Load/Unload Compressor Part-Load Energy vs VSD

Average power, specific power and annual energy of a load/unload air compressor at part demand, compared with a variable-speed drive machine.

Method: Load/unload averaging and proportional VSD power; Bureau of Energy Efficiency; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Power at full load	90.000	kW
Free air delivery at full load	15.000	m³/min
Average air demand	9.0000	m³/min
Unloaded power as a share of full-load power	25.000	%
VSD specific power relative to the fixed-speed machine at full load	1.0500	
Running hours per year	6,000.0	h
Electricity price per kWh (your currency)	8.0000	

Calculated results

Parameter	Value	Unit
Load factor	60.000	%
Average power, load/unload	63.000	kW
Specific power at this demand	0.11667	kWh/m³
Energy in a year, load/unload	378.00	MWh
Average power with a VSD machine	56.700	kW
Energy saved by a VSD in a year	37.800	MWh
Cost saved in a year	302,400	

Notes for this case

• A load/unload compressor runs at full power for the fraction of time Q_d/Q it is loaded and at its unloaded power the rest, so average power is P_f[Q_d/Q + f_u(1 − Q_d/Q)]. At 60 % load with 25 % unload power it draws 70 % power for 60 % air. A variable-speed machine draws power roughly in proportion to delivery, at a specific power a few per cent worse than a fixed-speed machine at full load. Blow-down losses and small receivers make real load/unload figures worse than this.

Formula and method

$$\bar{P} = P_f \left[\frac{Q_d}{Q} + f_u \left(1 - \frac{Q_d}{Q} \right) \right], \quad P_v = k_v P_f \frac{Q_d}{Q}$$

Variables

P_f	Power at full load	W
Q	Free air delivery at full load	m³/s
Q_d	Average air demand	m³/s
f_u	Unloaded power as a share of full-load power	-
k_v	VSD specific power relative to the fixed-speed machine at full load	-
t	Running hours per year	s
c	Electricity price per kWh (your currency)	-
Q_d/Q	Load factor	-

$\bar{P}$	Average power, load/unload	W
SP	Specific power at this demand	J/m³
E	Energy in a year, load/unload	J
P_v	Average power with a VSD machine	W
ΔE	Energy saved by a VSD in a year	J
ΔC	Cost saved in a year	-

Method and standards

Load/unload.

Assumptions and limits

- Steady average demand; one compressor; no blow-down or cycling penalty.

References

Load/unload averaging and proportional VSD power, Bureau of Energy Efficiency, Energy Efficiency in Electrical Utilities (Guide Book 3), ch. 3 Compressed air system

Report details

Report reference	FCC-HP90-H6DY (the same inputs always give the same reference)
Generated	23 November 2026, 18:00 UTC
Calculator	Load/Unload Compressor Part-Load Energy vs VSD
Method last reviewed	17 November 2026
Software release	FireCAD Calc, release of 22 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

https://calc.firecad.com/mechanical/compressors/compressor-load-unload-energy

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.