THE CAMFIL GROUP

AMC Control and Energy Cost Optimization for Advanced Fabs

SEMICON China 2017——Green High-Tech Facility Forum
Camfil Filtration
March 15th , 2017

Clean air solutions

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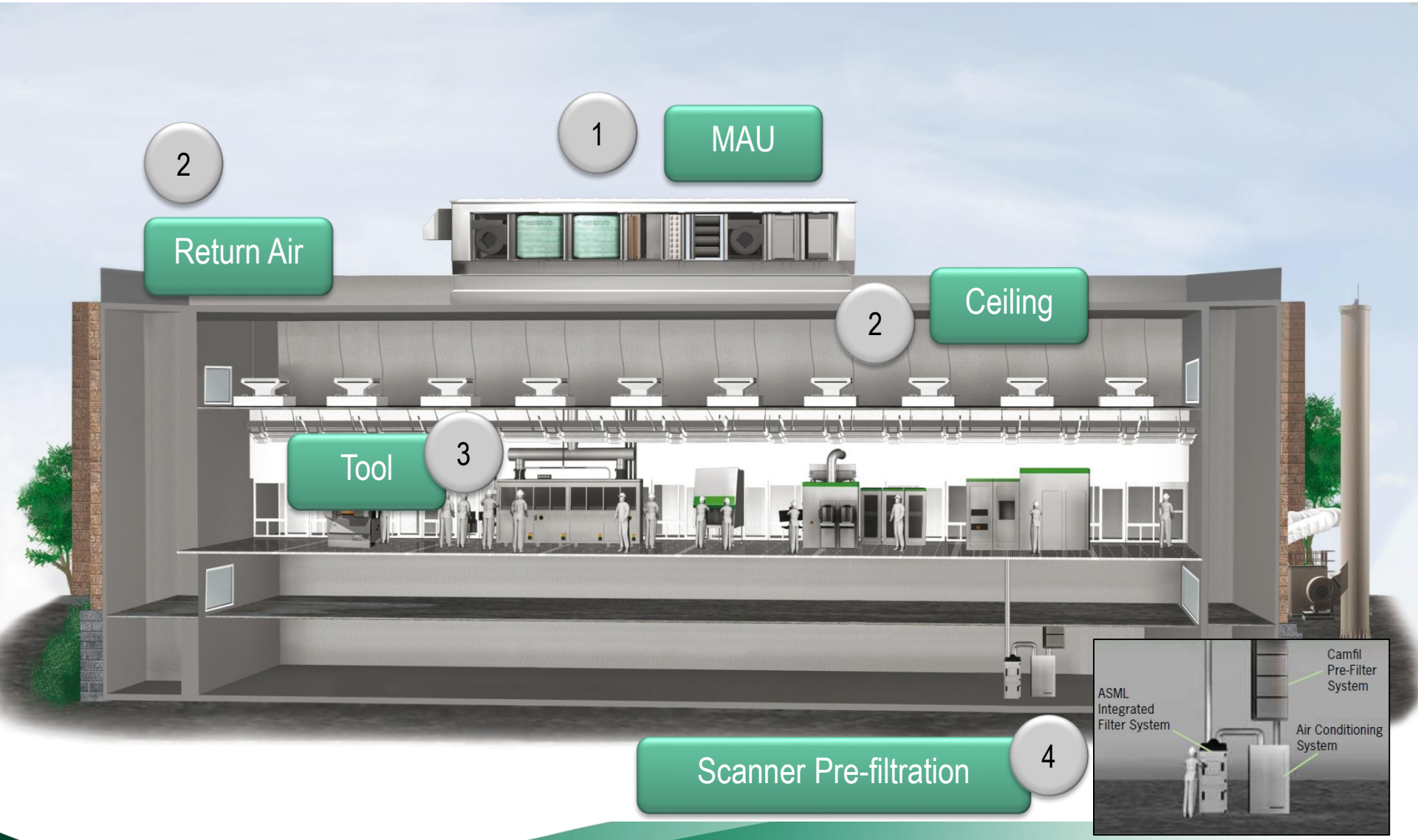
Challenges of AMC Control and Filter Evaluation

Energy Cost & LCC Optimization

Q&A

AMC filters are installed in various locations within a Fab



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Organic AMC are driving cost of AMC control

ACIDS	BASES	DOPANTS	REFRACTORIES
MA	MB	MD	MR
HF, hydrogen fluoride	NH3, ammonia	TEP, triethyl phosphate	, triethyl phosphate
HCl, hydrogen chloride	NMP, N-methyl pyrrolidone	TCEP, Tris(chloroethyl) phosphate	TMS, trimethyl silanol
SO2, sulfur dioxide	Triethyl amine	BF3, boron trifluoride	Hexamethyldisiloxane
CH3COOH, acetic acid	yl amine	boric acid	D4, Octamethylcyclotetrasiloxane
H2S, hydrogen sulfide	Ethanol amine	PH3, phosphine	Tetrachloroethylene

ORGANICS

ORGANICS

ORGANIC ACIDS

ORGANIC BASES

Table 4: Example of AMC following SEMI F21-1102 standard and new categories following later developments.

Category of organic contamination	AMC	Boiling point (°C)	Remark
Volatile organic compounds	IPA, Isopropanol	82	Common cleaning agent
	Heptane	98	Higher boiling point than benzene but elute before.
Volatile organics according to ITRS definition. GC-MS retention time >= benzene	Benzene	80	Vehicle exhaust contamination
	Toluene	111	
	Butanol	117	
	Xylene	140	hicle exhaust contamination
	PGMEA	146	ocess chemical. Often considered conde ble
MC: Condensable organics according to SEMI and ITRS definition	Ethyl lactate	154	ocess chemical
	Trimethyl benzene	165	Common traffic contamination
	NMP, N - methyl pyrrolidone	204	Process chemical
	Triethyl phosphate	215	Fire retardant
	BHT, butylated hydroxy toluene	265	Plasticizer
	Diethyl phthalate	298	Plasticizer
	DOP, Dioctyl phthalate	385	Plasticizer, Test aerosol for ULPA filters.

ORGANICS

VOLATILE ORGANICS

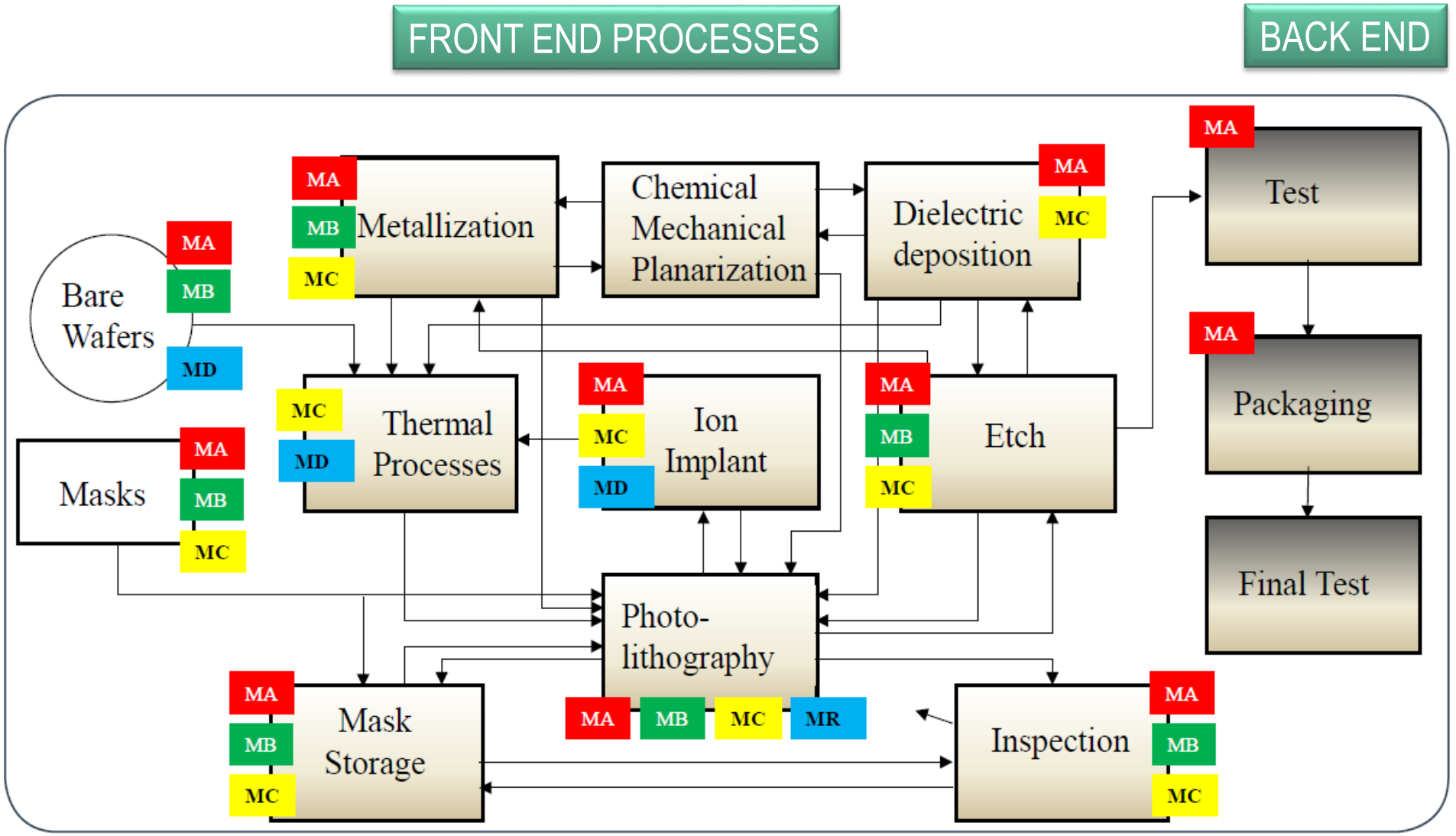
CONDENSABLE ORGANICS

BOILING POINT INCREASE

AMC CONTROL COST INCREASE

Table 5: Example of organic AMC following SEMI F21-1102, ITRS definitions and a more general definition for volatile organic compounds

Various AMC are present at each production process of a wafer



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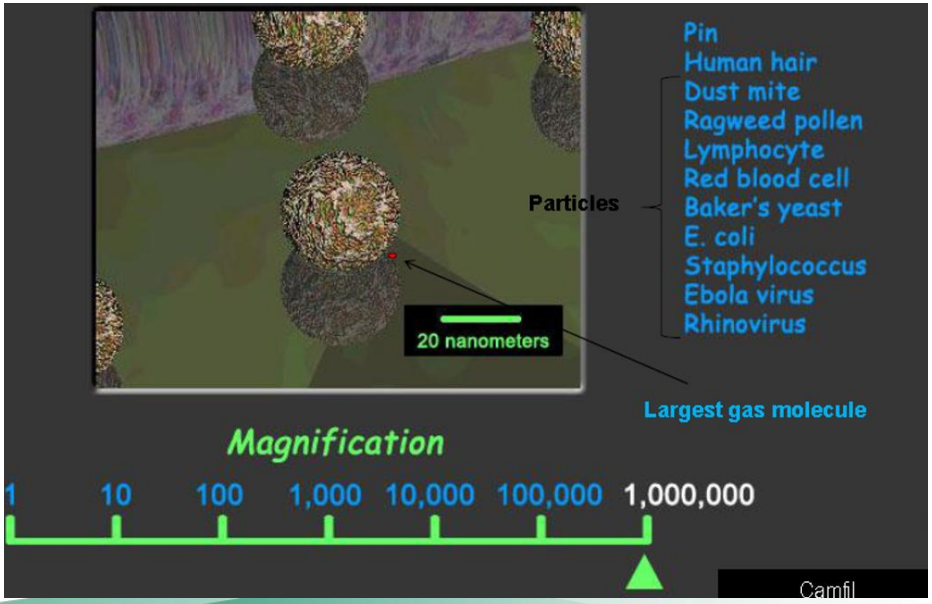
Challenges of AMC Control in Advanced Fabs

- Technology node has reached **14nm** and below (**7nm**) for advanced fabs; approximately **10** organic molecules side by side;

- Wafers go through 100s of different processes, each small contamination impact in any process will have serious consequences on the overall yield;

- Foundries are the most affected due to the diversity of processes and products produced within one facility.



Selection of high performance filter becomes critical

- New metrology challenges as **dimensions** shrink. Hard to separate wafer defects from background noise. Need to remove the noise with AMC filtration;

- Wavelength and optics are changing in metrology equipment. Need AMC protection identical to DUV lithography scanners in the past;

- VOC removal is a challenge due to cross contamination issues and filtration technology limitations;

Leak free filters are critical to the performance of an AMC filter

- Difference configuration or arrangement of the media layer will affect the overall filter pressure drop.

- A filter with high leakage rate will impact the removal efficiency significantly.

Filter performance test data as per ISO 10121-2:2014 – key to selection of high efficiency filters

INTERNATIONAL STANDARD **ISO 10121-2**

First edition
2013-04-01

Test methods for assessing the performance of gas-phase air cleaning media and devices for general ventilation —

Part 2:
Gas-phase air cleaning devices (GPACD)

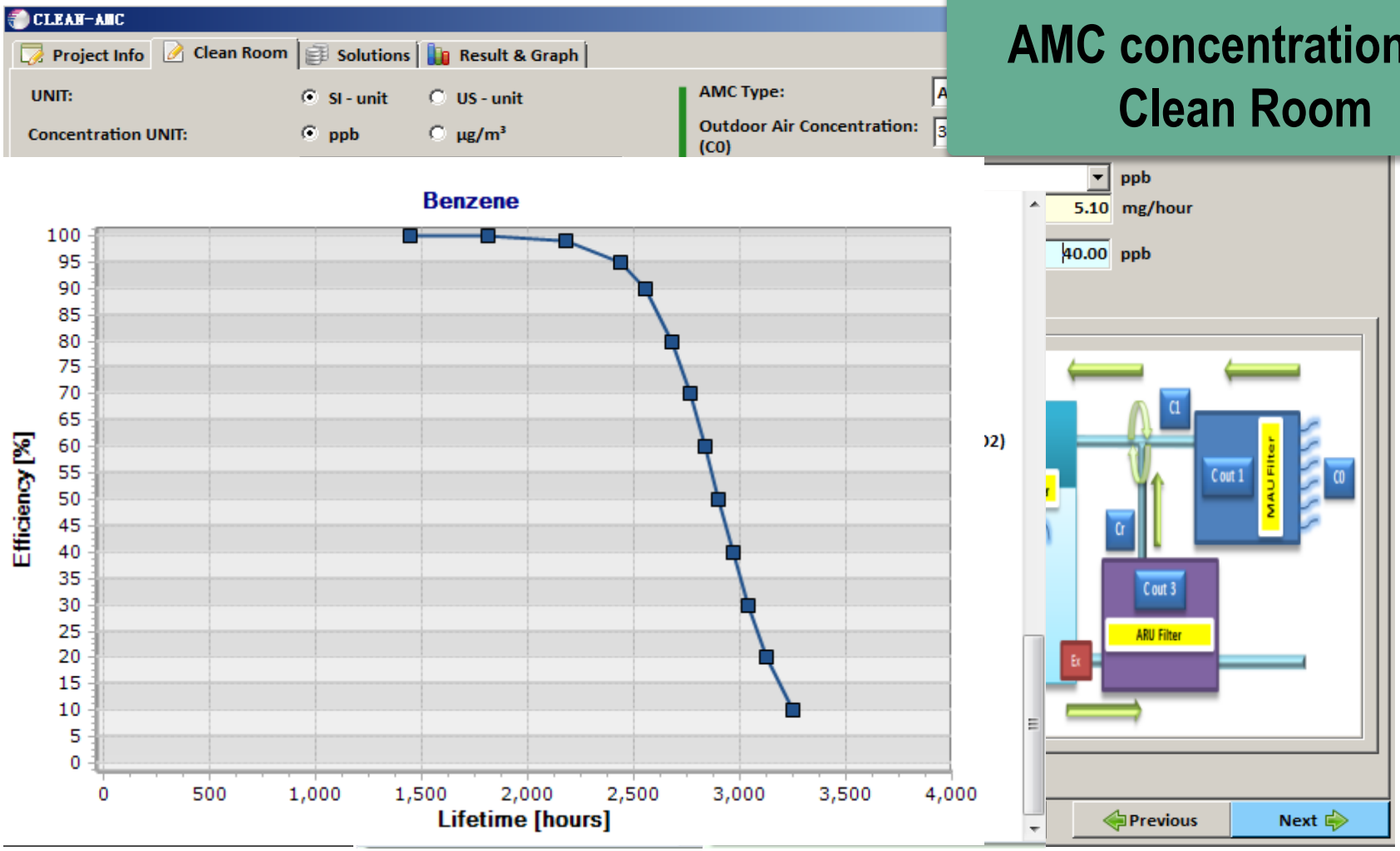
Méthodes d'essai pour l'évaluation de la performance des médias et des dispositifs de filtration moléculaire pour la ventilation générale —

Partie 2: Dispositifs de filtration moléculaire (GPACD)

Molecular Filter Test Rig According to ISO 10121-2: 2014

Filter selection based on actual simulation

Simulation software for AMC concentrations in Clean Room



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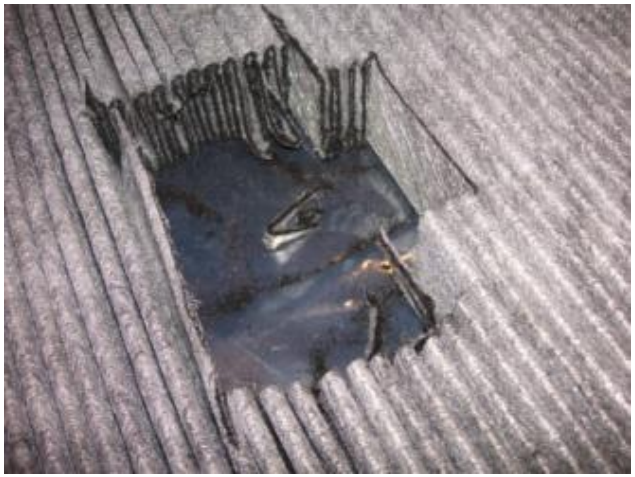
Other Analytical Services

Media Challenge Test as per ISO 10121-1:2014

Media analysis



Filter Outgassing Analysis

Air Quality Analysis

Online Monitoring

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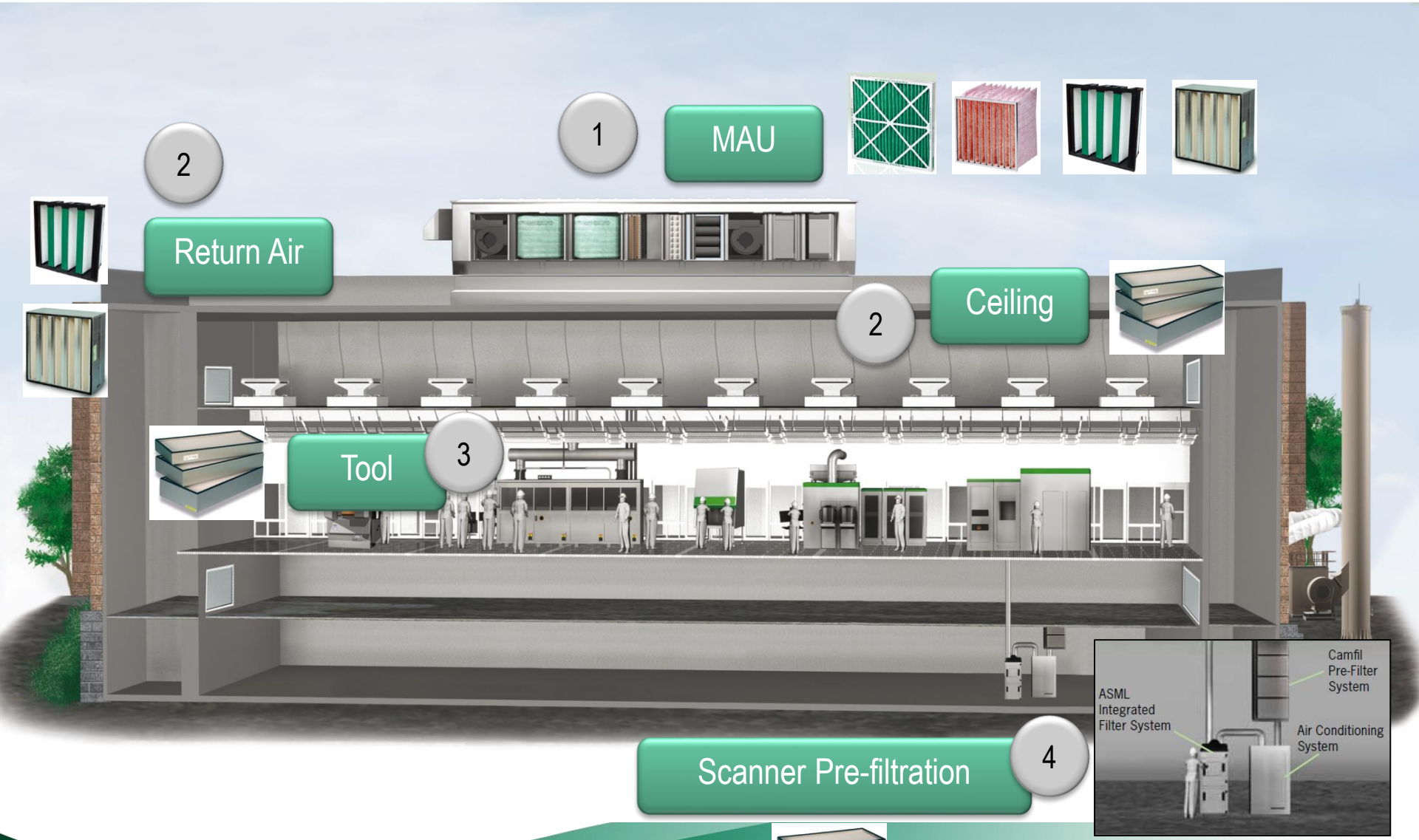
Summary

- AMC control becomes critical in advanced Fabs where the technology node reaches 60nm and below.
- Filter product performance for AMC and nanoparticles is more critical than ever.
- Filter outgassing / cleanliness must improve for high end facilities.
- High efficiency filter selection should be based on filter performance test in a ISO 10121-2 test rig and simulation results in a clean room

Particle filters are installed in various locations within a Fab



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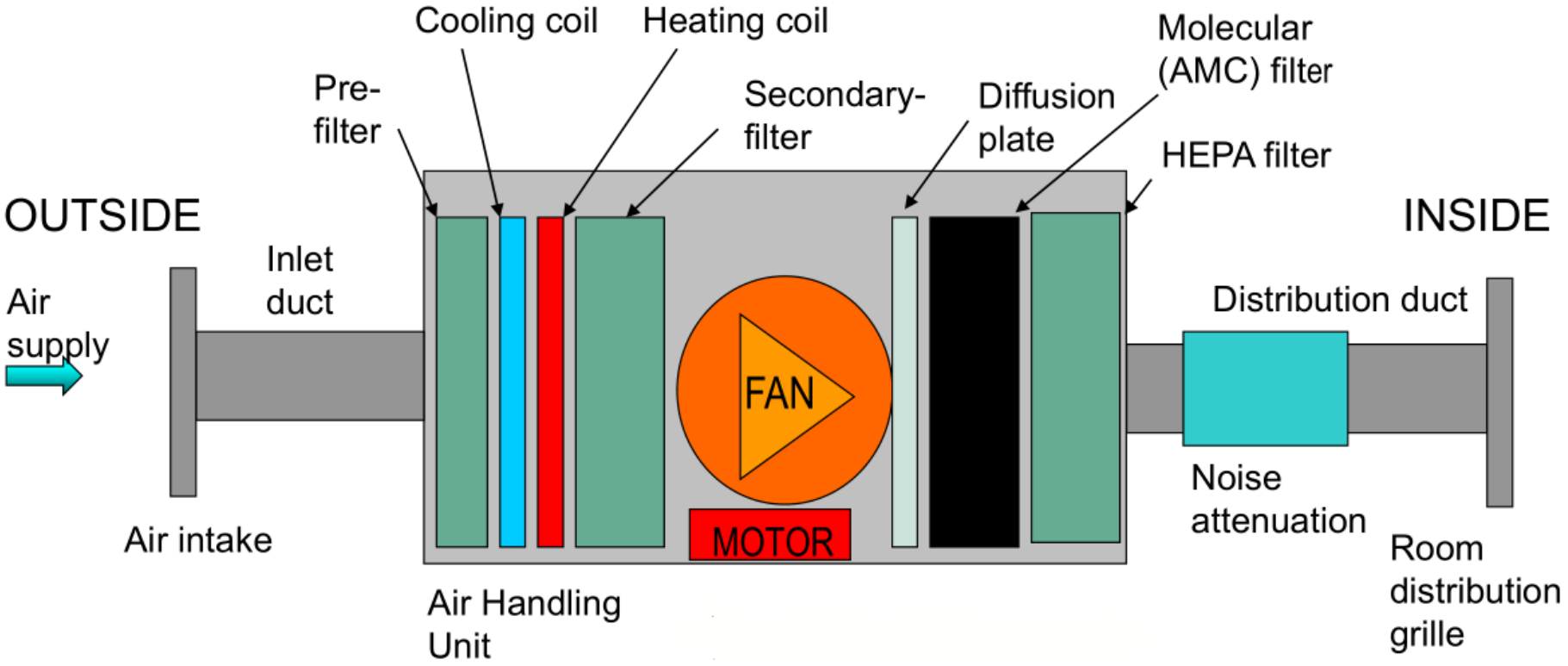
The energy cost of ventilation (simplified)



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Calculation formula of energy cost

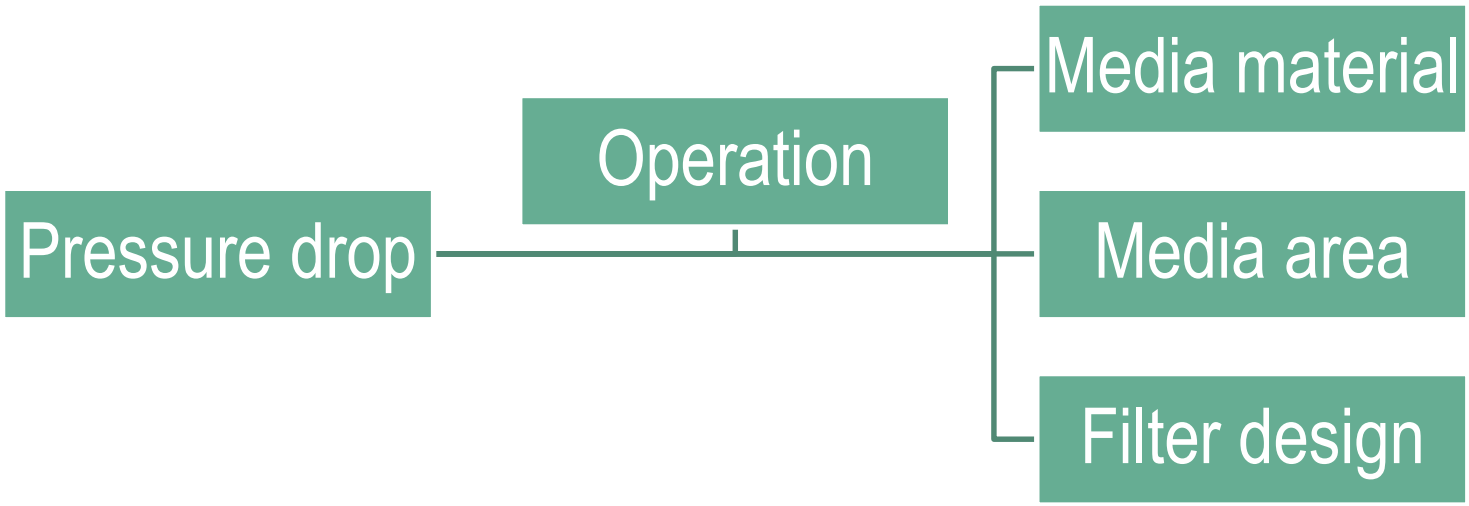
$$E = \frac{q \times dP \times t}{\eta \times 1000}$$

E	=	Energy cost	[kWh /year]
q	=	Airflow	[m^3/s]
dP	=	Pressure drop	[Pa]
t	=	Operation time	[hours/year]
η	=	Fan efficiency	[0.2~0.7]

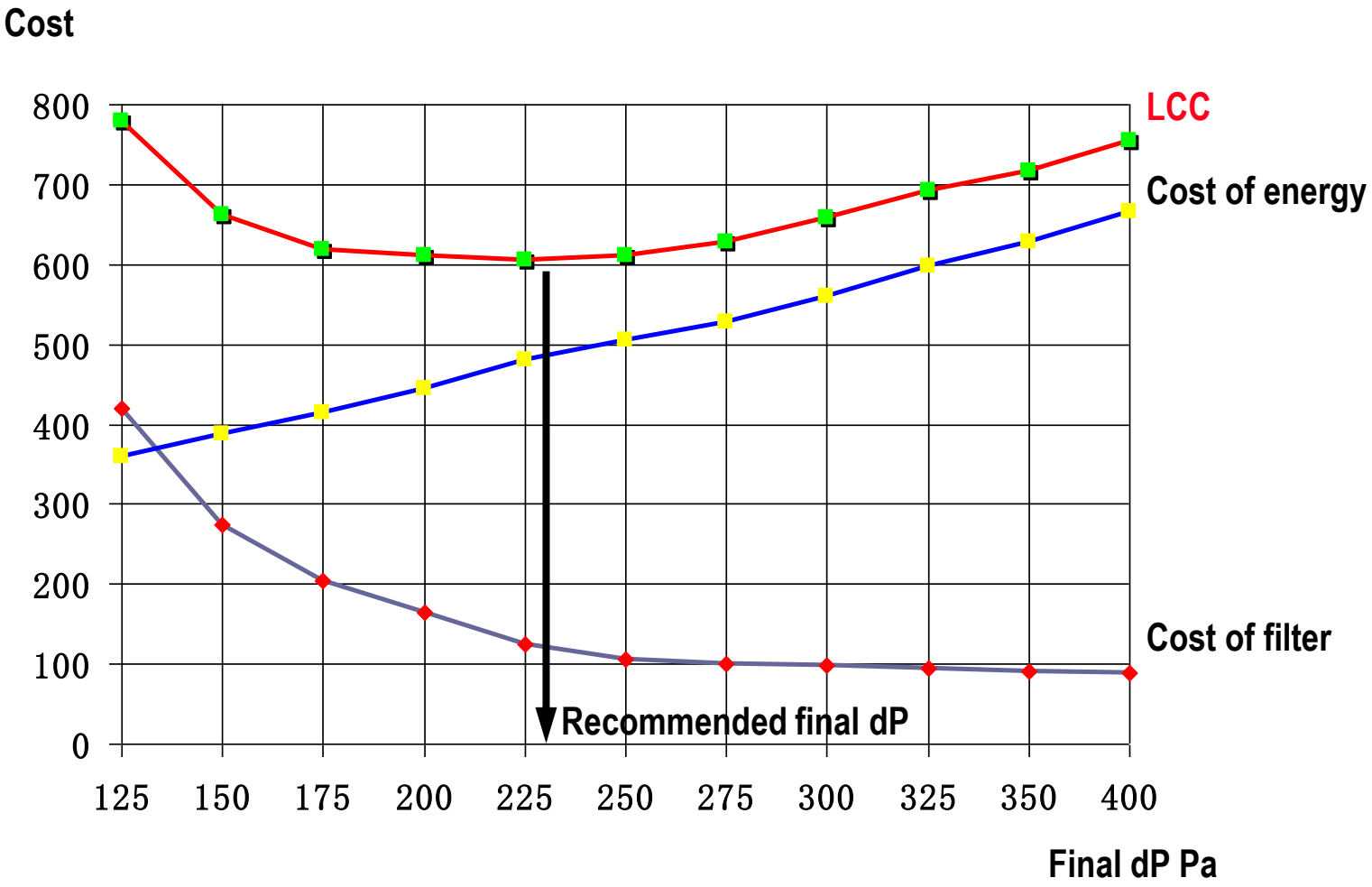
Example : Semiconductor Fresh Air Handling Unit

Item	Pressure Drop (Pa)	
Ducts (inlet- plus outlet air)	500	38%
Filters (Pre/Sec/AMC/AMC/HEPA)*	650	50%
Cooling coils	60	5%
Heater	50	4%
Sound reduction (inlet- plus outlet air)	40	3%
Joint duct	10	1%
*Average	1310	

A low filter pressure drop over its entire service life is the key to a low energy cost.



Impact of filter's final dP



LCC calculation with different replacement methods

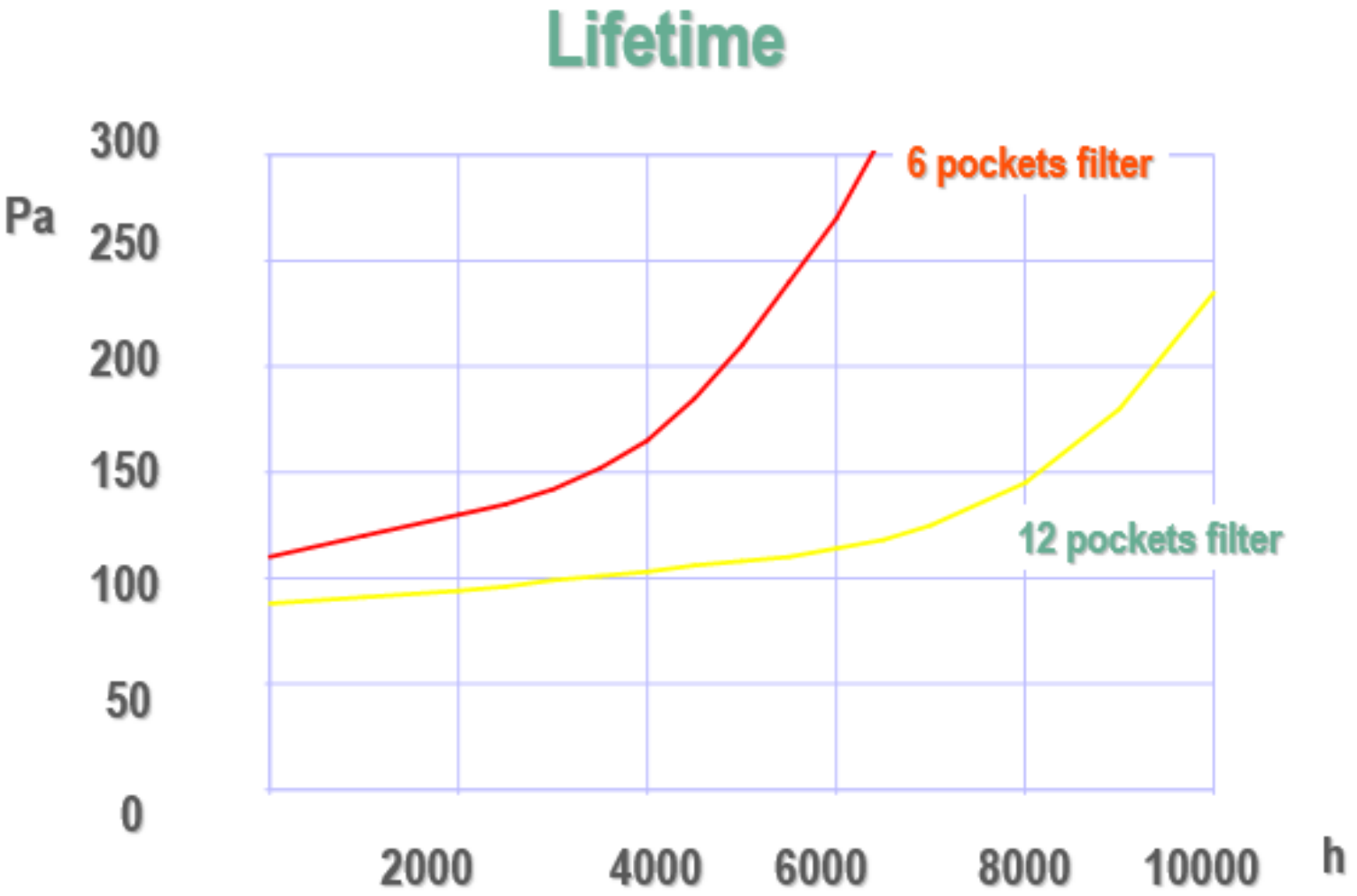
G4

F7

Replacement methods	Fixed Period (pre-2 months , Fine-4 months)	2 x initial dP	Recommended dP (pre-180Pa , fine-350Pa)
G4 Lifetime	1280h	550h	870h
F7 Lifetime	2920h	2930h	4650h
Filter cost of 5Y/CNY	11000	15500	10100
Energy cost of 5Y/CNY	19880	13538	18346
LCC*	30880	29028	28446

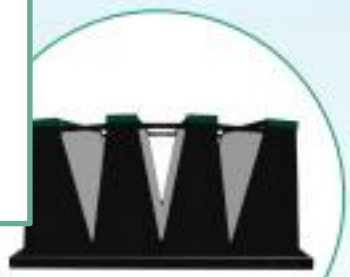
* by LCC simulation software

An example of the importance of correct filter area.



Design Highlights of A+ filter

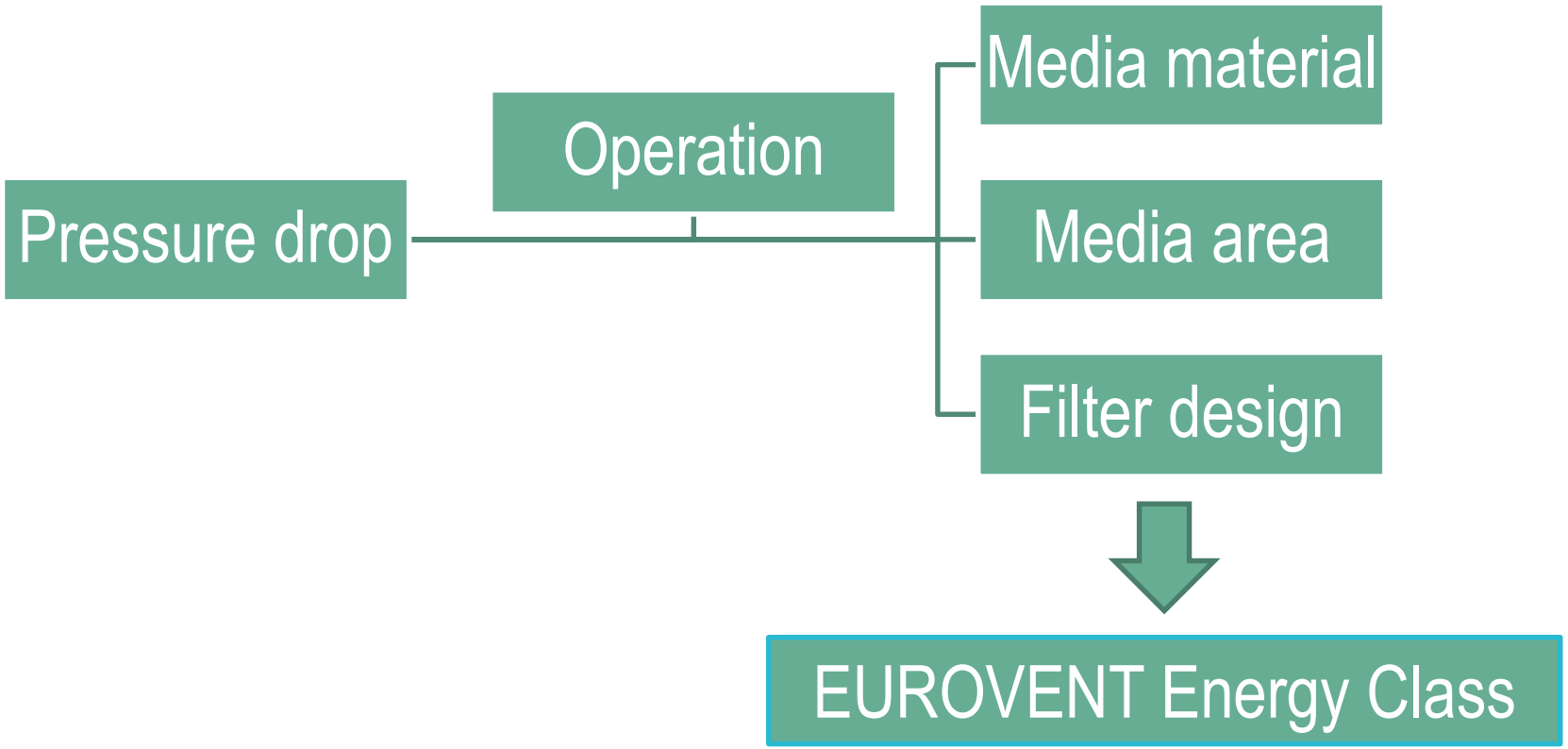
Radial V outlet reduces downstream air flow restrictions than standard straight V bed products ignore.



Seamless PU gasket

Fully optimized pleat design to reduce filter resistance and improve media utilization.

A low filter pressure drop over its entire service life is the key to a low energy cost.



EUROVENT CERTIFIED PERFORMANCE

ENERGY EFFICIENCY

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Opakfil ES

OPGP-F7-0592/0592/0296-ES-25-B00

www.eurovent-certification.com

AIR FILTERS

F7

EN779: 2012

Nominal airflow:	0.944	m^3/s
Initial efficiency 0.4 µm:	44	%
Minimum efficiency 0.4 µm:	44	%
Annual Energy Consumption:	782	kWh/annum

A+
A
B
C
D
E

A+ 2015

THRESHOLD REFERENCE SCALE YEAR : 2015

RS 4/C/001

Eurovent A+ Air filtrer

Save at least 20% energy cost with A+ filter

Classification of energy cost by Eurovent

Energy efficiency class limits for each filter class / kWH					
Class	M5	M6	F7	F8	F9
A+	<450	<550	<800	<1000	<1250
A	600	650	950	1200	1450
B	700	800	1200	1500	1900
C	950	1100	1700	2000	2600
D	1200	1400	2200	3000	4000
E	>1200	>1400	>2200	>3000	>4000

CLEAN AIR SOLUTIONS

Camfil is in the unique position to offer a total clean air concept to follow the most difficult challenges to come in semiconductor manufacturing!

THANK YOU!

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