Recommendation

Replace the current throttle controlled compressor with a variable frequency drive compressor to reduce electrical draw and demand costs, reducing associated annual energy consumption by 67.6%.

Annual Savings Summary

Source	*Quantity*	*Units*	*Cost Savings*
Electrical Consumption	55,187	kWh (site)	$4,167
Electrical Demand	317	kW Months / yr	$1,984
Total	**188**	**MMBtu**	**$6,151**

Implementation Cost Summary

Description	*Cost*	*Payback (yrs)*
Before Incentives	$36,950	6.0
After Incentives	$23,153	3.8

Facility Background

The facility uses one 50 hp air compressor to provide compressed air at 110 psig for blowdown on their machines and to operate pneumatic tools. A 35 hp backup compressor is used when the primary compressor is under maintenance. The compressors are connected in series with dedicated refrigerant dryers, which are connected in parallel with a replaceable dessicant pod to serve a low-humidity process. The 50 hp compressor is water-cooled. A malfunctioning valve on the cooling equipment is causing an additional annual water disposal cost of $200. A timer is used to turn the compressors off after they are no longer in use. The floor manager conservatively estimated that the main compressor operates at an average of 60% air capacity. Analysts requested the facility data-log this compressor for a week to determine its operating costs.

Opportunity Background

Throttle controlled compressors operate at approximately 68% of full load power when providing 0 cfm of air [1]. Power required at part load varies linearly from this to 100% at full load. This results in excessive energy consumption that only keeps the equipment warm. Variable frequency drive (VFD) controlled equipment operates as low as 3% [1] of full load power when providing 0 cfm of air. VFD controls significantly reduce energy use by providing an equivalent air volume with a lower incremental energy requirement. Replacing the current compressor with a VFD model will reduce power at 60% air capacity from approximately 90% to 70% of full load power at same pressure.

Proposal

Replace the 50 hp throttle controlled water-cooled compressor with a 50 hp VFD controlled air-cooled compressor. Associated annual cost savings are estimated to be $6,151 after an implementation cost of $36,950, resulting in a simple payback period of 6.0 years before incentives and 3.8 years after an estimated incentives of $13,797.

Vendor Data

Analysts reached out to a number of different vendors to get compressor cost information but got no response from them. So, an online cost information obtained from the webpage of a vendor [2] was used as the material cost. It should be noted that analysts do not recommend the specific manufacturer or compressor model over any other manufacturer or compressor model. Cost values of $36,000 and $31,900 were obtained. An average of these two costs was used as the material cost in the implementation cost analysis.

Implementation

Remove the current compressor and install a new VFD controlled air-cooled compressor in the same location. Alternatively, a VFD control may be retrofitted on the current compressor. However, given the age of current compressor, it likely does not have a VFD capable motor and may not continue to operate long enough to justify the investment.

Incentives

Companies paying a public purpose charge may qualify for Energy Trust of Oregon cash incentives. Incentives are calculated on a case-by-case basis and are based on the results of a technical analysis study. Electricity trimming projects may qualify for an incentive of $0.25 per annual kWh saved, up to 50% of the project cost.

Calculation Methodology

Figure 1 shows the power consumed by the 50 hp main compressor at different air flow values for two different control types, throttle and VFD. It is seen that, when producing 0 cfm airflow, the 50hp throttle controlled compressor draws approximately 28 kW while a VFD controlled 50 hp compressor draws approximately 2 kW. Note that a stock-VFD controlled compressor typically behaves as a load-unload compressor when delivering less than 27% airflow.

Using the data collected from one week of compressor operation, analysts calculated the percentage of time the compressor operated at different airflow capacities. It was found that for approximately 22% of the total operation time, the compressor produced 0% cfm, consuming 28 kW. Similarly, for approximately 11% of the total operation time, the compressor produced 100% cfm, consuming 41 kW.

To calculate the annual energy consumption of the current compressor, the observed operation pattern was extrapolated to a full year using the Compressed Air Baseline Analysis Tool (CABAT), found in the Site Data section of this report. The annual energy consumed by the current compressor was compared to the annual energy consumed by a 50 hp air-cooled VFD compressor to determine the energy savings. The area between the solid and dotted line in Figure 1 represents the power reduction potential.

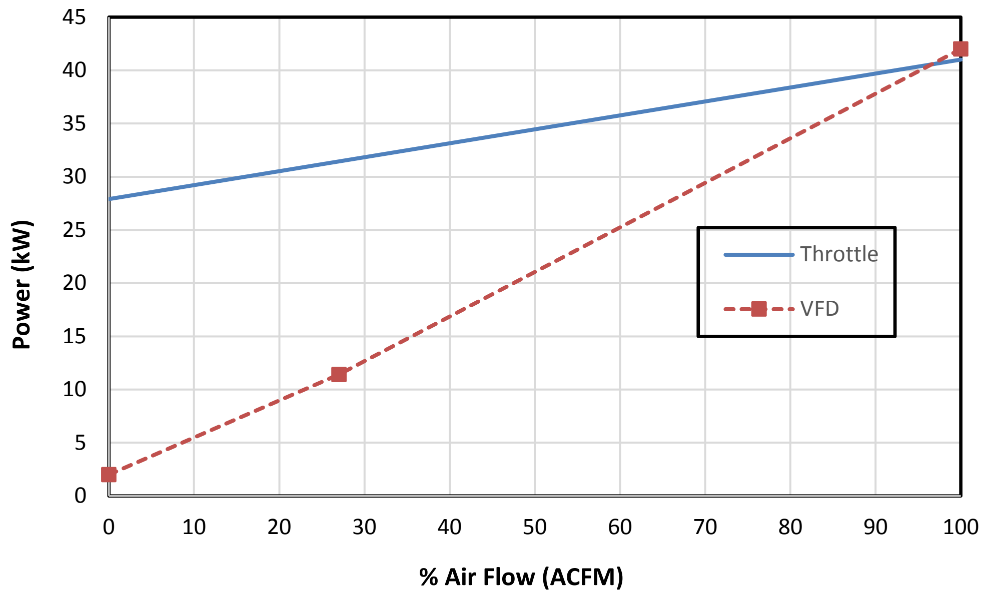

Figure 1: Airflow vs power consumption graph for throttle and VFD controls

References

[1] How to utilize variable speed drives with air compressors.. Carbon Trust, 2017 [Online]. Available: https://www.carbontrust.com/media/147017/ctl167_variable_speed_motor_driven_air_compressors.pdf. [Accessed: 02- Feb- 2018].

[2] "Atlas Copco 50 HP VFD Rotary Screw Air Compressor with Air Dryer 230V | 31.4 - 243.4 CFM | GA37VSD+ 175 FF", Compressorworld.com, 2018. [Online]. Available: https://www.compressorworld.com/50-hp-variable-speed-rotary-screw-air-compressor-integrated-air-dryer-31-4-243-4-cfm-ga37vsd-175-ff-atlas-copco-8153172096.html. [Accessed: 02- Feb- 2018]

[3] Mossman, M. (2016). RSMeans Mechanical Cost Data. 39th ed. Rockland, MA, pp.248-249.

3 - AR No. 4 - Data Preparation

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Data Collected

Compressor Data

Rated Power	(P_R)	50	hp	(N. 1)
Full Load Air Flow	(V_F)	220	acfm	(N. 1)
Operation Hours	(t_o)	2,311	hrs/yr.	(N. 1)

Current Conditions

Controls		*Throttle*		(N. 1)
Full-Load Power	($P_{FL,C}$)	41.1	kW	(N. 2)
No-Load Power	($P_{NL,C}$)	27.9	kW	(N. 2)
Average Power	($P_{AV,C}$)	35.3	kW	(N. 2)
Electrical Demand	(D_C)	426	kW-mo/yr	(N. 2)
Total Energy	(E_C)	81,578	kWh/yr	(Eq. 1)

Proposed Conditions

Controls		*Stock VFD*		(N. 3)
Full-Load Power Percentage	($\%_{FL,P}$)	103%	of ($P_{FL,C}$)	(N. 2)
Full-Load Power	($P_{FL,P}$)	42	kW	(Eq. 2)
No-Load Power Percentage	($\%_{NL,P}$)	4.9%	of ($P_{FL,P}$)	(N. 2)
No-Load Power	($P_{NL,P}$)	2	kW	(Eq. 3)
Average Power	($P_{AV,P}$)	11.4	kW	(N. 4)
Electrical Demand	(D_P)	109	kW-mo/yr	(N. 4)
Total Energy	(E_P)	26,392	kWh/yr	(Eq. 1)

Equations

Eq. 1) Total Energy (E_i)

$$P_{AV,i} \times t_o$$

Eq. 2) Proposed Full-Load Power ($P_{FL,P}$)

$$\%_{FL,P} \times P_{FL,C}$$

Eq. 3) Proposed No-Load Power ($P_{NL,P}$)

$$\%_{NL,P} \times P_{FL,P}$$

Notes

N. 1) Compressor nameplate and operation data collected by analysts during the assessment.

N. 2) Developed in the Compressed Air Baseline Analysis Tool (CABAT). See the CABAT summary in the Site Data section of this report.

N. 3) It is proposed that the throttle controlled compressor be replaced by a VFD controlled air-cooled compressor.

N. 4) The airflow values developed in the CABAT are converted back to a power value (found in the summary section of CABAT) based on the performance profile for a VFD controlled compressor.

Key Input Data

Recommendation Data

Current Operation Time	(t_o)	*2,311*	hrs./yr.	**(N. 5)**
Total System Energy	(E_T)	*81,578*	kWh	**(N. 6)**

Utility Data

Incremental Electricity Cost	(IC_E)	*$0.0755*	/kWh	**(N. 7)**
Incremental Demand Cost	(IC_D)	*$6.26*	/kW-mo	**(N. 7)**

Energy Analysis

Current Conditions

Current Energy Consumption	(E_C)	*81,578*	kWh/yr	**(Eq. 1, N. 6)**
Current Electrical Demand	(D_C)	*426*	kW-mo	**(N. 6)**
Current Energy Cost	(C_C)	*$6,159*	/yr.	**(Eq. 4)**
Current Demand Cost	(CD_C)	*$2,667*	/yr.	**(Eq. 5)**

Proposed Conditions

Proposed Energy Consumption	(E_P)	*26,392*	kWh/yr	**(Eq. 1, N. 6)**
Proposed Electrical Demand	(D_P)	*109*	kW-mo	**(N. 6)**
Proposed Energy Cost	(C_P)	*$1,993*	/yr.	**(Eq. 4)**
Proposed Demand Cost	(CD_P)	*$682*	/yr.	**(Eq. 5)**

Savings

Annual Energy Savings	(E_S)	*55,187*	kWh/yr	**(Eq. 6)**
Annual Demand Savings	(D_S)	*317*	kW-mo	**(Eq. 7)**
Annual Cost Savings	(S)	*$6,151*	/yr.	**(Eq. 8)**

Equations

Analysis Equations

Eq. 4) Energy Cost (C_i)

$$E_i \times IC_E$$

Eq. 5) Demand Cost (CD_i)

$$D_i \times IC_D$$

Eq. 6) Energy Savings (E_S)

$$E_C - E_P$$

Eq. 7) Demand Savings (D_S)

$$D_C - D_P$$

Eq. 8) Annual Cost Savings (S)

$$(C_C - C_P) + (CD_C - CD_P)$$

Notes

N. 5) Current operating hours of the energy consuming system.

N. 6) Developed on the Data Preparation page of this recommendation.

N. 7) Developed in the Utility Analysis section of this report.

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Vendor Data

Vendor Quote #1	(V_1)	*36,000*		**(Rf. 2)**
Vendor Quote #2	(V_2)	*31,900*		**(Rf. 2)**

Implementation Cost Analysis

Material Costs

50 hp VFD controlled compressor	(C_{M1})	*$33,950*	/unit	**(Rf. 3)**
Quantity	(Q)	*1*	units	
Total Material Cost	(C_M)	*$33,950*		**(Eq. 9)**

Labor Costs

Labor Rate	(R_L)	*$60*	/hr	**(N. 8)**
Labor Hours	(t_L)	*50.0*	hours	**(N. 8)**
Total Labor Cost	(C_L)	*$3,000*		**(Eq. 10)**

Economic Results

Annual Cost Savings	(S)	*$6,151*	/year	**(Eq. 8, N. 9)**
Implementation Cost	(C_I)	*36,950*		**(Eq. 11)**
Simple Payback	(t_{PB})	*6.0*	years	**(Eq. 12)**

Incentive Data

Annual Energy Savings	(E_s)	*55,187*	kWh	**(Eq. 6, N. 9)**

Equations

Eq. 9) Total Material Cost (C_M)

$$Q \times C_{MI}$$

Eq. 10) Total Labor Cost (C_L)

$$t_L \times R_L$$

Eq. 11) Implementation Cost(C_I)

$$C_L + C_M$$

Eq. 12) Simple Payback (t_{PB})

$$\frac{C_I}{S}$$

Notes

N. 8) Labor rate and time estimation for installation of a 50 hp compressor found in RS means [3].

N. 9) Developed on the Analysis page of this recommendation.

Incentive Analysis Summary

Description	*Incentive*	*After*	*Payback* (yrs)	*Notes*
Energy Trust of Oregon	*$13,797*	*$23,153*	*3.8*	*$0.25 per annual kWh saved*
Totals	*$13,797*		*3.8*	