THE COST OF FRESH AIR
– Heat losses due to ventilation

Amongst the public there is little awareness of heat losses due to ventilation. Some people still have a romantic attachment to open fires, even though a chimney continuously sucks warm air out of a room, whether the fire is alight or not. Old houses are usually over-ventilated, resulting in heat losses that are greater than necessary.

In a house built to current building regulations – in particular, to Parts F (Ventilation) and L1A (Conservation of Fuel and Power in New Dwellings) – the ventilation will be less excessive than in the past. But because the heat losses due to conduction have been so much reduced, the heat losses due to ventilation have become more prominent.

The need for fresh air

For an indoor air quality that is healthy for both the occupants and the building, houses must be well ventilated. Stale air with an excess of water vapour, VOC’s (Volatile Organic Compounds), smells, carbon dioxide, etc, needs to be replaced with fresh air from outside.

The chart below is taken from an Energy Saving Trust publication, Energy Efficient Ventilation in Dwellings.

![Ventilation rates to control pollution chart]

From the chart, a ventilation rate of 7 litres/sec per person is required in a typical home to minimise moisture build up. With this ventilation rate, all the other factors are under control, too. (The entry, ‘Control NOx during cooking’, presumably applies only to cooking by gas.)

Natural ventilation

In most houses, natural ventilation is used, with air flowing into and out of the house through cracks and gaps in the fabric – albeit the process is supplemented by the
occasional use of extract fans and perhaps by the use of trickle vents in window frames.

There are two mechanisms by which air naturally flows through a house:

- **Wind**
  There is increased pressure on the windward side of a house, and reduced pressure on the leeward side. If there are cracks in the fabric of the house, air flows through.

- **Stack effect**
  Warm air rises. With cold weather outside, warm air in the upper storey is under pressure and escapes to the outside through cracks. Meanwhile, cold air from outside is drawn into the lower storey.

An intuitive feel for these two effects can be gained by opening a couple of windows and keeping the internal doors ajar. On a windy day, open a window on the windward side and another on the leeward side – and feel the draft. On a cold day, open a window on the upper storey and another on the lower storey. On each occasion, the draft will be appreciable, though the effect on a windy day is likely to be the greater.

**Heat losses due to ventilation**

So how much heat is lost as a result of ventilation?

Some figures would be helpful, so I am going to do some sums for an imaginary, detached house with a simple box shape – plan area: 10 x 7 m; height of two stories: 5 m. (The unheated loft is excluded).

The floor area of the house is a modest 140 square metres.

\[
\text{Volume of the habitable space} = 10 \times 7 \times 5 \\
= 350 \text{ cu m.}
\]

\[
\text{Area of the envelope of the habitable space} = 2 \times (10 \times 7 + 10 \times 5 + 7 \times 5) \\
= 310 \text{ sq m.}
\]

(Note in passing that these two figures, 350 and 310, are very roughly equal. This will be seen to be significant in next month’s article.)

Let’s assume that the house has 4 occupants, each requiring 7 litres of fresh air per second, as suggested by the EST chart.

\[
\text{Volume of fresh air required} = 28 \text{ litres per second} \\
= 28 \times 60 \times 60 \div 1,000 \text{ m}^3/\text{hour} \\
= 115 \text{ cubic metres per hour.}
\]

A common way of expressing a ventilation rate is in air changes per hour (ach). In our example:

\[
\text{Ventilation rate} = 115 \div 350 \\
= 0.33 \text{ ach.}
\]

(This ventilation rate, which is in accord with the EST chart, is at the low end of what is considered to be acceptable – see later.)
Assuming this ventilation rate – 28 litres/sec or 0.33 ach – at what rate would heat be lost?

The heat capacity of air is 0.0012 joule/cm³°C. There are 1,000 cm³ in a litre.

Heat required to raise 28 litres of air through 1°C = 28 x 1,000 x 0.0012 = 33.6 joule.

Since 1 watt = 1 joule per sec:
Rate at which heat is lost = 34 watts.

This is a small rate, but it is only for a 1°C difference of temperature.
Let’s consider a cold day with the temperature 0°C outside, and 20°C inside:

Rate at which heat is lost on a cold day = 34 x 20 = 680 watts.

As we see below, a ventilation rate three times greater (ie, 1 ach) is quite possible, and then the rate of heat loss would be a sizeable 2 kW [≈ 3 x 680 ÷ 1,000].

**Energy losses with Heat Recovery Ventilation**

There is a way to drastically cut the heat losses associated with ventilation, and that is by installing Heat Recovery Ventilation (HRV, also called Mechanical Ventilation with Heat Recovery, MVHR).

In the heat exchanger of an HRV unit, about 85% of the heat required for the fresh air is gained by cooling the exhaust air.

For a 1°C difference of temperature:
Rate at which heat is lost with HRV = 5 watts [34 x 0.15]

With a 20°C temperature difference:
Rate at which heat is lost with HRV on a cold day = 100 watts. [5 x 20]

This is a big improvement on the 680 watts for natural ventilation, but it is not quite the end of the story. The energy used by the two fans needs to be taken into account.

The Energy Saving Trust say that for Best Practice the Specific Fan Power of the HRV system should be 1 watt/litre, or less. Using this figure, the power used for an airflow of 28 litres/sec would be 28 watts. Adding this to the rate of heat loss, above, we have:

Rate at which energy is lost with HRV on a cold day = 128 watts. [100 + 28]

This is much less than the rate at which heat is lost with natural ventilation (680 watts).

**Recommended ventilation rates**

Back in the Seventies, a ventilation rate of 2 ach was commonly recommended. Since then, the recommended rates have come down:

- The Energy Saving Trust recommends 0.5 to 1.5 ach. (The middle of this range, 1 ach, results in the 2kW rate of heat loss calculated previously.)
- The Passive House Institute in Germany recommends 0.3 ach.
For the building regulations, Part F expresses the minimum ventilation rate according to the number of bedrooms:

<table>
<thead>
<tr>
<th>Number of bedrooms</th>
<th>Ventilation rate, litres/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>28</td>
</tr>
</tbody>
</table>

The assumption is that the main bedroom has two occupants and the other bedrooms one occupant. Each occupant requires a ventilation rate of 4 litre/sec – and the house itself requires 5 litre/sec. The overall effect is that these Part F minimum rates are somewhat below the EST figure given at the start of the article of 7 litre/person (without any extra for the house).

With an HRV system in an airtight house, the ventilation rate can be set to the required figure. For a house utilising natural ventilation, the ventilation rate depends upon its airtightness. Nowadays, the airtightness of a house can be measured, and we look at this aspect next month.

### Ventilation systems

A range of different ventilation strategies are possible in new build. I wrote at length about them in 2007, but for convenience here’s a short summary. If you are planning a selfbuild, ventilation is unlikely to be a top propriety – though it might be for health reasons (eg, asthmatic children). Anyway, whether ventilation has a high or low priority, at some stage you will have to give it some thought.

Approved Document F (Ventilation) gives advice on four systems. The first two require background ventilators, usually trickle ventilators built into the window frames. The third system only requires background ventilators if the fabric of the house is very airtight.

1. **Background ventilators and intermittent extract fans**

   This is the most common option and the cheapest to install. Air in a wet room is expelled by an extract fan, as required.

2. **Passive Stack Ventilation, PSV**

   Air in wet rooms is extracted by utilising the stack effect, without the use of electricity. The air is ducted upwards from the ceiling of each wet room, through the roof.

3. **Continuous Mechanical Extract Ventilation, MEV**

   Air is extracted continuously from wet rooms via ducts to a single air handling unit, which is often located in the loft. The stale air is expelled via a duct to the outside.

4. **Continuous mechanical supply and extract with heat recovery, HRV (or MVHR)**

   Air is ducted from the wet rooms to the air handling unit and expelled to the outside, as in the previous system. In addition, fresh air is drawn from outside into the air handling unit, and then ducted to the dry rooms. Inside the air...
handling unit there is a heat exchanger, where the exhaust air gives up much
of its heat to the fresh supply air.
In the UK, HRV (Heat Recovery Ventilation) is often called MVHR
(Mechanical Ventilation with Heat Recovery.)

System 4 (HRV) is intrinsic to the Passive House methodology, and a favoured
approach for low/zero carbon houses. As we saw above, it greatly reduces the
ventilation heat losses. Another benefit is that this system helps to a limited extent in
distributing warmth around the house – important when there is no central heating
system.

But there is another way to capture the heat of the exhaust air. System 3 (MEV)
can be combined with a heat pump. This takes heat from the exhaust air, and heats up
water – for underfloor heating and/or for Domestic Hot Water. The method is popular
in Sweden, but so far little used in the UK. Another approach is to transfer the heat of
the exhaust air into an existing heat pump (Ground Source or Air Source) and
thereby improve its efficiency. (See Further Info.)

The approved document gives advice about using the four systems, but it also
recognises that other systems may be acceptable – for example, Positive Input
Ventilation.

Different levels of airtightness are appropriate for the different systems, and we
look at this topic next month.

FURTHER INFO:

*Energy Efficient Ventilation in Dwellings*
– Good Practice Guide 268.
Published by the Energy Saving Trust, 2006.
Free download:
www.energysavingtrust.org.uk.

*Nibe*
Exhaust air heat pumps.
www.nibe.co.uk.

*Danfoss*
‘Vent’ exhaust air unit, to be coupled with a heat pump.
www.heatpumps.danfoss.com


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