VFD Energy Saving (Fan or Pump)

Power and energy saved by a variable frequency drive instead of a damper, vanes or a throttling valve on a fan or pump, on a system curve with static head.

Method: Fan and pump affinity laws (AMCA 99, ANSI/HI 1.3)

Input parameters

Unit system: SI

Parameter	Value	Unit
Shaft power at the design duty (100 % flow)	150.00	kW
Operating flow as a share of design	75.000	%
Static share of the design pressure or head 0 for an all-friction system (most ID and FD fans); a boiler feed pump working against drum pressure has a large static share.	0	%
Shaft power with the damper or valve at this flow, as a share of P_d Read it from the fan or pump curve at the reduced flow at full speed (with inlet vanes, from the maker's vane curves).	85.000	%
Drive (VFD) efficiency	97.000	%
Motor efficiency	95.000	%
Hours per year at this flow	8,000.0	h
Electricity price per kWh (your currency)	8.0000	

Calculated results

Parameter	Value	Unit
Electrical power saved	65.539	kW
Energy saved per year	524.31	MWh
Cost saved per year (your currency)	4,194,466	
Electrical input with damper or valve	134.21	kW
Electrical input with VFD	68.672	kW
Shaft power with VFD	63.281	kW

Formula and method

$$P_v = P_d\, f\left(s + (1-s) f^2\right) \qquad P_{e,v} = \frac{P_v}{\eta_m\, \eta_v} \qquad P_{e,t} = \frac{r_t\, P_d}{\eta_m}$$

$$\Delta P = P_{e,t} - P_{e,v} \qquad \Delta E = \Delta P t_{op} \qquad \Delta C = \Delta E\,[\mathrm{kWh}] \cdot c_e$$

Variables

P_d	shaft power at the design duty	W
f	operating flow as a share of design	–
s	static share of the design pressure or head	–
r_t	throttled shaft power as a share of P_d	–
η_v	drive efficiency	–
η_m	motor efficiency	–
t_{op}	hours per year at this flow	s
c_e	electricity price per kWh	–
ΔP	electrical power saved	W

ΔE	energy saved per year	J
ΔC	cost saved per year	–
$P_{e,t}$	electrical input with damper or valve	W
$P_{e,v}$	electrical input with VFD	W
P_v	shaft power with VFD	W

Method and standards

With speed control the machine follows the system curve $p = p_d(s + (1 - s)f^2)$; at constant machine efficiency the shaft power is proportional to flow times pressure (the affinity laws of AMCA 99 and ANSI/HI 1.3 when $s = 0$). The throttled power comes from the machine's own curve at full speed.

Assumptions and limits

- Machine efficiency taken as constant at reduced speed: exact for $s = 0$, optimistic when the static share is large.
- Motor efficiency taken as equal in both cases; at low load it falls, which slightly favours the VFD.
- One operating point; for a load profile add the savings of each point weighted by its hours.

References

- Fan and pump affinity laws (AMCA 99, ANSI/HI 1.3)

Report details

Report reference	FCC-653K-9HT7 (the same inputs always give the same reference)
Generated	17 November 2026, 19:45 UTC
Calculator	VFD Energy Saving (Fan or Pump)
Method last reviewed	10 November 2026
Software release	FireCAD Calc, release of 17 November 2026
Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

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Reopens the calculator with the inputs of this report.