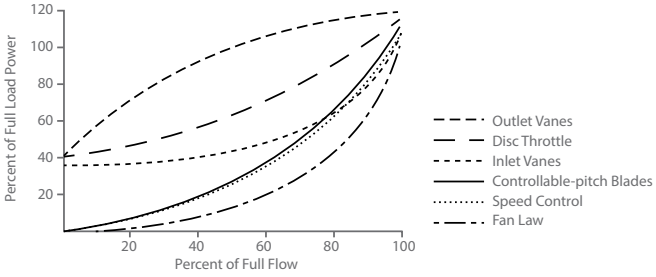
Better Plants
U.S. DEPARTMENT OF ENERGY

Fan System *Info Card*

Top 5 Energy Conservation Measures

1. Shut down fans when not needed by manufacturing processes
2. Use VFD instead of modulating dampers for air flow control
3. Use VFD instead of inlet guide vanes for air flow control
4. Replace standard V-belts with cogged V-belts
5. Operate close to Best Efficiency Point

Fan Capacity Control Options



Fan Brake Horse Power Formula

$$\text{Fan Brake Horse Power (hp)} = \frac{\text{Flow Rate (CFM)} \times \text{Head (in w.c.)}}{6356 \times \text{Fan Efficiency}}$$

Fan Affinity Laws

$$\frac{Q_2}{Q_1} = \frac{N_2}{N_1}$$

Q = Fan flow rate

$$\frac{H_2}{H_1} = \left(\frac{N_2}{N_1}\right)^2$$

N = Fan speed
H = Fan head

$$\frac{P_2}{P_1} = \left(\frac{N_2}{N_1}\right)^3$$

P = Fan power

Rules of Thumb

1. Fan power: 1000-1500 CFM/hp
2. Fan annual energy cost: $350/1000 CFM (24/7 operation)
3. Air handling unit fan air flow sizing: 400 CFM/ton

Unit Conversion

1 in w.c. = 0.036 psi; 1 CFM = 28.3 l/min; 1 HP = 745.7 W

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Air Density Correction Factors

Temp (°F)	Altitude (ft)							
	0 (Sea Level)	1000	2000	3000	4000	5000	6000	7000
50	1.04	1	0.97	0.94	0.9	0.87	0.84	0.81
55	1.03	0.99	0.96	0.93	0.89	0.86	0.83	0.8
60	1.02	0.98	0.95	0.91	0.88	0.85	0.82	0.79
70	1	0.96	0.93	0.89	0.86	0.83	0.8	0.77
80	0.99	0.95	0.92	0.88	0.85	0.81	0.79	0.76
90	0.97	0.94	0.90	0.86	0.83	0.8	0.77	0.75
100	0.95	0.93	0.88	0.85	0.81	0.78	0.75	0.73
110	0.94	0.92	0.86	0.83	0.8	0.77	0.74	0.72
120	0.93	0.9	0.85	0.82	0.79	0.76	0.73	0.71
130	0.91	0.88	0.83	0.81	0.78	0.75	0.72	0.70
140	0.89	0.86	0.81	0.8	0.77	0.73	0.71	0.68
150	0.87	0.84	0.80	0.79	0.75	0.72	0.70	0.67

**Air Density at sea level and 70° F: 0.075 lbm/ft³*

Air Speed and Volume Flow Rate Calculation Formulas

Air speed using actual air density	$V\left(\frac{ft}{min}\right) = 1096.7 \times \sqrt{\frac{P_V(in.\ w.c.)}{D\left(\frac{lbs}{ft^3}\right)}}$
Air speed using air density at sea level and 70° F	$V\left(\frac{ft}{min}\right) = 4005 \times \sqrt{P_V(in.\ w.c.)}$
Air volume flow rate	$Q\left(\frac{ft^3}{min}\right) = A(ft^2) \times V\left(\frac{ft}{min}\right)$
Air velocity pressure	$P_V = P_T - P_S$

Where: V=Air speed; P_V=Air velocity pressure; D=Air density; Q=Air volume flow rate; A=Cross section area; P_T=Air total pressure; P_S=Air static pressure

Energy Cost for Fan Driven by 100-hp Motor

Operating Time	Energy Costs for Various Electricity Costs				
	2¢ per kWh	4¢ per kWh	6¢ per kWh	8¢ per kWh	10¢ per kWh
1 hour	$1.30	$3.30	$4.90	$6.60	$8.20
24 hours	$39	$79	$119	$159	$198
1 month	$1,208	$2,416	$3,625	$4,833	$6,042
1 year	$14,500	$29,000	$43,600	$58,000	$72,600

**Assuming 90% motor efficiency*

Resources

1. Improving Fan System Performance: A Sourcebook for Industry by US Department of Energy
2. Fan System Assessment Tool (FSAT) by US Department of Energy
3. Advanced Variable Air Volume System Design Guide by Energy Design Resources