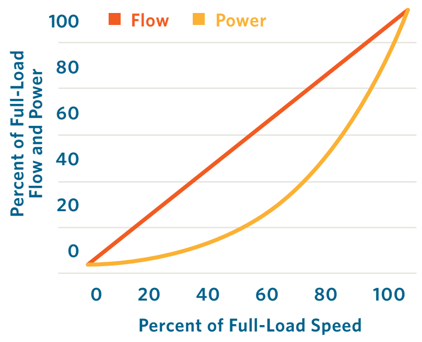
VFDs AND THE AFFINITY LAWS

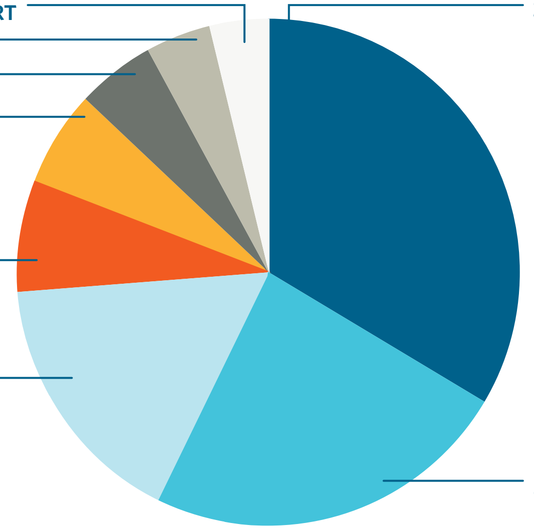


Variable frequency drives improve pump and fan efficiency by reducing motor shaft speed to the minimum revolutions per minute (rpm) necessary to satisfy flow requirements. A graph of the affinity laws shows that the flow produced by a pump or fan is directly proportional to shaft speed, while the power requirement for that flow is proportional to shaft speed cubed. For example, at 80 percent of full-load flow, a pump or fan operates at 80 percent of full-load rpm, but uses only 51 percent of full-load power, yielding a steady state energy cost reduction of 49 percent. At 50 percent of full-load flow, the pump or fan operates at 50 percent of full-load rpm, but uses only 13 percent of full-load power, yielding an energy cost savings of 87 percent.

Energy Plays a Major Role in Manufacturing

High-tech facilities operate up to 24 hours per day and are among the largest energy users in today's economy. They are characterized by large base loads, continuous operation and high energy-use intensities, offering opportunities for substantial energy savings.

TYPICAL HIGH TECHNOLOGY ENERGY USE DISTRIBUTION



MANUFACTURING FACILITIES IN OREGON ARE COMPETING IN A GLOBAL MARKETPLACE BY COMBINING MATERIALS WITH HUMAN INGENUITY.

In manufacturing, energy plays a central role in harnessing machines, materials and people.

Energy Trust can help your industrial facility take control of your energy and reduce the cost impacts of energy on your bottom line. Energy Trust provides cash incentives and technical services to help your facility improve energy efficiency and reduce operating costs. Our PDCs are highly skilled industrial energy experts who understand what works in your business and how to make the most of energy-saving opportunities. Energy Trust PDCs are located throughout Oregon, so they understand your local economy and industry.

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Get more from your energy. Talk with your PDC, or call Energy Trust directly at **1.866.202.0576** or visit **www.energytrust.org/industry-agriculture**.

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Energy Trust of Oregon is an independent nonprofit organization dedicated to helping utility customers benefit from saving energy and generating renewable power. Our services, cash incentives and energy solutions have helped participating customers of Portland General Electric, Pacific Power, NW Natural, Cascade Natural Gas and Avista save on energy costs. Our work helps keep energy costs as low as possible, creates jobs and builds a sustainable energy future. **Printed on paper that contains post-consumer waste. 4/17**

High Technology Energy Savings Guide

The high-tech industry is a crucial and dynamic part of Oregon's economy that is expected to grow faster than other industries over the next decade. Working in a highly competitive market, operations managers at Oregon fabrication plants continually look for ways to reduce costs, while improving production efficiency and product quality. Because fabs require a significant energy input, energy efficiency offers an expanding opportunity to trim operating costs.

Energy Trust of Oregon is dedicated to helping you identify options to improve the energy efficiency of your facility over time. The chart on the next page shows how energy is used in a typical fab and can help you understand where to focus your efforts. We've also compiled a list of "next steps" for you to review. Talk with your Program Delivery Contractor (PDC) about which of these steps could have the biggest impact on energy savings at your plant.

EnergyTrust of Oregon

CLEANROOM HVAC

How efficient is the recirculation system? Recirculation systems filter and condition a large quantity of air to maintain precise conditions. Optimizing cleanroom recirculation systems can significantly improve energy efficiency.

- ☐ Control airflow of less-efficient recirculation fans with variable frequency drives (VFDs) and air quality sensors that determine when airflow reductions are possible. Typical simple payback of one to three years.
- ☐ Add recirculation setback controls to existing recirculation systems. Typical simple payback of less than one year.
- ☐ Replace inefficient fan filter units with high-efficiency models with electronically commutated motors.
- ☐ Use low-pressure drop filters in recirculation systems to reduce system static pressure.

Could making operation improvements to, or capital investments in, cleanroom makeup air systems lead to robust savings? Replacing or retrofitting lower-efficiency equipment could reduce energy use while improving product quality and throughput.

- ☐ Retrofit cleanroom makeup air systems with VFDs that use sensors to optimize makeup air fan speed. Typical simple payback of one to three years.
- ☐ Optimize airflow by installing timers, motion sensors, or CO2 sensors that reduce airflow during unoccupied hours.
- ☐ Adjust preheat and reheat set points in makeup air units to eliminate simultaneous heating and cooling.
- ☐ Repair economizers and calibrate set points. Typical simple payback ranges from a few weeks to a few months.
- ☐ Optimize the quantity of outside air used for cleanroom pressurization and ventilation.

Does your cleanroom humidity control system use too much energy? Optimize set points or use new technology that improves humidity control while saving energy.

- ☐ Optimize preheating of the humidity control system to levels that reduce energy use. This can reduce chiller loads and yield significant energy savings.
- ☐ Retrofit existing dry-steam humidity systems with steam-line and nozzle insulation to reduce heat loss.
- ☐ Upgrade to higher efficiency adiabatic humidification. Typical simple payback as short as two years.

Does your scrubber function as well as it could? Scrubber systems could be wasting energy 24/7 if they are old and inefficient or if set points are not optimized. Changes to scrubber systems can also reduce energy use for makeup air that supports the cleanroom.

- ☐ Add VFDs and air quality sensors to exhaust fan motors to optimize the speed of scrubber fans.
- ☐ Switch to a lower pressure drop scrubber filter media so exhaust fans operate with less resistance.
- ☐ Install air-to-air heat exchangers to recapture heat from fab exhaust for use in heating processes within the fab.

Does your facility have fume hoods? Capital improvements to existing fume hood systems can increase energy efficiency. According to Lawrence Berkeley National Laboratory, new energy-efficient hood systems use 75 to 80 percent less energy than older designs.

- ☐ Determine if fume hoods are pulling more air than necessary to exceed minimum air quality standards. Reducing airflow reduces the amount of makeup air for the conditioned space.
- ☐ Replace inefficient fume hood models with more energy-efficient models.
- ☐ Integrate fume hood sash systems with controls that detect worker activity. When inactive, the fume hood sash closes and airflow is reduced.

CHILLERS

Could your chilled water system benefit from low-cost O&M improvements? Adjustments to your chilled water system can reap big energy savings, delivering a typical simple payback of two weeks to several months.

- ☐ Increase chilled water temperature set points while providing proper process water temperature. Typical payback of several weeks to one year.
- ☐ If you have multiple chillers, stage controls to allow one chiller to handle loads up to the point of highest efficiency before additional chillers go online. This takes advantage of better part-load efficiencies for the same cooling output.
- ☐ Don't use chilled water for low-intensity cooling processes that can be done using municipal water. Reducing chiller load reduces water chemical treatment and maintenance costs in addition to electricity consumption.
- ☐ Use VFDs to optimize the speed of the pump to the demand for pressure or flow, rather than running constantly at full speed.
- ☐ Reduce pump differential pressure in secondary chilled water. Typical simple payback as short as one month.
- ☐ Clean cooling tower coils and chiller tubes to improve efficiency.

Are there opportunities to save energy through capital improvements to your chilled water system? Replacing inefficient and aging equipment is often a cost-effective investment.

- ☐ Add VFDs to cooling towers to reduce fan speed while meeting the needs of the chiller.
- ☐ Install a water-side economizer. Free cooling allows the cooling tower to provide chilled water cooled by ambient air when outdoor conditions allow.
- ☐ Consider installing an oversized cooling tower to take greater advantage of free cooling.
- ☐ Replace existing chillers with new, high-efficiency models to boost chilled water system efficiency by up to 50 percent, while reducing maintenance costs and improving the system function.
- ☐ Implement Wet Bulb Approach strategy to maintain a fixed approach between condensing and wet bulb temperatures. This prevents imbalance of excessive condenser capacity when loads are low.

COMPRESSED AIR

Can the efficiency of your compressed air system be improved? Adjusting compressed dry air system settings and changing compressed air utilization can trim energy costs, resulting in simple payback periods of as little as a few weeks.

- ☐ Identify and repair leaks in your compressed air system to decrease compressor load. Fixing leaks in distribution lines and tools that use compressed air improves performance and reduces noise.
- ☐ Target and reduce compressed air dead load (compressed air demand when no production is occurring).
- ☐ Reduce compressed air system pressure to the minimum setting that satisfies demand. For every two psi in pressure reduction, energy use decreases by approximately one percent.
- ☐ Adjust controls for cylinder unloading to improve efficiency of reciprocating compressors.
- ☐ Adjust regulators and valves to optimize flow and pressure for a given process.
- ☐ Reduce or minimize open blowing to avoid unnecessary compressor cycling.
- ☐ Replace conventional nozzles with engineered nozzles to reduce wasted compressed air.
- ☐ Eliminate inappropriate use of compressed air in the plant, such as for cleaning, mixing or cooling. Use more energy-efficient methods.
- ☐ Identify processes, areas and times that allow one or more compressors to be turned off. This saves electricity and decreases the amount of heat exhausted into work areas.
- ☐ Increase receiver volume to reduce compressor cycling and improve demand response.
- ☐ Ensure that compressor intake air is as cool as possible to maximize compressor efficiency.

Would compressed air capital improvements deliver substantial energy savings? New energy-efficient compressor technology can reduce energy use and produce a fast return on investment.

- ☐ Install VFDs on existing compressors that operate under varying load, or invest in new compressors with VFDs. VFDs save energy by adjusting compressor speed to fit system demand. They also help reduce heat, noise and equipment wear.
- ☐ Upgrade inefficient compressed air dryers to more efficient systems, such as replacing noncycling dryers with cycling dryers.
- ☐ Explore replacement of oversized compressed air systems with equipment appropriate for the pressure, flow and end-use requirements.
- ☐ Upgrade to compressed air piping that is more free flowing for better system and energy performance.
- ☐ Install sequencing controls on systems with multiple compressors so the most efficient compressor supports base load and additional compressors go online only when the primary compressor is at full load.
- ☐ Consider installing a blower that produces low-pressure, high-volume airflow to replace less-efficient compressed air in processes that require open blowing.
- ☐ Retrofit controls to load/unload compressor operation rather than use inlet modulation control systems.
- ☐ Use small, dedicated compressors to provide compressed air for the dry-fire suppression system.
- ☐ Add controls and valves to reduce nozzle airflow as the process allows.
- ☐ Reduce or eliminate the runtime of standby compressors operating during nonproduction periods. Use a manual switch to provide timed use of the standby compressor for maintenance purposes. Reducing compressor runtime reduces part wear and maintenance in addition to saving electricity.
- ☐ Install zero-loss condensate drains.
- ☐ When possible, recover compressor heat for space or process heating demands.

PUMPING

Can energy be saved in process pumping? Pumps are often sized improperly or are fully powered when partial power would ensure high system performance.

- ☐ Reduce head pressure for process pumping to lessen the load and reduce energy use.
- ☐ Remove excess pumps from service.
- ☐ Install VFDs to match the pump speed to system demand.
- ☐ Control vacuum pump staging to operate the minimum number of pumps to support production.
- ☐ When practical, replace oversized positive displacement pumps and pump motors with pumps appropriately sized for the application, or trim the impeller if conditions allow on oversized pumps to optimize pump pressure and flow and reduce load. Trimming the impeller is frequently a lower-cost alternative to making larger capital investments in pumps, motors or control technology.
- ☐ Install controls on existing vacuum pump systems so pumps go into idle mode based on sensor feedback from process tools. Automated controls help reduce pump runtime, part wear and labor hours.
- ☐ Replace worn or inefficient pumps with new, high-efficiency pumps that use less energy and operate with less maintenance and downtime.
- ☐ Eliminate leaks in the vacuum system to reduce vacuum pump flow.
- ☐ Replace pump motor barrel heaters with solid state motor winding heaters.
- ☐ Install induction lighting in areas where long lamp life and low maintenance are necessary. Induction lighting is a good fit for areas that are difficult to access.

LIGHTING

Do lighting systems need an upgrade? Lighting that has not been recently upgraded offers an easy opportunity to cut energy costs.

- ☐ Use occupancy sensors, switches and timers to turn off lamps in unoccupied spaces and trim lighting energy substantially.
- ☐ Reduce the number of lamps in over-lit areas.
- ☐ Upgrade to LED lighting, which combines ultra-high efficiency with excellent performance and extremely long life. The long service life of LEDs reduces maintenance and production disruption due to light failure. LEDs also produce very little heat, which decreases cooling load.

SERVER ROOMS

Could operational or capital improvements to server room equipment lead to substantial energy savings? O&M improvements often reap energy savings with a minimum of investment. Capital investments can drastically reduce energy use.

- ☐ Develop strategies for turning off servers not in use.
- ☐ Adjust economizers to optimize free cooling.
- ☐ Install blanking panels in server racks not being used to improve airflow and cooling efficiency.
- ☐ Develop an efficient server room layout using hot- and cold-isle configuration.
- ☐ Replace older servers with new models that use the latest processors to improve performance while producing less heat. New, faster models also may enable a reduction in the total number of servers.
- ☐ Install VFDs on computer room air handlers so the speed of air handler fans matches cooling needs in the data center.
- ☐ Install air- or water-side economizers on server room HVAC units to take advantage of free cooling.

FAB TOOLS

Are there options for upgrading fab process tools? Although process-specific tools can be challenging to alter with respect to energy efficiency, some strategies can be successfully applied within the cleanroom. Discuss your production equipment needs with your PDC. If energy-efficient tool options exist, your PDC will work with you to determine how upgrades might qualify for Energy Trust cash incentives. Example projects include improved heat shields on crystal growers and upgrading to a chemical vapor deposition process from a less efficient physical deposition process.

- ☐ Reclaim heat from process tool cooling systems to preheat and reheat other processes within the fab.
- ☐ Consider installing point of use (POU) chillers near process tools.

ENERGY TRUST INCENTIVES MAY REDUCE PAYBACK PERIODS LISTED IN THIS GUIDE BY AS MUCH AS 90 PERCENT ON O&M PROJECTS AND 50 PERCENT ON CAPITAL UPGRADES.