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Don't Try to Push Air Uphill

Electric motors are generally designed to run at a speed which is a function of the power input, with that power being dissipated mainly as heat in the windings. We then attach a load to the motor in the form of an actuator (to move something), a pump or fan impellor. Now much more of the **power** input is used to do **work** rather than create heat. This is where the term efficiency comes from, power input divided by work output. Now it is not just a question of turning an impellor for the sake of moving something. That impellor must do useful work like ventilating a building.

In the case of fan impellors, they scoop the air and push it out on the discharge, thereby causing suction at the inlet and a positive pressure at the outlet. If that positive pressure builds up at the discharge, perhaps because the fan is pumping into a closed space, then the fan gets to a point where it is not able to inject any more air into the space and just rotates but achieves little. At this stage, the work output is much reduced and efficiency is well down. Apart from low efficiency, there is another downside to this situation. The power input to the motor stays largely constant throughout, so if work output is reduced then this power has to go somewhere. Sadly, it is into the windings of the motor in the form of heat that this power goes and is not only a waste of energy, but **detrimental to the life-span of the motor**. Like a cyclist going uphill, a ventilation fan doesn't like to have to push air into a closed or restricted area like an inappropriate duct system. Ideally, it would operate at maximum efficiency if used to throw air directly into a room without any duct connected, i.e. maximum work for the input power used.

But alas, we can't have everything, air has to be transmitted to and from certain areas where it is most useful and for this we use a duct system. As with all systems, certain rules must prevail. The rule in the case of duct systems is that the velocity or speed of the air must be kept at a certain low level and thereby keeping the pressure in the system low. This is apart from **noise issues** that arise from high velocity duct systems. $P_{dy} = ½ pv^2$ is the mathematical rule here. (P_{dy} is the dynamic pressure, p is density and v is the velocity). We can see that the dynamic pressure is not just proportional to velocity, it is quadratically proportional (v^2)! What this means is that if the velocity is doubled, the pressure is quadrupled.

The easiest way to manage pressure, in the design of ventilation systems is to ensure that the cross sectional area (CSA) of ducts is adequate, as a given amount of air will flow more slowly through a duct with a bigger cross sectional area. In a residential ventilation context the absolute minimum duct diameter should be 80mm and this should only be for short distances to small rooms.

There are small diameters, semi-flexible, semi-rigid, duct systems available on the market. They have been designed for the apartment market in central Europe, where rooms are smaller and duct runs are shorter. It is also common in this market for all service ducts to be buried in the concrete floors and fed down to areas below. This smaller diameter duct lends itself to this, but they are **always** run in pairs, as one of these ducts, which can have a diameter as small as 60 mm is **absolutely** not adequate for any room.

In the house owning culture of the UK and Ireland and especially with the self-builder who prefers to build larger, these smaller duct systems are totally inappropriate. Sadly, the problems only manifest themselves when the rogue supplier/installer (usually more ignorant than dishonest) has long departed.

Beware of **(a) low efficiency**
(b) higher energy use
(c) noise issues and
(d) shortened fan life-span.