



CONAMA  
METROPOLITANA  
DE SANTIAGO

# Emission Standard for Stationary Generators in the Metropolitan Region

Cecilia Barrios

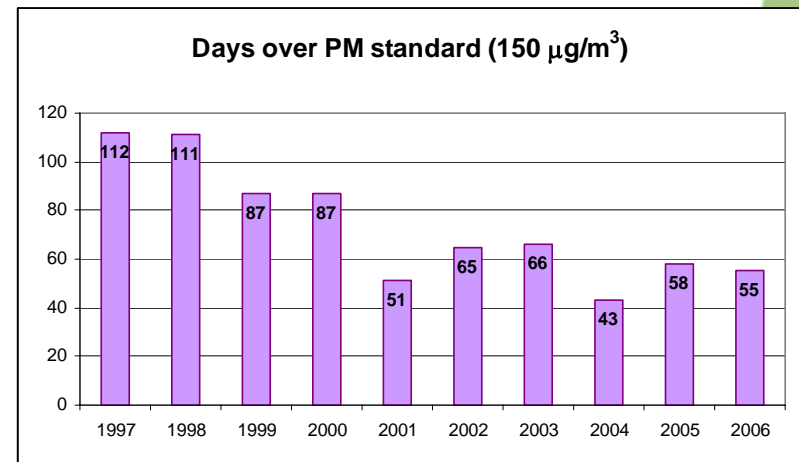
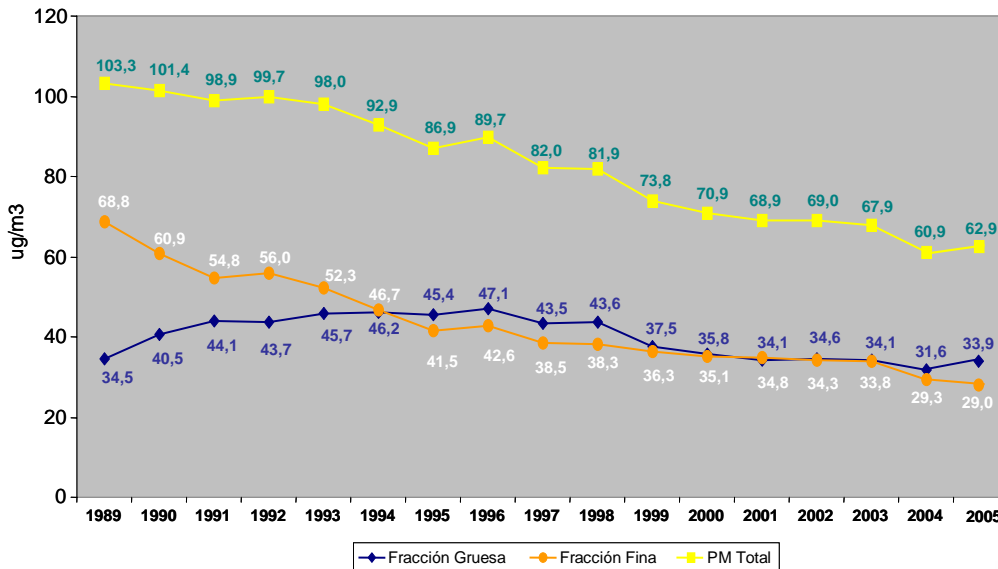
Air Pollution Control Area



# Overview

- PM, CO and O3 are usually above the Air Quality Standard in Metropolitan Region of Chile.
- Last years annual average of PM2,5 is increasing due rapid economic growing, usage of combustion sources and fossil fuels.

Estaciones Históricas Red Macam1 (1989-2005)  
MP10: Fracciones Fina, Gruesa y Total



# Stationary Generators

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- Diesel Powered
- From less than 100 to 8.000 units within 10 years
- High prices of electric demand in peaks.
- 15 minutes of over-consumption to pay for the highest demand
- Use: Prime or Emergency.
- Peak hours coincide with worst ventilation conditions (winter period after 18:00 hours)
- Total installed power is 1,8 GW (79% Emergency - 21% Prime)
- Thermal Power Plant in Santiago has 370 MW



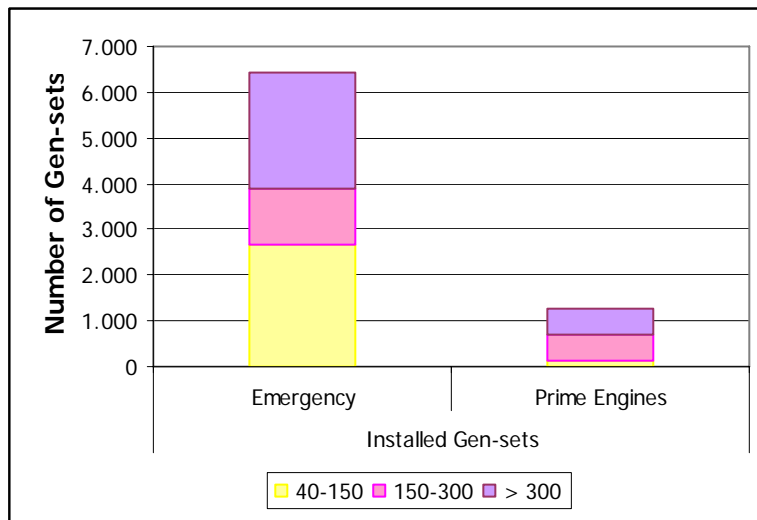
# Current Data

Estimated Number	Installed Gen-sets		New Gen-sets (annually)	
Power Range [kW]	Emergency	Prime	Emergency	Prime
40-150	2.648	151	189	22
150-300	1.265	565	217	38
> 300	2.526	539	55	132
<b>Total</b>	<b>6.439</b>	<b>1.255</b>	<b>461</b>	<b>192</b>

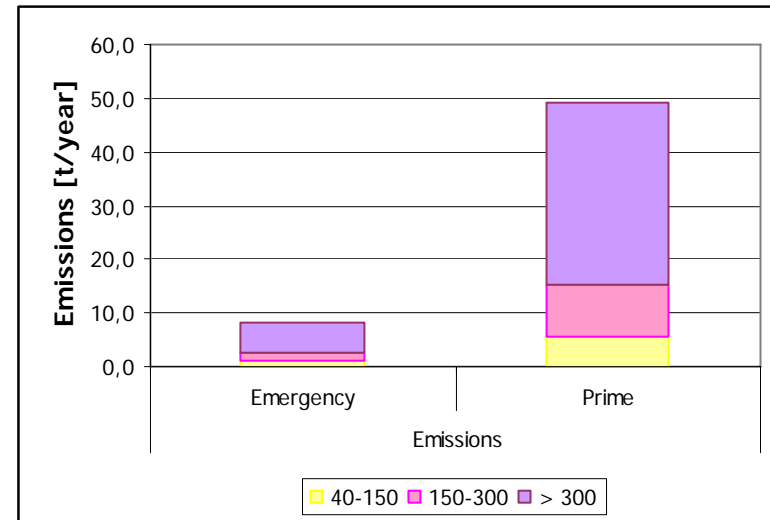
Emergency Engines: 93% installed at Residential Building and Commercial Sector

Prime Engines: 73% installed at Commercial Sector - 27% Industrial Sector

## Estimated Number



## Emissions



# Emissions during Winter Period (April 1<sup>st</sup> - August 31<sup>st</sup>)

Power Range [kW]	PM [tpy]	CO [tpy]	NOX [tpy]	HCT [tpy]
40-150	6,78	23,51	202,71	0,84
150-300	10,84	59,73	207,02	6,16
> 300	39,73	239,10	646,98	27,06
	<b>57,4</b>	<b>322,3</b>	<b>1.056,7</b>	<b>34,1</b>

Emission Source	PM [tpy]	NOX [tpy]	CO [tpy]	HCT [tpy]
Gen-sets	57,4	322,3	1.056,7	34,1
Industrial Sector	549,6	3.317,0	5.611,7	3.328,7
Mobile Sources	846,2	89.077,7	18.796,0	9.084,1

Gen-sets/Industries	10,4%	9,7%	18,8%	1,0%
Gen-sets/Transport	6,8%	0,4%	5,6%	0,4%



# Particle Measurement on Stationary Generators

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- Official measurement is gravimetric method. It provides incomplete information about the toxicity of the fine particles.
- New measurement approach was investigated: focussing on submicrometer particles
- 6 Prime engines measured with NanoMet directly in the stack.
- 3 sensors included in this unit measure:
  - Active surface concentration (LQ1-DC)
  - Soot (PAS2000)
  - Particle number concentration (CPC)




# Measurement Set up

Rotating disc diluter to reduce particle concentrations

Evaporation tube to evaporate volatile particles

MD19-2E	Dilution
1:15 ... 1:3'000	
heated 80/120/150 °C	
sample flow: 0.5 ... 5 lpm	

ThC-1	Heating
heating up to 300 °C	
sample flow 0.5 ... 5 lpm (from MD19)	

LQ1-DC	Surface [ $\mu\text{m}^2/\text{cm}^3$ ]
range 0 ... 2'000 $\mu\text{m}^2/\text{cm}^3$	
sample flow ~1.5 lpm	

Monitor for particle surface concentration

PAS 2000 (EcoChem)	Soot (~EC) [ $\mu\text{g}/\text{m}^3$ ]
range 0.1 ... 1'000 $\mu\text{g}/\text{m}^3$	
sample flow 2 lpm	

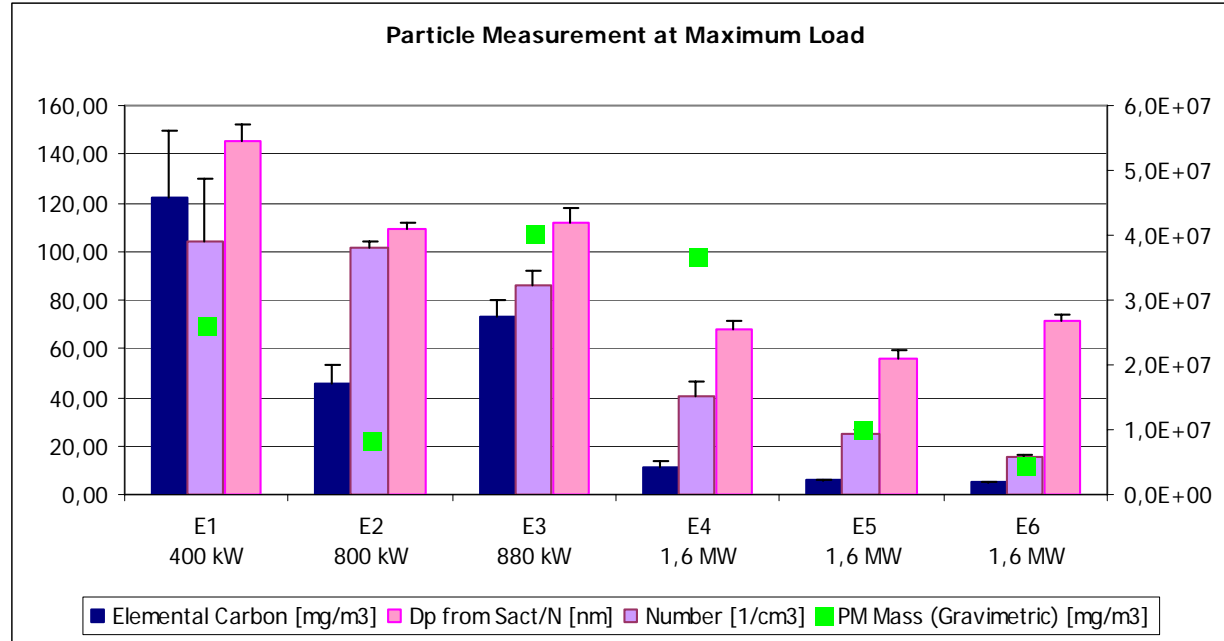
Monitor for soot concentration

CPC (TSI)	Number [ $\#/ \text{cm}^3$ ]
range 0.1 ... 10'000 $\#/ \text{cm}^3$	

Monitor for particle number concentration



# Measurement Results

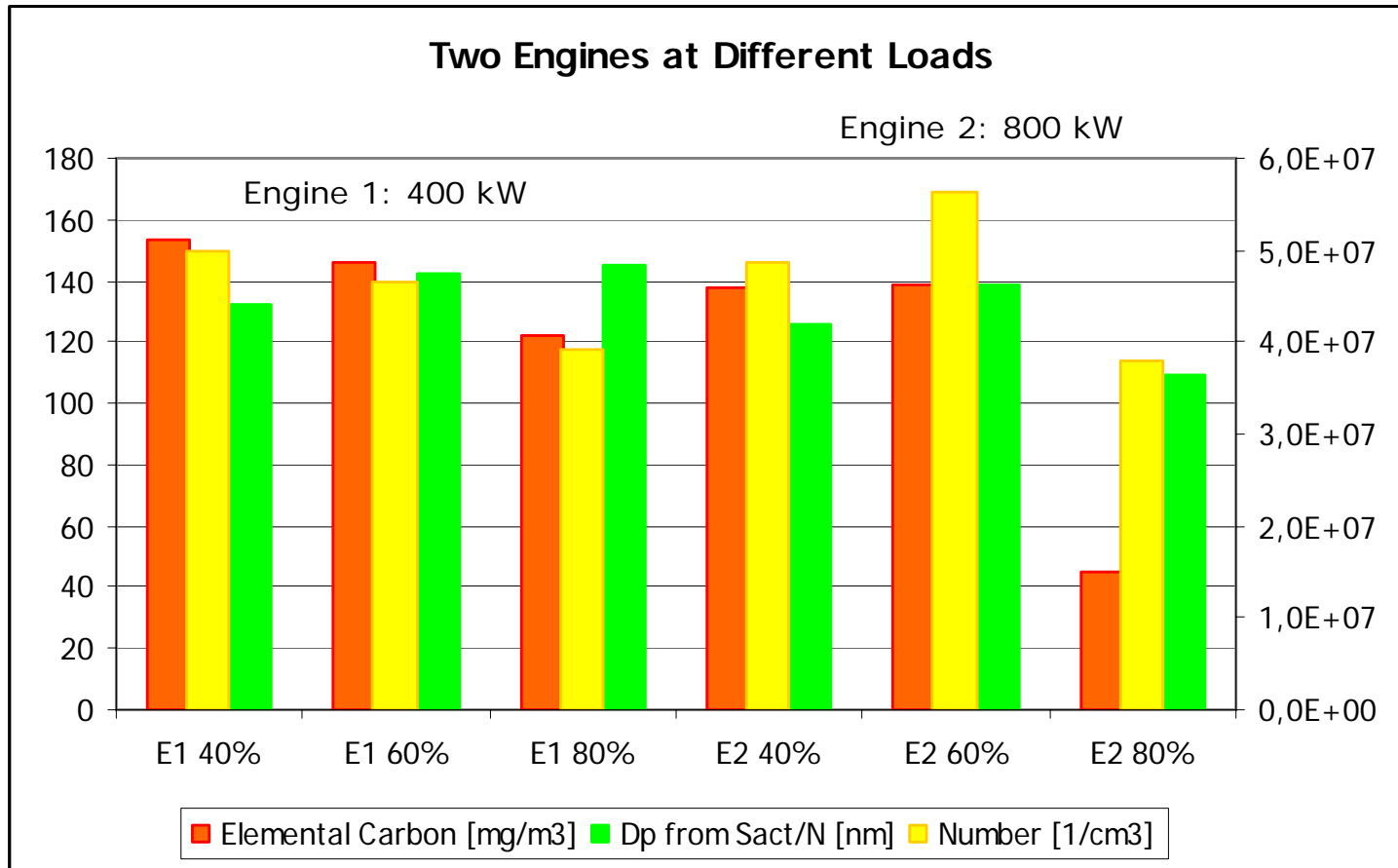


No correlation of measured EC concentrations with official PM emission values can be observed!!!





# Measurement of Prime Engines at Different Loads



Official Measurement is not available at the same conditions.  
Requirement is measure at maximum load.



# Emission Standard Project

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- Started in April 2006
- Target: Reduce the emissions
- Emission Standard Project have been discussed considering:
  - Information provided by regulated sector
  - Recommendations from experts
  - Comments during Public Consultation of Draft Version
  - Results of Cost-Benefit Analysis (over the Draft Version)
- Technology information were supported by the Swiss Agency for Development and Cooperation (DEZA).
- September 2007: Presentation to Ministers (Approval)



# Emission Standard Project

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## Applicability:

All stationary generator with nominal power  $\geq 40$  kW

## Registration Number:

Given by Supervising Authority for every generator.

## Hour meter:

A non-resettable hour meter shall be installed on **all engine**. (Prime or Emergency, New or In-use)



# Limit Values

In-Use Gensets	Power [kW]	MP [mg/Nm <sup>3</sup> ]	NOX [mg/Nm <sup>3</sup> ]	CO [mg/Nm <sup>3</sup> ]	HCT [mg/Nm <sup>3</sup> ]
Prime	150-300	45	5.000	600	400
Prime	>=300	30	5.000	600	400
Emergency	>=300	180	Not Required	Not Required	Not Required

New Gensets	Power [kW]	MP [mg/Nm <sup>3</sup> ]	NOX [mg/Nm <sup>3</sup> ]	CO [mg/Nm <sup>3</sup> ]	HCT [mg/Nm <sup>3</sup> ]
Prime	150-300	45	3.000	600	400
Prime	>=300	20	3.000	600	400
Emergency	>=300	75	Not Required	Not Required	Not Required

- Conditions: 1 atm, 25°C, 5%O<sub>2</sub>
- Technical problems in measurement of low power engines



# Some Reasons of Limit Values

## Prime:

- After-treatment technology only for high emission engines
- Engines with high technology level emit less than 20 mg/m<sup>3</sup>N
- Incentive to previous investment in high quality and technology
- New engines: Low Emission Engine or High Emission Engine+DPF
- 20 - 45 mg/m<sup>3</sup>N are cost-effective limit values

## Emergency:

- Operates in average 15 hours per year
- Most of them are low power
- Requirements in range 40-300 kW shall be registration and hour meter.
- Cannot operate more than 26 hours per year (30 minutes per week for maintenance and testing)



# Test methods

MP: EPA-5

NOX: EPA-7E

CO: EPA-10 or EPA-3A

HCT: EPA-25A

O<sub>2</sub>: EPA-3A

Gas Volume: EPA-2 or EPA-2A

- Measurement at maximum load: 80% -100% load
- Same condition for all stationary sources
- Application of simplified methods is qualitative
- Different methods are not comparable (EPA-5, Opacity, Smoke density, Bacharach scale)
- Measurement in Particle Number is not official



# Compliance Schedule

Power [kW]	In-Use		New	
	Emergency	Prime	Emergency	Prime
150 - 300	Not required	Measurement of PM, NO <sub>x</sub> , CO y HCT each 3 years.  1st meas. 18 months after coming into force	Not required	Measurement of PM, NO <sub>x</sub> , CO y HCT each 3 years.  1st meas. 6 months after engine registration
P ≥ 300	1 PM measurement  6 months since coming into force		1 PM measurement  6 months after engine registration	

- Period for fulfilment assumes selection, design, installation, test, etc. of appropriate after-treatment technologies or delays in imports and previous tests.
- For Emergency engines is not necessary any changes.



# Cost Benefit Analysis

[thousand US\$ per year]		
	Installed Gen-sets	New Gen-sets
Filters Cost	2.076	298
Measurement Cost	130	43
<b>Compliance Cost</b>	<b>2.206</b>	<b>341</b>
<b>Health Benefit</b>	<b>2.993</b>	<b>150</b>

Net Social Benefit at Present Value:

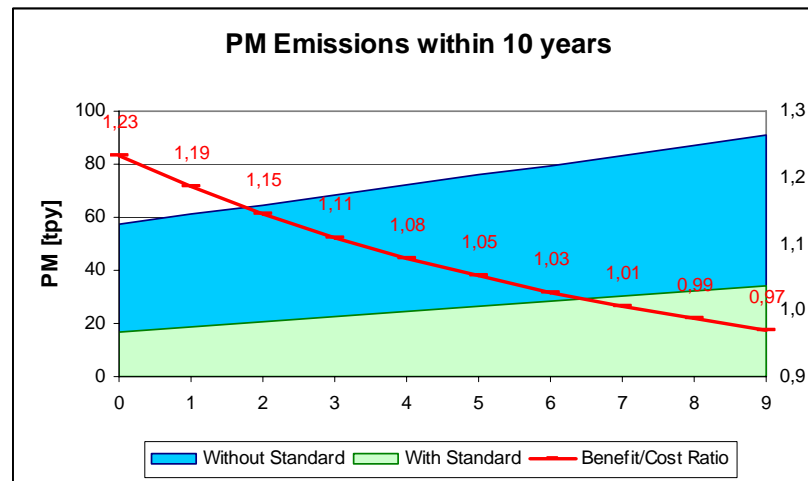
[thousand US\$]	
Period	Net Social Benefit
5 years	1.043
10 years	-784



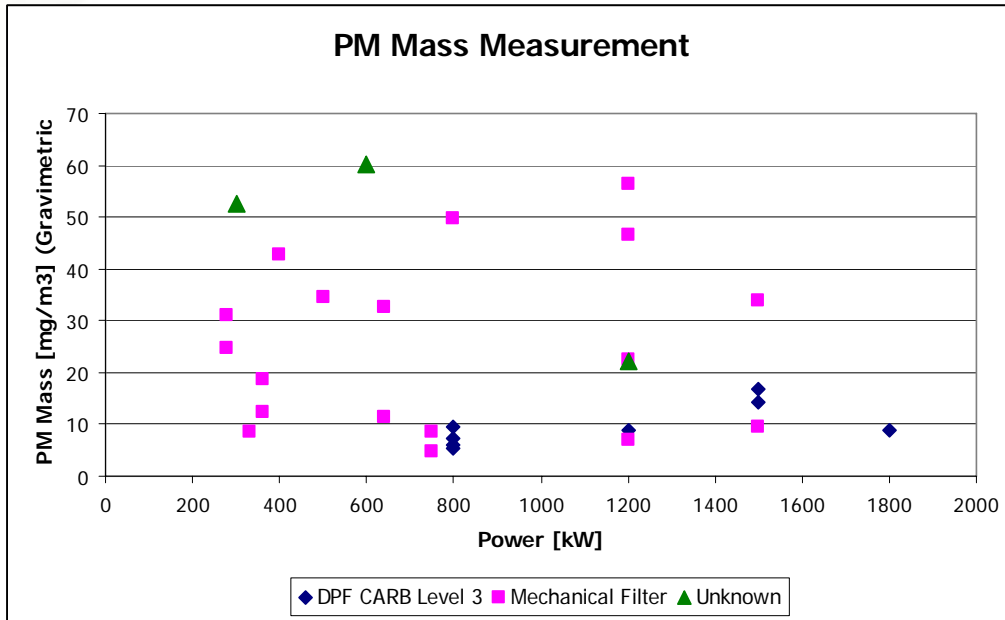


# Expected Results

PM [tpy]	Installed Gen-sets	New Gen-sets
Current	57,35	3,7
With standard	16,85	1,9
<b>Reduction</b>	<b>71%</b>	<b>49%</b>



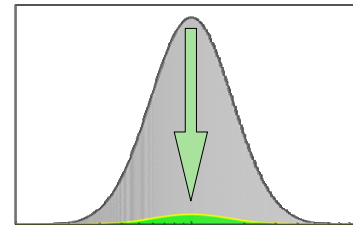
# After-treatment technology on Gen-sets



Particle Number Measurement should be necessary!!!!

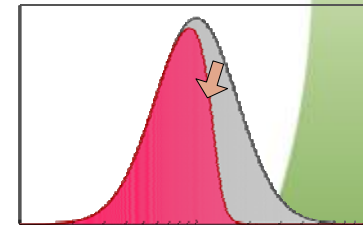
Good Filter:

Mass: -95%  
Number: -95%



Bad Filter:

Mass: -95%  
Number: -55%



mobility diameter [nm]

Conditions: PM at 25°C, 1 atm, 5% O<sub>2</sub>

29 Gensets with after-treatment technology

- 8 CARB Certified: 5 - 17 mg/m<sup>3</sup>
- 18 “mechanical Filter” (accumulator): 5 - 56 mg/m<sup>3</sup>
- 3 Unknown filters: 22 – 60 mg/m<sup>3</sup>



# Final Notes

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- Stationary engines are also important. Should they become a problem to regulate them?
- Local regulation cannot requires to use best available technology to eliminate ultrafine solid soot particles.
- Emission standard should be revised each 5 years.
- It is necessary requires an official test method in particle number, in order to assure an emission reduction. (Avoiding bad filters)
- This is the first regulation for stationary engines.
- **Next step: Off-road engines**



# Acknowledgments

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- A.Mayer - TTM
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**Thank you for your attention!!**

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