Defining and meeting the nexus of IAQ vs energy savings

EmiratesGBC Technical Workshop

Dani Elamana

Camfil Middle East

June 25, 2019

Agenda

OVERVIEW OF AIR POLLUTION

EXPOSURE TO AIR POLLUTION

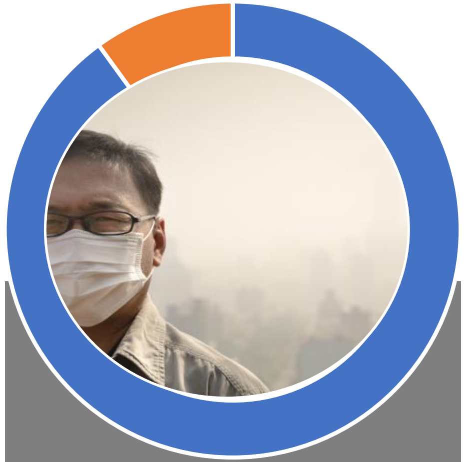
HEALTH RISK TO HUMANS

PM1 FOCUS

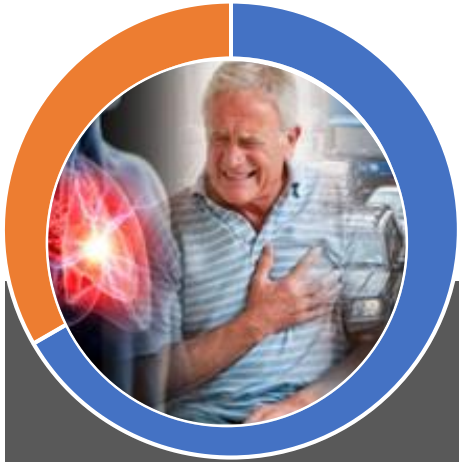
ISO16890

HOW FILTERS CONTRIBUTE ENERGY SAVING

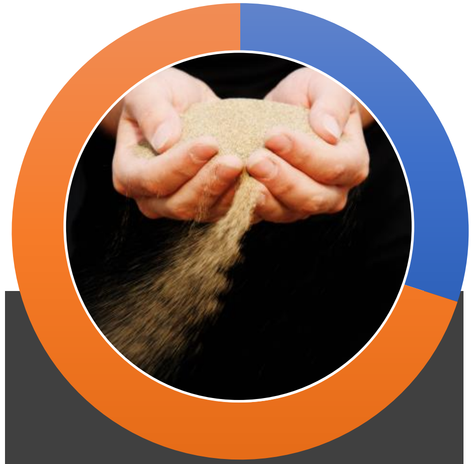
SUMMARY



95% of the world population is breathing unhealthy air

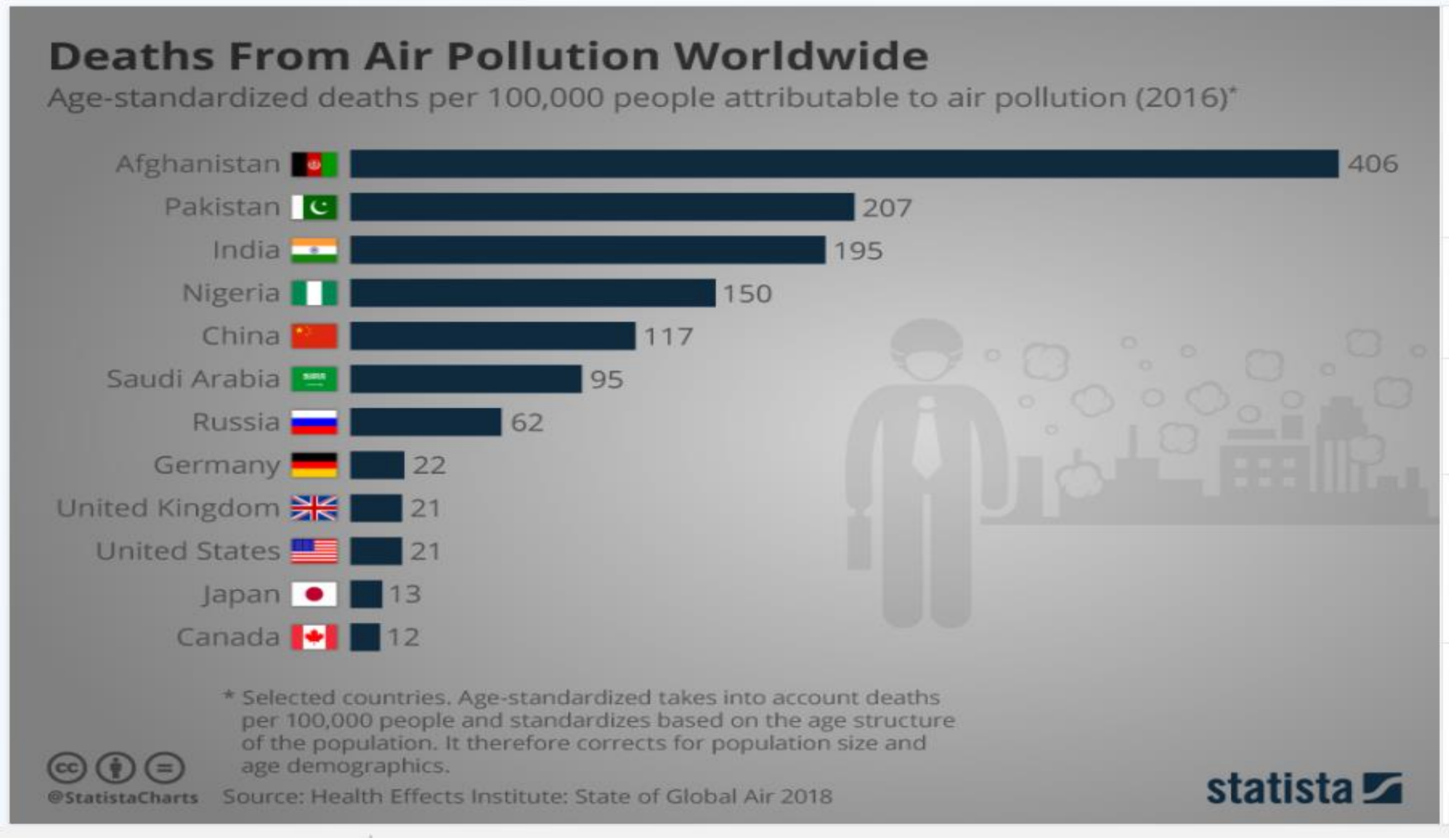


7 million people die yearly due to air pollution related diseases – 1/9 deaths



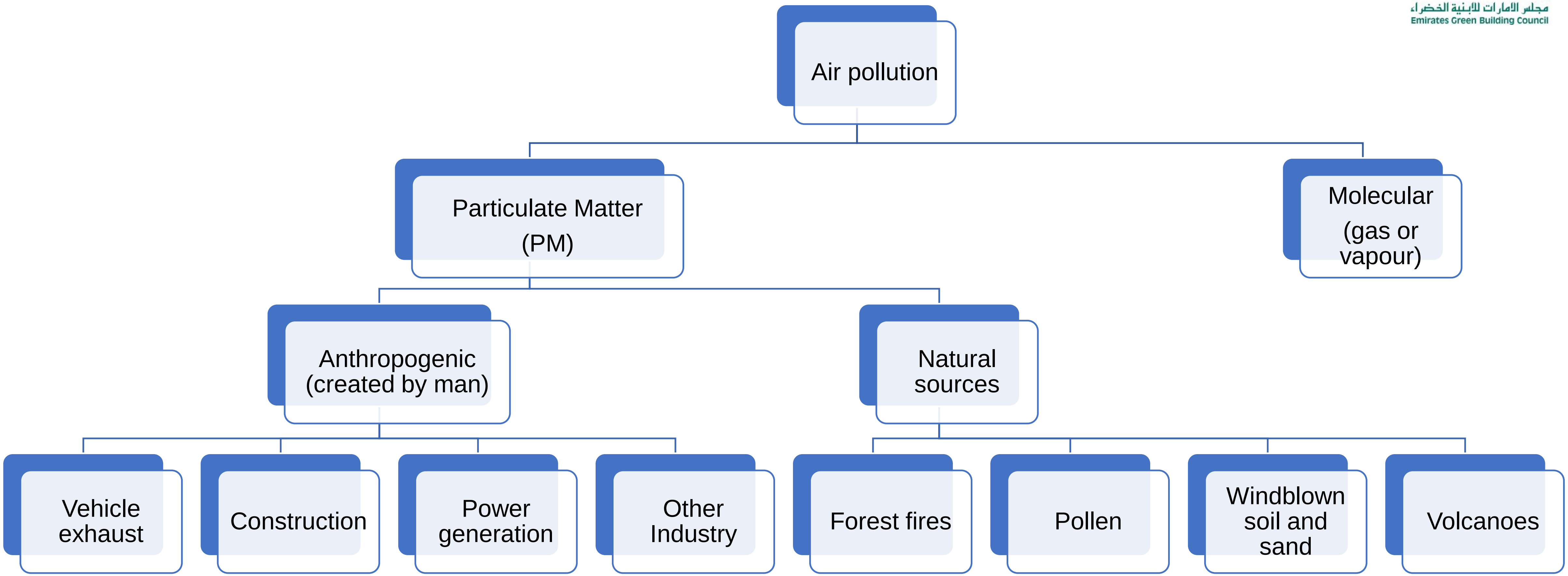
3 million people die as a result of ambient air exposure (*WHO*)

4 million people die as a result of household exposure *(WHO)*



EmiratesGBC
مجلس الامارات للابنية الخضراء
Emirates Green Building Council

Air pollution- type, source and significant examples



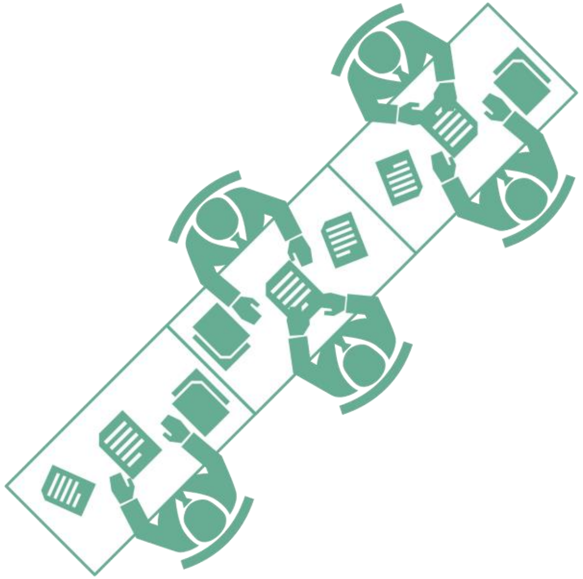
The air we breathe

Humans eat **1 kg** food/day

Humans drink **2 kg** fluids/day

Humans breathe **15 kg** air/day

We spend up to **90%** of our life indoors. This means that indoor air quality (IAQ) can substantially influence our health.



The indoor environment can be up to **50 times** more polluted than outdoor air.

Air pollution reporting

- Many governments and NGOs publish real-time data about PM
- Most commonly reported are PM10 and PM2.5
- PM10 all particles =/< 10µm (1µm = 0.001mm)
- WHO published air quality guidelines (AQG) in 2005, including PM10 and PM2.5

PM1 FOCUS

- By orders of magnitude, the number of PM1 > number PM2.5 > PM10

- Scientific and medical community are increasingly realising the risk of PM1 to human health
  - *Especially particles from combustion processes*
  - *A 2016 study linked PM1 polyaromatic hydrocarbons (PAH), mutagenicity and removal from city air by filtration*

- Ultrafine metallic particles linked to Alzheimer's
  - 06 September 2016
  - Researchers at Lancaster, Oxford and Manchester universities.
  - Report a link between ultrafine (<0.1 µm) metallic particles reaching the brain and onset of Alzheimer's Disease.
  - The metallic particles appear to have been exposed to high temperature (fused).
  - The suspected source of the particles is diesel engine emissions.

  Prof David Allsop et al, Proceedings of the National Academy of Sciences

- *WHO are currently consulting on new AQGs – to supplement PM2.5 and PM10 reporting.*

Or to be more precise:

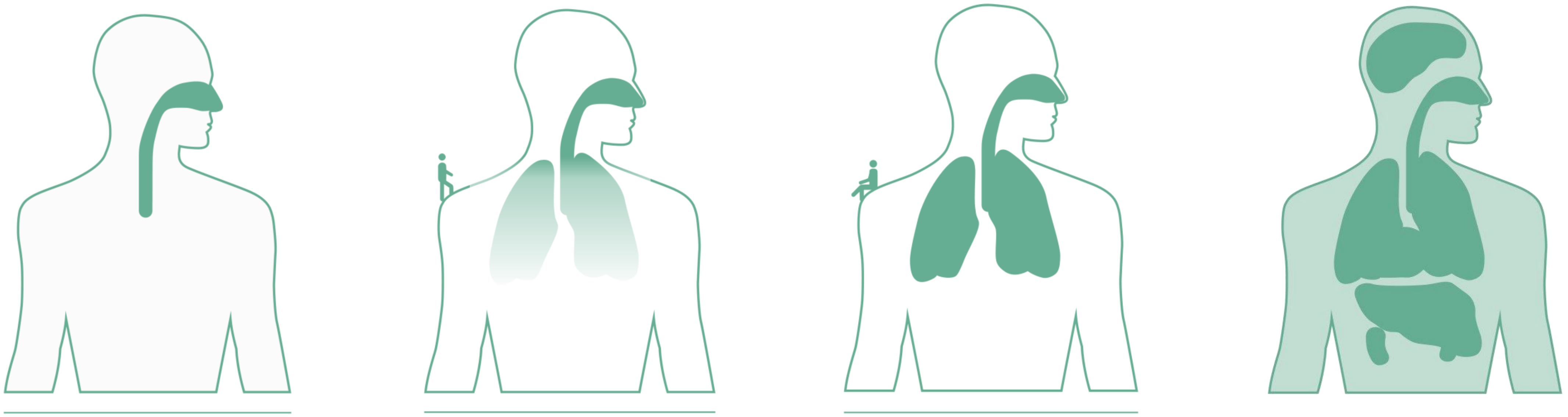
PM_1 particles are the most dangerous

The smallest of PM_1 particles are the most dangerous

Ultrafine < 0,1µm & Nano < 0,05µm

EmiratesGBC
مجلس الامارات للأبنية الخضراء
Emirates Green Building Council

Penetration of pm (particulate matter) into the body

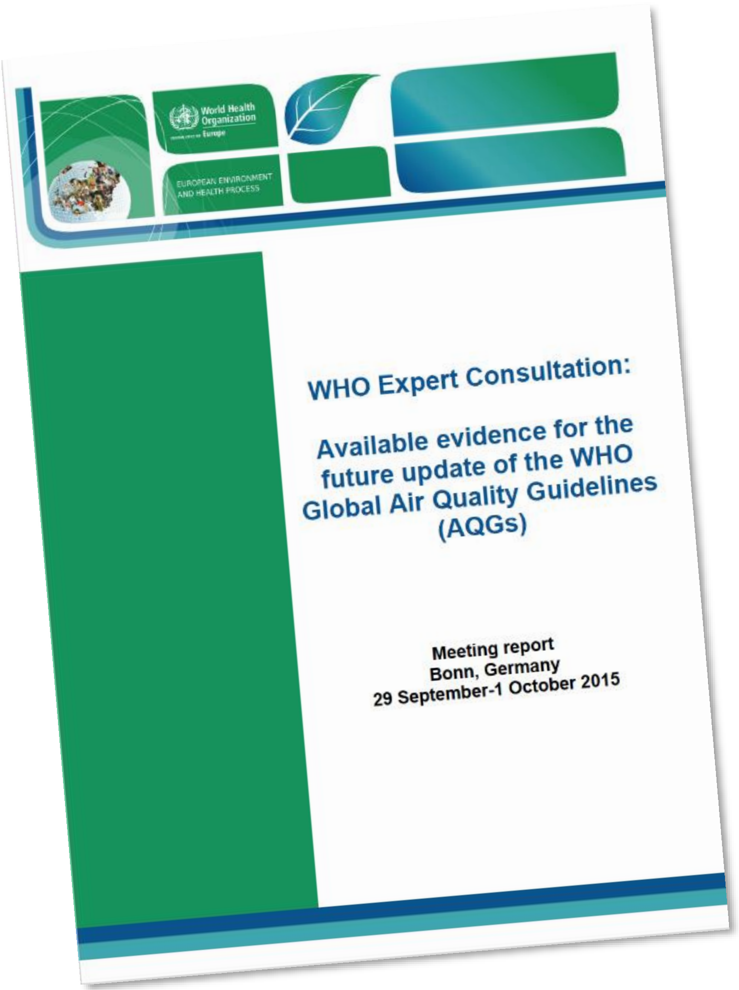


PM10 Size <10µm
Coarse particles.
Upper respiratory tract

PM2.5 Size <2.5µm
Fine particles.
Lower respiratory tract

PM1 Size <1µm
Inhaleable particles
Alveoli

Size <0.1µm
Ultrafine particles.
Bloodstream / whole body


WHO Expert Consultation:

Available evidence for the future update of the WHO Global Air Quality Guidelines (AQGs)

Meeting report
Bonn, Germany
29 September-1 October 2015

PM (particulate matter)

Nitrogen dioxide (NO_2)

Ozone (O_3)

Sulphur dioxide (SO_2)

Probable that future WHO Air Quality Guidelines will focus on ultra fine particles (<0.1µm)

Ultrafine particles correlate with nitrogen dioxide concentrations

THRESHOLD IN UAE

Sampling Schedule	Type of Samples	Maximum Acceptable	Sampling Duration
Before operating the Building.	Formaldehyde	< 0.08 ppm	8-hour continuous monitoring (8 hour time-weighted average [TWA])
	Total Volatile Organic Compound (TVOC)	< 300 micrograms/ m³	
	Respirable Dust (<10 microns)	< 150 micrograms/ m³	

Sampling Schedule	Type of Samples	Maximum Acceptable	Sampling Duration
Initial test completed by 31 December 2011. Further testing within 5 years of last compliant test.	Ozone	< 0.06 ppm (120 micrograms/ m³)	8-hour continuous monitoring (8 hour time-weighted average [TWA])
	Carbon Dioxide	< 800 ppm (1440 microgram/ m³)	
	Carbon Monoxide	< 9 ppm (10 micrograms/ m³)	
	Bacteria	< 500 CFU/ m³ (Algar plate)	
	Fungi	< 500 CFU/ m³ (Algar plate)	

ISO 16890

Air Filters for General Ventilation

INTRODUCTION

EmiratesGBC
مجلس الامارات للأبنية الخضراء
Emirates Green Building Council

- Global situation
  - USA
    - ASHRAE 52.2
  - Europe
    - EN 779:2012
  - Middle East / Asia
    - ASHRAE 52.2, EN779 and local standards

- A significant harmonisation for the air filtration industry has been recently adopted.

- A new standard for filter testing and classification with global coverage.

ISO16890 “Air Filters for General Ventilation”

Why a new global standard?
What are the customer benefits?

Recognition

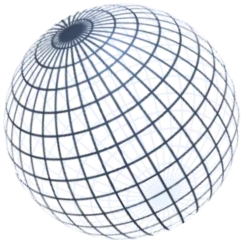
–

Air filters positively influence air quality and human health

More intuitive

–

Filter efficiency and classification aligned with real world air pollution

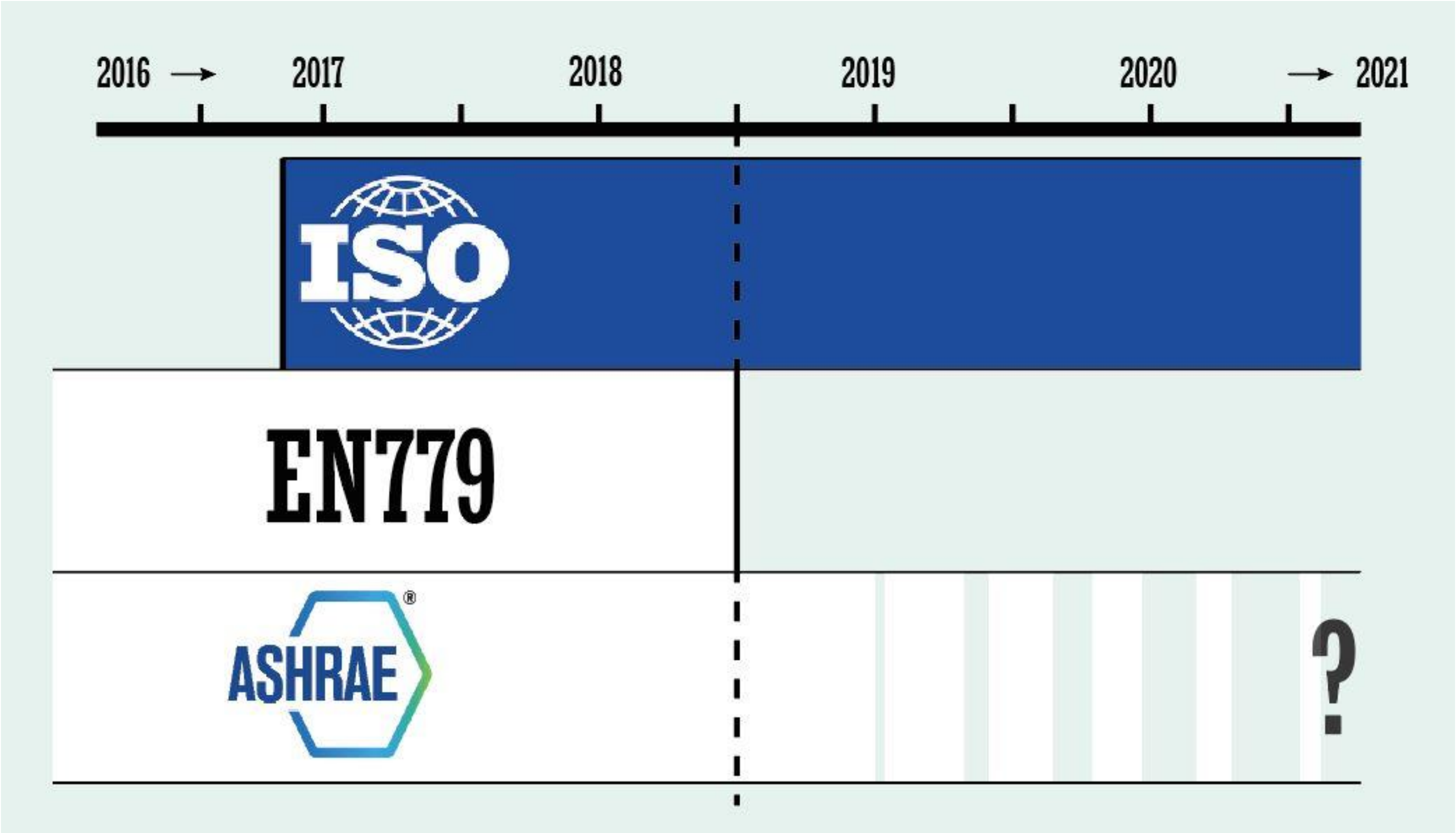


Global applicability

–

Eliminate confusion

ISO 16890: Timeline



COMPARISON OF TEST STANDARDS

	EN779:2012	ASHRAE 52.2	ISO16890
Filter test method	Testing efficiency with **0,4µm particles**	Testing efficiency with 0,3- 10 µm particles. Classifications relate to results for **E1, E2 & E3 efficiency classes – MERV rating**	Testing efficiency with 0,3- 10 µm particles. Classifications relate to result for **PM1, PM2.5 & PM10**
Discharging method	Discharges filter media only, using IPA soak **Tough discharging** method	Discharges entire filter Using KCL salt **Soft discharging** method (not mandatory – App. J)	Discharges entire filter using IPA vapor **Tough discharging** method
Filter loading method	Dustloading with ASHRAE dust **Coarse & sticky dust**	Dustloading with ASHRAE dust **Coarse & sticky dust**	Dustloading with ISO fine dust **Finer & less sticky dust**
Classification system	**9 Classes**	**16 Classes**	**49 classes** in **4 Filter Groups**

EmiratesGBC
مجلس الامارات للأبنية الخضراء
Emirates Green Building Council

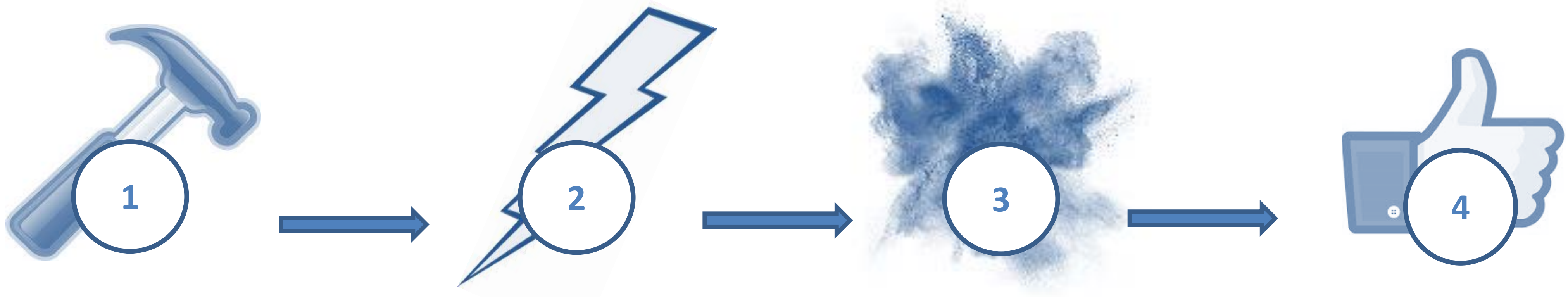
ISO16890: How Does it Work?
The standard is written in four parts:

Part 1: *Technical specifications, requirements and classification system.*

Part 2: *Measurement of fractional efficiency.*

Part 3: *Determination of the arrestance and the air flow resistance versus the mass of test dust.*

Part 4: *Conditioning method to determine the minimum fractional test efficiency.*



Measurement of fractional efficiency

Discharging method

Gravimetric test method (optional)

Classification system

Filter Classification
4 filter groups

ePM 1	ePM 2.5	ePM 10	ISO Coarse
0,3 – 1 µm	0,3 – 2,5 µm	0,3 – 10 µm	ISO Fine Dust Initial arrestance
Corresponding to **E1** ASHRAE 52.2	Corresponding to **E2** ASHRAE 52.2	Corresponding to **E3** ASHRAE 52.2	Filters with **ePM10 < 50%**

Filter groups

Group Designation	Requirement			Class reporting value
	ePM1, min	ePM2.5, min	ePM10	
ISO Coarse	-	-	<50%	Initial grav. arrestance
ISO ePM10	-	-	≥50%	ePM10
ISO ePM2,5	-	≥50%	-	ePM2.5
ISO ePM1	≥50%	-	-	ePM1

ISO16890: CLASSIFICATION SYSTEM

ISO16890: CLASSIFICATION TABLE

PM1 classification	PM2,5 classification	PM10 classification	Coarse
ePM1[95%] ePM1[90%] ePM1[85%] ePM1[80%] ePM1[75%] ePM1[70%] ePM1[65%] ePM1[60%] ePM1[55%] ePM1[50%]	ePM2.5[95%] ePM2.5[90%] ePM2.5[85%] ePM2.5[80%] ePM2.5[75%] ePM2.5[70%] ePM2.5[65%] ePM2.5[60%] ePM2.5[55%] ePM2.5[50%]	ePM10[95%] ePM10[90%] ePM10[85%] ePM10[80%] ePM10[75%] ePM10[70%] ePM10[65%] ePM10[60%] ePM10[55%] ePM10[50%]	Arrestance reported in 5% increments, starting at 5%.
Requirement: > 50% initial efficiency > 50% discharged efficiency	Requirement: > 50% initial efficiency > 50% discharged efficiency	Requirement: > 50% initial efficiency No discharge requirement	No discharge requirement

ISO 16890 TEST REPORT

ISO 16890-1:2016 - Air Filter Test Results						**Testing Organization:** RISE Research Institute of Sweden Brinellgatan 4, 501 15 Borås, Swedan +460105165000
GENERAL						
Report no.: 6P07577-25-rev1	Date of tests: 2017-02-16 - 2017-02-23					Date of report: 2017-03-02
Supervisor: CM				Device obtained (when and how obtained):		
Test(s) requested by: Camfil AB				The device was sent and obtained on 2017-02-14		
DEVICE TESTED						
Model: Hi Flo II XLT 7/640 50+ (HFGX-F7-592/592/640-10-25)		Manufacturer: Camfil AB				Construction: Pocket filter, 10 Pockets
Article number: 610165	Type of medium: Glass	Net effective filtering area: 7.3 m^2				Filter dimensions (width x height x depth) 592x592x640 mm
TEST DATA AND ATTACHED TEST REPORTS						
Test air flow rate: 0.944 m^3/s	Test aersole: KCl (1-10 µm) DEHS (0.3-1 µm)	Test report to ISO 16890-2				Report no. 6P07577-25-rev1 Appendix 2
		Test report to ISO 16890-3 (optional)				Report no. 6P07577-25-rev1 Appendix 3
		Test report to ISO 16890-4				Report no. 6P07577-25-rev1 Appendix 4
RESULTS						
Initial pressure differential: 72 Pa	Initial grav. arrestance: 97 %	$ePM_{1,min}$ 63 %		$ePM_{2.5,min}$ 73 %		ISO rating
Final test pressure differential: 300 Pa	Test dust capacity: 1160 g	ePM_1 64 %	$ePM_{2.5}$ 73 %	ePM_{10} 91 %		**ISO ePM $_1$ 60 %**

Eurovent 4/23

- Selection of ISO 16890 rated Air Filters for General Ventilation Applications

Eurovent 4/23

Recommendation for the selection of ISO 16890 rated air filters for general ventilation applications

Developed in a joint effort by the participants of the Eurovent Product Group ‘Air Filters

Published on 09 January 2018

Category	Description	Typical environment
ODA 1	**OUTDOOR AIR, WHICH MAY BE ONLY TEMPORARILY DUSTY** Applies where the World Health Organisation WHO (2005) guidelines are fulfilled (annual mean for $PM2.5 \leq 10\ \mu g/m^3$ and $PM10 \leq 20\ \mu g/m^3$).	
ODA 2	**OUTDOOR AIR WITH HIGH CONCENTRATIONS OF PARTICULATE MATTER** Applies where PM concentrations exceed the WHO guidelines by a factor of up to 1,5 (annual mean for $PM2.5 \leq 15\ \mu g/m^3$ and $PM10 \leq 30\ \mu g/m^3$).	
ODA 3	**OUTDOOR AIR WITH VERY HIGH CONCENTRATIONS OF PARTICULATE MATTER** Applies where PM concentrations exceed the WHO guidelines by a factor of greater than 1,5 (annual mean for $PM2.5 > 15\ \mu g/m^3$ and $PM10 > 30\ \mu g/m^3$).	

Outdoor Air (ODA) How clean is my Outdoor Air?

- 3 Outdoor Air Classes (ODA 1-3)
- Based on WHO Thresholds:
- Annual mean for PM2.5 < 10 µg/m3
- Annual mean for PM10 < 20 µg/m3

Supply Air Classes (SUP)

SUP 1	refers to supply air with concentrations of particulate matter which fulfilled the WHO (2005) guidelines limit values multiplied by a factor x 0,25 (annual mean for PM2.5 ≤ 2.5 µg/m^3 and PM10 ≤ 5 µg/m^3).
SUP 2	refers to supply air with concentrations of particulate matter which fulfilled the WHO (2005) guidelines limit values multiplied by a factor x 0,5 (annual mean for PM2.5 ≤ 5 µg/m^3 and PM10 ≤ 10 µg/m^3).
SUP 3	refers to supply air with concentrations of particulate matter which fulfilled the WHO (2005) guidelines limit values multiplied by a factor x 0,75 (annual mean for PM2.5 ≤ 7.5 µg/m^3 and PM10 ≤ 15 µg/m^3).
SUP 4	refers to supply air with concentrations of particulate matter which fulfilled the WHO (2005) guidelines limit values (annual mean for PM2.5 ≤ 10 µg/m^3 and PM10 ≤ 20 µg/m^3).
SUP 5	refers to supply air with concentrations of particulate matter which fulfilled the WHO (2005) guidelines limit values multiplied by factor x 1,5 (annual mean for PM2.5 ≤ 15 µg/m^3 and PM10 ≤ 30 µg/m^3).

EmiratesGBC
مجلس الامارات للابنية الخضراء
Emirates Green Building Council

Examples for Supply Air Classes (SUP)

EmiratesGBC
مجلس الامارات للابنية الخضراء
Emirates Green Building Council

CATEGORY	GENERAL VENTILATION		
SUP 1	-	-	
SUP 2	**Rooms for permanent occupation.** Example: Kindergardens, offices, hotels, residential buildings, meeting rooms, exhibition halls, conference halls, theaters, cinemas, concert halls.		
SUP 3	**Rooms with temporary occupation.** Examples: Storage, shopping centers, washing rooms, server rooms, copier rooms.		
SUP 4	**Rooms with short-term occupation.** Examples restrooms, storage rooms stairways.		
SUP 5	**Rooms without occupation.** Examples: Garbage room, data centers, underground car parks.		

CATEGORY	INDUSTRIAL VENTILATION	
SUP 1	**Applications with high hygienic demands.** Examples: Hospitals, pharmaceutics, electronic and optical industry, supply air to clean rooms.	
SUP 2	**Applications with medium hygienic demands.** Example: Food and beverage production.	
SUP 3	**Applications with basic hygienic demands.** Example: Food and beverages production with a basic hygienic demand.	
SUP 4	**Applications without hygienic demands.** Example: General production areas in the automotive industry.	
SUP 5	**Production areas of the heavy industry.** Examples: Steel mill, smelters, welding plants.	

Recommended Minimum Efficiency

			SUPPLY AIR				
OUTDOOR AIR			**SUP 1*** PM2.5 ≤ 2.5 PM10 ≤ 5	**SUP2*** PM2.5 ≤ 5 PM10 ≤ 10	**SUP3**** PM2.5 ≤ 7.5 PM10 ≤ 15	**SUP4** PM2.5 ≤ 10 PM10 ≤ 20	**SUP5** PM2.5 ≤ 15 PM10 ≤ 30
Category	PM2.5	PM10	ePM_1	ePM_1	$ePM_{2.5}$	ePM_{10}	ePM_{10}
ODA 1	≤ 10	≤ 20	60%	50%	60%	60%	50%
ODA 2	≤ 15	≤ 30	80%	70%	70%	80%	60%
ODA 3	> 15	> 30	90%	80%	80%	90%	80%

Table 3: Recommended min. ePMx filtration efficiencies depending on ODA and SUP category. Annual mean PMx values in $\mu g/m^3$

* Minimum filtration requirements ISO ePM_1 50% refer to a final filter stage

** Minimum filtration requirements ISO $ePM_{2.5}$ 50% refer to a final filter stage

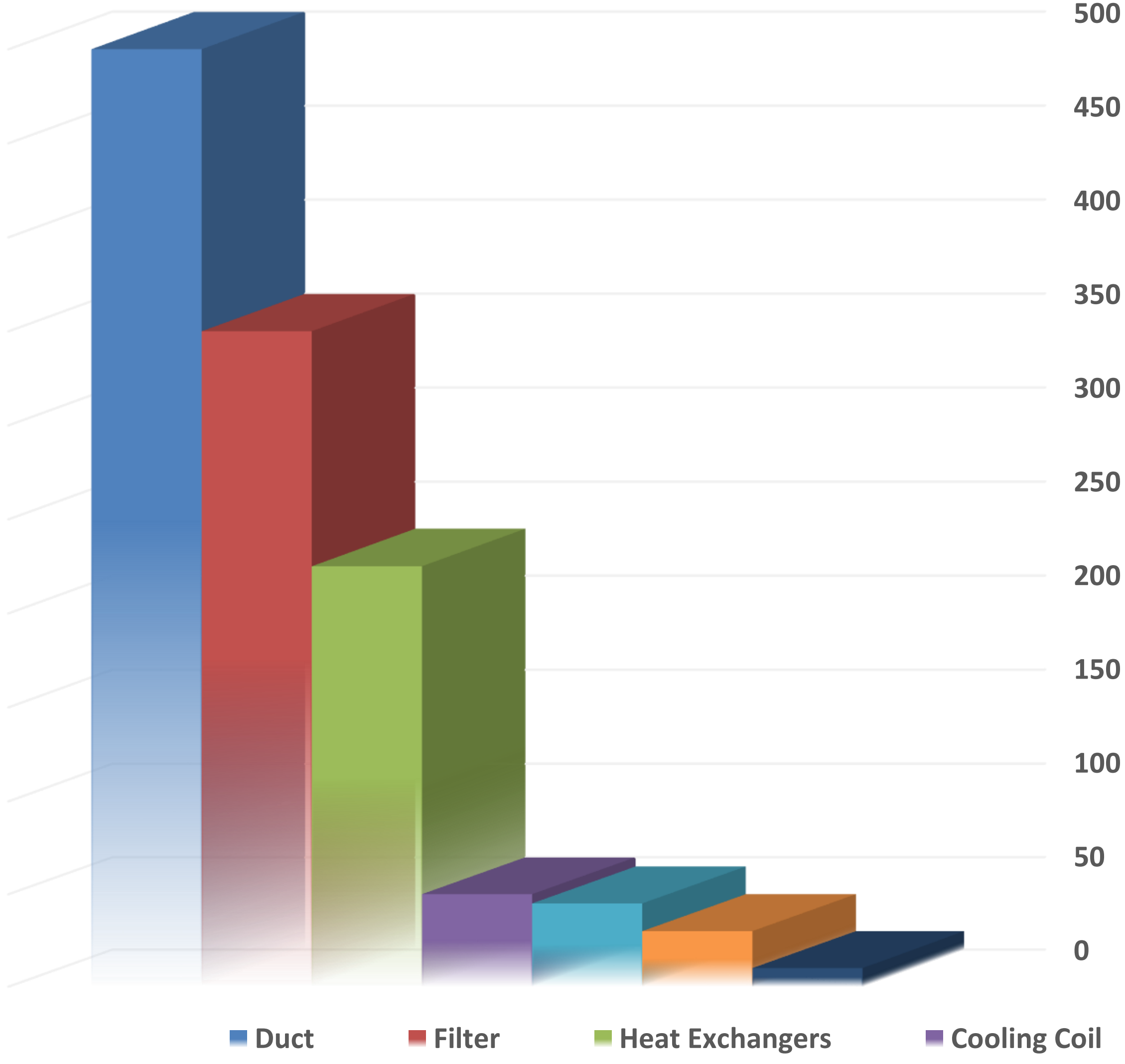
Presented efficiency values concern both single filter and multi-stage filtration systems with a cumulated efficiency.

Eurovent 4/21

- Energy efficient air filtration

ENERGY SAVING POTENTIAL WITH FILTERS

- Filters are the 2nd largest contributor of Pressure drop in a HVAC air side
- Rule of thumb says that 70% of the energy bill comes from HVAC air side
- Out of 70% - 20% is because of the filters



THE COST OF ENERGY

$$E = \frac{q \times dP \times t}{\eta \times 1000} [kWh/year]$$

Without reducing Indoor Air Quality (IAQ)?

q	= Air flow (m^3/s)
dP	= Pressure drop (Pa)
t	= Operating time (hours/year)
η	= Fan efficiency (0,1 - 0,7)

Eurovent 4/21:2018

M_x = 200 g (AC Fine)	AEC in kWh/y FOR ePM_1 (ePM_1 and $ePM_{1,min} \geq 50\%$)					
	A+	A	B	C	D	E
50 & 55%	800	900	1050	1400	2000	>2000
60 & 65%	850	950	1100	1450	2050	>2050
70 & 75%	950	1100	1250	1550	2150	>2150
80 % 85%	1050	1250	1450	1800	2400	>2400
> 90%	1200	1400	1550	1900	2500	>2500

M_x = 250 g (AC Fine)	AEC in kWh/y FOR $ePM_{2.5}$ ($ePM_{2.5}$ and $ePM_{2.5,min} \geq 50\%$)					
	A+	A	B	C	D	E
50 & 55%	700	800	950	1300	1900	>1900
60 & 65%	750	850	1000	1350	1950	>1950
70 & 75%	800	900	1050	1400	2000	>2000
80 % 85%	900	1000	1200	1500	2100	>2100
> 90%	1000	1100	1300	1600	2200	>2200

M_x = 400 g (AC Fine)	AEC in kWh/y FOR ePM_{10} ($ePM_{10} \geq 50\%$)					
	A+	A	B	C	D	E
50 & 55%	450	550	650	750	1100	>1100
60 & 65%	500	600	700	850	1200	>1200
70 & 75%	600	700	800	900	1300	>1300
80 % 85%	700	800	900	1000	1400	>1400
> 90%	800	900	1050	1400	1500	>1500

Filters rated from A+ to E , A+ is the least energy consumed filter and E the highest

CASE STUDIES

BBC Television Centre – Indoor Air Quality & Energy Project

Leave a reply

Camfil Farr UK, have been awarded the TFM contract for this world famous Television studio, commencing with the first filter change which was completed on 30th January 2008.

The contract includes, supply, fit and disposal of all filters throughout the Building, in addition to IAQ monitoring and trials on similar air handling units for Energy Savings and TM44 compliance.

Indoor Air Quality program to improve IAQ across the estate is underway. In parallel the energy optimisation is being rolled out through JCI as air handling units are due for filter change.

All air handling units are being fitted with single stage low energy Hi-Flo bag filters, thereby significantly reducing the pressure exerted on the fans. Graham Massey, Energy Conservation Manager initiated the pilot study in May 2009 and commented: –

"The study was conducted on two identical air handling units. This has been monitored monthly and Camfil filters are still going strong. The energy savings are significant, saving over £3000 alone per year on one air handling unit".

Based on multiple Air Handling Units accommodating

over 4100 air filter sets per year

Cost saving per filter set* £54

Cost saving for all filters* £233396

Energy saving per filter set (kWh) 771

Energy saving for all filters (kWh) 3162857

CO2 saving per filter set (tonnes) 0.42

CO2 saving for all filters (tonnes) 1720

*** calculations based on £0.07 / kWh**

King's College save energy and improve air quality

Leave a reply

Camfil Farr – Energy Saving Case Study.

Camfil Farr won a 3 year contract at King's College London to optimise AC plant. By working closely with the College, Camfil have identified **substantial savings on their HVAC plant**.

Over several buildings including 28 air handling units savings are projected to be 55 thousand pounds over 5 years with capital payback of less than 12 months. After conducting a thorough **Air Handling Plant Assessment** Camfil were able to accurately predict savings on **Filters**, **Energy**, Labour and **Waste disposal**.

Camfil Case Study – Astra Zeneca Progressive Energy Reduction Strategy

Leave a reply

Camfil Farr secured supply contract at Astra Zeneca sites across the United Kingdom back in 2004. Since then accumulated savings resulting from low energy product procurement strategy has reached £1.2 million and over 1000 tonnes of CO_2.

Download the Astra Zeneca Progressive Energy Reduction Strategy Case Study here

Subscribe to the Low Energy Air Filter Blog **here**

Summary

- 1/9 death is from air pollution
- Ultrafine particles are more harmful
- ISO16890 is a new global standard for testing and classification of air filters
- Selecting ePM1 filters will result in improved air quality and lower health risk
- Eurovent 4/23 provides hands on and effective advice for HVAC planners and manufactures of ventilation equipment to correctly design filtration
- By selecting right filters, upto 20% of energy savings can be achieved


WHAT? HOW? WHEN?
WHO? WHERE? WHO?
WHEN? WHY? WHAT?
WHY? HOW?
WHERE? WHO?
HOW? WHAT?
WHERE?
WHO? WHERE? WHO? WHY? HOW?
HOW? WHERE?
WHAT? WHY? WHAT?
WHO? WHERE? WHEN?
WHY? WHAT?
WHERE? WHO?
HOW? WHAT?
WHO? WHERE?
WHY? WHAT? HOW?
HOW? WHO? WHEN?
WHAT? WHERE?
WHY? WHEN? WHAT?
WHERE?
WHO? WHY? HOW?
HOW? WHERE?
WHAT? WHY?
WHEN?
WHO? WHAT?
WHERE? WHAT? HOW?
WHO? WHY? WHERE?
WHAT? WHEN?
WHERE?
WHO? WHAT?
WHERE? WHY?
HOW? WHEN?
WHAT? WHO?
WHEN?
WHY? WHERE?
WHEN? HOW?
HOW? WHERE? WHO? WHAT?
WHY? WHAT? WHEN?
WHERE? HOW?
WHAT?
WHEN? WHO?
WHERE?