Cost-effectiveness Analysis of Fan & Pump VSD

DOE Proposal: C-5; ICC proposal: TBA
for 2018 IECC commercial code
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PURPOSE

Find the smallest size for cost-effective VSD application for fans and pumps in commercial buildings. The current IECC fan threshold is 7. 5 hp and the pump threshold is 10 hp.

BASIS

The cost-effectiveness analysis is conducted according to the DOE cost-effectiveness methodology.[1] In the DOE method, the long term economic impacts for two cases are determined:

- Scenario 1 is for publicly-owned buildings and is based on a FEMP method.[2]
- Scenario 3 is for privately-owned buildings and is based on the 90.1-2016 scalar method.

15.0 year measure life (Electronic controls)[3]

Scenario 1 electric UPW factor with 3% discount and EIA energy escalation:[4] 12.65

The Scenario 3 threshold for electric savings over a 15 year measure life is 10.8 years. In Scenario 3, measures are found cost-effective when the simple payback ≤ the scalar threshold.

Annual operation:

Fans at 5096 hours based on 7 days a week, 14 hours a day; pumps at 5824 hours based on 16 hours/day.
Note that many fans and pumps in commercial buildings operate longer hours to allow tenant schedule flexibility. Chilled water pumps often have longer hours because they must often serve equipment cabinets or server rooms that have 24/7 operation. Fan and pump profile is similar to large office building prototype.

Operating profiles:

	Time at flow				Time at flow	
Flow	Pump	Fan		Flow	Pump	Fan
0%	0.0%	0.0%		60%	2.0%	3.0%
10%	40.0%	0.0%		70%	1.0%	2.0%
20%	15.0%	32.0%		80%	1.0%	1.0%
30%	30.0%	22.0%		90%	1.0%	0.0%
40%	7.0%	25.0%		100%	0.0%	0.0%
50%	3.0%	15.0%				

Motor efficiencies from IECC for 1800 rpm general purpose open drip-proof motors.

Savings calculation method is the DOE VSD calculator for Pumps and fans.[5]

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[1] Hart, R., and Liu, B. (2015). *Methodology for Evaluating Cost-effectiveness of Commercial Energy Code Changes.* Pacific Northwest National Laboratories for U.S. Department of Energy; Energy Efficiency & Renewable Energy. PNNL-23923 Rev1. https://www.energycodes.gov/development/commercial/methodology.

[2] Fuller, Sieglinde, and Stephen Petersen. "LIFE-CYCLE COSTING MANUAL for the Federal Energy Management Program." NIST, U.S. Deptartment of Commerce, 1995. http://fire.nist.gov/bfrlpubs/build96/PDF/b96121.pdf.

[3] ASHRAE. (2015). *2015 ASHRAE Handbook Applications*. American Society of Heating, Refrigerating and Air Conditioning Engineers [ASHRAE], Atlanta, GA.

[4] Rushing, Amy S., Joshua D. Kneifel, and Priya Lavappa. *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis-2014: Annual Supplement to NIST Handbook 135*, 2015. http://dx.doi.org/10.6028/NIST.IR.85-3273-29.

Energy Prices

Energy rates for 2014 commercial annual average from July 2015 EIA STEO.
Energy escalation/present value rates from NIST 2015 annual supplement.[6]

Commercial Sector			2014	Annual Average		Most recent full year
			2015 July	EIA Short Term Energy Outlook		
Prices	$0.1075	$/kWh	$1.0555	$/therm	(2014 EIA average)	for Scenario 1 analysis
	$0.1013	$/kWh	$1.0000	$/therm	SSPC 90.1 for 2016	for Scenario 3 analysis

Cost

2014 R. S. Means cost source with 25% General Contractor OH&P.[7] Added controls are included with a deduct for the motor starter replaced by the VSD. Pump controls cost is slightly higher for differential pressure sensor. The incremental cost values by motor horsepower are shown under Cost-effectiveness.

Energy Savings Results

Energy saving results are shown for proposed additions to code requirements.

Annual Energy Savings $0.1075 $/kWh Scenario 1 prices Scenario 3 (90.1-2016)

	kWh/year		$/year		Simple Payback		Simple Payback	
Motor HP	Pump	Fan	Pump	Fan	Pump	Fan	Pump	Fan
2.0	4,101		$441		8.9		9.4	
3.0	5,945		$639		6.3		6.7	
5.0	9,909	3,789	$1,065	$407	4.0	9.0	4.3	9.6
7.5	14,618		$1,571		3.0		3.1	

Cost-effectiveness

The cost-effectiveness is evaluated using Scenario 1 (FEMP) for the public sector and Scenario 3 (90.1-2016) for the private sector.[8] For Scenario 1, the savings to investment ratio (SIR) indicates a measure is cost-effective when greater than 1.0. For Scenario 3, when the simple payback shown under Energy Savings Results is less than the scalar threshold of 10.8 years, a measure is cost-effective.

Cost-effectiveness Analysis: Commercial Methodology Scenario 1

Motor	Added First Cost		Present Value of Savings		Net Present Value of Savings		Savings to Investment Ratio	
HP	Pump	Fan	Pump	Fan	Pump	Fan	Pump	Fan
2.0	$3,920		$5,577		$1,657		1.4	
3.0	$4,026		$8,085		$4,058		2.0	
5.0	$4,274	$3,670	$13,475	$5,153	$9,201	$1,483	3.2	1.4
7.5	$4,650		$19,879		$15,229		4.3	

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[5] https://ecenter.ee.doe.gov/EM/tools/Pages/VSDPumps.aspx

[6] Lavappa, Priya, and Joshua D. Kneifel. *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis-2015: Annual Supplement to NIST Handbook 135*, 2015. http://dx.doi.org/10.6028/NIST.IR.85-3273-30.

[7] Means, R. S. *2014 Mechanical Cost Data*. R.S. Means Company, 2014. http://www.rsmeans.com/.

[8] Hart, Reid, and Bing Liu. "Methodology for Evaluating Cost-Effectiveness of Commercial Energy Code Changes." Pacific Northwest National Laboratories for U.S. Department of Energy; Energy Efficiency & Renewable Energy., August 2015. https://www.energycodes.gov/development/commercial/methodology.

CONCLUSION:

Variable speed drives are cost-effective for:

- 2 HP and larger pumps
- 5 HP and larger fans or fan arrays

Note that fan arrays operating at the same speed can be served by one variable speed drive.