Efficiency, energy and benefits of filtration in AHU systems & occupied spaces of India

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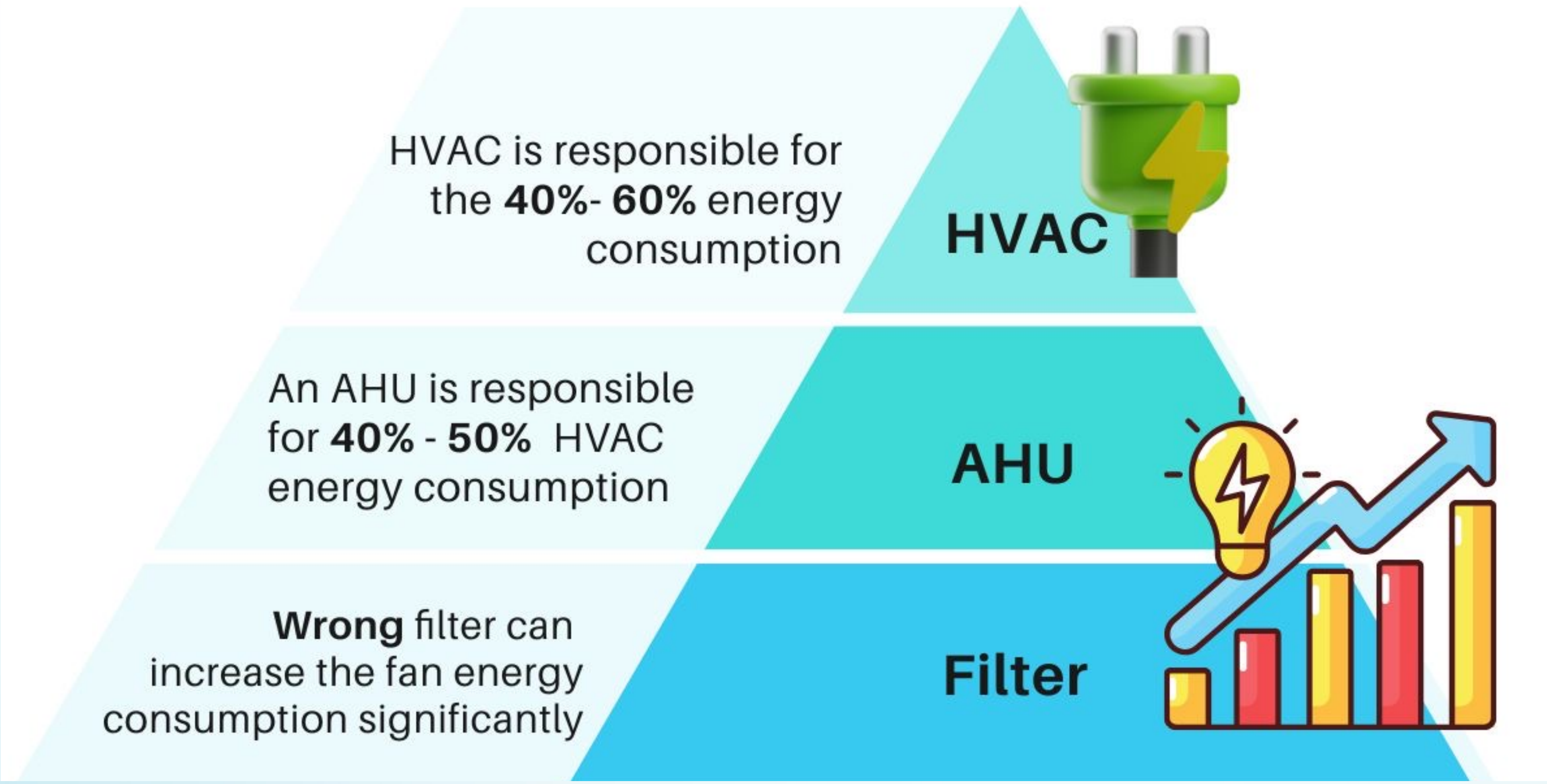
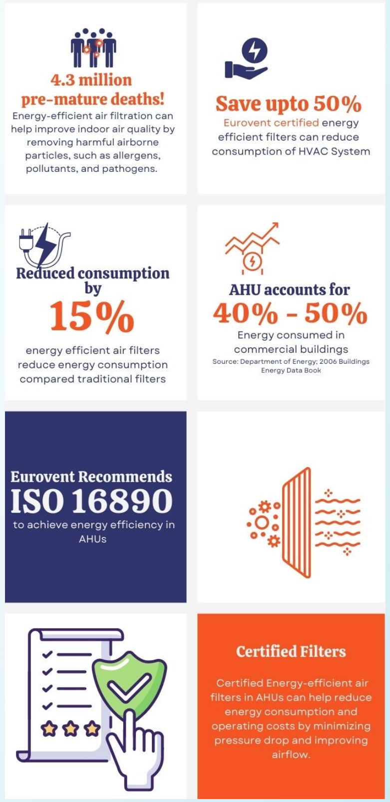
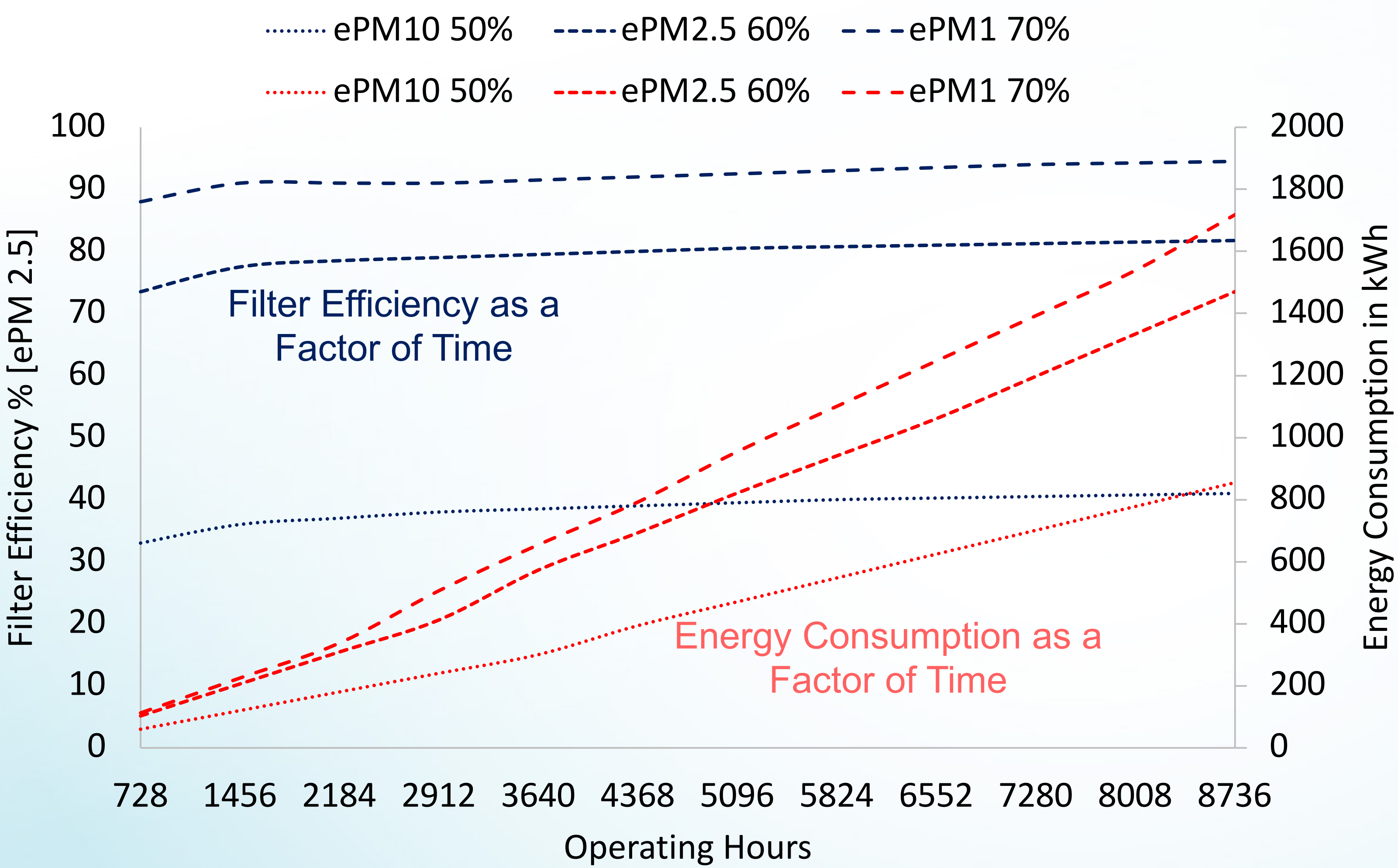
Need for Energy Efficiency in HVAC





Factors affecting air filter energy consumption and its impact

Energy Consumption vs. Filter Efficiency vs. Operating Hours



Key Points

Filter Efficiency improves over the usage time
Also, Energy Consumption Increases over the usage time

Filter Efficiency, Selection, Type, Dust Holding Capacity / usage time and operating Airflow are the important factors that determines the consumption of the filter.

For 1 Lac sq.ft building

ePM10 50% consumes: Rs. 6.3/sq.ft
ePM2.5 60% consumes: Rs. 10.75/sq.ft
ePM1 70% consumes: Rs. 12.60/sq.ft

Case Study: Commercial Office Space

Area	100000	Sqft
Air Cleanliness	3	ACPH
No. of People	2941	100% Occupancy
Electric Cost	8.25	INR/kWh
Assumed Outdoor Contaminant Levels [Average] – Urban Polluted - Industrial	25	µg/m3
	Option 1	Option 2
No. of Filter Stages	2	2
Stage 1	ePM Coarse	ePM 10 50%
Stage 2	ePM 2.5 70%	ePM 1 70%
Filter Purchase Cost [Appx.]	₹ 1,12,500	₹ 1,75,000
Capital Cost of Filters on 1 Person per day	₹ 0.006	₹ 0.010
Cumulative Power Consumption [kWh]	55,500	64,325
Annual Energy Cost	₹ 4,57,875	₹ 5,30,681
Energy Cost on 1 Person per day	₹ 0.43	₹ 0.49
Dust Exposure to ePM 1 & 2.5 per Day per Person on Average [g]	0.011	0.002
No. of Particles we are exposed in a Day based on the Dust Exposure	1.38536E+12	2.51883E+11
Assuming 1/10,000,000 of a particle is Contagious, No. of Particles exposed on 1 Person per day	138,536	25,188

With ~**14%** Higher Expenses [Operational Cost and Capital Cost] you will be Protecting people from ~**82%** of the Potent Contagious Particles every Day

In Filtration, Ventilation Effectiveness, Exfiltration, Occupant Activity level etc. parameters are considered to be same in both the cases

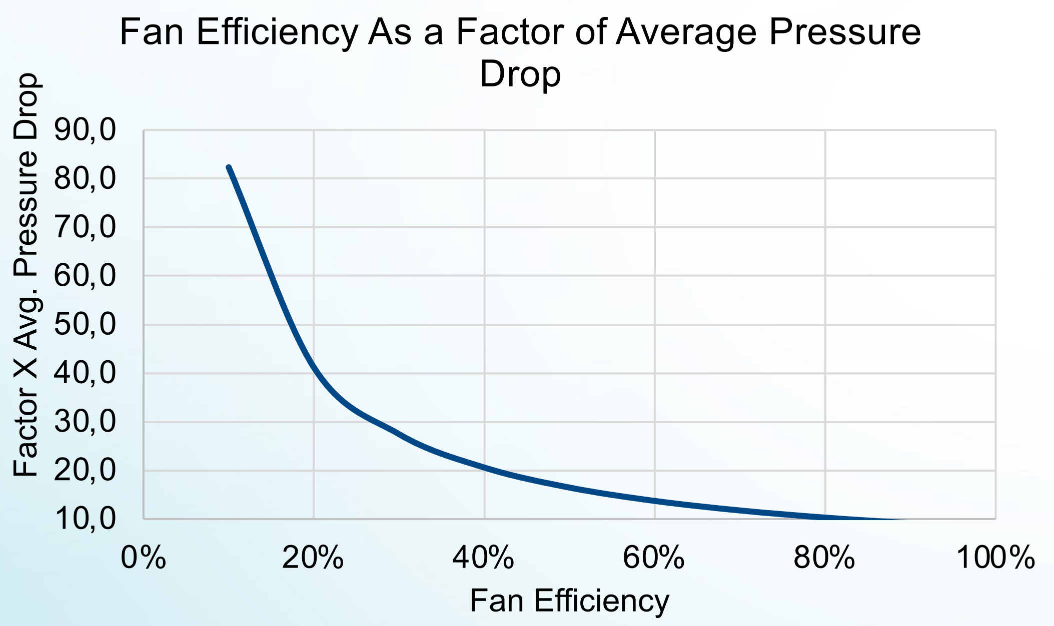
References : Standards and Guidelines as per ISO16890, ASHRAE52.2, ASHRAE 62.1, WHO and AAF Ventilation IEQ Tool

Estimating Energy Consumption in operating condition

Energy Efficiency Calculation Method

- Time Based Method
- Condition Based Method

Effect of Fan Efficiency on Power Consumption



$$W = \frac{q_V \cdot \overline{\Delta p} \cdot t}{\eta \cdot 1000}$$ → **Eq 1**

q_V = Airflow Rate in m3/s

Δp = Average Pressure Drop

t = Time in Hours per anum

η = Efficiency of Fan

W = kWh/a

Source: Eurovent 4/24:2023

Time Based Method

1) Carry out a full test according to the ISO 16890 series of standards at nominal volume flow rate and determine the ePMx efficiencies and the ISO ePMx group as described in ISO 16890-1.
2) Load the filter with ISO L2 dust (AC Fine) according to the procedure described in ISO 16890-3, feeding the total amount of dust given in Table 1 (rounded up to 10 g) or to the final pressure drop (300 Pa), whichever comes first. During the course of dust loading, the pressure drop curve versus dust fed shall be recorded with at least nine data points (mi, Δpi) including the initial data point (m0 = 0 g, $\Delta p0$) (minimum of eight loading steps). For the last loading step, the total amount of dust fed mn (n ≥ 8) shall be equal or slightly larger than the amount of dust given in Table 1. The additional dust loading increments should give a smooth curve pressure drop versus dust fed. The total amount of dust that shall be fed to the filter is defined in Table 1, depending on the ISO classification.

ISO group	ISO ePM_1	ISO $ePM_{2,5}$	ISO ePM_{10}
Amount of dust fed M_x for the flow rate q_V (m^3/s)*	$\frac{q_V}{0.944} \cdot 200$ g	$\frac{q_V}{0.944} \cdot 250$ g	$\frac{q_V}{0.944} \cdot 400$ g

Table 1: Dust amount used for Eq. (2)

*The amount of dust is based on estimated dust concentrations in real life: ePM_1: ~10 µg/m³, $ePM_{2.5}$: ~12 µg/m³, ePM_{10}: ~20 µg/m³

3) Calculate the average pressure drop by using Eq. (2) from the n+1 data points pressure drop versus mass of dust fed.

$$\overline{\Delta p_i} = 0{,}5 \cdot (\Delta p_i + \Delta p_{i-1}) \text{ where } i = 1 \dots n-1$$

$$\overline{\Delta p_n} = \Delta p_{n-1} + 0{,}5 \cdot \frac{\Delta p_n - \Delta p_{n-1}}{m_n - m_{n-1}} \cdot (M_x - m_{n-1}) \text{ where } m_{n-1} < M_x \text{ and } m_n \geq M_x$$

$$\Delta m_i = m_i - m_{i-1} \text{ and } \Delta m_n = M_x - m_{n-1}$$

$$\overline{\Delta p} = \frac{1}{M_X} * \sum_{i=1}^{n} \overline{\Delta p_i} * \Delta m_i \quad (2)$$

4) Calculate the yearly energy consumption W related to the filter using Eq. (1). All data used for the energy efficiency evaluation (ePMx efficiency, ISO ePMx rating, and pressure drop curve) shall result from the same filter specimen.

Source: Eurovent 4/24:2023

Condition Based Method

In case filters are changed when they have reached the final pressure drop, the average pressure drop is not time dependent (as long as the time interval for calculating the average pressure drop always considers full filter lifetime intervals), and the only variable to determine the average pressure drop is the shape of the pressure drop curve as a function of the time.

- In this case, the average pressure drop can be estimated by using Eq. (3): $\overline{\Delta p} = 2/3\ \Delta p0 + 1/3\ \Delta p\mathrm{final}$ where Δp final is the predefined final pressure drop at which filters are changed.

- In case the final pressure drop is defined as a multiple x of the initial pressure drop Eq. (3) can be also written as Eq. (3a): $\Delta p\mathrm{final} = x \cdot \Delta p0$ and $\overline{\Delta p} = \Delta p0\ (2/3 + 1/3\ x)$

assuming, after EN 13053, that the multiplier x equals 3, the equation becomes $\Delta\ \overline{p} = 1.67 \cdot \Delta p0$

- In case the final pressure is defined as the initial pressure drop increased by a certain value Δp, Eq. (3) can be also written as Eq. (3b): $\Delta p\mathrm{final} = \Delta p0 + \Delta p$ and $\overline{\Delta p} = \Delta p0 + \Delta p/3$

assuming, after EN 13053, that Δ p equals 100 Pa, the equation become $\overline{\Delta p} = \Delta p0 + 33.3$
Calculate the yearly energy consumption W related to the filter using Eq. (1) and $\overline{\Delta p}$ determined according to (3), (3a) or (3b).

Example

Source: Eurovent 4/24:2023

The red line marks the average pressure drop.

Step	Dust feed m_i [g]	Pressure drop Δp_i [Pa]	Dust increment Δm_i [g]	Av. pressure drop $\overline{\Delta p_i}$ [Pa]
0	0	78		
1	30	82	30	68,5
2	40	84	10	69,5
3	55	88	15	70,5
4	65	91	10	72,5
5	80	96	15	75
6	90	99	10	77
7	105	105	15	79
8	120	111	15	82

Table 2: Test data for the pressure drop according to EN ISO 16890-3 as a function of the AC Fine dust feed

As an example, the calculation method is shown based on test results for a panel filter rated as ISO ePM$_1$ 50% at 0,277 m³/s according to EN ISO 16890.

The Dimensions of the filter for width x height x depth are 592 mm x 287 mm x 50 mm. According to Annex 1, this filter could be calculated with a test filter in the same filter family. In this case a filter with dimensions 592 mm x 592 mm x 50 mm and an accordingly fitted volume flow rate of 0,556 m³/s.

According to Table 1, the total amount of dust is 120 g.

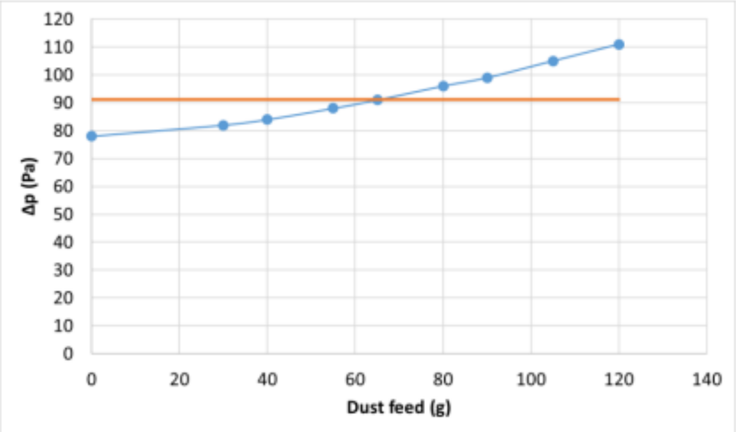


Figure 1: Pressure drop as a function of the dust loading at 0,944 m³/s according to EN ISO 16890-3

With the data given in Table 2, the average pressure drop calculates to $\overline{\overline{\Delta p}}$ = 91,2 Pa and the yearly energy consumption to W = 609 kWh/a.

Total Cost of Ownership

Research shows facilities with poor IAQ can expect an **9% drop in productivity**

33% loss

for companies, due to the lack of productivity

15-40% of the lifetime ownership cost of an AHU (Air Handling Unit) is directly attributable to the air filters selected

Approximately 50% of a building's energy consumption goes to heating, cooling and moving of AIr

Energy Costs upto 81% higher in facilities with deferred maintenance 71% of this is HVAC is related

Deferred maintenance results in $5 Million in annual facility operating costs. **36%** of companies surveyed say this number is even higher

Source: Department of Energy; 2006 Buildings Energy Data Book
Sources: The 2015 Core Facility Benchmarking Study, iLab Solutions, 2015; How Facility Managers Can Handle Occupant Complaints, Facilities Net, 2014.

WHY ENERGY EFFICIENT FILTRATION?

SUSTAINABLE ENERGY OPPORTUNITIES

GLOBAL ENERGY DEMAND GROWING RAPIDLY

Inefficient ventilation systems can consume up to 40% of a building's total energy use.

SUSTAINABLE DEVELOPMENT GOALS

Source: Department of Energy; 2006 Buildings Energy Data Book
Sources: The 2015 Core Facility Benchmarking Study, iLab Solutions, 2015; How Facility Managers Can Handle Occupant Complaints, Facilities Net, 2014.

CERTIFICIATIONS & COMPLIANCE

Having filters certified helps in complying with ETHS, OSHA, LEED, GRIHA, OSHA, RESET etc...

SAVE 60% ENERGY

Demand-controlled ventilation can reduce energy use by up to 60% compared to fixed ventilation systems.