

Don't Dismiss the Life Cycle Cost of Pump Drive Systems

When municipalities are in the market for a new pump system there are many cost factors that need to be considered. Efficiency and acquisition cost of the drive system are generally the easiest to identify, but the one that is most often overlooked is the Life Cycle Cost of the system.

The Life Cycle Cost of a piece of equipment is defined as the sum of all costs associated with that equipment from the day it is purchased throughout its entire operating life. The costs that would need to be put together would include acquisition cost, which are the costs of all components of the drive system; installation and construction costs; operating costs such as training, energy, spare parts, maintenance, and downtime costs. Life Cycle Costs give you a bottom-line approach to decisions regarding pumping projects. Variable speed pumping systems are no exception. By selecting variable speed systems that provide reliable performance at the lowest Life Cycle Cost provide the utility the greatest value.

For most modern variable speed pumping systems, there are typically two competing technologies: Variable Frequency Drives (VFDs); and Eddy Current Drives (ECDs).

Considerations	Variable Frequency Drives	Eddy Current Drives
Harmonic noise/RF interference	Extensive	None
Long-term cost of operation	Can be extensive	Minimal
Line voltage sensitivity	Extensive	Minimal
Heat/Cold sensitivity	Extensive	Minimal
Upgradable to new components	Limited	Available
Cooling/air conditioning	Often required	None required
Power regulation	Recommended	None required
Electronic footprints	Very large	Small
Total Cost of installation	Varies widely by operating environment and space requirements, can be extensive	Up to 65% lower than VFDs in 4160VAC and 2300VAC installations, comparable primary equipment costs in 400VAC and 575VAC installations

Acquisition and Operating Costs

In comparison to VFDs, ECDs typically have higher acquisition costs. However, higher horsepower applications may require voltages of 2300 or 4160, in which case ECDs and VFDs will be closer in acquisition costs. Additionally, larger horsepower applications at any voltage often require the addition of air conditioning to cool the VFDs. Moreover, these larger VFDs need ample space because of their size. In many cases it is often necessary to house VFDs in an electrical room which will not only decrease the size of the area being cooled but will also shield the VFDs against dirt, debris and, in the case of wastewater applications, H₂S – hydrogen sulfide gas. When these factors are considered, an ECD solution may well provide a lower Life Cycle Cost.

Since they are inherently a simple design, ECDs are not a complicated electrical solution. This is because the ECD is composed three power conversation items: the motor; the ECD; and the pump. The Eddy Current Controller is actually wired in parallel to the motor and the ECD and typically has a single-phase

power input. In general, the motor is run by either a standard across the line starter or a soft starter – either of which is appropriate for its HP rating.

VFDs take AC, convert it to DC and switch the DC across the motor windings. Full motor power passes through the VFD and the VFD's capacitor bank stores this electrical energy. Because the VFD has this capacitor bank, they generally require some form of input impedance that has inductive reactance. The input impedance does several things to improve VFD performance; (1) it minimizes the effect to the VFD of transients on the distribution system; and (2) it reduces harmonic distortion the VFDs create on the distribution system. In contrast, the ECC is a low power unit which is most often connected to single-phase 115V or 230V power sources. VFDs require the user to use Inverter Duty rated AC induction motors which have improved magnet wire insulation and improved phase and slot insulation – typically Class F as a minimum. In some applications, VFDs are oversized to ensure there is enough current for the motor to produce enough torque. Moreover, it is in the best interests of the user to use VFD rated cables on the output of the VFD between the VFD and the motor. The reason for this is that the VFD output is Pulse Width Modulated (PWM) voltage and often induces Radio Frequency Interference (RFI) and Electromagnetic Interference (EMI) as well as voltage spikes (dv/dt) and standing wave phenomenon. In cases where VFD rated cables aren't enough to mitigate these issues, the user often has to purchase either load reactors, dv/dt filters or sine filters to alleviate the situation. All this adds significant cost and decreases operating efficiency. Considering these factors, the acquisition cost of a VFD drive system goes up correcting for these electrical issues. Conversely, the ECD system doesn't have any of these problems and there isn't a need to correct these electrical problems.

Because each drive type has different characteristics: foundations; wiring; sizing; control requirements; cooling; etc. installation costs may vary. Large VFDs are generally packaged in chassis mount enclosures that can be either convection or forced air cooled that are susceptible to contamination. VFDs and their associated equipment require additional floor space which causes the overall size of the VFD to grow and installation costs to increase. ECCs, even for large ECDs, are small and can be located adjacent to the ECD to minimize inter-connect wiring. When the environment dictates, they are easily packaged in totally enclosed NEMA 12 or NEMA 4X cabinets.

Minimize Downtime and Maintenance

One of the primary objectives of any plant is to minimize downtime and maximize the availability of the machinery to perform its intended function. It is often difficult to assign a cost to machine downtime. However, these costs are real and must not be ignored. One must consider the following items in determining the appropriate costs per hour of downtime for a situation.

- Loss of profit on un-produced product
- Operator idle time
- Overhead cost adjustments
- Maintenance and repair costs - both preventative and corrective

Downtime cost can easily run from several hundred to several thousands of dollars per hour. Considering the inherent simplicity and increased reliability of the eddy current drive, thousands or even tens of thousands of dollars can be realized from reduced down time annually.

Maintenance and repair costs are major contributors to the cost of downtime. In order to properly evaluate these costs, the following items must be considered for each drive type.

- Cost of spare parts inventory
- Skill level of repairmen
- Equipment needed for repair
- Complexity of drive components
- Ease of trouble shooting and repair

Considerations	Variable Frequency Drives	Eddy Current Drives
Long-term reliability	7-10-year manufacturing run, resultant obsolescence	20-40-year average life of mechanical components, 15-20-year control life
Optimum efficiency at 75-100% operating speed	Yes	Yes
Ancillary equipment energy usage	Yes	No
Upgradable to new components	Limited	Available
Cost of replacement parts	Can be high (if available at all)	Low
Replacement parts availability	Limited, if at all after 5-8 years	Excellent: 40+ year manufacturing period
Service and repair	Complex (by factory personnel)	Simple (by customer)
Inter-brand support	No	YES
Downtime if problems with electronics	Can be weeks or months	Minutes (simple component swap-out)

Simplicity is obviously the key to minimize costs in these areas. The ECD can readily be serviced by normal plant maintenance personnel using basic trouble shooting techniques and equipment. Maintenance requirements consist of simple bearing lubrication. The ECC, which typically consists of a single printed circuit board, requires no maintenance. Since one controller can operate drives from 1/4 to 200 horsepower, spare parts inventory costs are kept to an absolute minimum.

Another consideration is the cost of replacement parts 5 or 10 years after the system is installed. With the rapid changes in solid state electronics, controllers become obsolete approximately 4-5 years after introduction. Unfortunately, this occurs at a time when these controllers are increasingly more susceptible to printed circuit board failures. Since the ECC consists of a single printed circuit board, if replacement parts become unavailable, an entire control can be replaced for relatively low dollar amount for drive systems up to 200 horsepower.

Since many users expect a drive system to last 10 to 15 years, repair boards for vintage systems can easily cost three times what they cost just a few years earlier and may be unavailable for quick delivery at any cost. This frequently leads to the user replacing the entire system much sooner than anticipated adding thousands of unexpected dollars to the Life Cycle Costs.

Life Cycle Cost Paybacks

After calculating the Life Cycle Cost of a pump system, there is always the opportunity of return on investment (ROI). When choosing the correct drive system for the application, municipalities can save a considerable amount in annual payback. As shown in the chart below of Life Cycle Costs calculations of a pump drive system data, between an ECD, VFD and VFD with cooling requirements, the eddy current is shown to have the lower Life Cycle Cost and an annual payback of about \$10,000 or a 3.81% ROI.

Life Cycle and Payback This tool compares total cost of ownership for various flow control strategies. Line items are based on: *Pump Life Cycle Costs: A guide to LCC Analysis for Pumping Systems*, published 2001 by Hydraulic Institute and Europump

Enter Customer Data in Green Cells
Calculated data appears in Blue Cells

Analysis for 30 years
Motor, Pump costs are presumed to be the same, and thus not compared in these calculations

Initial Capital Costs	Eddy Current	VFD	VFD w/ A/C	Throttled Valve
Including purchase price, aux. services	\$ 175,000	\$ 215,000	\$ 265,000	\$ -
Installation, commissioning, training	\$ 40,000	\$ 40,000	\$ 40,000	\$ -
Brick/mortar mods to accommodate skopt	\$ -	\$ 60,000	\$ 85,000	\$ -
Calculated as 30% of above costs	\$ 21,500	\$ 31,500	\$ 39,000	\$ -
Initial inventory of spares	\$ 10,000	\$ 30,000	\$ 30,000	\$ -
End of life disposal (15% of initial cost)	\$ 26,250	\$ 32,250	\$ 39,750	\$ -
Total Initial Cost	\$ 272,750	\$ 408,750	\$ 498,750	\$ -

Annual Costs	Eddy Current	VFD	VFD w/ A/C	Throttled Valve
From System Info results x years of service	\$107,675	\$104,615	\$115,399	\$124,802
Labor for normal operation & supervision	\$ 1,500	\$ 1,500	\$ 1,500	\$ 1,500
Routine and predicted maintenance	\$ 1,500	\$ 500	\$ 500	\$ 1,200
Total Annual Costs	\$110,675	\$106,615	\$117,399	\$127,502

Recurring Costs (not annual)	Eddy Current	VFD	VFD w/ A/C	Throttled Valve
Loss of production	\$ 1	\$ 1	\$ 1	\$ 1
Costs in excess of pumped liquid	\$ 2	\$ 4	\$ 4	\$ 8
Repairs in excess of routine maintenance	\$ 10,000	\$ 15,000	\$ 20,000	\$ 15,000
Cost to replace failed, obsolete skopt	\$295,000	\$351,000	\$421,000	\$ 50,000

Total Life Cycle Costs	Eddy Current	VFD	VFD with A/C	Throttled Valve
	\$ 3,623,005	\$ 4,354,211	\$ 4,922,717	\$ 3,935,084

ROI/Payback Calcs	Eddy Current	VFD	VFD with A/C
Total Initial Cost (investment)	\$ 272,750	\$ 408,750	\$ 498,750
Initial Annual Savings (Energy, Operating, Maintenance)	\$ 16,828	\$ 20,887	\$ 10,104
Initial Simple payback (years)	16.2	19.6	49.4
Initial Simple Return on Investment	6.17%	5.11%	2.03%
Life Cycle Cost Savings	\$12,080	(\$419,127)	(\$987,631)
Annual Return on Investment over Life Cycle (dollars)	\$10,403	(\$13,971)	(\$32,921)
Annual Return on Investment over Life Cycle (percent)	3.81%	-3.42%	-6.60%

For decades, ECDs have outlasted other drive systems in a wide range of water/wastewater applications. ECDs are rugged and reliable clutch design and are highly tolerant of fluctuations in power quality. Unlike VFDs, ECDs produce virtually no harmonic noise into the electrical system or onto the utility grid. By comparison, VFDs continue to be complex devices bearing higher ownership costs with shorter product life cycles. These significantly higher costs are attributable to quicker VFD product series obsolescence, faster parts obsolescence and earlier forced product replacements.

Want to know your own pump drive systems life cycle costs? Contact Gary Patterson at Dynamatic to get your results. Gary Patterson is the Municipal Market Manager for Dynamatic. Patterson holds a bachelor's degree in electrical engineering from Michigan Technological University. For more information, visit www.dynamatic.com.