WHITE PAPER

How to make big energy savings with pumps, fans, and compressors

Summary

Using variable speed drives (VSDs) is a common way to reduce the energy consumption of fans, pumps, and compressors operating at variable load in industrial applications. But did you know VSDs can also save energy and reduce emissions for fans and pumps operating at constant load?

In this white paper, we take a closer look at two studies conducted by the Fraunhofer Institute for Chemical Technology (ICT) in Karlsruhe, Germany. The first study[1] looked at how VSDs can reduce the energy consumption of fans, pumps, and compressors operating at variable load. The second study[2] looked at how VSDs can reduce the energy consumption of fans and pumps operating at constant load.

The main findings from the studies are as follows:

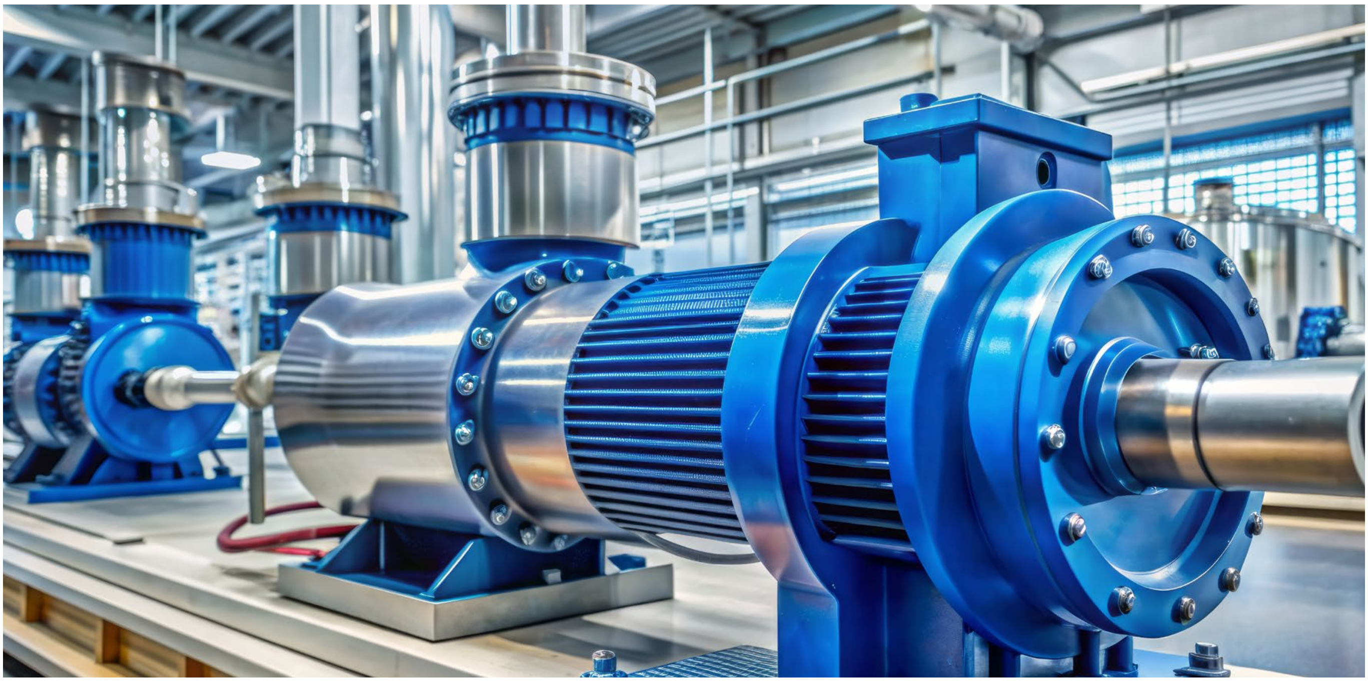
- The total saving potential for pumps, fans and compressors operating at variable load in the EU is about 121.1 TWh/year, equivalent to 9% of annual electric motor power consumption. This 121.1 TWh/year is in addition to the 41 TWh/year that is already saved today by using VSDs. The potential savings are split into:

  - Pumps: 36 TWh/year
  - Fans: 70.3 TWh/year
  - Compressors: 14.8 TWh/year

- The total energy saving potential for fans and pumps operating at constant load in the EU is about 19.6 TWh/year, equivalent to 4.05% of annual electric motor power consumption. This is split into:

  - Pumps: 15.7 TWh/year
  - Fans: 3.9 TWh/year

[1] "Study on the energy saving potential of electric motors with variable speed drives in the European Union," Alexander Schröder, Johannes Liebertseder, Martin Doppelbauer, 2023/12/15, Fraunhofer Institute for Chemical Technology, Karlsruhe, Germany
[2] "The energy saving potential of electric motors at constant load operation with variable speed drives," Alexander Schröder and Martin Doppelbauer, 2024/12/16, Fraunhofer Institute for Chemical Technology, Karlsruhe, Germany



I. Introduction: why VSDs make sense for variable and constant load applications

VSDs, also known as variable frequency drives (VFDs), are widely used in industrial applications to control the speed or torque of electric motors in fans, pumps, and compressors more efficiently.

The European Committee of Manufacturers of Electrical Machines and Power Electronics (CEMEP) commissioned the Fraunhofer ICT to study the energy-saving potential of electric motors with VSDs in the European Union for both variable and constant load applications.

VSDs are already widely used in variable load applications for pumps, fans, and compressors. There is scope to increase VSD usage even more.

At first glance, using VSDs for electric motors with a constant load profile might not seem to be energy efficient due to the unavoidable additional losses that come from using a VSD. When a VSD is added to a motor-driven system, losses increase slightly because the device only operates at an efficiency of 95% to 99%.

However, these losses are negligible compared to the energy savings from running the fan or pump to meet exact demand. This is because fans and pumps tend to be oversized. By using a VSD to throttle down an oversized fan or pump, you can match the equipment's speed to the actual demand rather than running it at full capacity continuously.

Traditional throttling methods like dampers or valves reduce flow mechanically. While this decreases the energy input, it raises the pressure. This means the energy consumption is still higher compared to a VSD system where you control the speed to optimize flow and pressure – meaning a VSD leads to more savings on energy, money, and emissions.

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II. Use case 1: pumps

Many pumps operating at variable loads in the EU already benefit from VSDs. That's because VSDs allow the pump to exactly match demand, saving energy. Pumps are also commonly run at constant loads. For example, in the EU approximately:

- 56% of drinking water pumps operate at constant load
- 36% of building pressure booster pumps operate at constant load
- 54% of heating and cooling pumps operate at constant load
- 53% of industrial pumps operate at constant load
- 97% of swimming pool pumps operate at constant load
- 91% of wastewater pumps with liquid operate at constant load
- 98% of wastewater pumps containing solids in the fluid operate at constant load

However, several factors lower the efficiency of pumps operating at constant load.

Motor speed and pump efficiency
When flow and pressure are set requirements in a pump application, motor speed is the only remaining parameter to influence pump speed and efficiency. In constant load applications without VSDs, the speed is fixed at multiples of the grid frequency. The result is a limited number of pump types and sizes on the market, with the available pumps not necessarily in the best efficiency range. Using a VSD allows you to precisely set the rotational speed of the motor.

In addition, constant load cycles are not always constant. At certain periods in the load cycle, pumps operate at partial load 25% of the time and overload 25% of the time. This reduces efficiency from 100% at full load to 94.7% at partial load or 98.5% at overload. Using a VSD eliminates these efficiency reductions.

Dealing with oversized pumps
When selecting pumps, choosing the correct size is extremely important. When a unit is too large, a throttling valve decreases the pump's volume flow to match the application requirement, which the pressure in the system and adds mechanical stress to the installation. This means oversized pump units don't work at their Best Efficiency Point (BEP), leading to higher energy consumption and increased costs. This is especially true in high-power units due to the limited number of units and sizes on the market.

Oversizing pumps is a common practice, especially in the water and wastewater industry. These systems are designed with a 20 to 25-year lifespan and are often deliberately oversized to accommodate the expected increase in loads over this time.

With a VSD, flow regulation via a throttle valve is not needed and you can avoid energy losses due to oversizing. The end result is a rotational speed that exactly matches your requirements, reducing energy consumption by up to 12% per unit in all pump applications.

Is impeller trimming a good alternative?
To ensure pumps match the desired load point, impeller trimming was often used in the past. This is when the diameter of the impeller is decreased to reduce the flow and pressure.

Impeller trimming is not suitable for low-power swimming pool pumps. It is also unsuitable for wastewater applications, which often need to handle water containing mud and solid particles. This can mean the impeller gets clogged, so wastewater pumps are designed accordingly, making impeller trimming unsuitable. For this reason, using a VSD to optimize rotational motor speed is the best option for saving energy in these applications.

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III. Use case 2: fans

In the EU, many fans operating at variable load already use VSDs. A VSD allows the fan to run at the exact speed needed to match the actual demand, saving energy.

The Fraunhofer ICT also investigated fan applications at constant load. For air fans in buildings in the EU, about 40% operate at a constant load cycle. In industrial applications, the figure is also about 40%. For fans in refrigerant and HVAC applications, about 70% operate at constant load.

Dealing with oversized fans

The energy efficiency model for fans is much simpler than for pumps. Increasing the speed of a fan generally increases losses, as energy consumption is cubic with speed. Unlike pumps, fans don't benefit from the effects of friction reduction and impeller regulation is not used.

However, ventilation systems can benefit from the use of VSDs as fans used for ventilation are often oversized to ensure adequate airflow even when filters start to become clogged. This is needed because most ventilation systems use air filtration to reduce the volume of dust and bacteria in circulation. As the filter becomes dirty during operation, there is a drop in air pressure.

To meet the minimum flow requirement under all filter conditions, the fan must be able to run at a higher speed until the filters are cleaned. Oversized fans provide the pressure needed to compensate for the filter pressure drop.

Using VSDs allows users to set the correct speed for oversized fans. In the average scenario of the ICT study, the energy savings per oversized fan unit with a VSD are around 10%.

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IV. Use case 3: compressors

In many industrial processes, air demand varies. Without VSDs, compressors either run at full capacity or rely on throttling mechanisms or frequent stop-start cycles.

A VSD allows compressors to vary speed and power usage to exactly match demand, which reduces energy consumption.

In constant load compressor units, additional VSDs will introduce losses and reduce efficiency. For this reason, there are minimal energy savings for VSD compressors in constant load applications.

However, compressors can benefit from VSDs in constant load applications for other reasons like fine-tuning for pressure or flow rates.

A VSD allows compressors to vary speed and power usage to exactly match demand.

VI. Conclusion

Fans, pumps, and compressors operating at variable load can gain significant energy savings from VSDs. This is also true for fans and pumps operating at constant load.

At variable load, a VSD allows units to match actual demand. In constant load applications, a VSD allows oversized units to be throttled so that the motor's rotational speed exactly matches your requirements, saving energy and emissions.

In summary, when using VSDs with pumps, fans, and compressors at variable and constant load, a total of around 140 terawatt hours less energy could be required across Europe each year. This would reduce carbon dioxide emissions by 38 million tons.

Considering that Europe wants to be carbon-neutral by 2040, this savings potential would be a significant contribution to achieving this goal – especially as the relevant technology is already available and only needs to be used consistently.

Interested in finding out how you can save energy and cut emissions in constant load fan and pump applications? Contact an ABB expert and start a conversation about our proven solutions.

Torben Poulsen: torben.poulsen@dk.abb.com

Increased energy savings with ABB drives
By analyzing the specific application, ABB can help to choose the correct product to obtain maximum efficiency in terms of energy, performance, and cost.

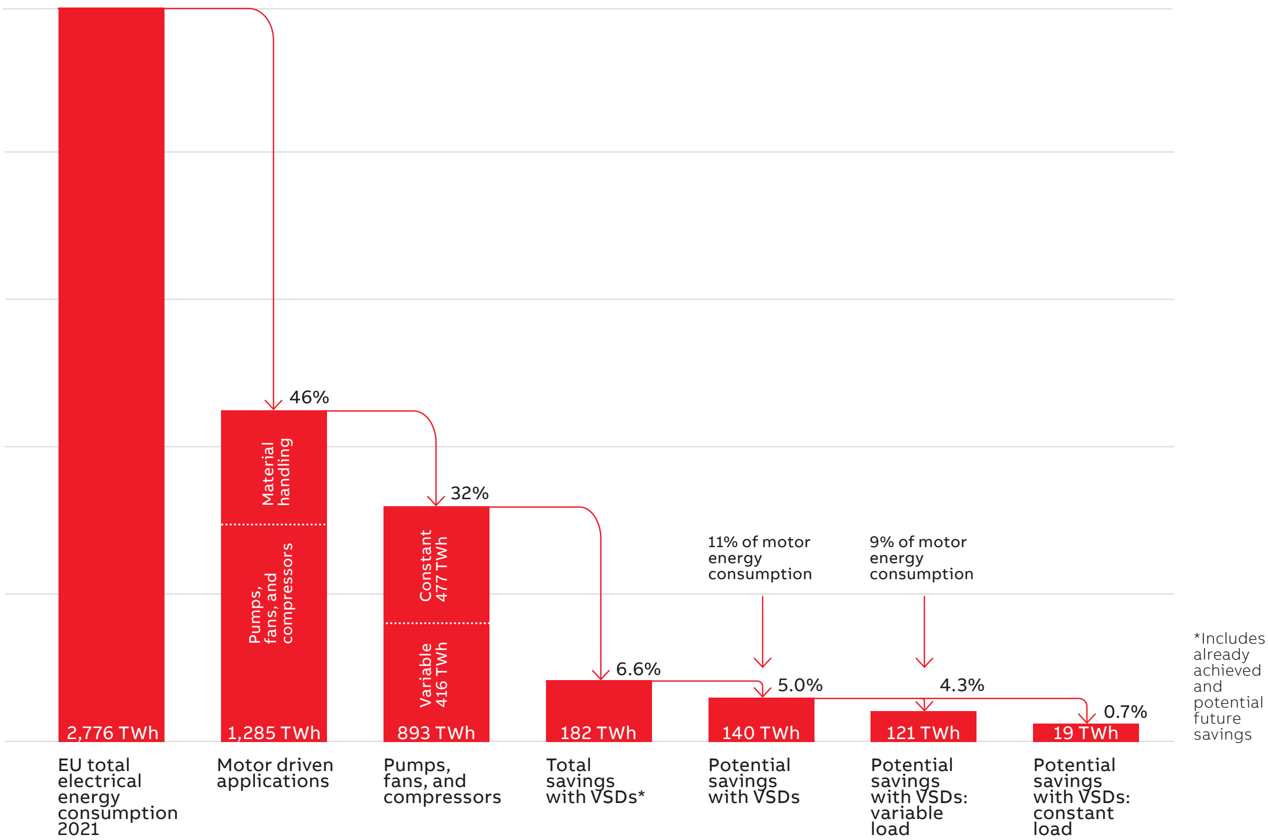
The portfolio has been developed to meet the specific needs of key segments including:

- ACH580 for HVAC-R applications
- ACQ580 for water and wastewater applications

All drives in the ABB VSD x80 family can increase the energy savings of your system. They have a power range from 0.37 kW to 1200 kW and a supply voltage range from 230 V to 690 V. All models can guarantee maximum open-loop dynamic speed and torque performance to match the BEP of the fan or pump. All ABB VSD x80 family drives can easily interface with all the main communication protocols for programmable logic controller (PLC) integration.

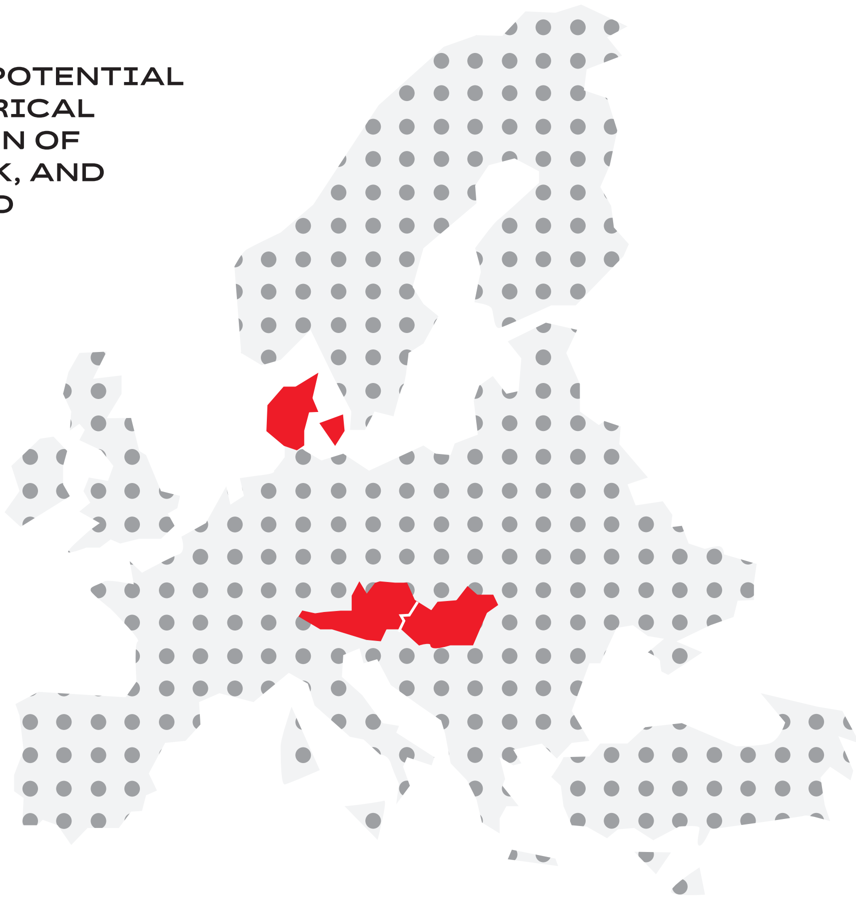
ABB drives allow for easy integration and are easy to use. ABB's global support network and proven performance across industries will help keep your application running smoothly for years to come.

FRAUNHOFER STUDY RESULTS FOR PUMPS, FANS, AND COMPRESSORS AT VARIABLE AND CONSTANT LOAD IN THE EU



140 TWH SAVINGS POTENTIAL EQUALS THE ELECTRICAL POWER PRODUCTION OF HUNGARY, DENMARK, AND AUSTRIA COMBINED

Denmark 34 TWh
Hungary 36 TWh
Austria 70 TWh



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