In any industrial environment, a design decision needs to be made on the choice between direct driven and belt driven fans.
Assuming the requirements do not make a belt driven fan mandatory, we recommend opting for a direct driven fan.

A direct drive system has one potential point of failure—the motor.
A typical belt drive system has *four potential points of failure* in its drive system alone. These include belts, motor, shaft and bearings.

Energy loss with belt driven fans is a given. Even at their most efficient design, performance, and configuration (properly installed, maintained, and adjusted) a typical belt-driven centrifugal fan loses upto ten percent of its energy and maybe more in some cases if there is improper alignment of shafts, pulleys and motor. Vibration issues can add to maintenance costs and are also responsible for premature failure of belts, spring isolation mounts, and flexible duct connections.

- No transmission losses -> Less power required
- No belt residue -> No cleaning required
- Low maintenance -> Reduced operating costs
- Easy to clean -> Better hygiene
- Lower load on motor bearing -> Longer life time
- Low vibration levels -> Smooth and quiet operation
- Motor directly connected to wheel -> Compact, space saving design
- No bearings in the fan inlet -> Higher performance
- Reduced weight -> Easy handling
- Easier to control with variable-frequency drives (VFDs)
- Lower cost of capital

Belt-drive fans typically have more performance flexibility because they can be selected at any speed. They can be used in high-temperature- or contaminated-air applications, as the motor usually is located outside of the air stream.
Belt drives offer the ability to adjust fan speed and balance a system; however, efficiency losses range from a median 10-15 percent for fractional-horsepower motors to 4 percent for larger motors (Figure below).
During the life span of a direct driven fan, it is pertinent for customers to check whether the loss of flexibility is comparable with the operating costs of a belt driven fan.

Whether a fan is belt or direct-driven impacts efficiency.

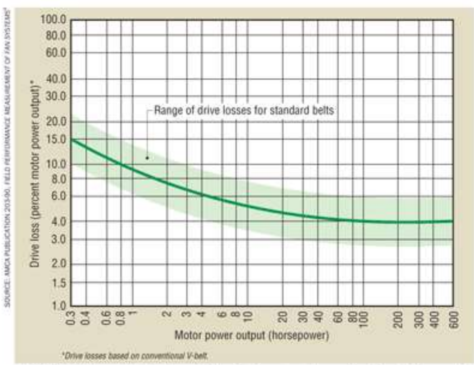


FIGURE 5. Belt loss. Higher belt speeds tend to have greater losses than lower belt speeds at the same horsepower.

Additionally, belt-driven fans require regular maintenance. As belts wear, dust accumulates around a fan; in an air handler or makeup-air unit, this causes filters to load faster or, in the absence of filters, compromises air quality.

Because the impeller is connected directly to the motor shaft, direct-drive fans do not have the losses associated with belt-driven fans. Also, without belts, pulleys, and shaft bearings, they require less maintenance, and, with fewer rotating components, they generally experience less vibration. However, the larger, lower-speed motors associated with larger direct-drive fans generally cost more; thus, return-on-investment calculations should be performed.

Variable-Frequency Drives

Variable-frequency drives (VFDs) are used in both belt-drive and direct-drive systems to maximize energy savings. Reducing input power frequency with a VFD as load decreases lowers motor speed, airflow, and power. Fan speed can be changed and power consumption reduced.

Where Does Lost Energy Go?

Most of the energy lost in a system is converted to heat. For example, mechanical and electrical energy losses in a fan motor raise the surface temperature of the motor. If the motor is in an air stream, the heat will be transferred directly to the air. In a belt-driven system, losses are the result of belt friction, slippage, and/or flexing. All such losses are converted to heat and, if the belt drive is in an air stream, increase the temperature of air. Fan losses quantified by fan efficiency contribute to air-temperature rise as well. As a fan works on a fluid, the friction attributed to the airflow decreases the fan's efficiency and creates heat.

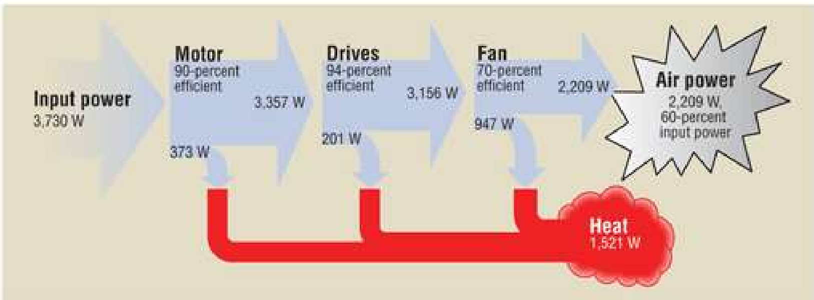
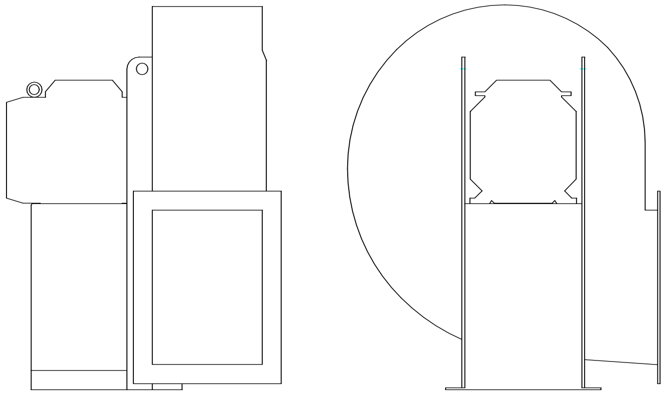


FIGURE 6. Energy loss in a typical fan.

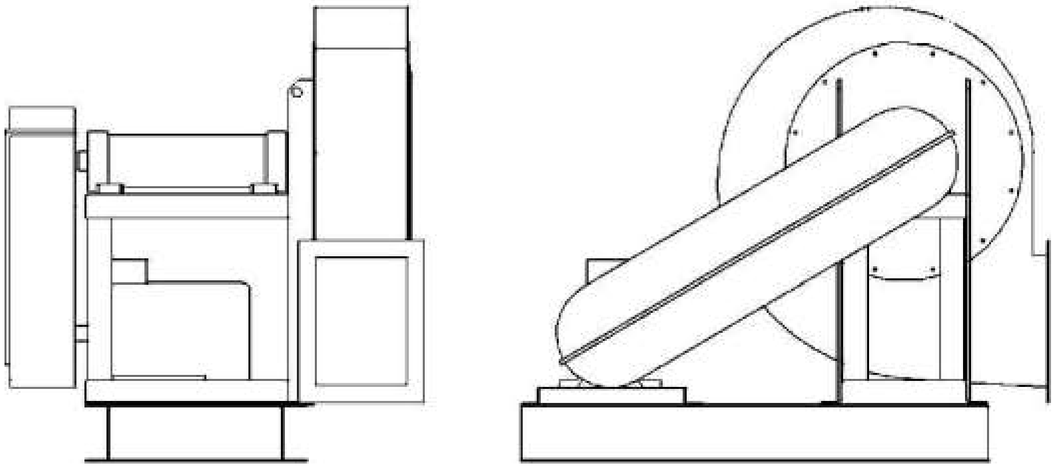
Figure above shows energy transfer in a typical high efficiency belt-driven fan with high efficiency motor. The energy flow starts with the power supplied to the motor and ends with the air power generated by the fan. In this example, the motor receives 3,730 W of power, or the equivalent of 5 hp.

After losses in the motor, drives, and fan, 2,209 W of air power is delivered despite a high efficiency motor and fan. That air power accounts for only 60 percent of the power supplied to the motor. The 1,521 W lost in the process is converted to heat. If the components were located in an air stream, the heat would transfer to and increase the temperature of the air.

As the efficiency of a system decreases, air-temperature rise increases. In a cooling application, this means increased energy consumption on the part of the compressor. Minimizing inefficiencies results in energy savings.



Direct driven centrifugal fan (Arrangement 4)



Belt driven centrifugal fan (Arrangement 12)

	Direct driven	Belt driven
Efficiency – Running costs	Advantageous	Cost from 5% to 10% higher
Investment-Capital costs	Advantageous	60% to 80% higher
Maintenance-Operating costs	Advantageous	Disadvantageous
Space saving – Compactness-Weight	Advantageous	Disadvantageous
Operating temperature	Up to 150°C	Up to 450°C
Flexibility	Disadvantageous	Advantageous
Maximum size	Ø 1400 mm	Ø 2000 mm
Maximum power	200 Kw	315 Kw