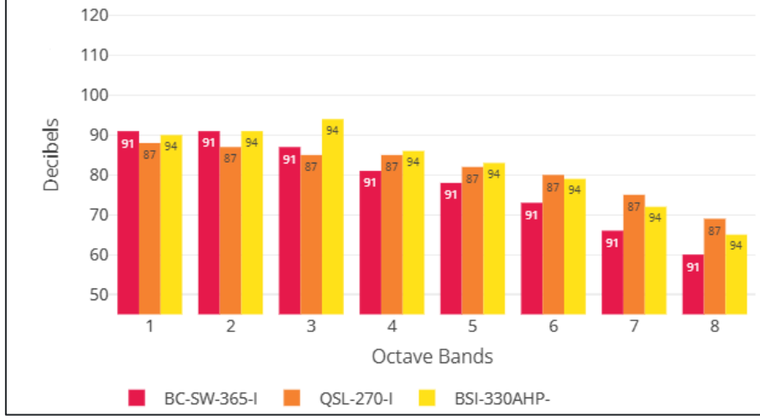
Mid-Run Ducted Fan

Fan Product Comparison

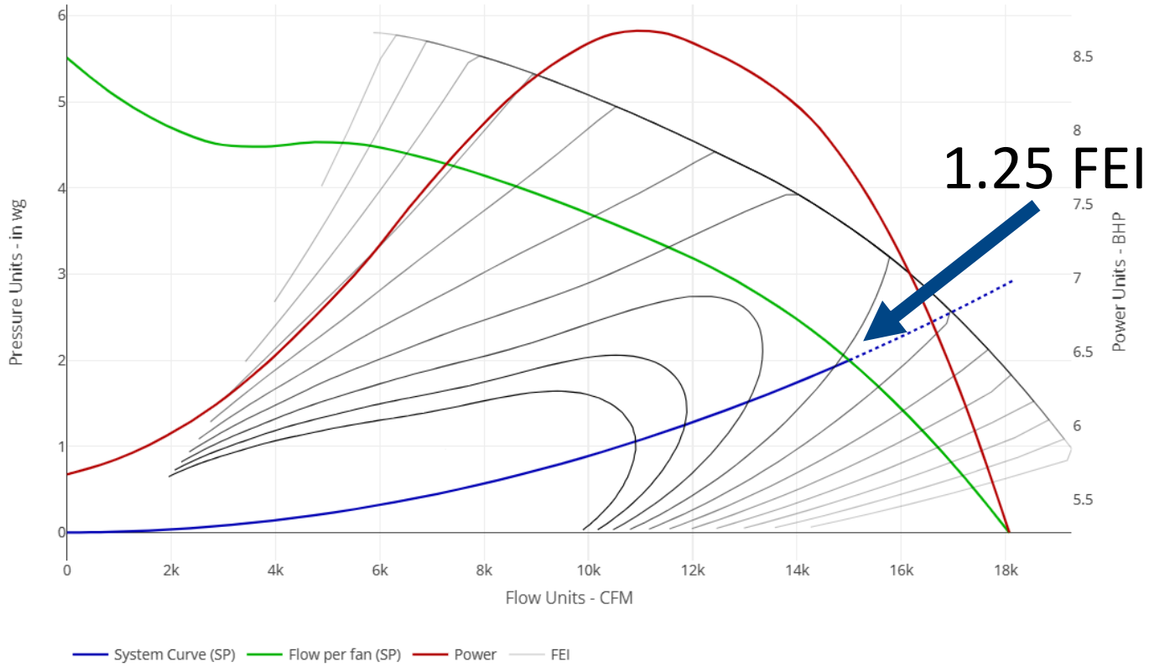
	 BC-SW-365-I	 QSL-270-I	 BSI-330AHP
Performance			
Volumetric Flow (CFM)	15000	15000	15000
Static Pressure (in wg)	2.000	2.000	2.000
Total Pressure (in wg)	2.239	2.264	2.052
Operating Power (BHP)	6.87	7.75	10.26
RPM	710	1331	939
Static Efficiency %	68.7	60.9	46.0
% of Peak Static Pressure	73.3	44.1	53.6
Fan Energy Index (FEI)	1.38	1.24	0.87
Sound			
Inlet LwA	84	87	90
Inlet Sones	23	26	30

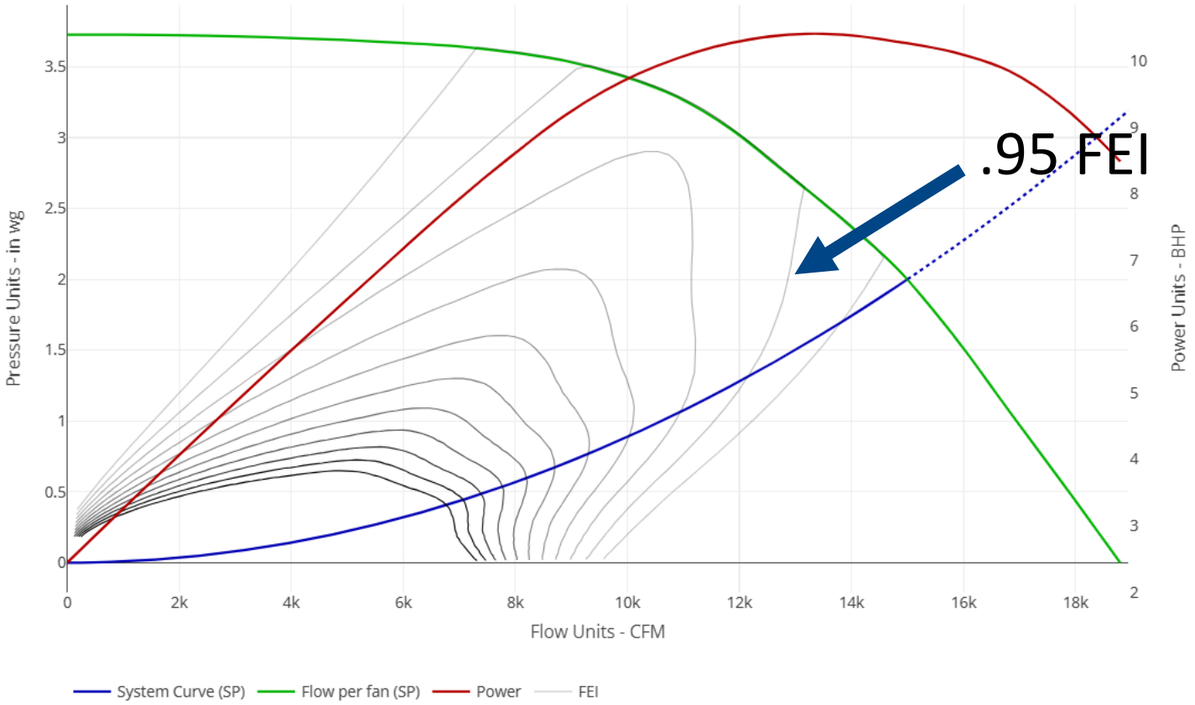


Sound Graph



Mid-Run Ducted Fan





Dust Collection

Dust Collection

20,000 CFM at 6” w.c. Static Pressure

Dust Collection

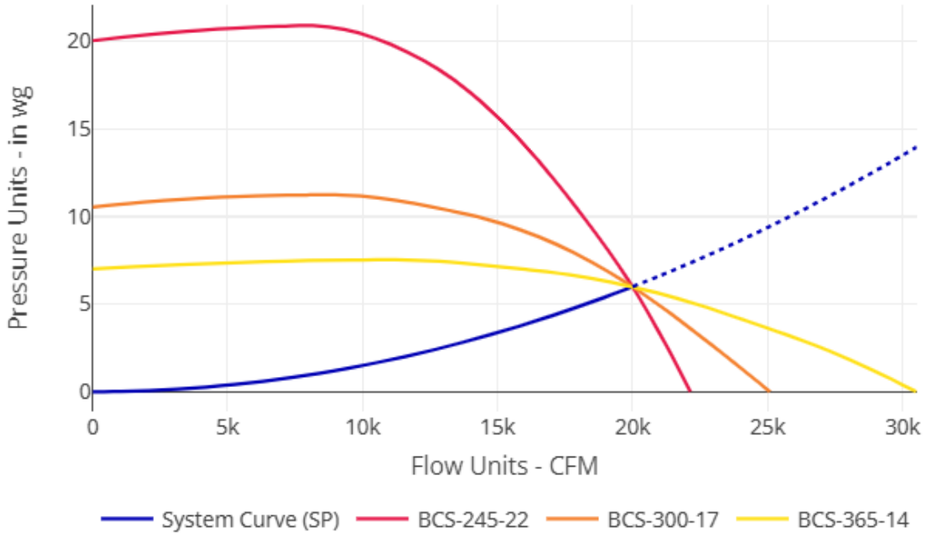
Fan Product Comparison

BCS-245-22

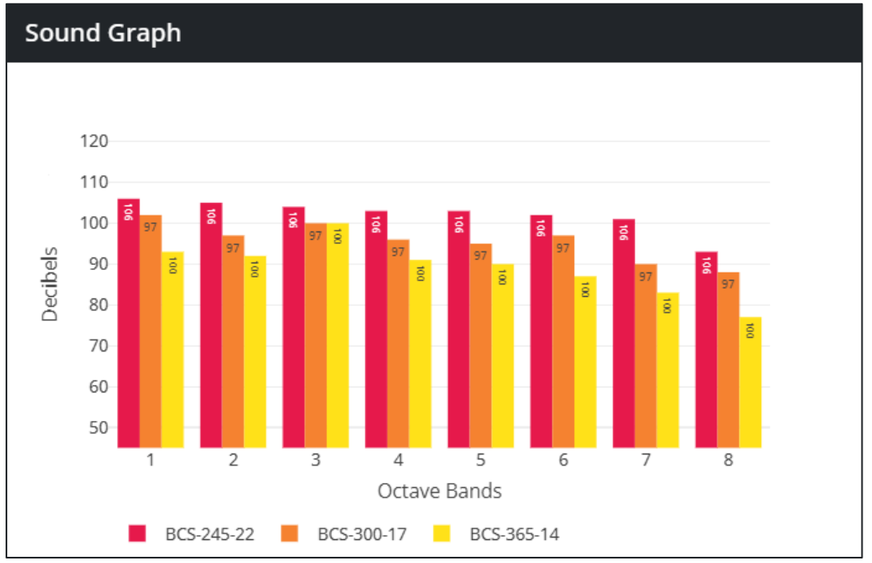
BCS-300-17

BCS-365-14

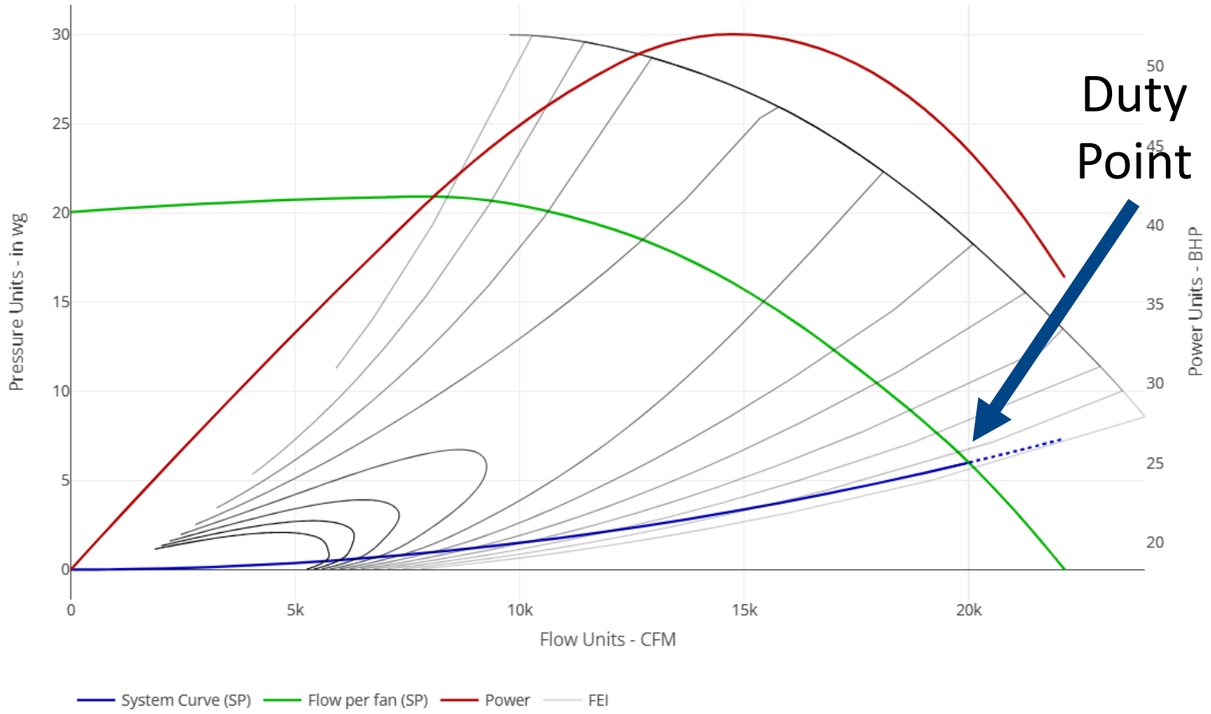
	BCS-245-22	BCS-300-17	BCS-365-14
Performance			
Volumetric Flow (CFM)	20000	20000	20000
Static Pressure (in wg)	6.000	6.000	6.000
Total Pressure (in wg)	8.091	6.931	6.424
Operating Power (BHP)	44.67	30.21	25.14
RPM	2982	1796	1202
Static Efficiency %	42.1	62.3	74.9
% of Peak Static Pressure	28.7	53.4	79.6
Fan Energy Index (FEI)	0.92	1.22	1.30
Sound			
Inlet LwA	109	102	96
Inlet Sones	113	69	45



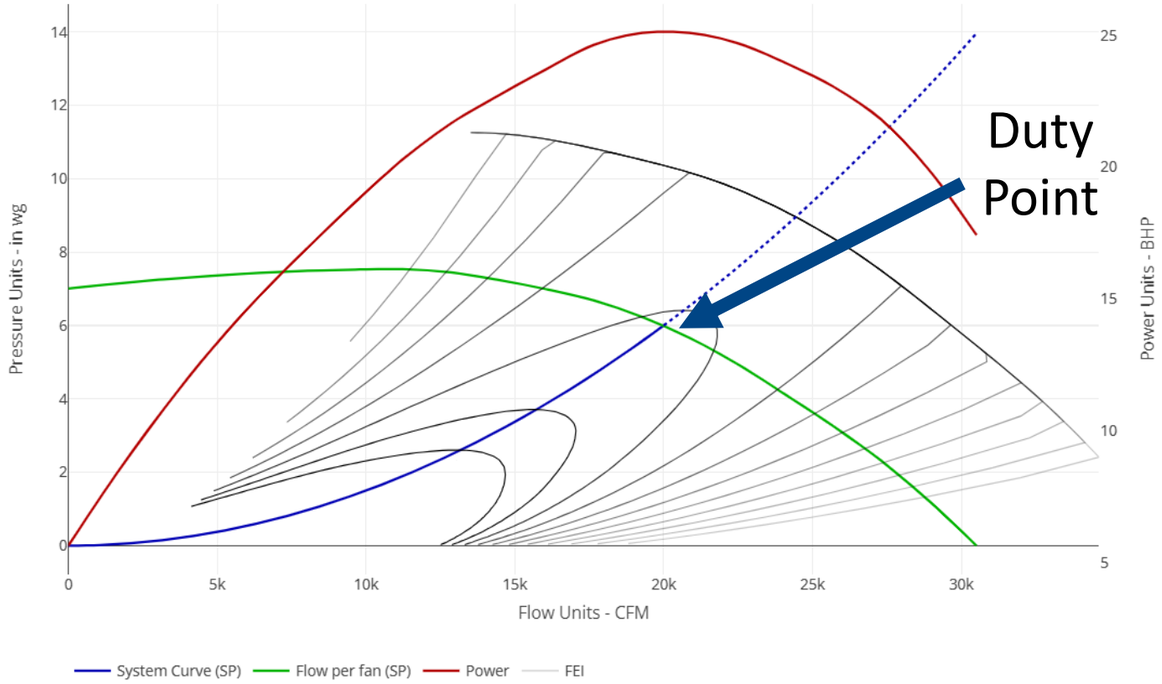
Sound Graph



Dust Collection



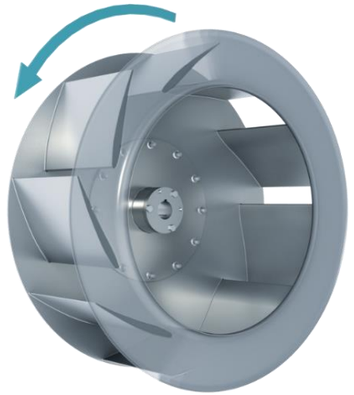
Size 245
FEI = .92
BHP = 44.67



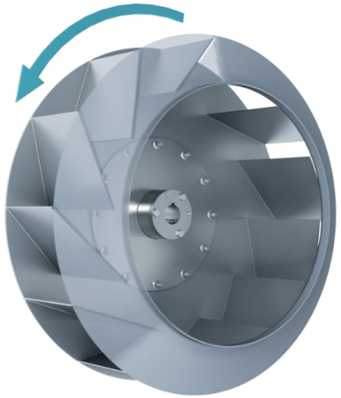
Size 365
FEI = 1.3
BHP = 25.14

Variable Air Volume

Max design flow rate: 18,000 CFM at 5.4” w.c. Static Pressure

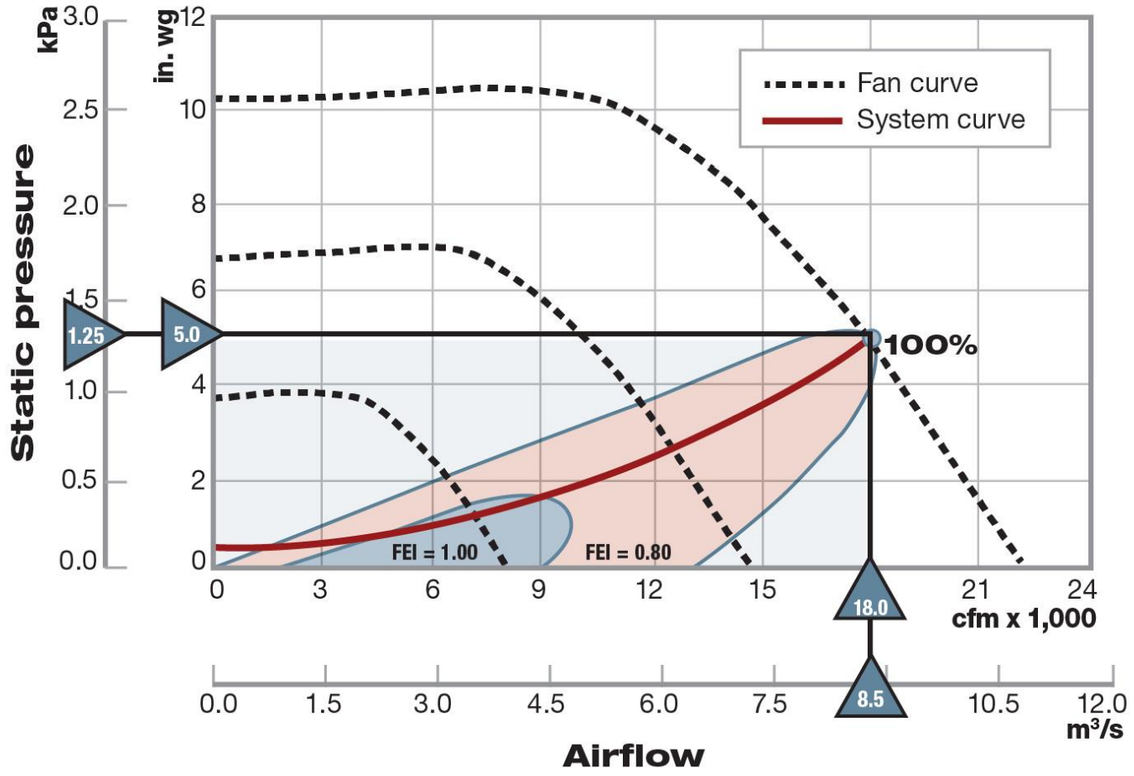


Fan Size	Fan Type	FEI 40% Flow (7,200 CFM)	FEI 70% Flow (12,800 CFM)	FEI 100% Flow (18,000 CFM)
18	Airfoil	1.05	0.89	0.9
20	Airfoil	1.17	1.06	1.05
22	Airfoil	1.21	1.15	1.13
24	Airfoil	1.24	1.25	1.23
27	Airfoil	1.20	1.23	1.21

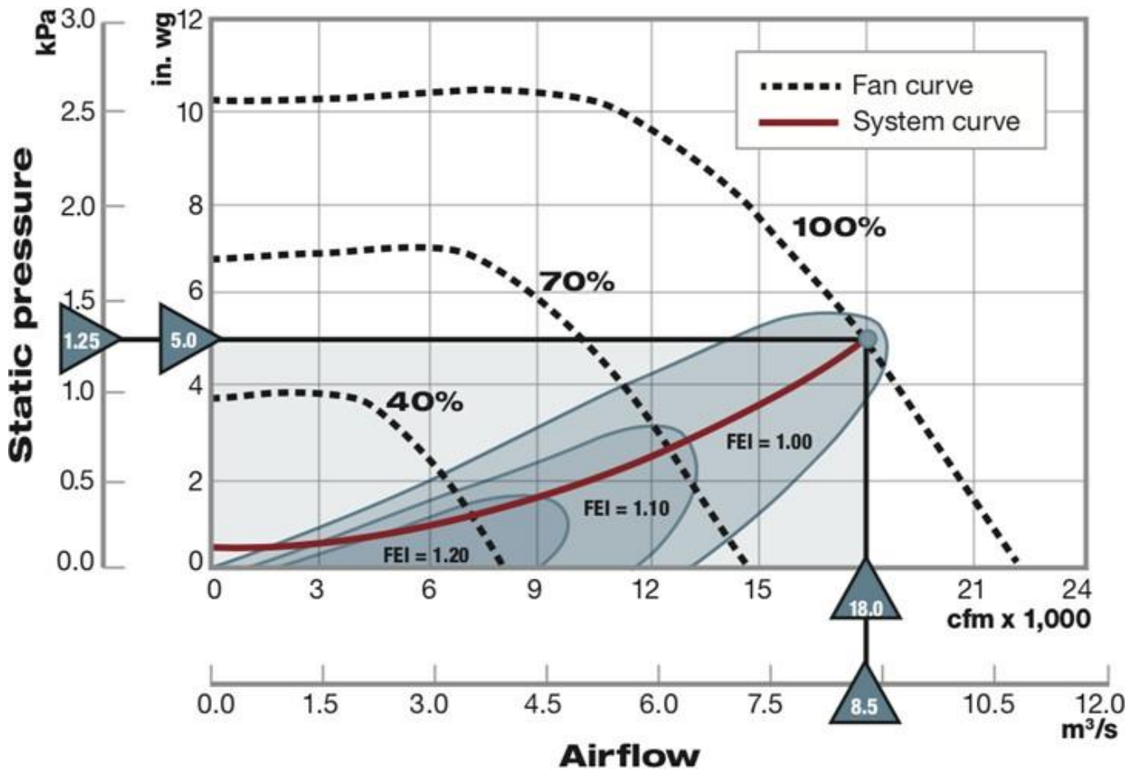


Fan Size	Fan Type	FEI 40% Flow (7,200 CFM)	FEI 70% Flow (12,800 CFM)	FEI 100% Flow (18,000 CFM)
18	Backward Inclined	1.02	0.9	0.82
20	Backward Inclined	1.11	0.94	0.93
22	Backward Inclined	1.21	1.12	1.05
24	Backward Inclined	1.22	1.18	1.16
27	Backward Inclined	1.19	1.2	1.17

Variable Air Volume



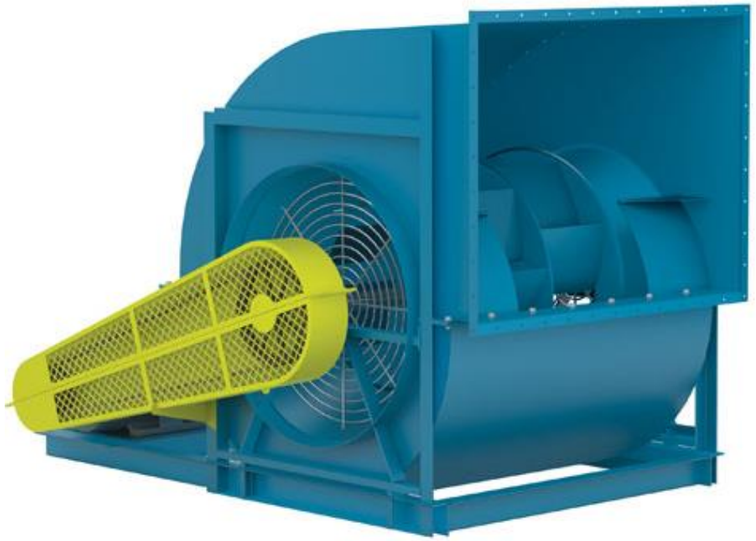
Backward Inclined
Size 182



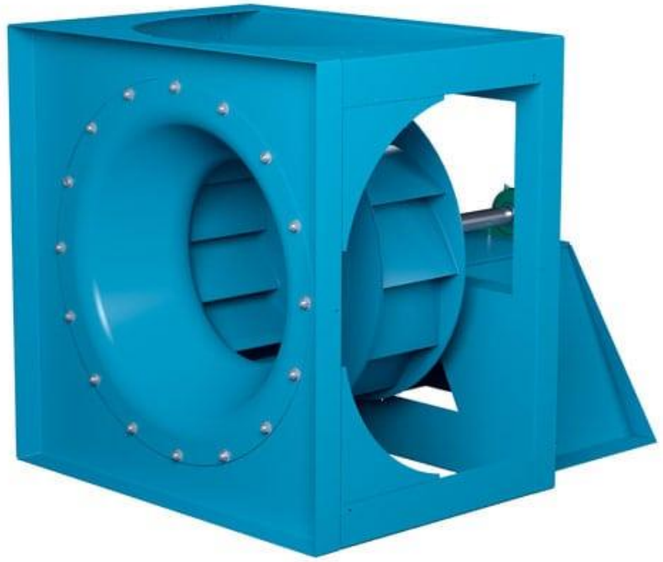
Backward Inclined
Size 222

Air Handling Units – Supply Fans

Double Wide



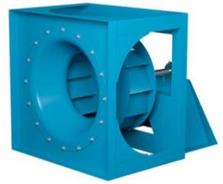
Plenum Fan



Plenum Fan Array

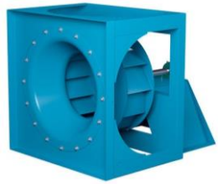
40,000 CFM at 6.5” w.c. Static Pressure

Air Handling Units – Fan Compare



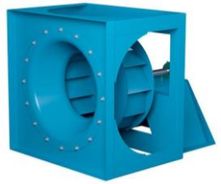
Metric	Double Wide	Single Plenum	4 Fan Array	16 Fan Array
Fan BHP				
System BHP				
Static Efficiency				
Total System FEI				
Individual Fan FEI*				
System FEP (KW)				
System LwA (db)				
EQ FLH				
KWH				
Elec Rate				
Operating Cost				
Delta				
System Cost				

Air Handling Units – Fan Compare

Metric	Double Wide	Single Plenum	4 Fan Array	16 Fan Array
Fan BHP	51.68	55.43	14.69	3.77
System BHP	53.75	55.43	58.76	60.32
Static Efficiency	79.3%	74.0%	69.8%	68.0%
Total System FEI	1.27	1.27	1.25	1.22
Individual Fan FEI*	1.27*	1.27*	1.28*	1.34*
System FEP (KW)	44.04	45.41	46.13	47.35
System LwA (db)	103	96	96	99
EQ FLH	6000	6000	6000	6000
KWH	240,585	248,104	263,009	269,992
Elec Rate	.12	.12	.12	.12
Operating Cost	$28,870	$29,772	$31,561	$32,399
Delta	Base	$902	$2691	$3529
System Cost	1.15	1.0	1.58	3.23

Air Handling Units – Fan Compare

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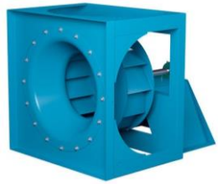
Air Handling Units – Fan Compare

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Trends

Trends

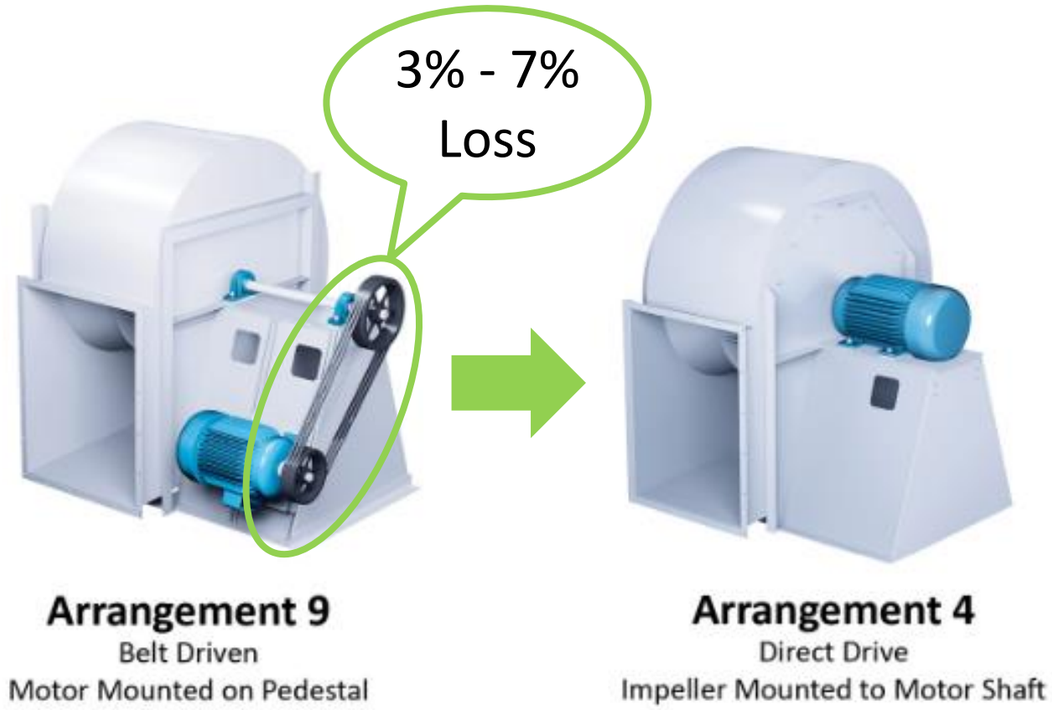
What to Expect: Fans and equipment in systems are going to get bigger with an emphasis on more efficient blade designs.

Benefits:

- Slower Speeds
- Energy Efficiency
- Decreased Sound Levels
- Increased Bearing / Motor Life
- Decreased Vibration Potential

TRENDS

Direct Drive Incentive



Brand/Product Efficiency Incentive

National Electrical Manufacturers Association (NEMA) motor tables are too conservative

Variable Frequency Drives

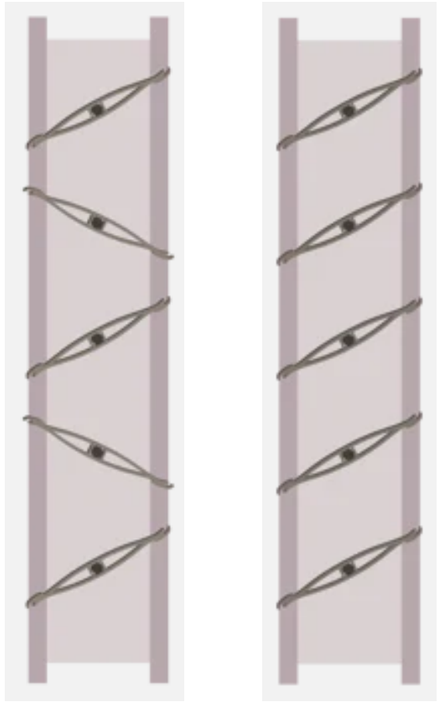
- *Race to include accessory data in selection software?*
- *Incentive to sell as a unit from fan manufacturer?*

- VERY GRAY AREA

Trends

Flat vs. Airfoil
Fans, Louvers and Dampers

Opposed vs. Parallel
Blade Dampers



Optimization of Duct Sizing

Overall Goal: Minimize Pressure Drop

Trends

Retrofit / Replacement – Included in Regulation

Overall Goal: Minimize Pressure Drop

Potential Outcome: More Parts instead of Replacement

Opportunities for Improvement

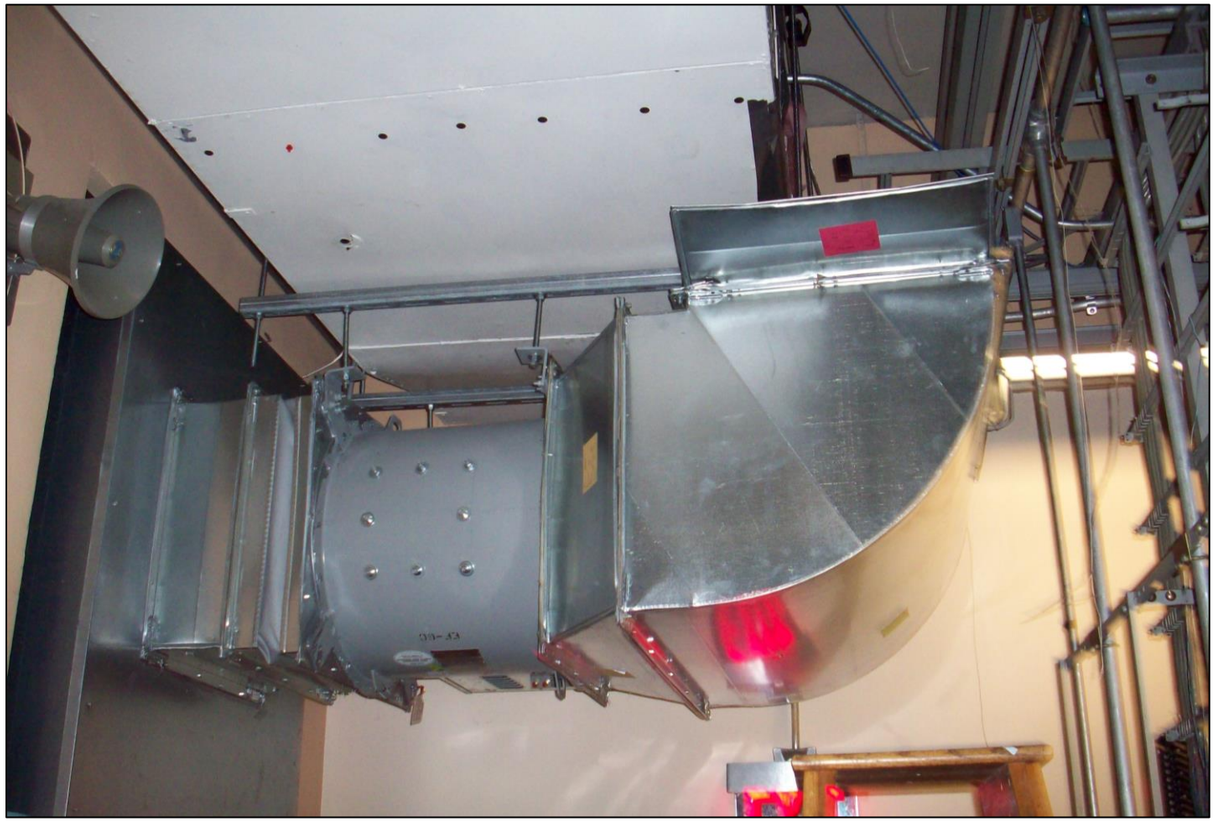
What to expect: Heavy focus on system design. Reducing pressure drop.

- Mitigating selection safety factors
- Education on system effect
- Inefficient products will be penalized
- Contractors need to prioritize duct work over other trades

Opportunities for Improvement

Opportunities for Improvement

Opportunities for Improvement



Opportunities for Improvement

Call to Action

1. Make the choice!
   - Increasing safety requirements
   - Energy efficiency is more important than ever
2. Get ahead of regulations! They are here and more are coming.
3. Ask the experts! Every system is different and important.

Questions?

Twin City Fan Companies, Ltd.

TCF
Twin City Fan

Aerovent
Industrial Ventilation Systems

Clarage
Industrial Fans & Services