Efficient Variable Speed Pumping:
A Low Cost Approach to Green Energy

By Gary Patterson:
Pump, Fan and Compressor Technical Specialist
Dynamatic, Inc.

Worldwide, private and public enterprises are seeking to become more "green" in their operations, either by regulatory mandate or by conscientious choice. A concern over climate change is driving energy users to find ways to reduce or eliminate emissions of greenhouse gases, most notably CO_2. No single solution, at this time, can be found to this complex problem. Although, many new technologies are under development to try to produce more energy with less emission, but most of these ideas require significant cost and long-term development. With the burning of fossil fuels still dominate for energy consumption, the issue of emissions will continue for the foreseeable future, but there are some changes now that companies can do to reduce their carbon footprint.

A recently published study of the worldwide wastewater treatment industry suggests that a significant dent can be made in emissions. This can be done by reducing energy usage in the transportation and treatment processes with existing technologies that are readily available. Powering the Wastewater Renaissance, published on line by Xylem, Inc., reports that worldwide, nearly 50% of all electrical usage in wastewater applications could be curtailed by implementing mature, accessible technologies. In the United States, the estimate is about 38%, still a substantial amount. Even better news is that most of these improvements can be made at zero or "negative cost". Since the reduction in electrical billing offsets initial expenditures over a few years, and continue to operate at a reduced cost for years beyond the initial payback. [1]

Overall energy usage, primarily electricity, can be expressed as an equivalent CO_2 emission, as million metric tons (Mt). Natural gas being cleaner than various grades of fossil fuels makes emission amounts vary with application. A reasonable average working number is that one kilowatt-hour (kW-hr) of electrical power yields about 2 pounds of CO_2.[2]

Among the most promising and easily implemented improvements cited in the study was the use of "optimal speed" and "high efficiency" pumping. By applying these improvements at all levels of the collection, treatment, and discharge processes of the wastewater treatment industry, can easily reduce energy usage. In practical terms, this would mean variable speed pumping, as the "optimal speed" changes according to varying influent and weather conditions. Variable speed pumping has long been recognized as a key strategy for optimizing hydraulic system performance and minimizing energy usage. Despite a long and successful history, many more opportunities exist to implement new or retrofit variable speed to centrifugal pumps and aeration blowers.

Engineers often default to choosing a variable frequency drive (VFD) when considering variable speed pumping. However, electromagnetic (i.e., eddy current) drives deserve consideration, and are often preferred. The electromagnetic drive offers energy reduction comparable to or even better than a typical VFD. Figure 1 shows an example of an actual field comparison.

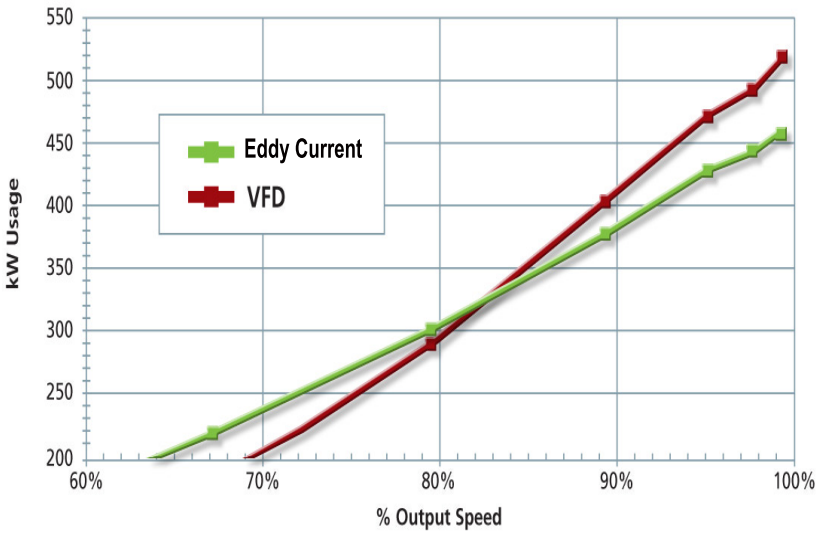


Figure 1: Comparison of VFD vs. Eddy Current Drive energy usage on identical pumps

For a quick review, consider the affinity laws that apply to any centrifugal pump, fan, or compressor: Flow is reduced in direct proportion to the rotating speed, while input power (expressed as brake horsepower or kilowatt-hours) reduces by the cube of speed reduction. Moreover, in most centrifugal pump applications, the full spectrum of required flow can be produced over a relatively narrow speed range. In the example shown, the pump runs against a closed check valve until it develops sufficient pressure to overcome static head and push the valve open. It then runs from minimum flow at approximately 89% speed, to full flow at 100% speed.

Dynamatic®
DRIVE SOURCE INTERNATIONAL, INC.

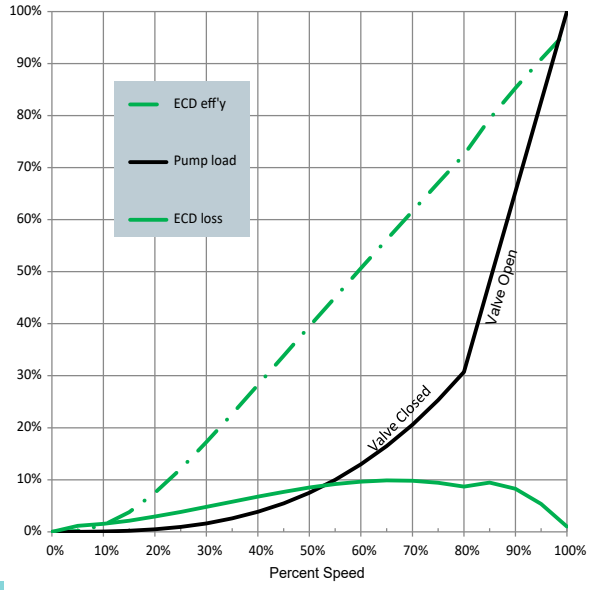
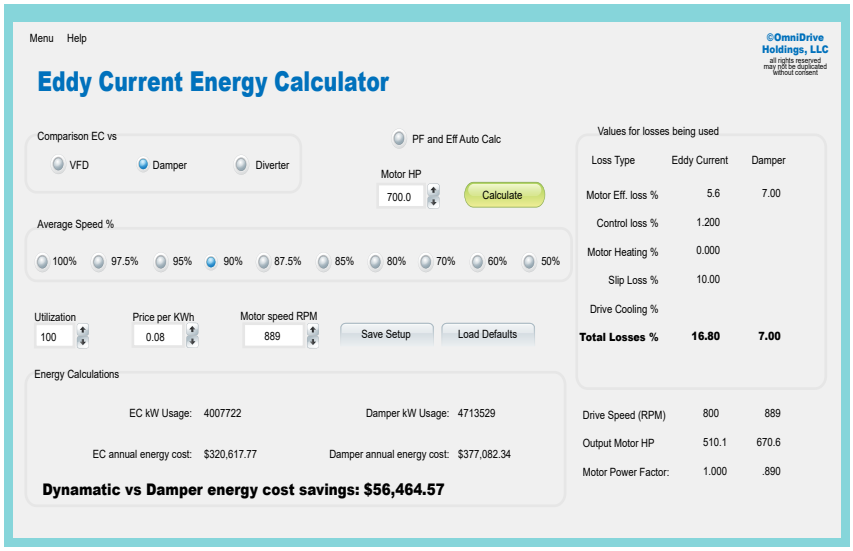


Figure 2: This pump operates from minimum flow at 80% speed to full flow at 100% speed

Implementing variable speed pumping can achieve significant savings in electrical usage. Consider figure 3, below. Here, we compare the annual cost of electricity for a 700 hp pump using a throttling valve to control flow, versus the same pump operating at an average speed of 90% to achieve the same flow rate. The motor and pump are assumed to be the same in each instance. A close examination of the data reveals that the electromagnetic (eddy current) drive uses almost 706,000 fewer kW-hr than the throttled full speed pump. This can be translated to a reduction in equivalent CO_2 emission. In addition, the user will see a $56,000 reduction in his annual electric bill for this pump.

Figure 3: Screen shot from Dynamatic Energy Calculator, an automated tool for estimating available energy savings by implementing electromagnetic variable speed drives.



In this way these measures can be considered to be zero- or negative-cost:

Assumed project cost:	$190,000
Annual Power Saving:	705,807 kW-hr
Annual Equivalent CO_2 reduction: metric ton (t)	1411614 lb. = 526.8
40 yr. Equivalent CO_2 reduction:	21,072 t
Annual Power Cost saving:	$56,465
Simple Payback Period:	3.3 years
40 yr. Power Cost Saving:	$2,258,600

A VFD for this application might also be considered. At this average speed, however, the eddy current drive still appears to be the better choice. The VFD produces the same speed reduction and resultant pump brake horsepower, but nets more total losses, especially considering harmonic related losses and a likely the need for air conditioning. A VFD could also require considerably higher cost to implement, specifically if new construction is needed to house the equipment, or air conditioning is required to accommodate the VFD.

More importantly, experience suggests that a VFD would need replacement on an average of a 7 to 12 year schedule. While the eddy current drive could be expected to be in service for the full life of the pump and motor – often over 40 years. End users wishing to observe greener practices may want to consider the environmental impact of more frequent disposal of the VFD equipment in addition to the expense of replacing the equipment two to four times over the full life of the pump or motor.

Conclusion:

The benefits of variable speed pumping have long been recognized, including reduced power cost, reduced mechanical wear and process optimization. In today's economy and environmental awareness, a significant reduction of a company's carbon footprint can now be added to the list of benefits. Electromagnetic drives can often prove to be the best path to achieve these results, and can be shown to pay for themselves over a long period of service.

1 Powering the Wastewater Renaissance (Energy Efficiency and Emissions Reduction in Wastewater Management), Glen Trickle, Albert Cho, Randolf Webb, Alan Merry, Aleksandra Lazic, Alexis de Kerchove, and Lars Larsson. Published on line at www.poweringwastewater.xyleminc.com. Cited by permission of the authors.

2 U.S. Energy Information Administrations, Frequently Asked Questions. https://www.eia.gov/tools/faqs/faq.cfm?id=74&t=11

Gary Patterson holds a BS degree in Electrical Engineering from Michigan Technological University, where he pursued the Power Option, specializing in rotating equipment and electrical power generation, transmission, and distribution. He began his career with a manufacturer of large motors, assigned as a factory application engineer, specializing in the firm's line of eddy current variable speed drives, and their emerging variable frequency drive technology. He served later as a field sales engineer in Chicago, and eventually assumed regional responsibility. He has worked in field sales as a region manager for a variable frequency drive manufacturer, and has also been employed as a sales engineer with a manufacturer's representative firm, responsible for a large variety of electrical and mechanical equipment. He presently serves as the Pump, Fan, and Compressor Technical Specialist for Dynamatic, focusing on pumping and similar applications in the industrial and municipal markets.