

# Mitigating Traffic-Related Particle Pollution

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Copenhagen, Denmark  
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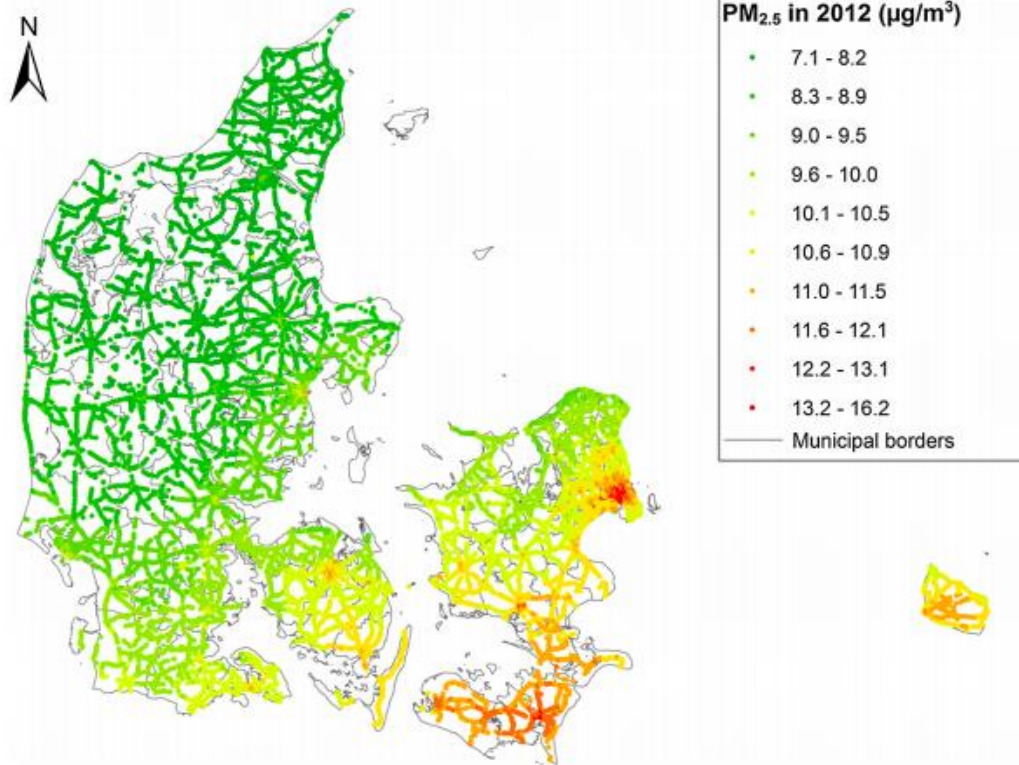


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# Particle Pollution in Denmark



# Particle Pollution: Sources and Classification



## Vehicle Emissions

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Diesel  
Petrol  
(*combustion*)



## Energy Production

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Coal  
Biomass  
(*combustion*)



## Abrasion Surfaces

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Tires  
Brakes  
Roadware



## Construction Sites

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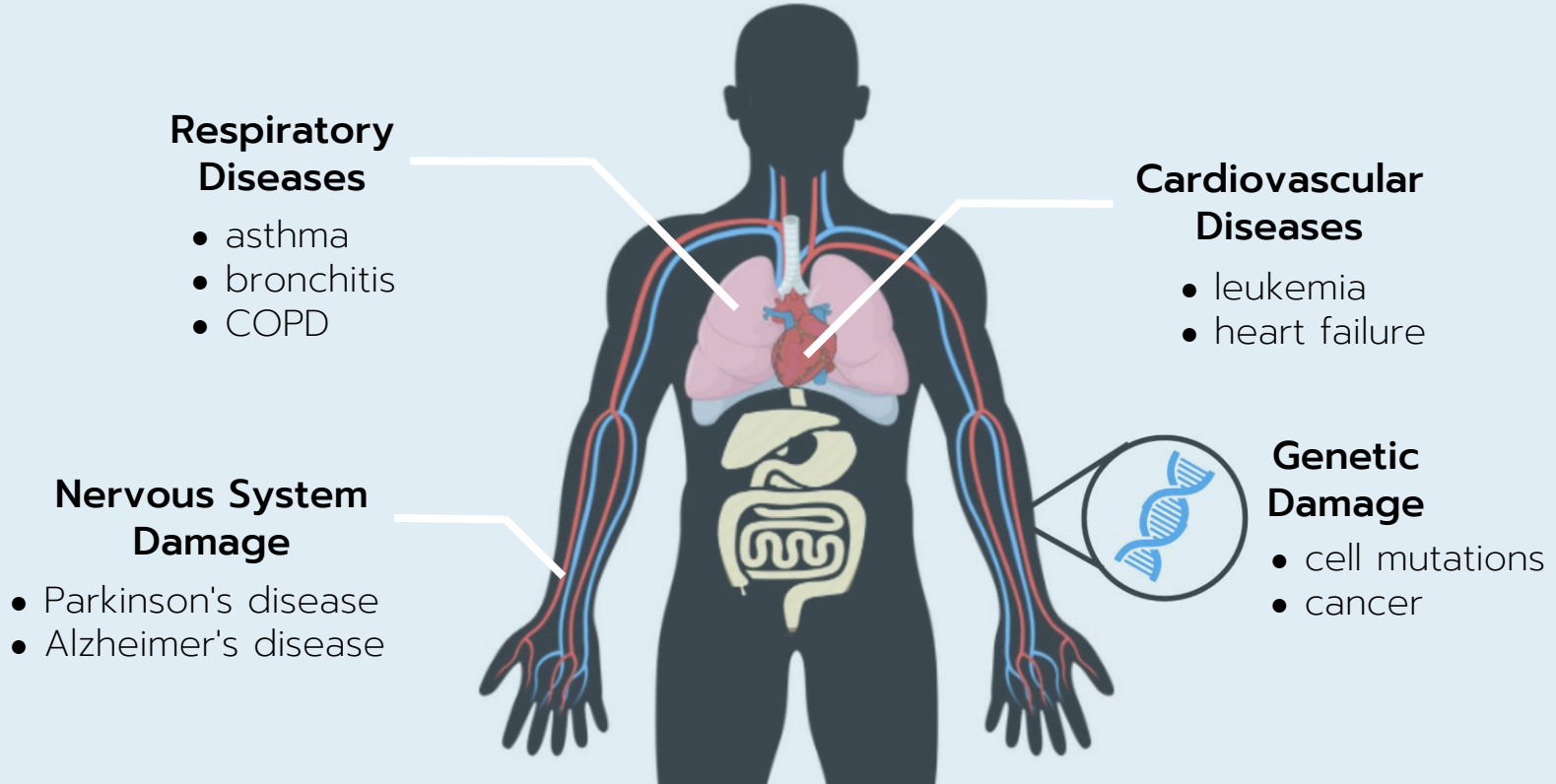
Machinery  
Earthworks  
Demolition

# Particle Pollution: Sources and Classification



PARTICLE TYPE	ABBREVIATION	DIAMETER ( $\mu\text{m}$ )	METRIC
coarse particles	$\text{PM}_{10}$	2.5 - 10	$\mu\text{g}/\text{m}^3$
fine particles	$\text{PM}_{2.5}$	< 2.5	$\mu\text{g}/\text{m}^3$
ultrafine particles	$\text{PM}_{0.1}$	< 0.1	number/ $\text{m}^3$
nanoparticles	$\text{PM}_{0.02}$	< 0.02	number/ $\text{m}^3$

# Particle pollution has many serious adverse health effects



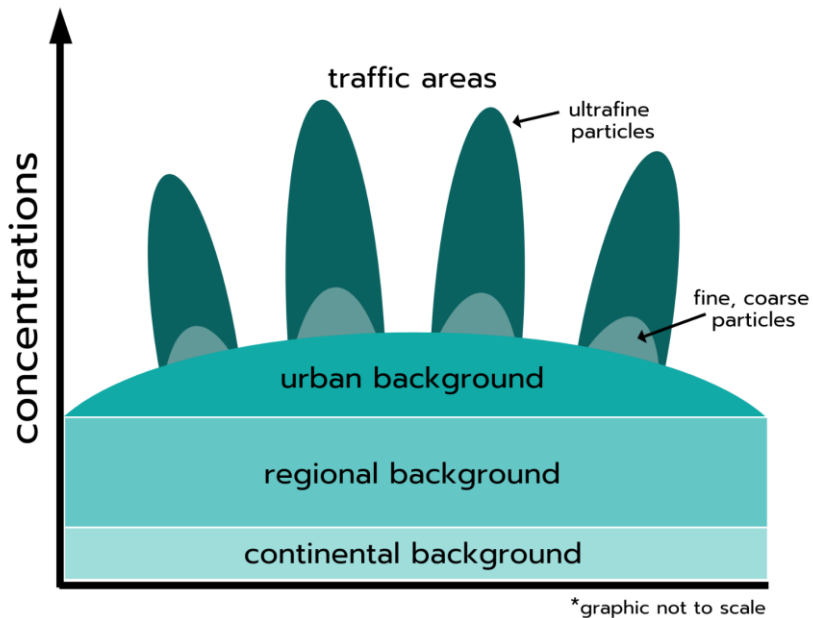
# PM concentration limits hide the urgency of reducing PM pollution in Copenhagen, especially UFPs

PARTICLE TYPE		EU Limit ( $\mu\text{g}/\text{m}^3$ )	WHO Limit ( $\mu\text{g}/\text{m}^3$ )	HC Andersens Blvd. ( $\mu\text{g}/\text{m}^3$ )
coarse particles	PM <sub>10</sub>	40	20	25
fine particles	PM <sub>2.5</sub>	25	10	13
ultrafine particles	PM <sub>0.1</sub>	?	?	13,000 part./cm <sup>3</sup>

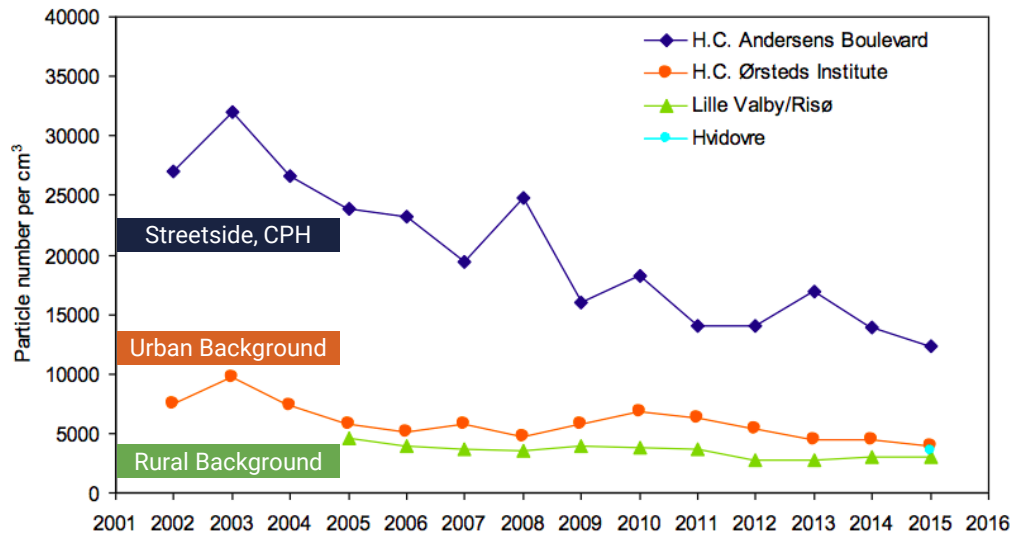
**“4,000 Danes die [prematurely] every year due to fine particle pollution. That’s 7% of all Danish death[s]... That makes fine particles in outdoor air our **third highest risk factor**”**

– Kåre Press-Kristensen

# Traffic is the most significant contributor to dangerous levels of Copenhagen's roadside UFP pollution



## Particle Number (UFP) Concentrations in Denmark





# Project Objectives

## 1 International Study



- Global Efforts
- Existing Trends
- New Strategies

## 2 Local Investigation



 *Copenhagen, DK*

## 3 Identifying Solutions



Regulation & Enforcement



Effective Technology



Social Adoption



# Project Tasks

## LITERATURE REVIEW

- policy
- technology
- practice

## KEY INTERVIEWS

- technical
- academic
- political
- public interests
- private interests

## DATA COLLECTION

- busy street
- bus stop
- idling taxis

## INFORMATION ANALYSIS

- cross-verification
- prioritization
- feasibility

## Filter technology & emissions tests of many on-road diesel passenger cars are not effective



### TECHNOLOGY



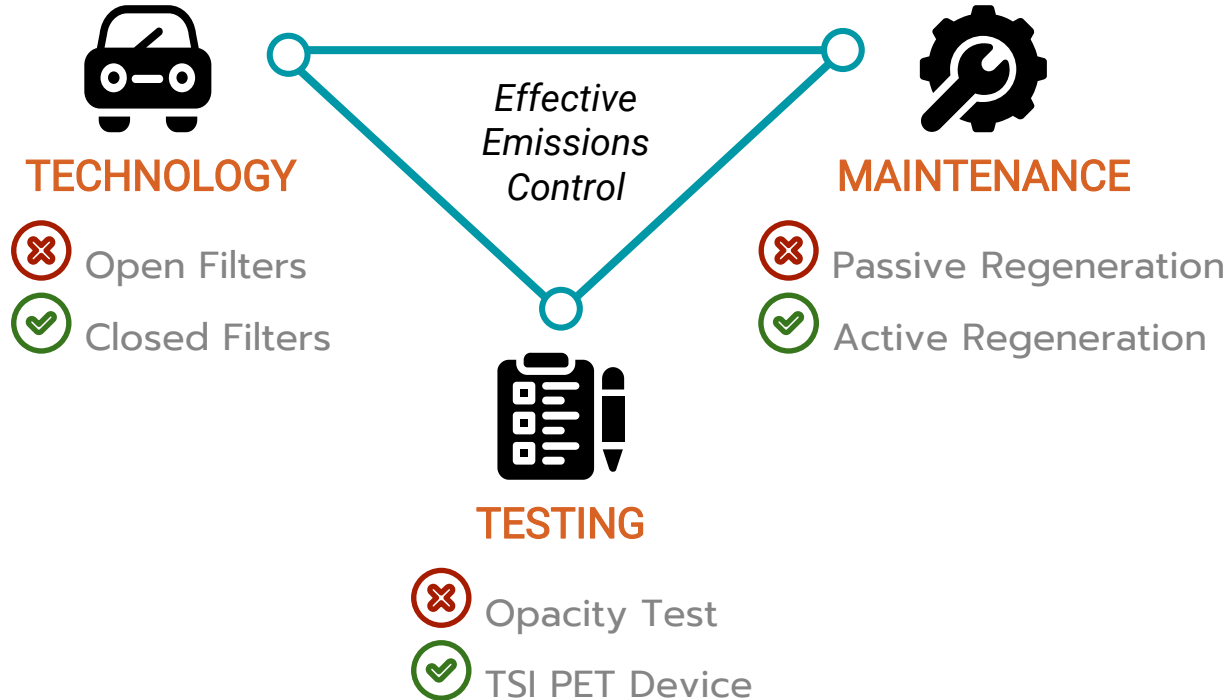
Open Filters



Closed Filters

	Diesel Vehicle	Effective Date Factory/Sale	Particle Mass Limits	Particle Number Limits
<b>Euro 1</b>	Passenger Car	1992/1993	140 mg/km	--
<b>Euro 2</b>	Passenger Car	1996/1997	100 mg/km	--
<b>Euro 3</b>	Passenger Car	2000/2001	50 mg/km	--
	Truck/Bus	2000/2001	100 mg/km	--
<b>Euro 4</b>	Passenger Car	2005/2006	25 mg/km	--
	Truck/Bus	2005/2006	20 mg/km	--
<b>Euro 5</b>	Passenger Car	2009/2010	5 mg/km	6e11 part./km
	Truck/Bus	2009/2010	20 mg/km	--
<b>Euro 6</b>	Passenger Car	2014/2015	5 mg/km	6e11 part./km
	Truck/Bus	2013/2013	10 mg/km	8e11 part./kWh

# Filter technology & emissions tests of many on-road diesel passenger cars are not effective



## Movia's public bus fleet contains many diesel buses with outdated, ineffective filter technology



### TECHNOLOGY

Open Filters

Closed Filters



### MAINTENANCE

Passive Regeneration

Active Regeneration

VEHICLE TYPE	TECHNOLOGY SPECIFICATION	# OF BUSES
Euro 2	CRT	1
Euro 3	CRT	73
Euro 4	----	96
	SCRT Retrofitted to Euro 6	12
Euro 5	----	93
	SCRT Retrofitted to Euro 6	7
EEV	----	400
	SCRT Retrofitted to Euro 6	179
Euro 6	----	453
Electric	----	78
<b>Total</b>		<b>1,392</b>

CRT = Continuous Regeneration Technology  
 SCRT = Selective Catalytic Reduction Technology  
 EEV = "Enhanced Environmentally-Friendly Vehicle"

**6%** of buses are electric  
*78 Electric / 1,392 total*

**50%** of diesel buses use open filters  
*663 buses / 1314 diesel buses*




At minimum,  
**74** buses use passive regeneration filters



## Traffic companies often supplement the EU regulated emissions tests with their own procedure



### TESTING

-  Opacity Test
-  On-Board Diagnostics Test
-  Particle Number Count

Opacity

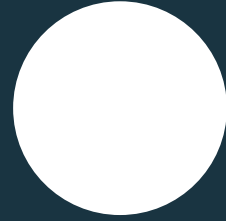


OBD



Miljøsyn





**Eliminate preventable particle pollution**  
from diesel vehicles during the transition to  
emissions-free transportation

# Long term efforts should support the transition to zero-emission transportation

## LIGHT-DUTY

(diesel passenger cars)



- new car registration tax
- filter tax
- city emissions tax



extend Euro 6 **environmental zone** to passenger vehicles

## HEAVY-DUTY

(diesel buses)



Funding for more **electric buses** in Movia's fleet



# Short term efforts should address the imminent problems with diesel emissions

## LIGHT-DUTY

(diesel passenger cars)



**Retrofit** vehicles with Euro 6 emissions-equivalent filters



Regulate use of **TSI PET** emissions test

## HEAVY-DUTY

(diesel buses)



**Retrofit** vehicles with Euro 6 emissions-equivalent filters



Regulate use of **P-Trak** (UFP) measurement in emissions test

# Immediate efforts should engage citizens in the issue while the government passes legislation



Public Awareness Events

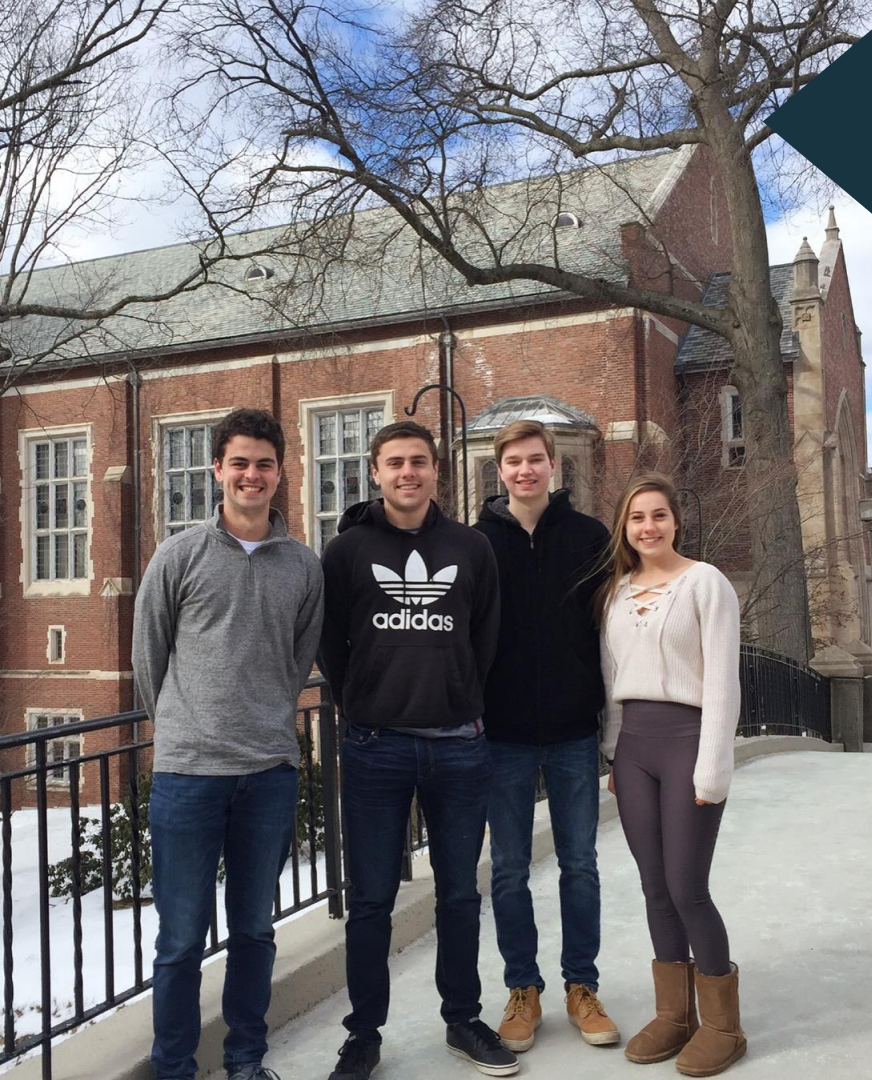
## Handkerchief Emissions Test



- 1 Attach white handkerchief or kitchen towel to tailpipe
- 2 Drive car or rev engine
- 3 Check towel; if dirty, the filter is malfunctioning and should be brought in for maintenance



Reporting Idling & Malfunctioning Public Buses via Municipality App



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Questions?

