5756

Energy Efficiency of Residential Fans

Greg Allen, Richard Kadulski

Fans are used to ventilate buildings to ensure comfort and health of the occupants. They move air in and out of the building, through the envelope that separates the indoor spaces from the outdoors. They also circulate air between indoor spaces.

As fresh ventilation air and air circulation are real needs, it is okay to use some energy to meet those requirements. But it should be done efficiently, ensuring that minimum needs are met, avoiding excessive flows and energy consumption. Unfortunately many existing residential systems are not only ineffective, they do not reliably meet minimum needs and they are terribly energy inefficient. To ensure good, reliable air quality and indoor climate, in much of the northern hemisphere balanced mechanical ventilation is not an option, it's a must.

Why bother with ventilation fan and furnace blower efficiency? In larger buildings air handling can account for 30% to 50% of a building's electricity use, less in houses. 20% to 25% or more of the electrical energy input to an air-handling system is lost in the fan itself.

Normally furnace blowers are set at one speed. They are either on when heat is called for, or they are allowed to run continuously during the heating season. Where the furnace fan operates only on demand during the heating season it could be running for 2400 hours over the year. There is a tendency now for furnace blowers to be run continuously for central air conditioning, air filtration, and ventilation, so power consumption is even higher.

An oversized fan usually operates at a lower efficiency than one which is properly sized; the inefficiency results in heat gain which is an additional cooling load under cooling conditions (where cooling is provided), but a useful internal heat gain when heating is called for. When gas heating is used, however, it is not an efficient or economical way to supply heat.

How inefficient are fans used now? Just how bad is it?

It seems that few devices produced by modern man are as pathetically inefficient as residential motor/fan sets.

The power in an air stream is the volume of flowing air times the pressure drop. The power needed to move air in a typical heating system that moves 450 l/s (950 cfm) @ 80 Pascals is theoretically 36 watts. So why do furnace blowers use 350 - 450 watts or more?

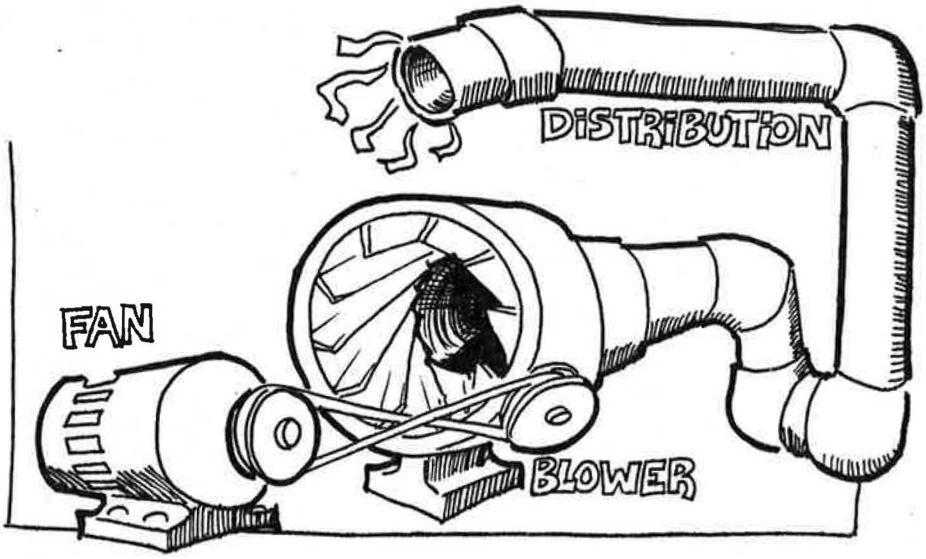
A typical ventilation rate for a house is about 50 l/s @ 80 Pa. In theory it takes 4 watts of power to move that volume of air, but most use around 100 watts or more. The real input power to a motor can be even more.

Fan Efficiency Limits

There are several elements of a fan system that affect total fan efficiency: the motor, the blower design and the distribution system. The most important element is the overall efficiency of conversion of electrical to mechanical energy. A good, efficient motor will draw the least amount of power. The most efficient are DC motors. Permanent shaded (PSC) motors are the norm in the industry, while shaded pole motors (very inefficient) are still being sold.

Some equipment is so inefficient that it actually draws more power than is measured by the meter. In the electrical industry they have a term to describe the inefficiency of electrical equipment: they call it the *Power factor*.

The power factor is used by utilities to describe and measure the efficiency of equipment at converting electricity. In commercial applications, there are even adjustments made to the rate structure to take into account the lower efficiency. Simplified, if a piece of equipment has a



power factor of 0.5 it means it is actually drawing double the power, so the utility makes adjustments accordingly.

Because they are a big element in energy use, fans used in large buildings are designed to deliver over 70% total efficiency, up to 85% for the most efficient units. In residential ventilation and heating units it's a different situation.

The efficiency in commonly used blowers and motors used in typical residential furnaces is only 20% at best. Motor efficiencies in typical bathroom fans is also about 20%, a long way from the 95% plus range that is attainable for the best available technology, and a good deal less than the reasonably achievable level of 80%.

The design of blower blades also affects the total system efficiency. It is not unusual to have measured flow rates at less than half of the fans' rated capacity and the system pressure drop more than the design value. Use of poor components and poor workmanship as well as the use of undersized, flexible ducting is a major culprit.

Both field and laboratory tests on bathroom fans and kitchen range hoods indicate that they under perform their manufacturer's data, even though total efficiencies based on manufacturer's data range from about 1% to about 6%, averaging around 3%. The typical 50 l/s (105 cfm) @ 80 Pa fan draws about 90 to 120 W, for an efficiency of 4.4%. Forced air circulation blowers are slightly better at about 10%.

In the case of furnaces, the perfect fan will move 1500 cfm at 75 Pa static pressure for 53 watts, while a common furnace fan with a 14% overall efficiency will use 380 watts.

In areas where electrical energy is expensive, an efficiency of only 3% to 15% can be a financial hardship just to run these fans.

Design and construction is usually based on what's the cheapest system to meet the code, regardless of the actual requirements. Even if that were not the only criteria, it is difficult to specify something that does not exist, and efficient motor/fan sets do not exist.

Unfortunately, fan motor manufacturers do not appear willing to manufacture a more energy efficient higher quality product. It's a catch-22 situation. Whatever the industry delivers, the market buys, so there's no incentive to tool up to make a better product until the marketplace changes. But the "marketplace" doesn't have a mechanism to demand product improvements other than through regulations which is not the same thing. Most of us are hesitant about regulations as they can easily be abused.

We can focus on the use of energy-efficient motors. But there is another issue: the oversizing of pumps and fans. This is even a bigger concern and represents more inefficiency. Oversizing generally results from the application of large safety factors during the design process.

CSA standards now specify that furnace oversizing should not be more than 40% of design requirements. Common practice in the past was to oversize by much more than 40%. In the Vancouver area oversizing furnaces by 100% and more was almost the norm. Too often furnace sizing was a matter of what was in the shop, rather than what was required.

The problem with oversizing is that the bigger the furnace, the lower the efficiency of the furnace, and the blowers attached to it.

The most effective step to take is to improve construction by building super energy efficient houses that don't need a furnace or a blower, and need minimal heating. The next improvement in energy efficiency is to increase blower efficiency and decrease airflow and static pressure to create an energy efficient forced air system. Reducing the airflow requirements (i.e. the heat load) and the static pressure are integral to this upgrade.

Fan efficiency: how big an issue is it?

Pumping and air handling account for a significant fraction of global electricity use. Improved efficiencies of these systems can be important in reducing future electricity supply needs.

If the power draw of a blower operating continuously for 6 months is reduced by 200 watts, it represents a savings over the year of 876 kWh (at $0.05/kWh this is about $43.80 in energy savings). Over a several years that adds up.

In addition, it also is a savings to the utility and the community. If we assume 10,000 houses (the number in a smaller city) have continuously operating furnace blowers a 200 watt performance improvement means an electricity savings of 8,760 MWh. This is about the same as the reduction in electrical service capacity of 2 MW, or enough power for about 200 houses.

The Bonneville Power Administration in the northwestern USA discovered during an unseasonal cold spell in 1990 that the peak electrical consumption was lower than predicted. On examination it was found that the energy conservation measures set in motion in recent years reduced the peak demand.

The moral of the story is that little savings repeated many times add up to very significant savings.