What factors influence the air-flow rate in PSV (Passive Stack Ventilation) systems?

The air-flow rate in a Passive Stack Ventilation (PSV) system is primarily influenced by the stack effect, which is driven by temperature differences between indoor and outdoor air, alongside wind speed and direction acting on the terminal. Other critical factors include the system's design, such as the diameter, length, and route of the ducting, the number of bends, and the height of the stack. Furthermore, the placement and size of background ventilators (trickle vents) in the room are essential, as they provide the necessary air inlet for the system to function effectively.

Understanding the Mechanics of Passive Stack Ventilation

Passive Stack Ventilation is a fundamental component of many UK homes, particularly those built to certain Building Regulations standards. It's a beautifully simple concept that leverages basic physics to move air, but its effectiveness hinges on a delicate balance of environmental and design factors. Unlike mechanical systems that force air movement with fans, a PSV system relies entirely on natural forces. This makes its performance inherently variable and deeply connected to the conditions inside and outside your home.

At its core, a PSV system consists of vertical ducts, typically running from ceiling vents in 'wet' rooms like kitchens and bathrooms up to terminals on the roof. The principle is that warm, moist air rises. This movement creates a natural updraft, drawing the stale, humid air out of the room and up through the stack. For this cycle to complete, fresh air must enter the property to replace what's being extracted. This is where background ventilators, often in the form of trickle vents in window frames, play their absolutely crucial role. Without an adequate and unobstructed air supply, the entire system grinds to a halt.

The Dominant Force: The Stack Effect

The stack effect is the engine of a PSV system. It is the phenomenon where warm air, being less dense than cold air, rises. The strength of this effect is directly proportional to the temperature difference between the indoor and outdoor air (the ΔT). On a cold winter's day, when it might be 2°C outside and 20°C inside your kitchen, that 18-degree difference creates a powerful driving force. The warm, moist air from cooking or showering will rush up the stack with notable vigour.

Conversely, during a warm summer spell, the temperature differential might be minimal. If it's 25°C outside and 26°C inside, the stack effect is almost negligible. The driving force is incredibly weak, leading to significantly reduced, or even non-existent, airflow rates. This is the primary reason PSV systems can be unreliable as a sole means of ventilation in the UK's temperate climate; their performance is at its worst precisely when windows are closed and humidity can still build up from everyday activities.

The External Power: Wind Effects

While the stack effect is a thermal force, wind provides a mechanical one. Wind blowing across the roof of a house creates pressure variations. When wind blows over the terminal of a PSV stack, it can create a negative pressure (suction) at the outlet, which actively pulls air up and out of the duct, enhancing the flow rate. The effect can be substantial.

However, wind is unpredictable. Its speed and, crucially, its direction are constantly changing. A wind blowing from a specific direction might actually create a positive pressure on the terminal, fighting against the stack effect and reducing or even reversing the airflow. This is why the design and placement of the terminal are so vital. Terminals are designed to try and leverage wind from any direction to assist extraction, but it remains an inconsistent factor that designers must account for.

The Internal Architecture: Ductwork Design

The path the air must travel is just as important as the forces pushing it. Ductwork introduces resistance, or pressure drop, which the natural forces must overcome.

- **Diameter:** A wider diameter duct presents less resistance to airflow than a narrower one. Building Regulations provide guidance on minimum diameters for expected extract rates.
- **Length:** The longer the vertical duct run, the more friction the air encounters. While greater height can strengthen the stack effect, excessive length can introduce too much resistance if not correctly sized.
- **Route and Bends:** This is often the biggest culprit in poorly performing systems. Every bend, elbow, and offset in the ductwork drastically increases resistance. Ideally, ducts should be as straight and vertical as possible. A route that is convoluted, with multiple sharp bends, will choke the airflow, regardless of how strong the stack effect is. Insulating the ductwork, particularly when it passes through cold loft spaces, is also critical to prevent the warm air from cooling down and losing its buoyancy before it exits.

The Often-Forgotten Partner: Air Inlets

For air to flow out, fresh air must flow in. This is the most common point of failure in PSV systems. The extract vents in the ceiling are useless if the room is sealed tight. Background ventilators, typically trickle vents in windows or walls, are installed to provide this continuous, low-level air supply.

If occupants block these vents because they feel a draught, or if they are never installed correctly in the first place, the PSV system cannot work. The pressure in the room would drop slightly, but without a fresh air inlet, no further extraction can occur. The system becomes stagnant. Therefore, the size, location, and crucially, the *use* of these background ventilators are non-negotiable factors influencing the overall system's airflow rate.

The Case for Mechanical Assistance

Academic sources suggest the following: PSV can be an effective, low-energy solution when all design parameters are perfectly aligned and occupant behaviour supports its operation. However, while PSV has its place, its passive nature makes it fundamentally inconsistent. Its performance is at the mercy of the weather, leading to potential under-ventilation on still, warm days and over-ventilation (and associated heat loss) on cold, windy days.

This is where modern mechanical ventilation solutions provide a definitive upgrade, offering control and consistency that PSV simply cannot match.

- **For Continuous Extract:** Systems like our **ARIA dMEV** (decentralised Mechanical Extract Ventilation) provide a constant, low-level extract from wet rooms. They are fan-assisted, meaning they operate effectively regardless of outdoor conditions. They can also boost their speed based on humidity levels, ensuring peak moisture is removed instantly, something a passive system can never guarantee.

- **For Whole-House Ventilation with Heat Recovery:** For the ultimate in efficiency and air quality, a **RESPIRO MVHR** (Mechanical Ventilation with Heat Recovery) system is the gold standard. It continuously extracts stale air from wet rooms and supplies fresh, filtered air to living rooms and bedrooms. Crucially, it passes the two airstreams through a heat exchanger, recovering up to 90% of the heat that would otherwise be lost out of the stack. This provides superb air quality without the draughts and heat loss associated with passive ventilation.
- **For Retrofits and Single Rooms:** Our **FLUXO** and **AUREN** single-room MVHR units are perfect for refurbishment projects where ducting is impractical. They are installed through an external wall, extracting stale air and supplying fresh air while recovering heat, all within a compact, self-contained unit. They overcome all the limitations of PSV by providing controlled, efficient ventilation exactly where you need it.

To ensure consistent and effective ventilation in your UK property, speak with our experts about upgrading to a controlled mechanical system that guarantees air quality regardless of the weather.