Honeywell

# Energy efficiency ...

## ... through Variable Frequency Drives

Tomi Ristimäki
Produkt Manager

08 I 2008

**Constantly increasing energy prices have substantially heightened interest among business owners who want to save energy and money. While discussion usually revolves around alternative energy sources and new energy-saving technologies, it is surprising that little attention is given to existing technical solutions that could provide huge savings if they were applied more widely. One proven and low-cost solution is Variable Frequency drives for speed control in heating, ventilation and air conditioning (HVAC) applications. Few other technologies can provide a payback in less than a year. At same time, they offer many other benefits by improving a HVAC system's controllability.**

### Energy saving with Variable Frequency Drive (VFD) speed control

Flow-generating equipment like fans, pumps and compressors are often used without speed control. Instead, flow is traditionally controlled by throttling with a valve or damper. When flow is controlled without regulating the motor speed, it runs continuously at full speed. Because HVAC systems rarely require maximum flow, a system operating without speed control wastes significant energy over most of its operating time. Using VFD to control the motor speed can save up to 70% of the energy. Fig. 1 below shows the basic principle.

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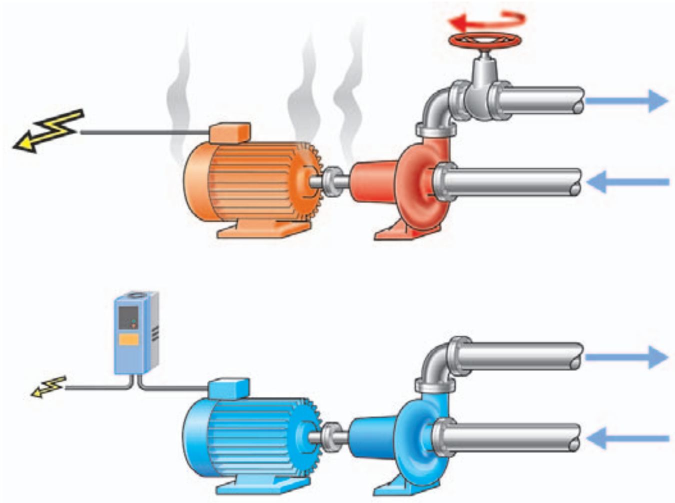

Fig. 1: The principle of energy saving with VFD speed control.

### What is Variable Frequency Drive (VFD)?

Most electric motors used in HVAC and water applications are "squirrel cage" motors, also called induction or asynchronous motors. Their popularity is due to their reasonable price, low maintenance costs and reliability. The only way to control the motor's speed is to change the frequency of the alternating current (AC) power in the input: this is where VFD comes into the picture.
A Variable Frequency Drive is known by many names, such as an inverter, variable-speed drive (VSD), frequency converter or AC drive. All mean essentially the same thing: an electronic device that provides step-less speed control in an electric motor. However, today's VFDs also feature other functionality, including control and protection to other equipment in the system.

### Affinity Laws

The relationship between variables, such as pressure; pump head; flow rate; shaft speed; and power, can be expressed with affinity laws. These apply to fans and pumps in both centrifugal and axial flows (see Fig. 2).

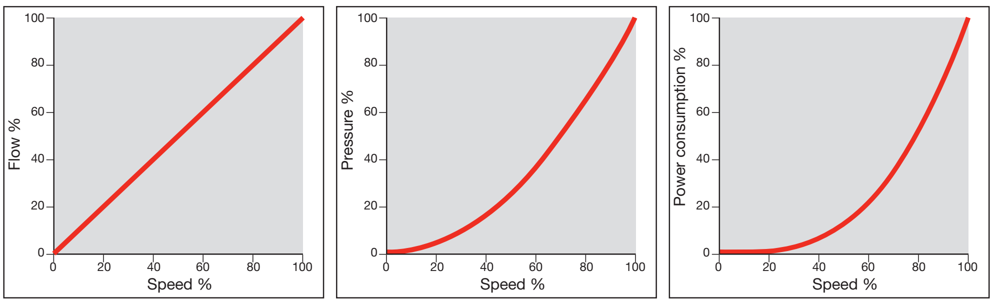


Fig. 2: Affinity laws express relationship between rotational speed and other variables.

From the laws, we can see that flow is directly proportional to speed, while pressure is proportional to the square of speed. Most importantly from the energy savings perspective is that the power consumed is proportional to the cube of speed. This means even minimal reductions in speed can provide savings in consumed power. So, for example, it can be seen from Fig. 2 that at 75% speed this provides 75% of the flow, but uses only 42% of the power needed to generate full flow; when the flow is lowered to 50%, the power consumption is reduced to 12.5%.

## Flow control methods in comparison to speed control

Other typical ways to control the flow are:

- **Throttling control with dampers or valves.**
- **Using inlet vanes in centrifugal fans to restrict the flow of air into a fan.**
- **Using fluid or eddy current couplings to control the torque between the fan and the motor.**
- **On/Off control.**
- **Pitch adjustment with axial fans, where the angle of the fan blades is altered to change the flow.**

The downside of traditional flow control is that none directly affects the main power consumer. There are possibilities to decrease the power consumption of some of these components, but none are as effective in energy efficiency as using speed control with a VFD. For example On/Off control will generate much mechanical stress and pressure peaks due to both the extra starts and stops and the current peaks into the electrical supply when the motor is started without the use of VFD. Fig. 3 below compares the power consumption using throttling control with valve or damper and speed control.

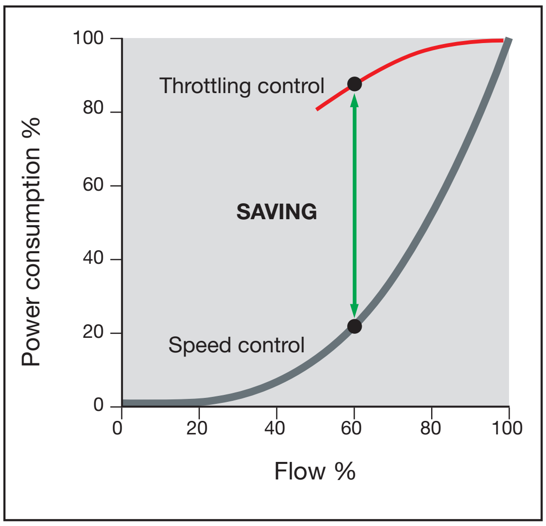


Fig. 3: Comparison between Throttling Control and Speed control with 60% flow.

## The typical HVAC system operating cycle

A typical system is designed to handle peak demand, which is rarely needed during operation. So this means that fans and pumps are "oversized" for most of their operational time. It can be seen from Fig. 4 that for most of the time the normal HVAC operating cycle works below 100% load. Using the affinity laws, one can see substantial energy savings could be achieved by controlling the speed of the motor driving the pump or fan. The Figure below also shows that over 90% of the operating time occurs below 70% flow.

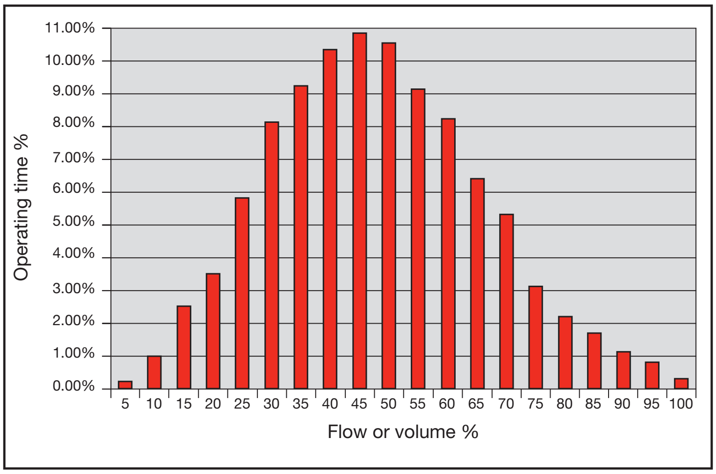


Fig. 4: Typical operating cycle of a HVAC system. Source: UK Department of Trade and Industry.

## Life-cycle costs of a Fan or Pump investment

The initial purchase price of the equipment is just one small part of the total life-cycle cost of fans and pumps. Maintenance is a significant cost, but the majority of operating costs come from energy consumed. Fig. 5 represents the typical life-cycle costs of a pump. It shows that energy savings of up to 70% can have substantial effect on the cost-of-pump ownership. For fans, the typical life-cycle costs are very similar to those shown for pumps.

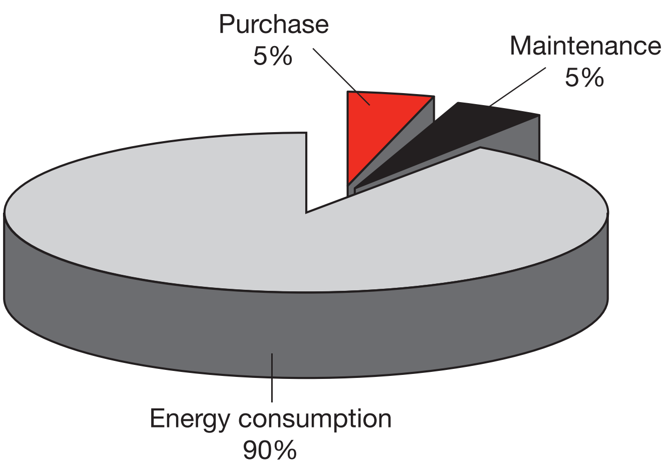


Fig. 5: Typical life time costs of ownership of pump. Source: Hydraulic Institute www.pumps.org

## Special functions to increase the savings even more

The Honeywell NX VFD product family is features functionality that optimises the consumption of energy by relying on pumps and fans. Normally, the VFD operates with a directly proportional frequency-to-voltage relationship. This means that when the VFD increases the frequency/speed of the motor by 10%, the voltage also increases by 10%. The Honeywell NX family of VFDs have an automatic function called "Flux optimisation," which can optimise voltage levels by changing this relationship. This energy saving function can yield an additional increase of up to 5% in energy savings.
In addition, the whole product range is equipped with the capability to turn off its own cooling fan when it is not required. This provides an additional small energy saving and also extends the life of the only moving part in the VFD.

Fig. 6: Honeywell NX family (from left): NXL Compact, NXL HVAC and NXS.

## Energy savings in practice

As previously demonstrated, the savings from using VFDs should be considered when evaluating costs and payback times. Honeywell fan and pump savings calculators can assist in estimating the savings created by investment in VFDs. The calculators use the most typical traditional control methods, such as damper and vane control for fans or valves and on/off control for pumps, as the basis of comparison. Fig. 7 shows the starting view of the Honeywell fan savings calculator.

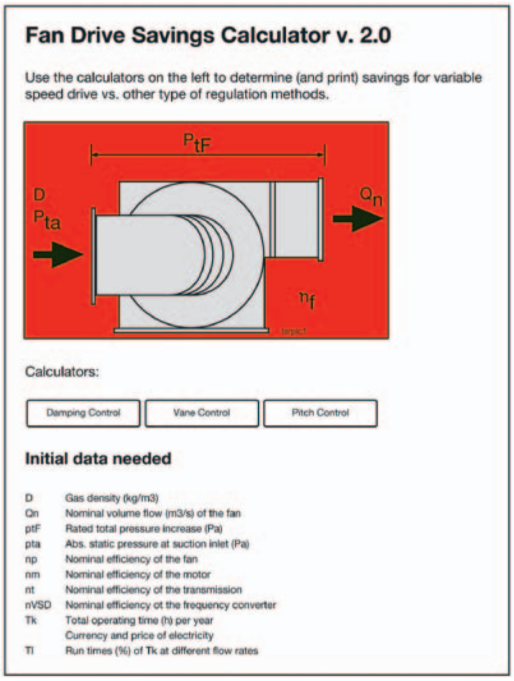


Fig. 7: Honeywell Fan Drive Savings Calculator.

## Energy savings with fan application

The example shows a savings calculation for a typical 5.5 kW centrifugal fan in air handling application comparing throttling control with dampers and the speed control with Honeywell VFD.

The initial data needed for the calculator is:

- **Gas input data: In HVAC application these can be left as default values since dealing with circulation of air.**
- **Fan data: Nominal volume flow and rated pressure increase can be obtained from the fan datasheet.**
- **Efficiency:**
  - If possible, use real values; otherwise, default values give good estimations.
  - The fan in question is a direct-driven fan so transmission efficiency is 1.
  - Honeywell VFDs are typically as high as 0.98 efficient.
- **Energy price should be the real price to provide the most accurate estimates.**
- **Hours of use per year are always estimated. This calculation assumes 80% use per year with typical operating cycles for air handling application.**
- **The cost difference in this calculation is an estimated price difference for this size of VFD and damper system investment.**

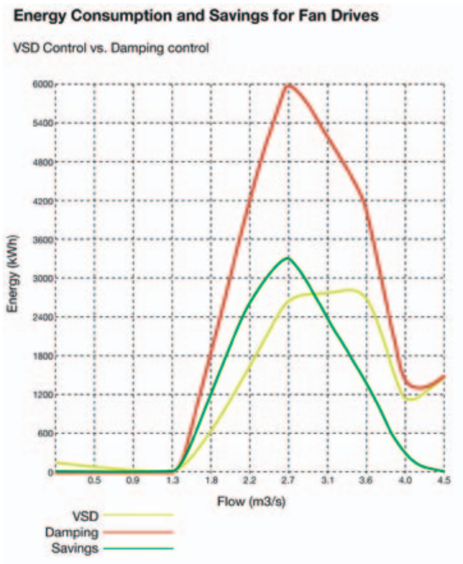


Fig 8. Energy saving calculation with 5.5 kW fan with Honeywell Fan saving calculator

**The results reveal annual savings in energy cost of 992 euros and a payback time of 0.65 years for the VFD investment.**

## Cost savings with small VFD in pump application

Here is shown a rough calculation comparing the investment of direct online connected and VFD controlled pump system.

**Alternative 1.** Direct online (DOL) connected pump:

| | |
|---|---|
| Pump and Motor (~3kW) | 1000 Euro |
| Installation | 1000 Euro |
| Total cost DOL: | 2000 Euro |
| Energy 15 years | |
| Consumption with DOL | 394 200 kWh |
| **Energy cost with DOL (9 sent/kWh)** | **35 478 Euro** |

**Alternative 2.** Solution with VFD:

| | |
|---|---|
| Pump and Motor (~3 kW) | 1000 Euro |
| VFD | 800 Euro |
| Installation | 1200 Euro |
| Total with VFD: | 3000 Euro |
| Energy 15 years (assumed 30% energy savings) | |
| Consumption with VFD | 275 940 kWh |
| **Energy cost with VFD (9 sent/kWh)** | **24 834 Euro** |

| | |
|---|---|
| **Energy savings 15 years:** | **118 260 kWh** |
| **Energy cost savings 15 years:** | **10 643 Euro** |
| **Energy cost savings 1 year:** | **709 Euro** |

## Conclusion

Using Variable Frequency drives in speed control of flow devices, such as pumps, fans and compressors, is not a new innovation. However, the new technology in these devices has made them even more attractive, due to their lower cost. There is much potential to save energy by using more Variable Frequency control for electrical motors in HVAC systems. The technology will be a major contributor in meeting the demands from local and international agreements and norms for energy savings and for lower $CO_2$ emissions.

Author: Tomi Ristimäki
Produkt Manager


**Automation and Control Solutions**
Honeywell GmbH
Böblinger Straße 17
D-71101 Schönaich/Germany
Tel. 07031 637 01
Fax 07031 637 493
http://ecc.emea.honeywell.com



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