Ing. Vojtěch HAROK
Ing. Veronika JENČÍKOVÁ

MANDÍK, a.s.

Air Flow Regulators: What the Environmental Product Declaration Does (And Does Not) Say

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Reviewer
doc. Ing. Vladimír Zmrhal, Ph.D.

Is a mechanical constant air volume regulator more environmentally friendly, or is an electronic variable air volume regulator better? The Environmental Product Declaration for these regulators – as for other ventilation components – only partially answers this question due to the prescribed methodology. The remaining part of the answer can be found (or should be found) in a realistic estimate of the energy consumption of the ventilation unit fan, based on the air flow rates and pressure losses of the system.

Keywords: *Environmental Product Declaration, EPD, airflow regulators, CAV, VAV, pressure loss*

INTRODUCTION

The aim of an Environmental Product Declaration (EPD) is to use a standardised methodology to determine the environmental impact of a construction product throughout its entire life cycle. Although the preparation of an EPD is not yet a legal requirement, some manufacturers pay close attention to the preparation of these documents, if only because they are increasingly required in tendering procedures. An EPD is usefully employed in tendering procedures or for building certification in the form of a document.

The authors of this article reflect on the following questions: Can an inquisitive engineer simply deduce from an EPD which product is 'more environmentally friendly'? And how does it actually work out? Does the 'birth' and 'burial' of a product consume more resources than the benefit the product will bring during its 'lifetime'? Does 'smart ventilation' make sense? Is there a difference in the informative value of EPDs for bricks and for ventilation components?

EPDs FROM A LEGAL PERSPECTIVE

When preparing an EPD, a life cycle assessment of the product must first be carried out (Life Cycle Assessment, LCA), which assesses the product's environmental impacts from the extraction and production of raw materials, the manufacture of the product itself, all transport of materials, through to the use of the product (regarding the inclusion of product use phases, see discussion) and finally the disposal, reuse or recycling of the product.

A uniform LCA methodology is ensured by the standards ČSN EN ISO 14040 [11] and ČSN EN ISO 14044 [12], and for the product category of construction products by standard EN 15804, which serves as the Product Category Rules (PCR). The ČSN ISO 14025 [13] standard is applied for the creation of EPDs. In addition to the standards, this process must be governed by general programme instructions (GPI), which are administered by the relevant programme operator (in the Czech Republic, this role is fulfilled by the Ministry of the Environment of the Czech Republic), alongside other types of eco-labelling [1]. The largest and most international programme is The International EPD System (sometimes referred to as Environdec), which had published more than 18,000 EPDs in its database by 2025 [2]. However, many manufacturers think twice about registering with this programme due to the associated costs and stricter rules. In order for an EPD to be published in a public database and used for communication with the end customer, independent third-party verification is required, which includes an assessment of compliance with management standards and PCRs, a critical review of the LCA and an on-site assessment at the production site, as well as verification of the credibility, quality and accuracy of the data in the EPD.

EPDs remain a voluntary tool from a regulatory perspective, but are increasingly required by customers and used in tendering processes. Particularly in the Nordic countries, they are becoming indispensable in the construction products market. It is not uncommon for information on a product's carbon footprint to already be included in e-shops and various catalogues. However, the incorporation of environmental issues into binding regulations is currently taking place across the European Union, specifically in relation to EPDs and categories of construction products in the new CPR-2024 (Regulation (EU) 2024/3110 of the European Parliament and of the Council, which lays down harmonised rules for the marketing of construction products and repeals Regulation (EU) No 305/2011 [3]), which sets out the basic requirements for construction works and products and, amongst other things, also contains so-called pre-defined basic environmental characteristics. These are based, just like EPDs, on standard EN 15804 and contain identical impact categories (environmental indicators).

The obligation to declare them will be gradually incorporated into new harmonised technical specifications, which set out the essential characteristics of construction products and will now have the option to establish the relevant threshold levels and classes for the aforementioned environmental characteristics. However, the aim is not to introduce mandatory EPD preparation, but to have the ability to declare the same characteristics depending on the product in question, taking into account the environmental issues associated with it. The introduction of this obligation is divided into three phases. The first phase concerns climate change impacts, which will be required to be declared for the first newly issued harmonised standards under CPR-2024 (with a transition period of one year from publication).

Fig. 1 Low-velocity variable air volume regulator for possible installation directly behind an elbow, type RPM-LV

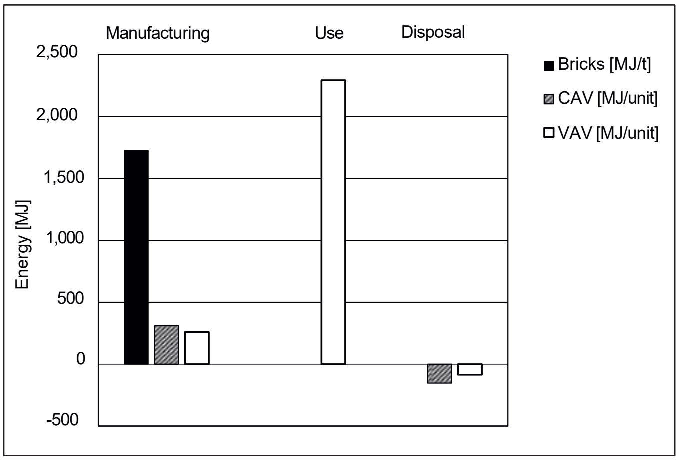

Fig. 2 Graph of total energy consumption per product according to the EPD for individual life-cycle stages; for bricks, CAV regulator RPM-K 315, and VAV regulator RPM-LV 315; assumed service life of 20 years; one MJ corresponds to 0.278 kWh

The EPD can serve many purposes. One of these should be to provide a basis for assessing a building, reducing its carbon footprint and, as early as the design stage, selecting those products – ideally systems comprising interlinked individual products – which, taken together, place a lower burden on the environment.

AIR FLOW REGULATORS

An air volume flow regulator is a component of a building's ventilation system that ensures that, under varying pressure conditions in the air duct, the air flow remains constant or is equal to the required value by automatically and continuously adjusting itsof local pressure loss – this is an autonomously operating throttling element. The differences between mechanical constant air volume (CAV) regulators and electronic variable air volume (VAV) regulators were discussed in [4].

For the purposes of the EPD, it is essential that in both cases the regulator consists of a sheet metal body and a sheet metal blade; in the case of CAV, there is also a relatively simple spring mechanism, whereas in the case of VAV, there is a more or less subtle aerodynamic element in the duct, but primarily an electric servo-actuator equipped with a pressure sensor and evaluation electronics. The VAV regulator consumes electrical energy for measurement and actuation, whereas the CAV regulator does not. Yet the size and weight of these devices for a given ventilation ductwork are very similar.

A case study comparing the energy consumption or wastage of CAV versus VAV is included in [4]. A properly designed and operated HVAC system with VAV regulators typically exhibits a pressure drop that is tens of pascals lower than that of a system with CAV regulators. Will this be reflected in the EPD?

EPD FOR BRICKS, CAV REGULATORS AND VAV REGULATORS

For simplicity, we have chosen a single parameter for comparison – the total energy ("renewable", "non-renewable") for a given life cycle phase, where we will consider a summary division into just three phases: production, use and disposal.

As an example, we consider Porotherm bricks [6], the CAV regulator RPM-K 315 [7], [9], and the VAV regulator RPM-LV 315 [8], [9]. The results are shown in the graph in Fig. 2. The values for the RPM-K 315 regulator (i.e. 315 mm diameter) were determined for the purposes of this study as the arithmetic mean for regulators of 200 and 400 mm dimensions. Unfortunately, the aforementioned EPD for bricks does not cover all life cycle stages. Although, by the nature of the product, energy consumption during the use phase of the bricks is zero, factors such as the transport of bricks to the construction site, the energy required for demolition, and waste disposal are relevant.

The RPM-LV VAV regulator is a newer generation product than the RPM-K CAV regulator, made from a smaller amount of material; therefore – although the VAV contains electronics – the CAV is less energy-intensive to manufacture. However, for the total energy consumed per product according to the EPD, the electricity consumption of the VAV regulator's electrical equipment plays a key role, even though the EPD does not calculate the constant full power consumption of the servo drive; instead, consumption is determined via a time utilisation coefficient based on an assumption provided by an expert.

It might therefore seem that an electronic VAV regulator is clearly a far less environmentally friendly solution than a CAV regulator.

CONSIDERATIONS BEYOND THE SCOPE OF THE EPD FOR AN AIR HANDLING COMPONENT

As mentioned above, an air flow regulator (like any other HVAC component) exhibits a pressure drop when air flows through it. In doing so, the regulator dissipates the mechanical energy of the air flow, which is converted (with a certain degree of efficiency) from electrical energy by the fan of the air handling unit. A regulator that exhibits a lower average pressure drop at a given point in the ductwork (VAV regulator) saves the fan's energy, whereas a regulator with a higher pressure drop (CAV regulator) wastes more energy.

This wasted energy is not directly reflected in the EPD of the given HVAC component, but should theoretically be reflected in the EPD of the air handling unit during the use phase (as the fan's electrical power consumption), see Fig. 3. If we were to attribute this wasted energy to the given HVAC component (regulator), the result for that component would be different, see the graph in Fig. 4.

In the final calculation of the energy required for production, use and disposal, it ultimately follows that a properly designed and operated system with VAV regulators is more environmentally friendly than a system with CAV regulators, precisely due to the lower pressure loss of the VAV system.

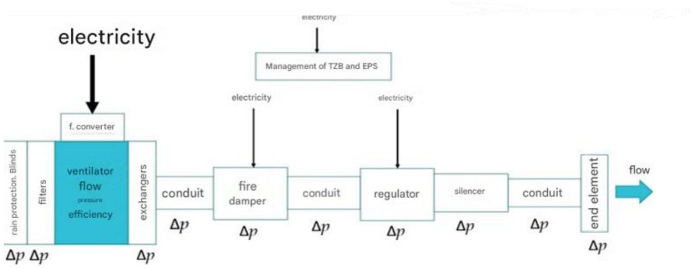

Fig. 3 Schematic diagram of the air-handling system and the relationship between the pressure loss of HVAC components and the energy consumption of the AHU fan (duct leakage neglected); pressure loss of HVAC components increases the fan energy consumption

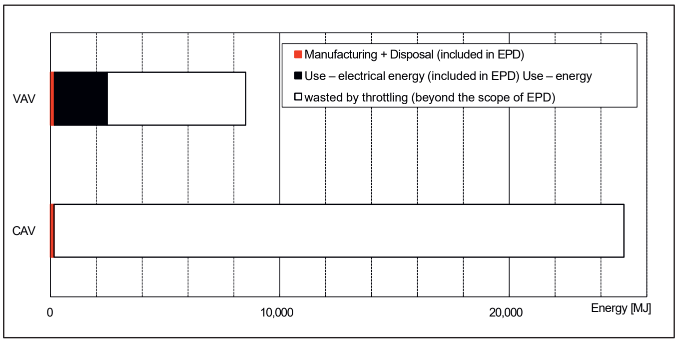

Fig. 4 Graph of total energy consumption per product according to the EPD and beyond the EPD scope for the CAV regulator RPM-K 315 and the VAV regulator RPM-LV 315; service life assumed to be 20 years; one MJ corresponds to 0.278 kWh

DISCUSSION

Comparable model operating conditions for the equipment

The principle of selecting more sustainable products involves comparing the EPDs of interchangeable products from the same manufacturer, or from different manufacturers, although this may currently be problematic. For an EPD to be comparable, it must be based not only on the specified LCA standards the same PCRs, but equivalent requirements for data quality, collection and allocation methods should also be applied, and furthermore – with regard to ventilation and air-conditioning system components – in particular the same or at least comparable model operating conditions, which are defined in the EPD by a specific usage scenario.

Manufacturer of air handling units

If a manufacturer of air handling units decides to include the product use phase in their EPD, they should bear in mind that the entire ventilation system must be taken into account, including the type of ventilation components used and the intended use.

However, as the manufacturer of an air handling unit usually does not know in advance the representative operating conditions determined, among other things, by the selection of the system's ductwork and terminal air handling components, they should:

- ❑ highlight the importance of the influence of operating conditions on energy consumption during the use phase, and may:
  - provide tools (e.g. a calculation programme) to simulate energy consumption for individual operating conditions determined by at least by combining the air flow rate and the pressure loss in the air duct (external pressure difference),
  - provide a calculation example for at least the nominal operating conditions and some other possible operating conditions.

Manufacturer of HVAC components

Conversely, manufacturers of ventilation components, such as CAV or VAV air flow regulators, should:

- ❑ draw attention to the influence of pressure loss in HVAC components on the energy performance of the HVAC system, and could:
  - include this note, together with a model example of a fan energy consumption calculation, directly in the components' EPDs, as is done, for example, in [9].

CONCLUSION

Energy consumption during the operational phase of HVAC components and the entire system is arguably the largest component of the environmental impact across the entire life cycle; therefore:

- ❑ This phase of the product life cycle should not be omitted entirely from the EPD for ventilation units (although Eurovent may, in document [10] recommend the opposite approach for non-residential ventilation and air-conditioning units),
- ❑ the EPDs of individual ventilation components, such as air flow regulators, often do not yet address the question of whether more environmentally friendly: a mechanical CAV regulator with constant air flow, or, conversely, an electronic VAV regulator with variable air flow,
- ❑ demand-controlled ventilation with airflow control has a positive impact on the environment, and therefore the work of specialists on projects and investors' in technically and financially more demanding VAV solutions are significant.

Contact the authors:harok@mandik.cz ; jencikova.veronika@mandik.cz

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