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

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Fan Selection Using FEI

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 electric 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.

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Acknowledgements

AMCA International

Appliance Standards Awareness Project

ISO Technical Committee 117 Fans

Northwest Energy Efficiency Alliance

U.S. Department of Energy's Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC)

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Standard 207 - Fan System Efficiency and Fan System Input Power

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

Brendel. 2015
ASHRAE Journal 08-2015 – Selecting Fans for Minimum Energy Consumption

Outline

- Basic understanding of FEI
- Property owner’s perspective
- Engineer’s perspective
- Fan supplier’s perspective

  Extras, if time permits

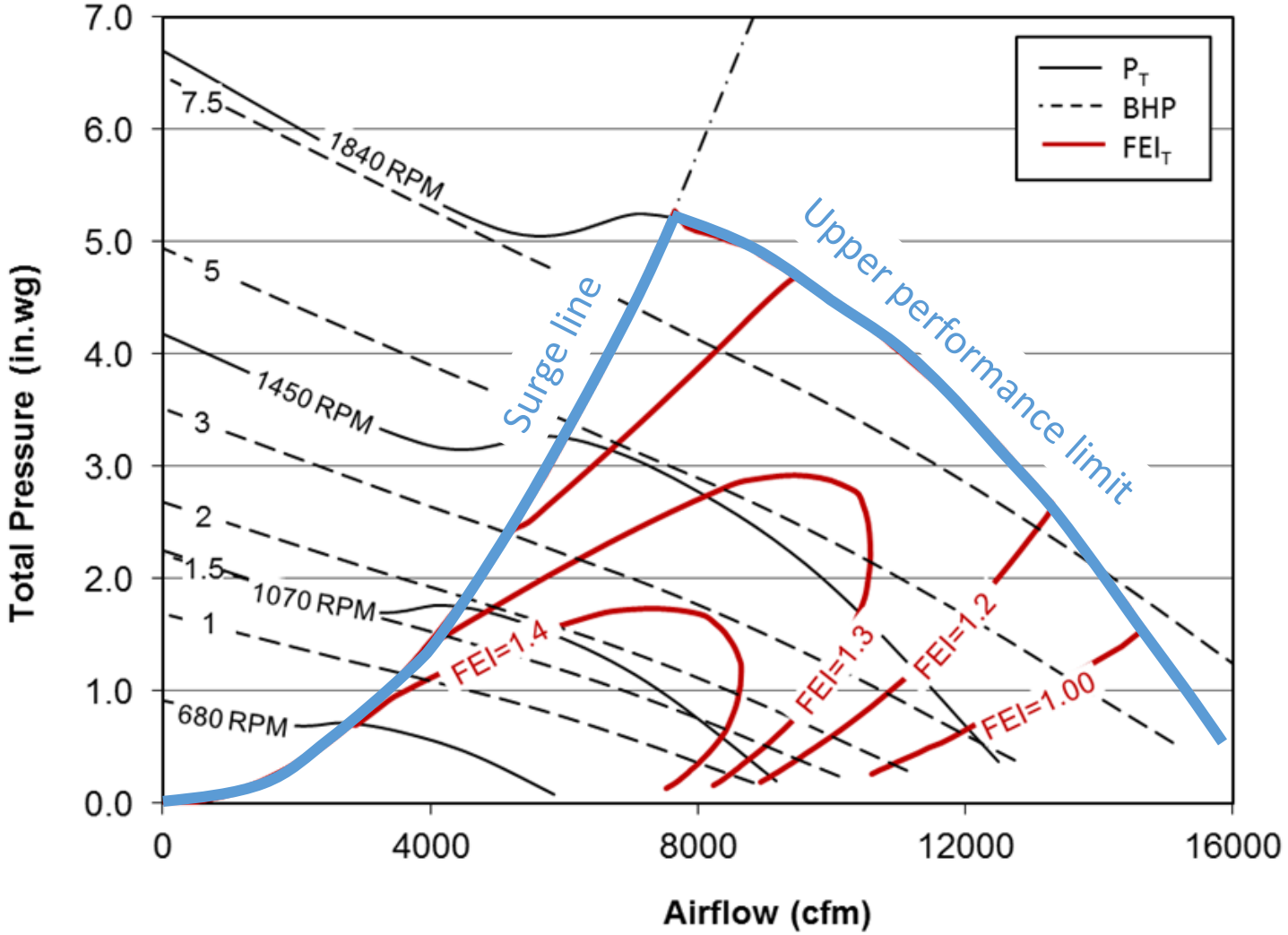
Basic understanding of FEI

Basic understanding of FEI
Fan performance representations

		Static Pressure (in. wg)					
Airflow (cfm)		**0**	**1**	**2**	**3**	**4**	**5**
7500	rpm	1010	1180	1331	1468		
	bhp	1.7	3.1	4.6	6.2		
	FEI_S	1.67	1.54	1.46	1.4		
10000	rpm	1230	1378	1505	1626	1738	1843
	bhp	2.6	4.3	6.2	8.2	10.2	12.3
	FEI_S	1.42	1.45	1.43	1.4	1.38	1.36
12500	rpm	1467	1590	1709	1814	1912	2009
	bhp	3.9	5.9	8.2	10.4	12.8	15.4
	FEI_S	1.18	1.31	1.35	1.37	1.36	1.35
15000	rpm	1712	1819	1921	2021	2112	2196
	bhp	5.6	8.0	10.6	13.2	15.9	18.7
	FEI_S	0.98	1.16	1.25	1.29	1.31	1.33
17500	rpm	1961	2058	2146	2233	2320	2402
	bhp	7.8	10.7	13.5	16.5	19.6	22.8
	FEI_S	0.81	1.01	1.13	1.2	1.24	1.27
20000	rpm	2214	2301	2382	2459	2535	2612
	bhp	10.7	13.9	17.2	20.5	23.9	27.3
	FEI_S	0.67	0.89	1.02	1.11	1.17	1.21

Fan performance table using AMCA 207 default motor efficiencies

Basic understanding of FEI
Fan performance representations



Fan performance curves with lines of constant FEI using AMCA 207 default motor efficiencies

Property owner's perspective
Specification of design intentions

Example:

The duty point of a ventilation fan is firmly specified. The property owner requests proposals for three options:

Good	Better	Best

Property owner's perspective
Specification of design intentions

Example:

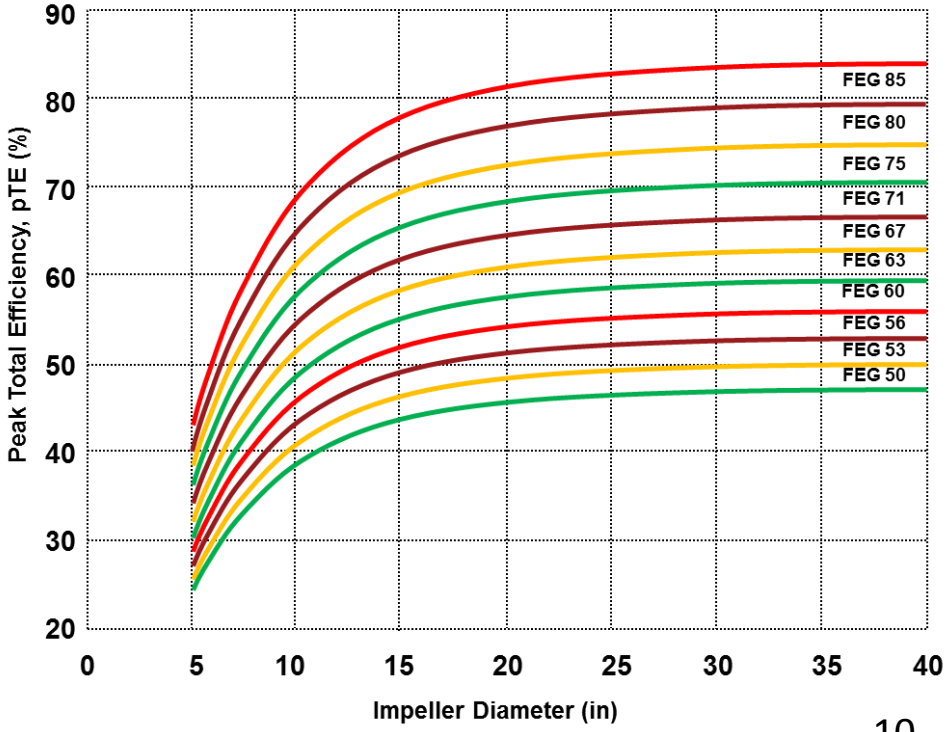
The duty point of a ventilation fan is firmly specified. The property owner requests proposals for three options:

Good	Better	Best

Possibility 1:
Rank by fan efficiency (in %)

Problem:
Fan applications differ much.

- Pressure range
- Air power
- Size



Property owner's perspective
Specification of design intentions

Example:

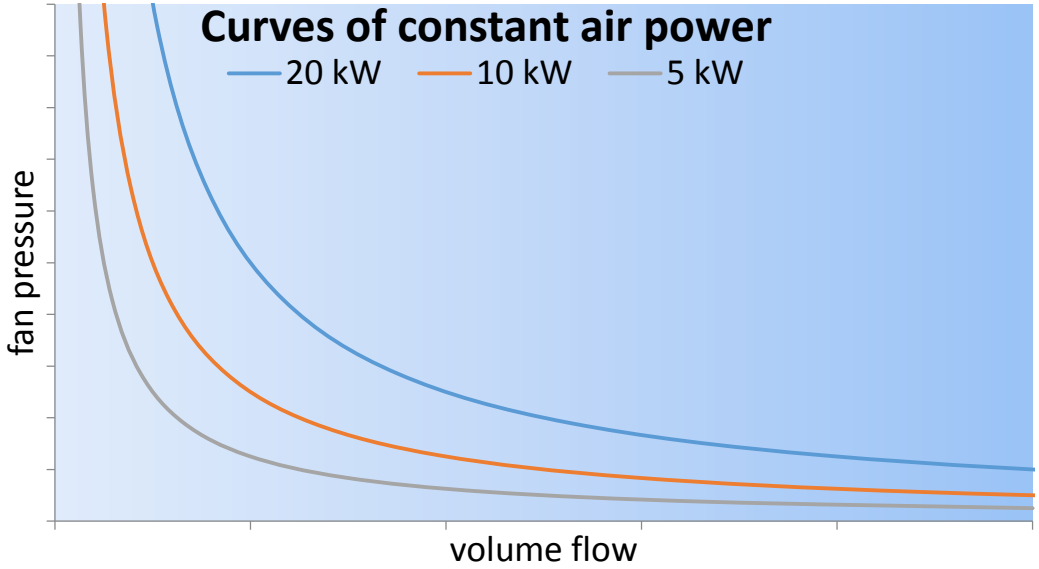
The duty point of a ventilation fan is firmly specified. The property owner requests proposals for three options:

Good	Better	Best

Possibility 2:
Rank by impeller shaft power

Problem:

- Which shaft power limitation would be reasonable for fan comparisons?



$$air\ power = (flow \times pressure)$$
$$shaft\ power = (flow \times pressure) \div fan\ efficiency$$

Property owner's perspective
Specification of design intentions

Example:

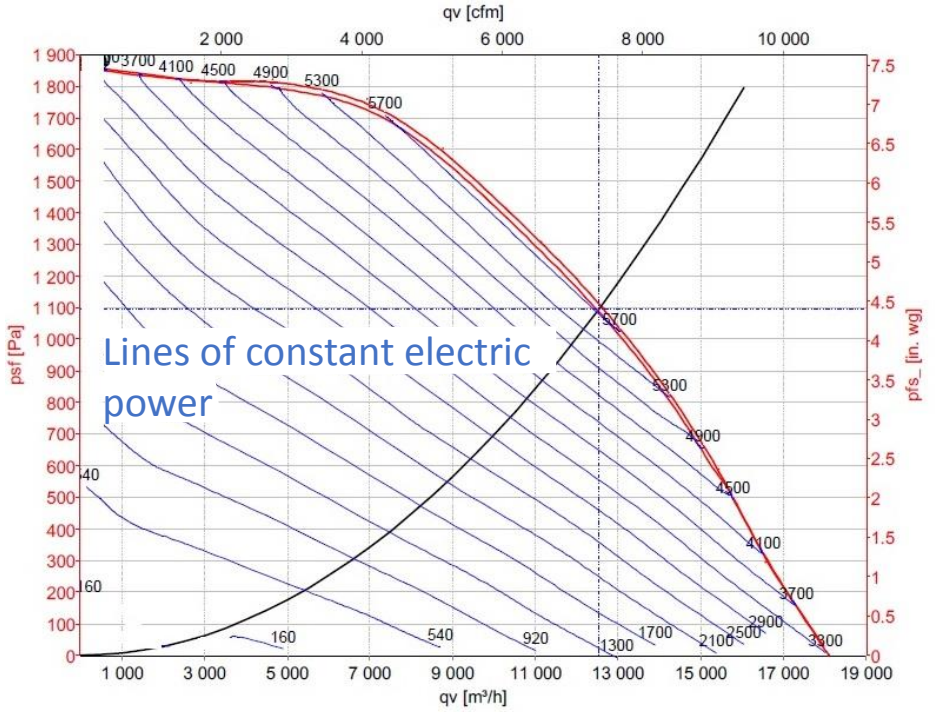
The duty point of a ventilation fan is firmly specified. The property owner requests proposals for three options:

Good	Better	Best

Possibility 3:
Rank by electric power

Problems:

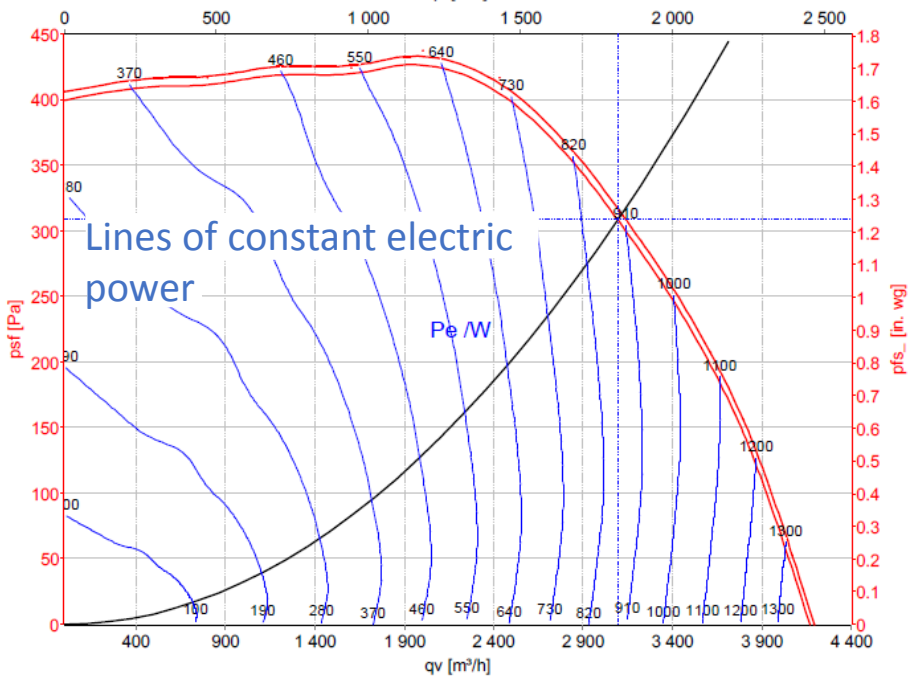
- Which electric power thresholds are good / better / best?

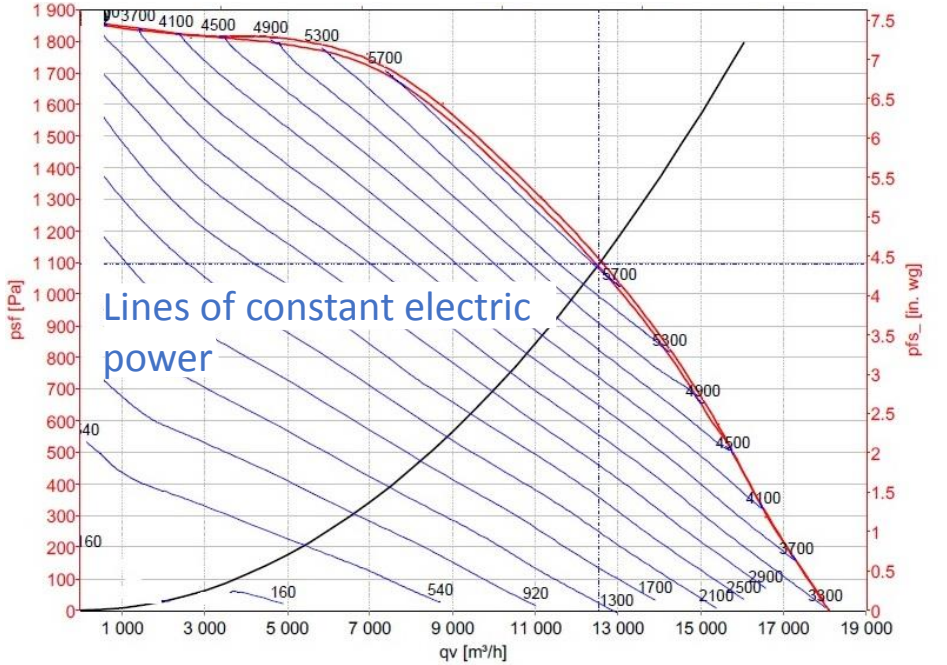


Possibility 3:
Rank by electric power

Problems:

- Which electric power thresholds are good / better / best?





Property owner's perspective
Specification of design intentions

Example:

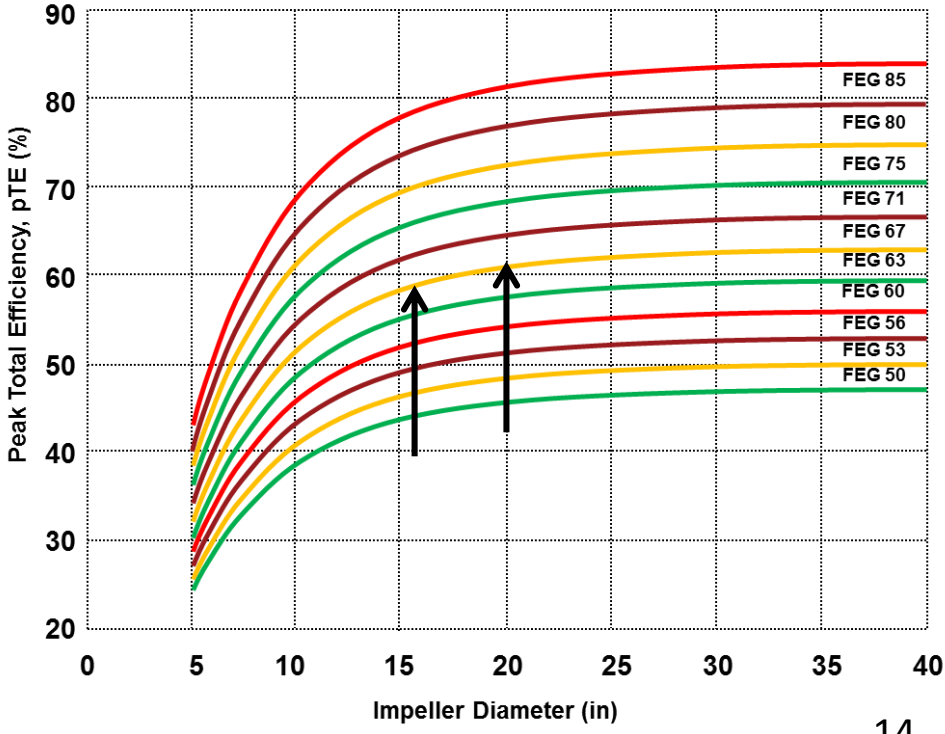
The duty point of a ventilation fan is firmly specified. The property owner requests proposals for three options:

Good	Better	Best

Possibility 4:
Rank by fan efficiency grade (FEG)

Problems:

- Low granularity
- FEG omits motor and transmission losses.
- Dependence on fan diameter prevents comparison of differing fan types.



Property owner's perspective
Specification of design intentions

Example:

The duty point of a ventilation fan is firmly specified. The property owner requests proposals for three options:

Good	Better	Best

Possibility 5:
Rank by FEI

Fan Size	Speed (rpm)	Fan Total Effic. (%)	Shaft Power (bhp)	Elect. Power (kW)	FEI_T
18	3047	49%	15.3	12.8	0.83
20	2448	58%	13.0	10.9	0.98
22	1940	67%	11.2	9.42	1.13
24	1621	75%	10.1	8.49	1.25
27	1378	77%	9.81	8.27	1.28
~~30~~	1185	76%	9.89	8.33	1.27
~~33~~	1058	72%	10.5	8.82	1.20

Property owner's perspective
Specification of design intentions

Example:

The duty point of a ventilation fan is firmly specified. The property owner requests proposals for three options:

Good	Better	Best

Possibility 5:
Rank by FEI

Fan electric power and wire-to-air efficiency are reflected in a single number.

Fan Size	Speed (rpm)	Fan Total Effic. (%)	Shaft Power (bhp)	Elect. Power (kW)	FEI_T
18	3047	49%	15.3	12.8	0.83
20	2448	58%	13.0	10.9	0.98
22	1940	67%	11.2	9.42	1.13
24	1621	75%	10.1	8.49	1.25
27	1378	77%	9.81	8.27	1.28
30	1185	76%	9.89	8.33	1.27
33	1058	72%	10.5	8.82	1.20

If the fan duty point is fixed, then the FEI are inversely proportional to the consumed kW.

Perspective of code authorities / incentive programs

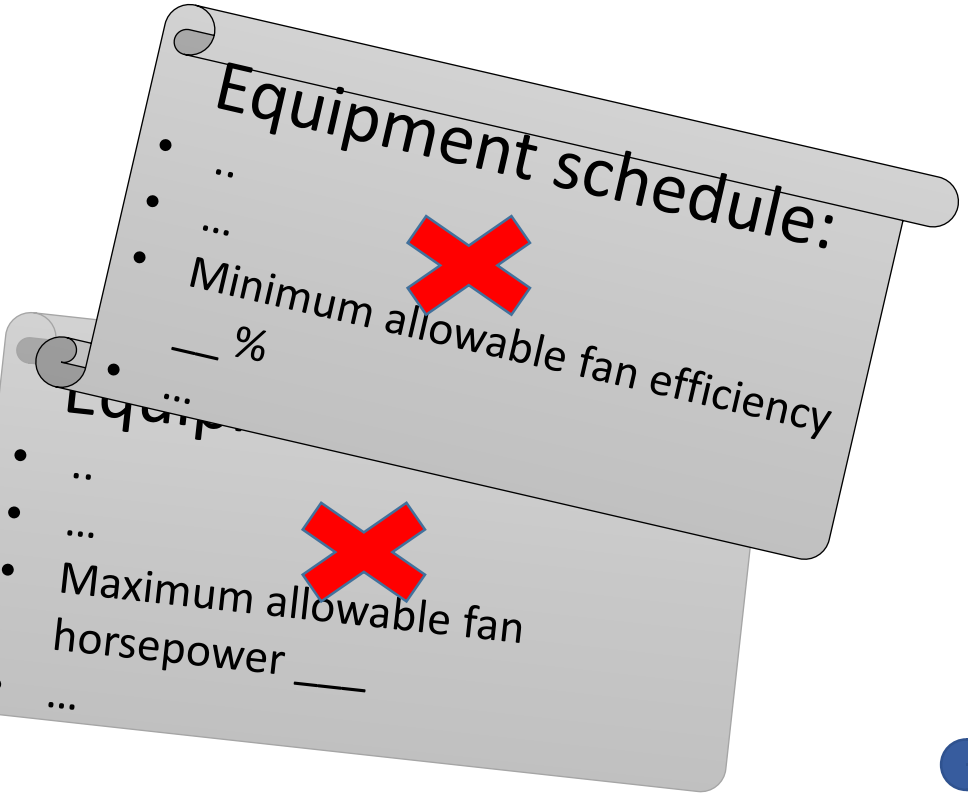
Specification template (Example):

Fans shall have a fan energy index (FEI) of 1.00 or higher at fan system design conditions, based on manufacturer's certified data.

Engineer’s perspective

Engineer's perspective

Design practices and specification templates:



Universal and convenient with FEI

Equipment schedule:

- ..
- ...
- Minimum allowable Fan Energy Index **1.20**.
- ...

- ..
- ...
- Minimum allowable Fan Energy Index **1.00**.
- ...

Engineer's perspective

Manufacturer catalog information:

Airflow (cfm)		Static Pressure (in.wg) 0	1	2	3	4	5
7500	rpm	1010	1180	1331	1468		
	bhp	1.65	3.07	4.60	6.18		
	FEI_S	1.67	1.54	1.46	1.40		
10000	rpm	1230	1378	1505	1626	1738	1843
	bhp	2.56	4.32	6.18	8.19	10.23	12.29
	FEI_S	1.42	1.45	1.43	1.40	1.38	1.36
12500	rpm	1467	1590	1709	1814	1912	2009
	bhp	3.86	5.93	8.16	10.43	12.83	15.36
	FEI_S	1.18	1.31	1.35	1.37	1.36	1.35
15000	rpm	1712	1819	1921	2021	2112	2196
	bhp	5.56	8.02	10.55	13.22	15.93	18.70
	FEI_S	0.98	1.16	1.25	1.29	1.31	1.33
17500	rpm	1961	2058	2146	2233	2320	2402
	bhp	7.81	10.70	13.54	16.50	19.58	22.77
	FEI_S	0.81	1.01	1.13	1.20	1.24	1.27
20000	rpm	2214	2301	2382	2459	2535	2612
	bhp	10.69	13.92	17.22	20.48	23.86	27.34
	FEI_S	0.67	0.89	1.02	1.11	1.17	1.21

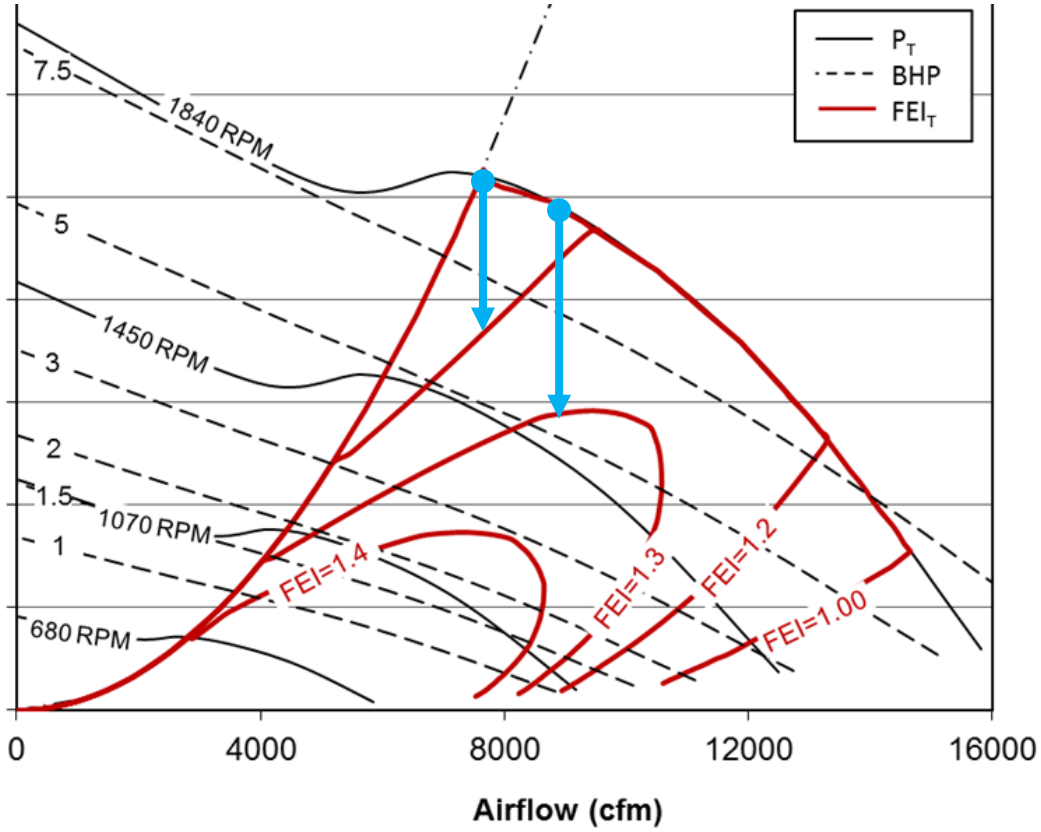
Equipment schedule:

- ..
- ...
- Minimum allowable Fan Energy Index **1.20**.
- ...

- ..
- ...
- Minimum allowable Fan Energy Index **1.00**.
- ...

Engineer's perspective

FEI increase with system design pressure reduction.

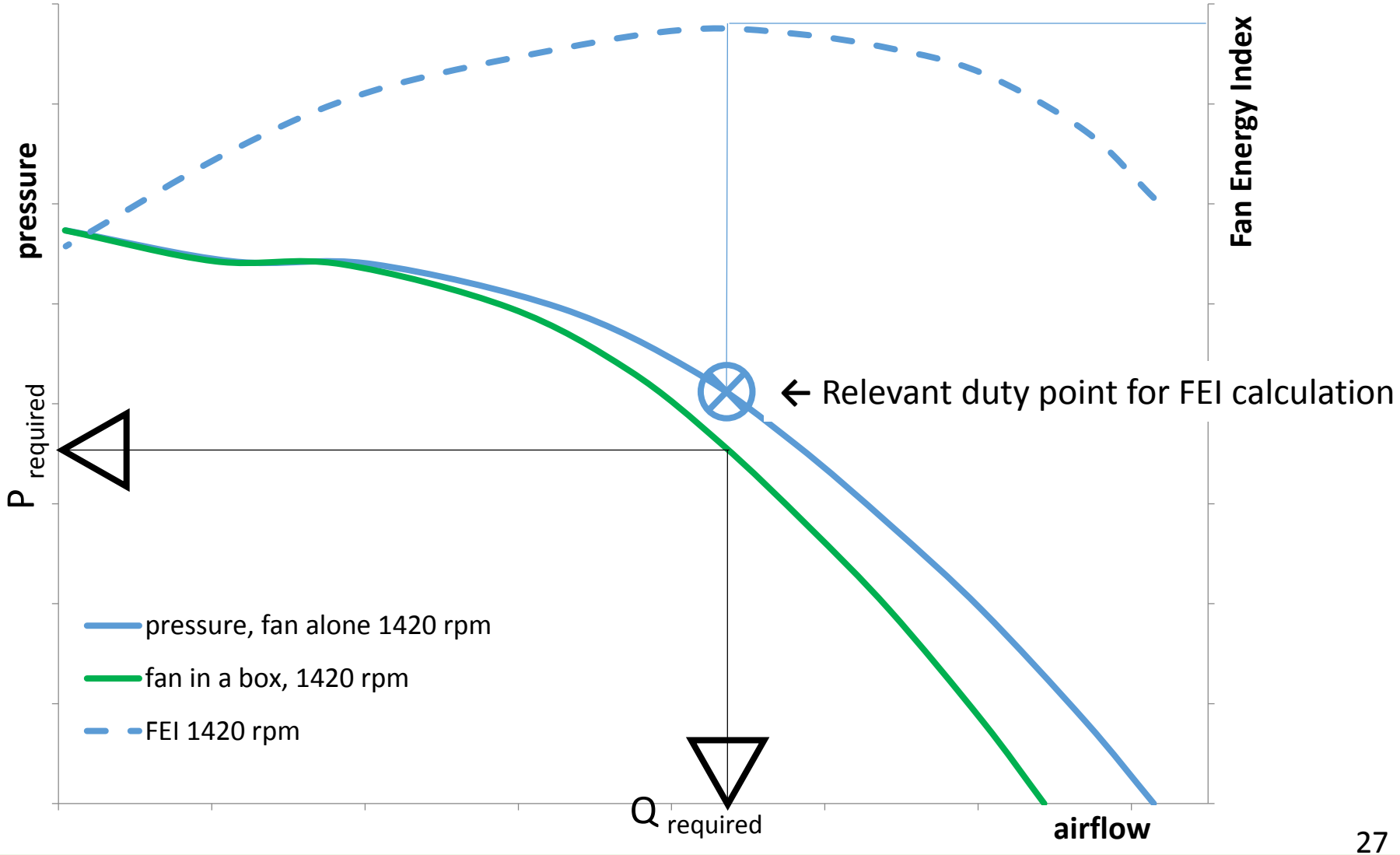


Fan supplier’s perspective

Fan supplier's perspective
Accounting for Appurtenance

Fan supplier's perspective
Accounting for Appurtenance

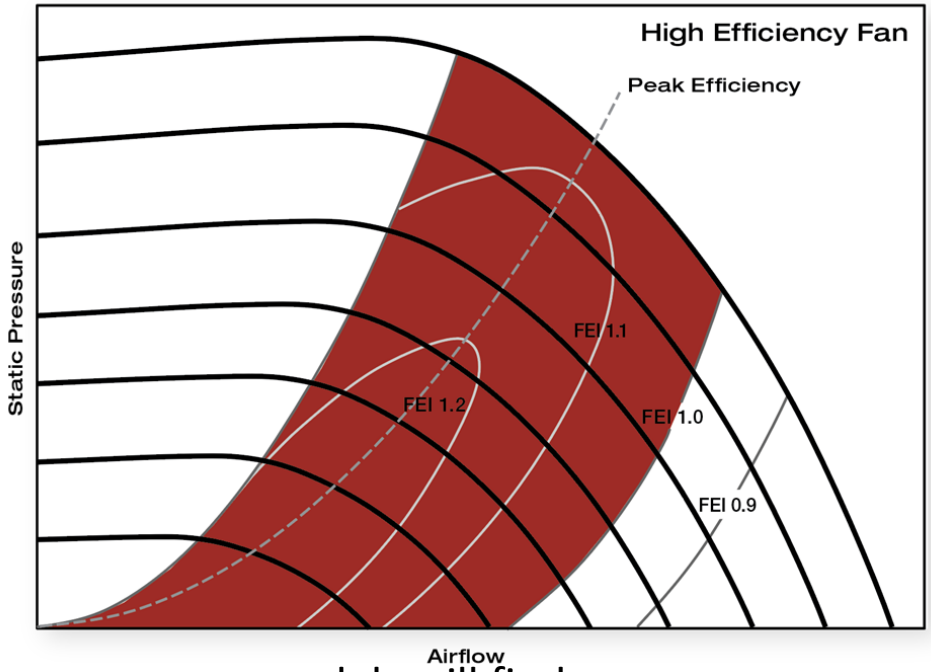
Fan supplier's perspective
Accounting for Appurtenance



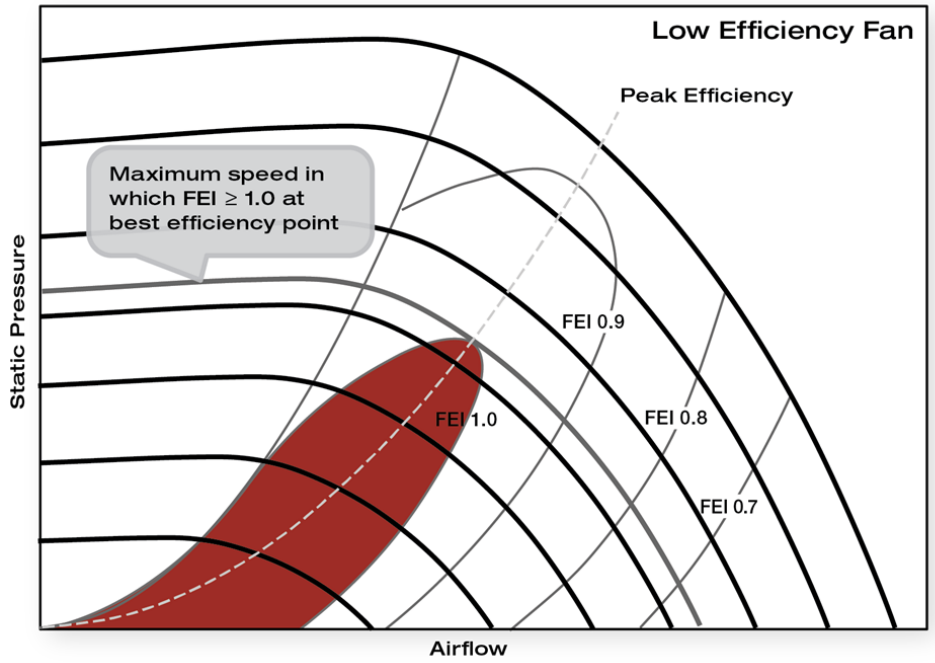
Fan supplier's perspective

Most existing fans have an operating area with a high FEI:

Fans therefore will not become obsolete, but…



…some models will find more users ...

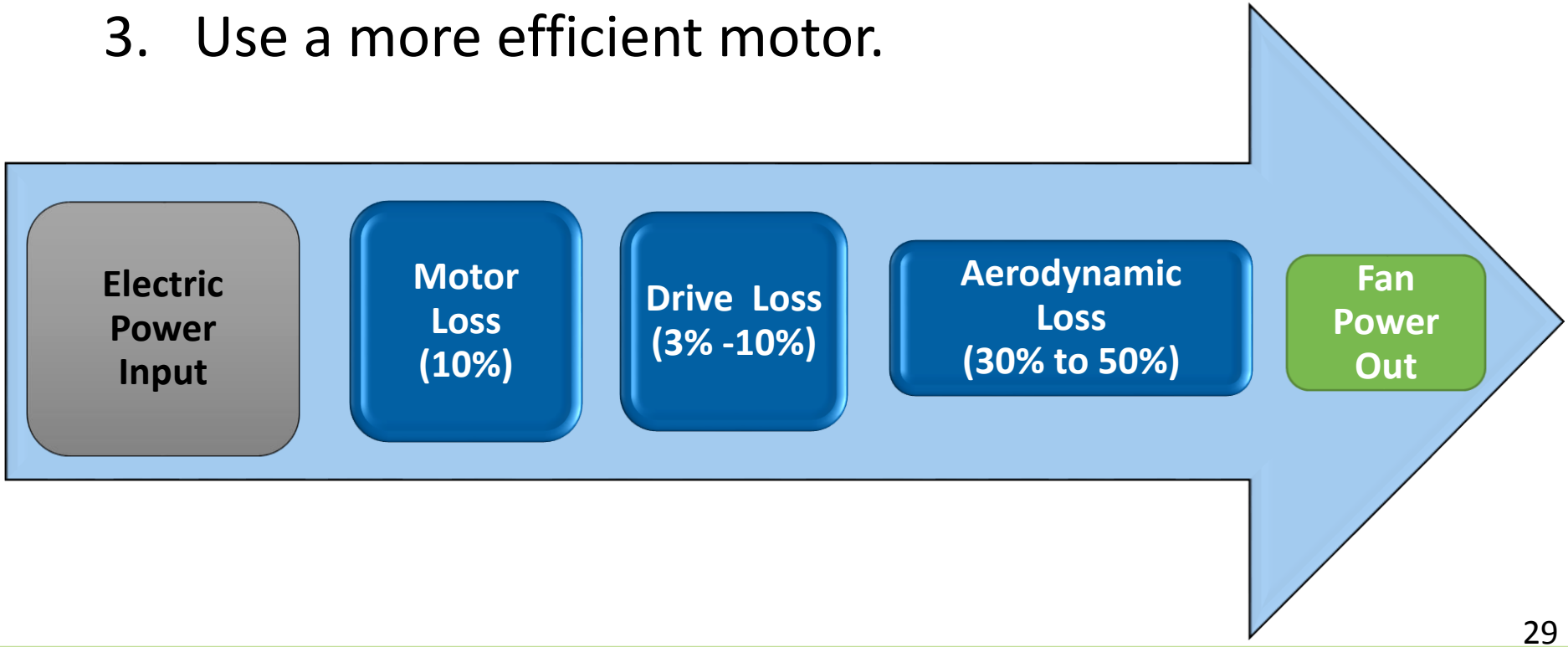


…others will be less often suitable.

Fan supplier's perspective

Possibilities to increase FEI of an existing fan:

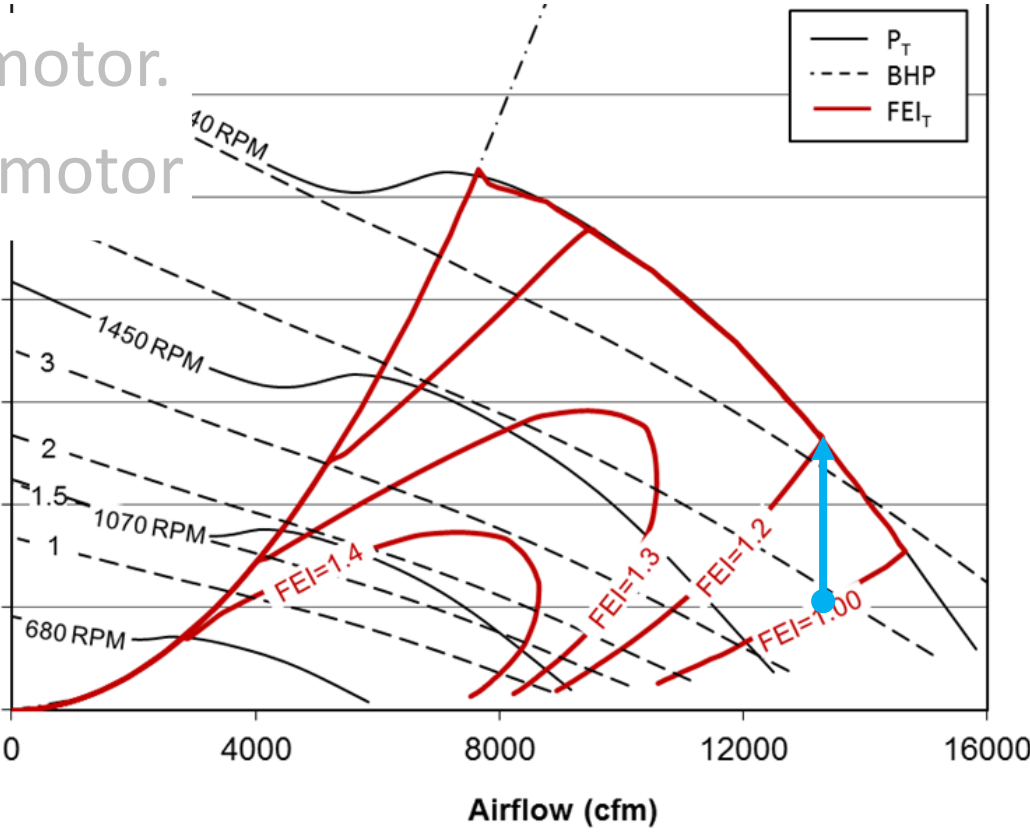
1. Reduce any belt losses.
2. Do not oversize the motor. (Part load losses)
3. Use a more efficient motor.



Fan supplier's perspective

Possibilities to increase FEI of an existing fan model:

1. Reduce belt losses
2. Do not oversize the motor.
3. Use a more efficient motor
4. Sell a larger fan of the same model.



Fan supplier's perspective

Possibilities to increase FEI of an existing fan model:

5. Sell a larger fan of the same model. (Illustration)

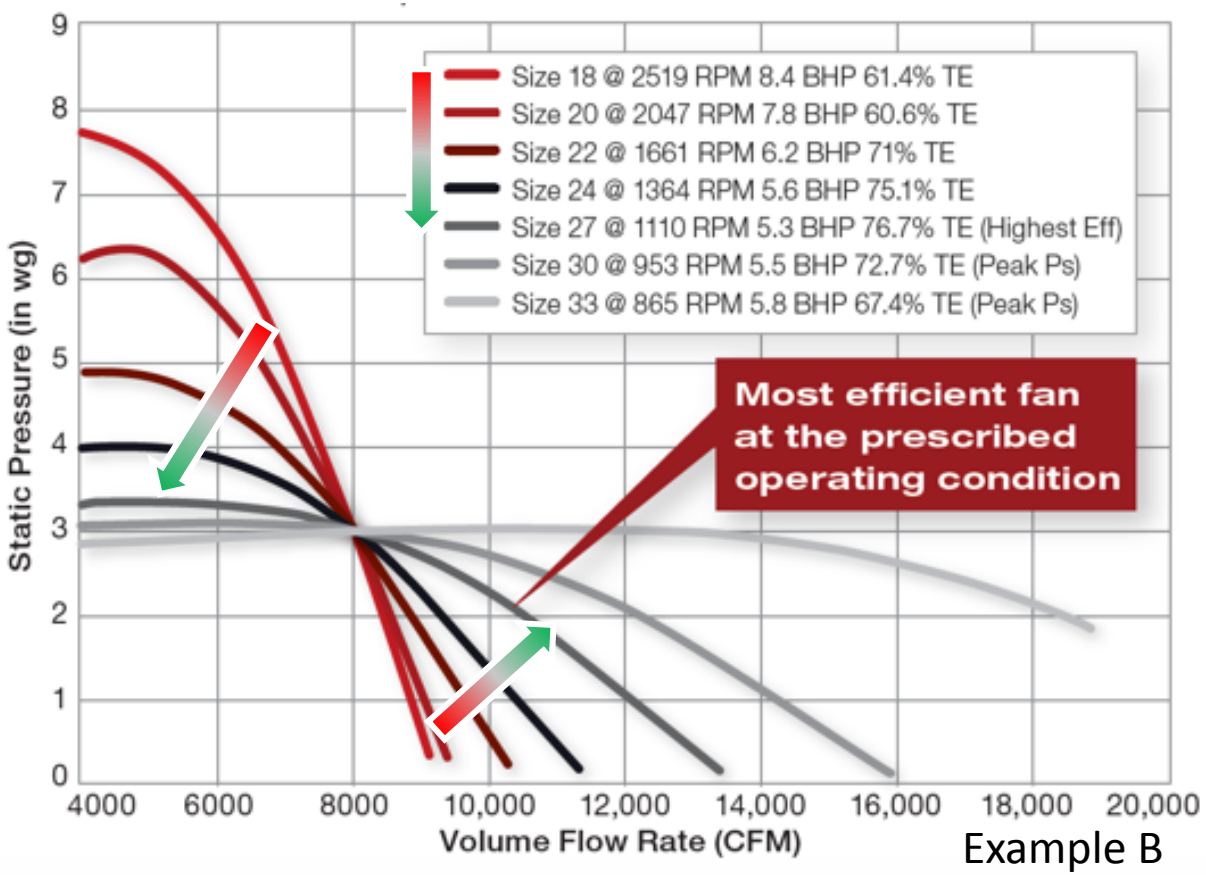
Fan Size	Speed (rpm)	Fan Total Effic. (%)	Shaft Power (bhp)	Elect. Power (kW)	FEI_T
18	3047	49%	15.3	12.8	0.83
20	2448	58%	13.0	10.9	0.98
22	1940	67%	11.2	9.42	1.13
24	1621	75%	10.1	8.49	1.25
27	1378	77%	9.81	8.27	1.28

Example A

Fan supplier's perspective

<u>Possibilities to increase FEI of an existing fan model:</u>

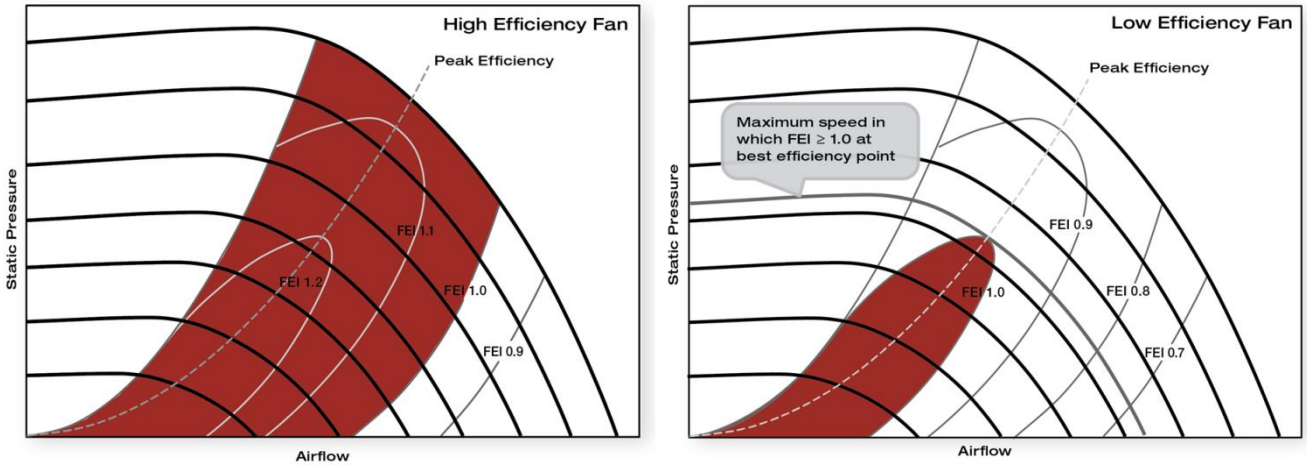
5. Sell a larger fan of the same model. (Illustration)



Example B

Fan supplier's perspective

Incentive to design aerodynamically more efficient fans:



• Airfoil • Mixed flow etc.	• Single thickness blades • Centrifugal inline

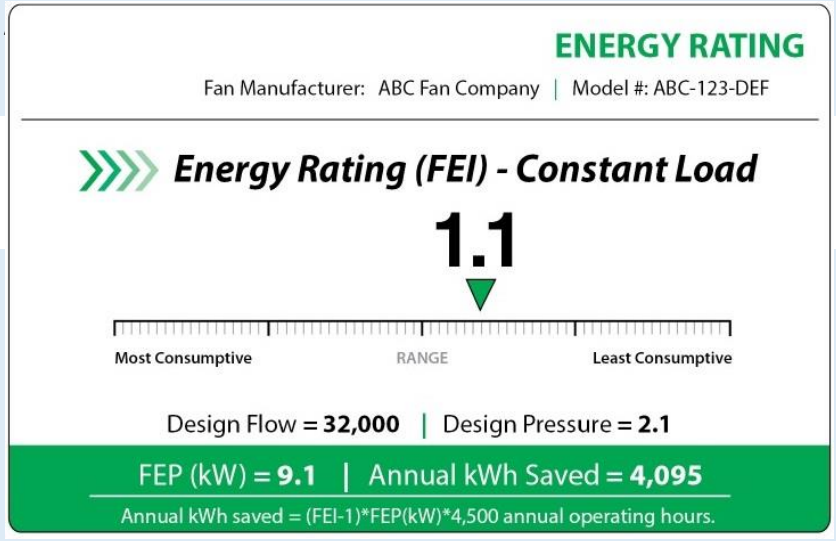
Fan supplier’s perspective

Requirement when FEI is on the fan nameplate

If the application duty point is known	If the application duty point is not known
Application duty point performance including	The FEI at the highest performance curve including
• impeller rotational speed, • FEI	• impeller rotational speed, • FEI
• airflow, • fan pressure • gas density (if other than standard air)	

Fan supplier's perspective

Draft option when FEI is on the fan nameplate

If the application duty point is known	If the application duty point is not known
	…then no Energy rating label

Questions, or Extras

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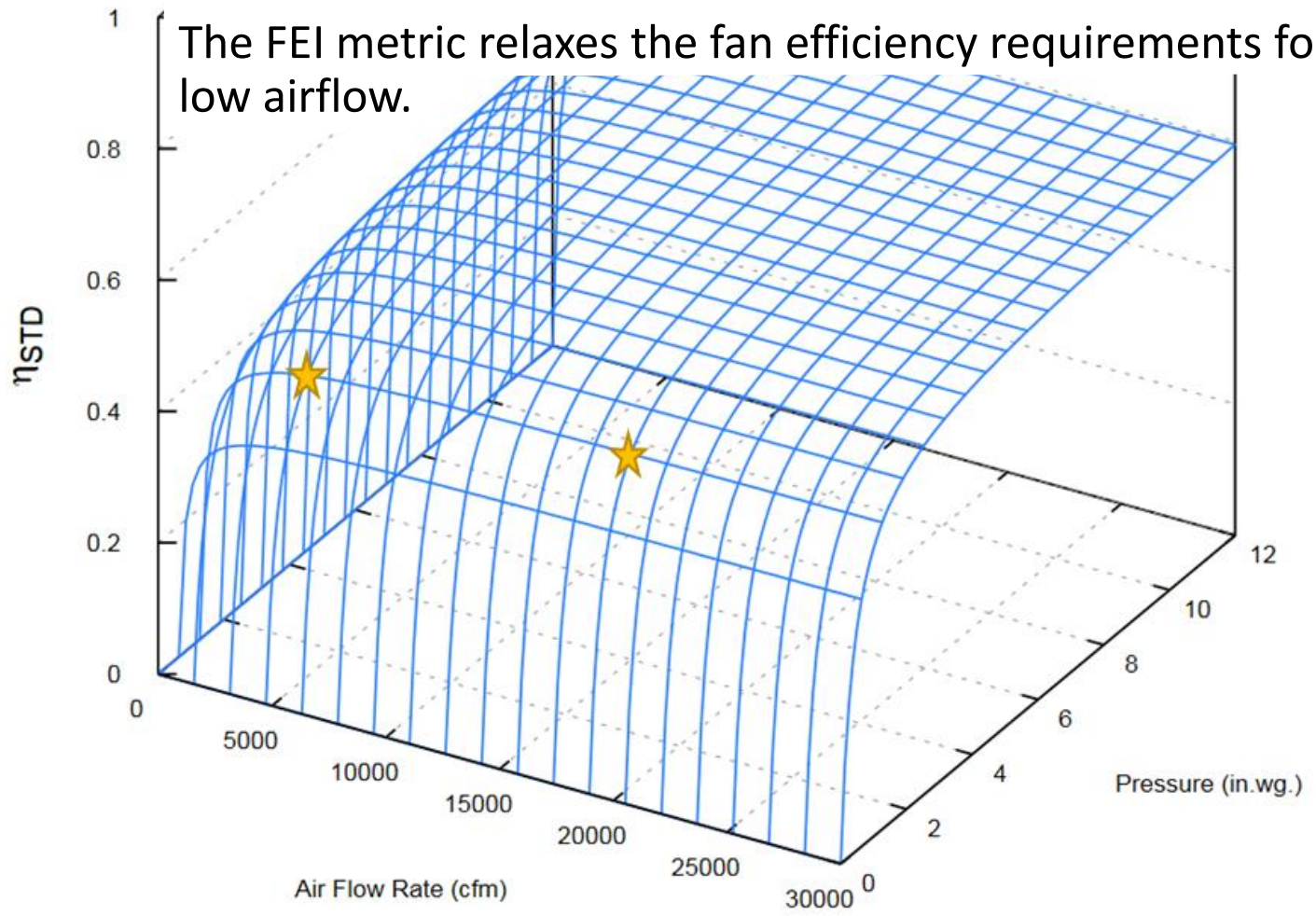
Extras

5. AMCA 208 Annex C
6. Fan selection for multiple duty points (load profile)
7. FEI comparison when competing fans do not meet the desired duty point.

Annex C of AMCA 208

Background:

The FEI metric relaxes the fan efficiency requirements for low fan pressure, low airflow.



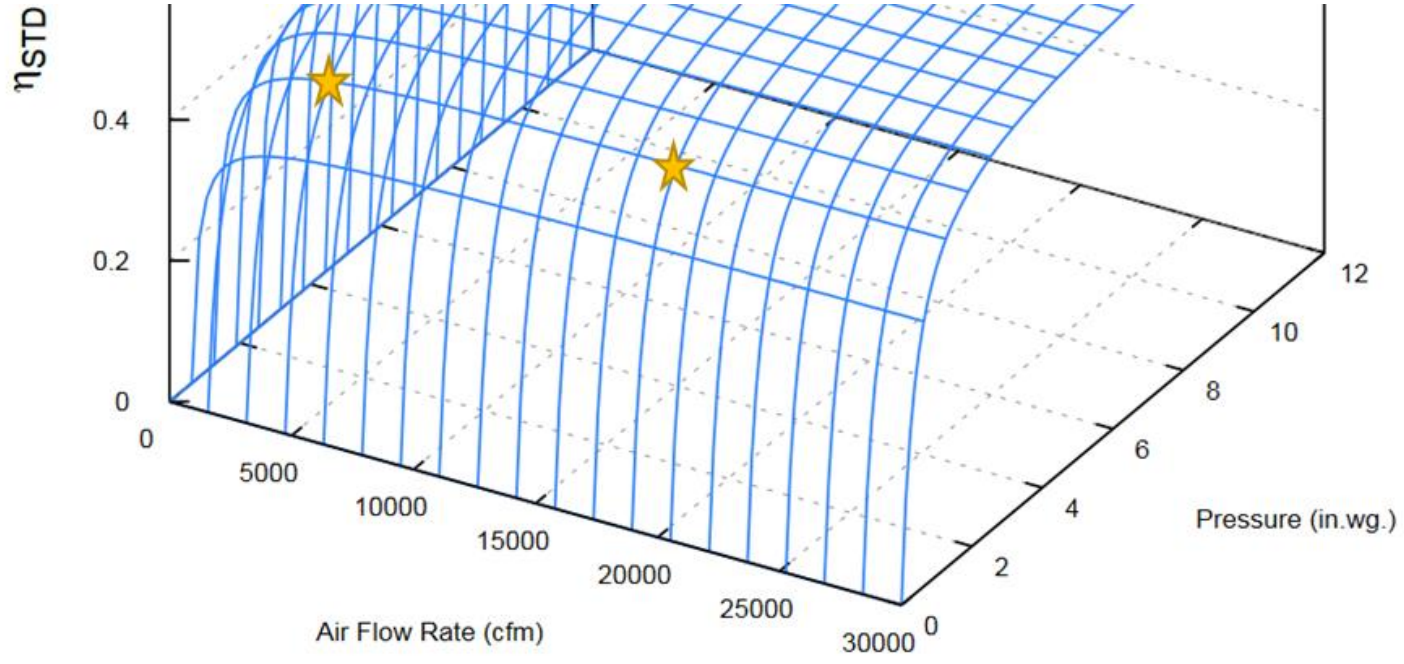
Annex C of AMCA 208

Background:

The FEI metric relaxes the fan efficiency requirements for low fan pressure, low airflow.

Potential problem (example):

An assembly of 4 or 9 fans could use more power than a 1-fan solution.



Annex C of AMCA 208
Fan Array

Background:

The FEI metric relaxes the fan efficiency requirements for low fan pressure, low airflow.

Potential problem (example):

An assembly of 4 or 9 fans could use more power than a 1-fan solution.

Solution for fan arrays:

Divide the reference power value by the number of fans.

$$FEI(1) = FEP(reference) \div FEP(actual)$$

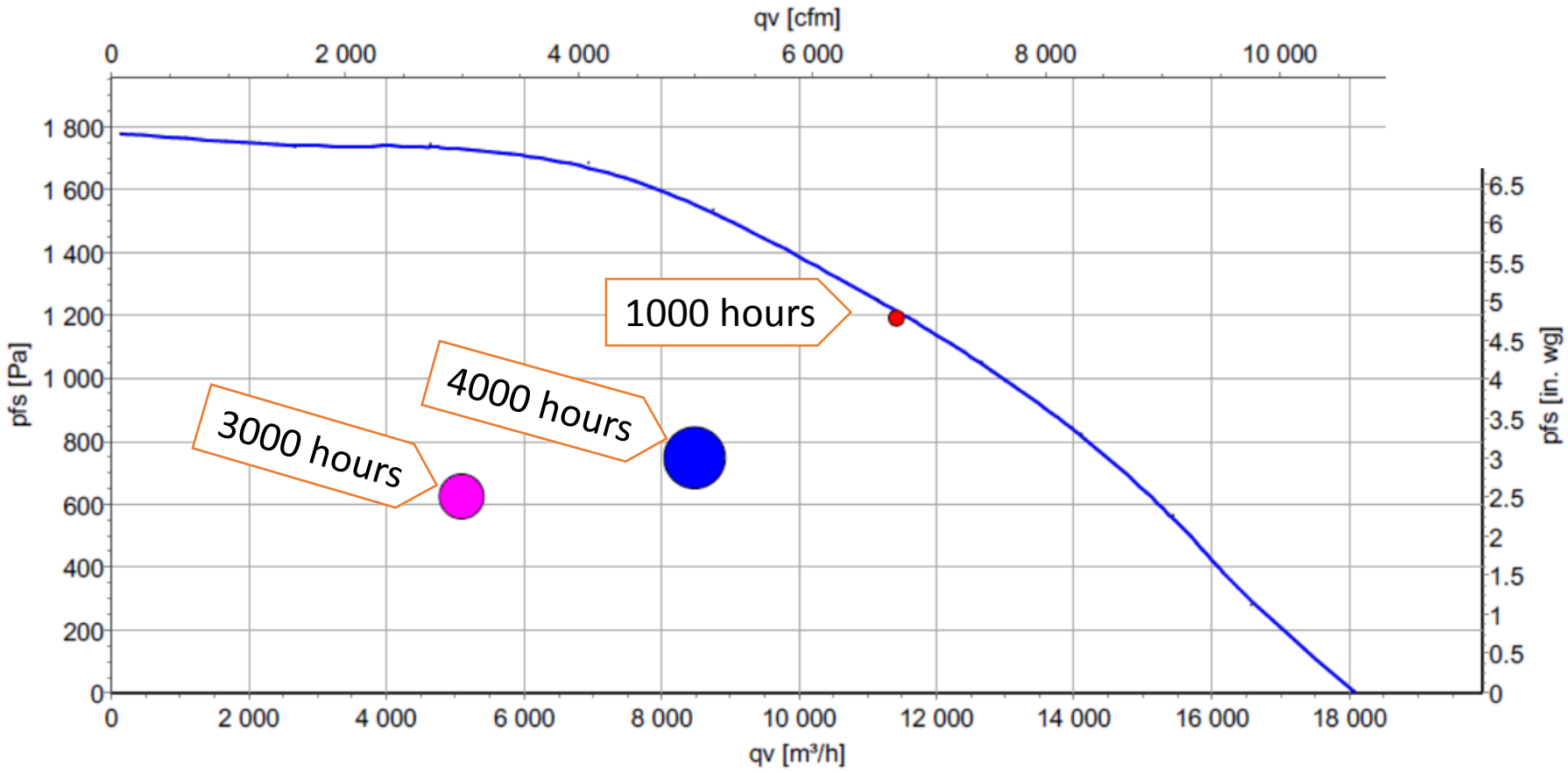
$$FEI(4) = (1/4) \times FEP(reference) \div FEP(actual)$$

$$FEI(n) = (1/n) \times FEP(reference) \div FEP(actual)$$

```
Specification template:
The FEI for fans used in fan arrays shall be
calculated in accordance with AMCA 208 Annex C.
```

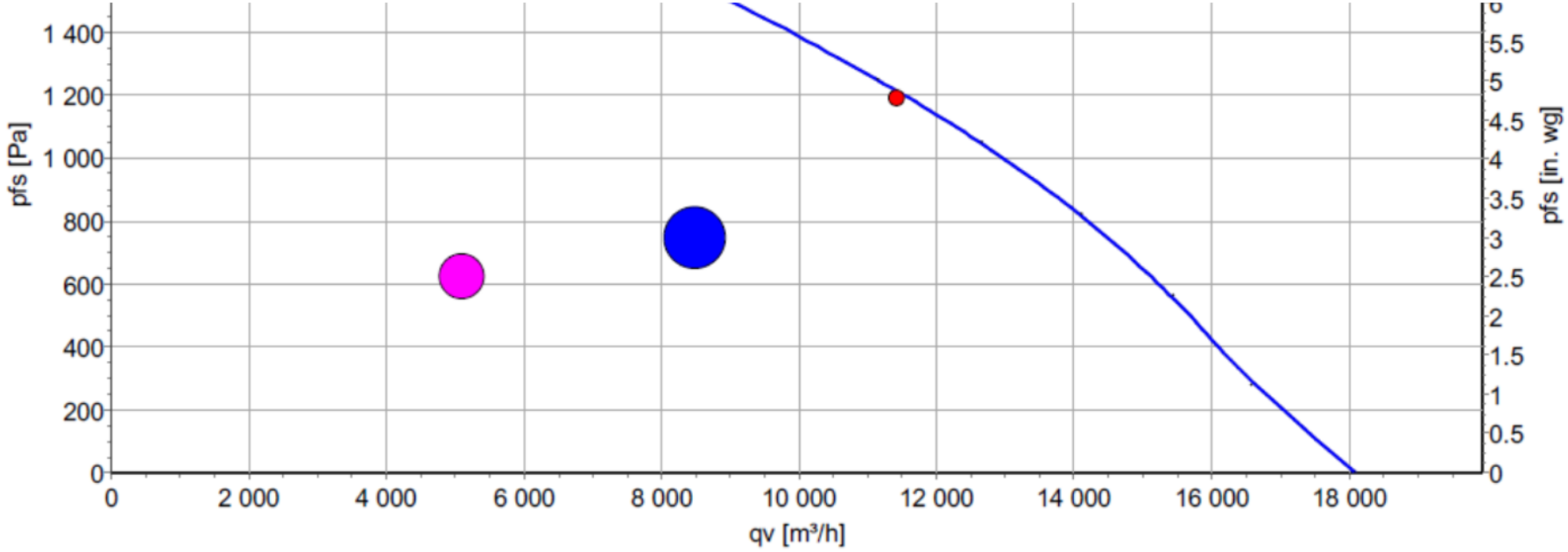
Fan selection for multiple duty points (load profile)

Air performance

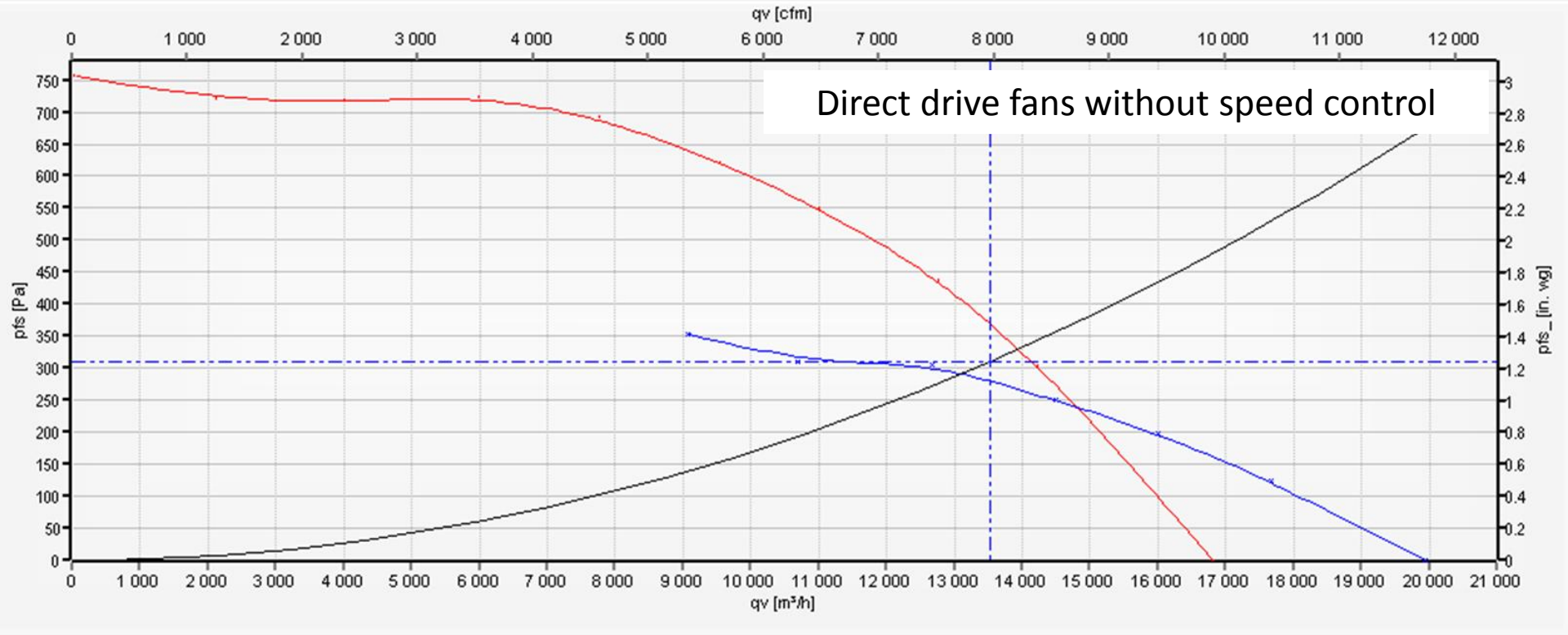


Fan selection for multiple duty points (load profile)

duty	cfm	in. wg	rpm	hours	Wire-to-air efficiency %	kW	kWh	FEI
1	6727	4.78	2244	1000	67	5.67	5667	1.43
2	5000	3	1743	4000	66	2.67	10677	1.54
3	3000	2.5	1421	3000	60	1.46	4379	1.54
p.a.				8000			20723	



FEI comparison when competing fans do not meet the desired duty point exactly



Side-by-side comparisons require identical duty points, no matter which fan efficiency metric is used.

Questions

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