Revisión de eficacias de las actuaciones sobre tráfico rodado para la mejora de calidad del aire urbano en Europa. Resultados de AIRUSE

X. Querol[1], F. Amato[1], A. Karanasiou[1], A. Alastuey[1], F. Lucarelli[2], S. Nava[2], G. Calzolai[2], R. Udisti[2], S. Becagli[2], R. Traversi[2], M. Severi[2], S. Borselli[2], C. Alves[3], C. Pio[3], T. Nunes[3], L. Tarelho[3], M. Duarte[3], M. Cerqueira[3], E. Vicente[3], D. Custódio[3], H. Pinto[3], E. Montfort[4], I.Celades[4], V. Sanfelix[4], R. Harrison[5], C. Holman[5], K. Eleftheriadis[6], L. Diapouli[6], V.L. Gianelle[7], C. Colombi[7]

1 idaea CSIC Consejo Superior de Investigaciones Científicas
2 Università degli Studi Firenze Dipartimento di Fisica e Astronomia
3 universidade de aveiro
4 AICE jtc Universitat Jaume I
5 University of Birmingham
6 Demokritos National Centre for Scientific Research
7 ARPA Lombardia Agenzia Regionale per la Protezione dell'Ambiente Settore Monitoraggi Ambientali

UIMP, Palacio de la Magdalena, Santander 20-21/07/2015

Bases Científico-Técnicas para mejorar la calidad del aire en España

AIRUSE

B7: MEDIDAS ESPECÍFICAS PARA EVITAR RESUSPENSIÓN

1 Report experimental evaluation of the efficiency of specific measures for abatement of road dust

B8: ESTRATEGIAS Y ACTUACIONES DEL N Y CENTRO DE LA UE: EVALUACIÓN Y ADAPTACIÓN

10 reports on evaluation efficiency of specific measures

1. Street cleaning – **draft completed**
2. Dust suppressants – **draft completed**
3. Low Emission Zones - **draft completed**
4. Discourage diesel cars – **draft completed**
5. Encourage use of EVs, HEVs and gas vehicles – **draft completed**
6. Eco-efficient car labels – **draft completed**
7. Traffic NOx abatement measures – **draft completed**
8. Shipping
9. Biomass burning - agricultural and domestic sectors
10. Air quality/climate change synergies/interferences

Remediation Measures

Preventive

- Reduce number of vehicles
- Reduce traffic speed
- Reduce HDV
- Reduce wear

Mitigation

- **Street washing (and sweeping)**
- **Calcium Magnesium Acetate (CMA)**
- **$MgCl_2$**
- **Polymers**
- $CaCl_2$
- Porous asphalt
- ….

Mitigation tests

	Redust	CMA+	Aldrin et al., 2008	Norman and Johansson, 2006	Reuter, 2010	Barratt et al, 2012	AIRUSE
	Finland	**Alps**	**Norway**	**Sweden**	**Germany**	**UK**	**South EU**
Washing	40% weekly						??
CMA		20-30% daily		35% daily	NO effect	40% only at industrial site	??
$MgCl_2$			30% daily				??
$CaCl_2$	40% daily						??

B7: MEDIDAS ESPECÍFICAS PARA EVITAR RESUSPENSIÓN

AIRUSE tests

Road dust

At **typical urban road**:

- Street cleaning
- CMA
- $MgCl_2$

At **industrial paved road**:

- Street cleaning
- CMA

At **unpaved road**:

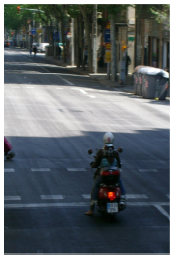
- Water flushing
- CMA

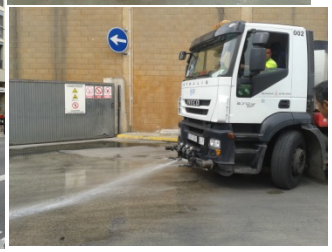
Soil dust

At **urban park** we tested nano-polymer

B7: MEDIDAS ESPECÍFICAS PARA EVITAR RESUSPENSIÓN

Urban road (Barcelona)



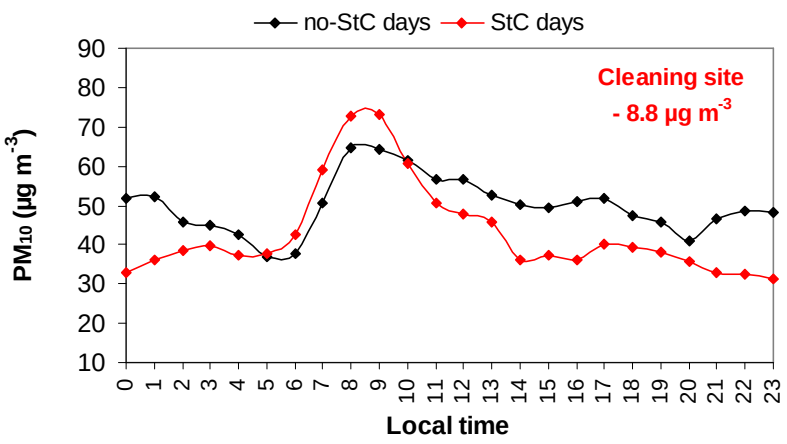


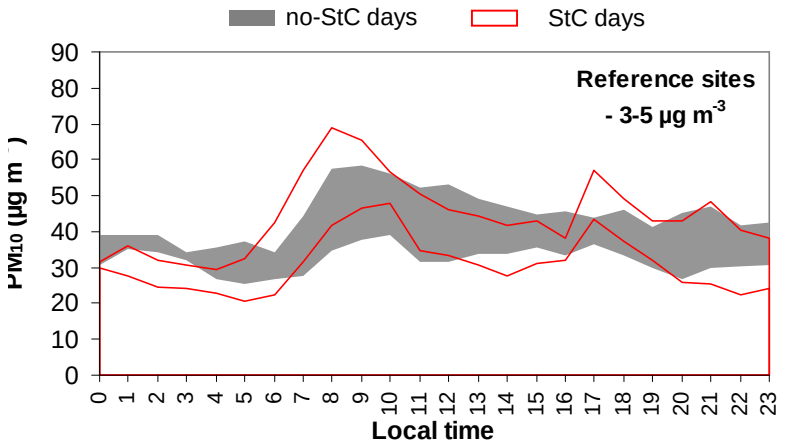
- Dust Track, TEOM and GRIMM;
- High volume samplers PM10 (daily)
- High volume samplers PM2.5 (every third day).
- PM chemical characterization (ions, elements, OC and EC);
- Streaker for PM2.5 and PM2.5-10;
- Black Carbon (MAAP and mini-aeth);
- NOx, O_3 and SO_2 and meteo.

B7: MEDIDAS ESPECÍFICAS PARA EVITAR RESUSPENSIÓN

Urban road (Barcelona): street cleaning



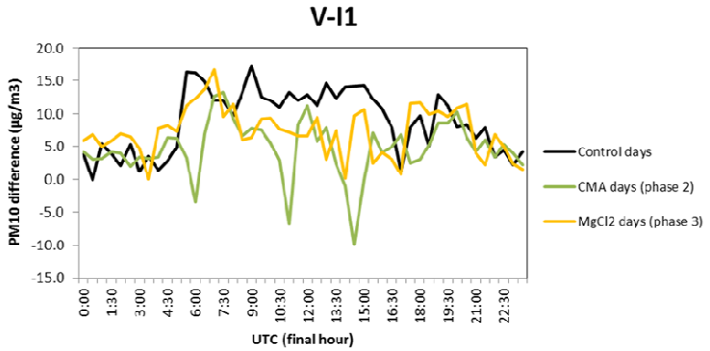


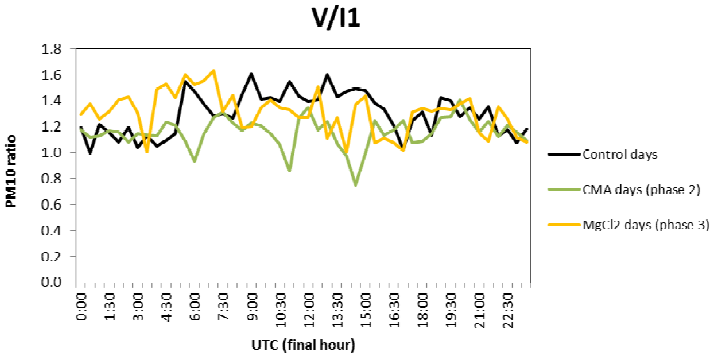


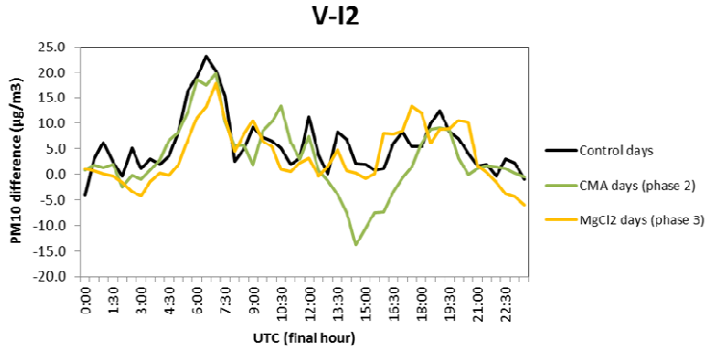
Reduction: 4-5 µg m^{-3} (7-10%)

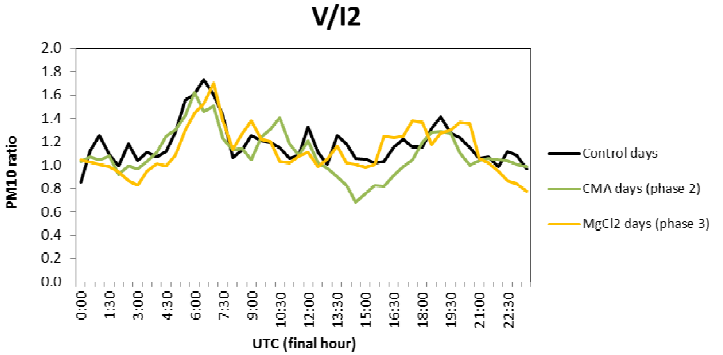
AIRUSE

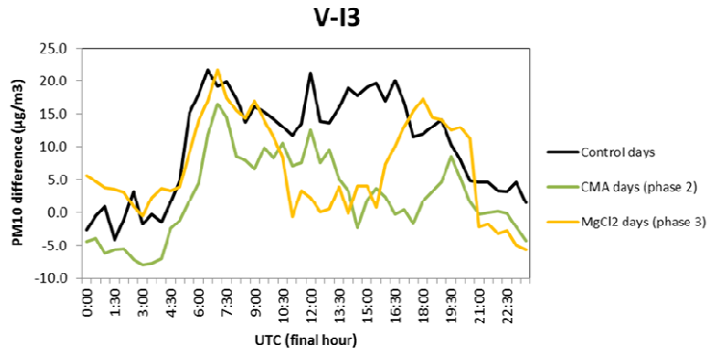
Urban road (Barcelona): CMA and $MgCl_2$

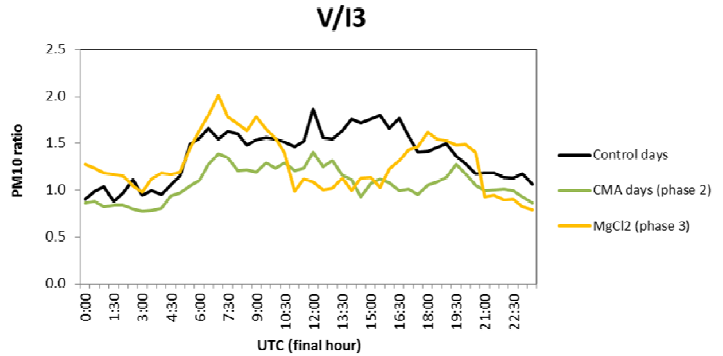




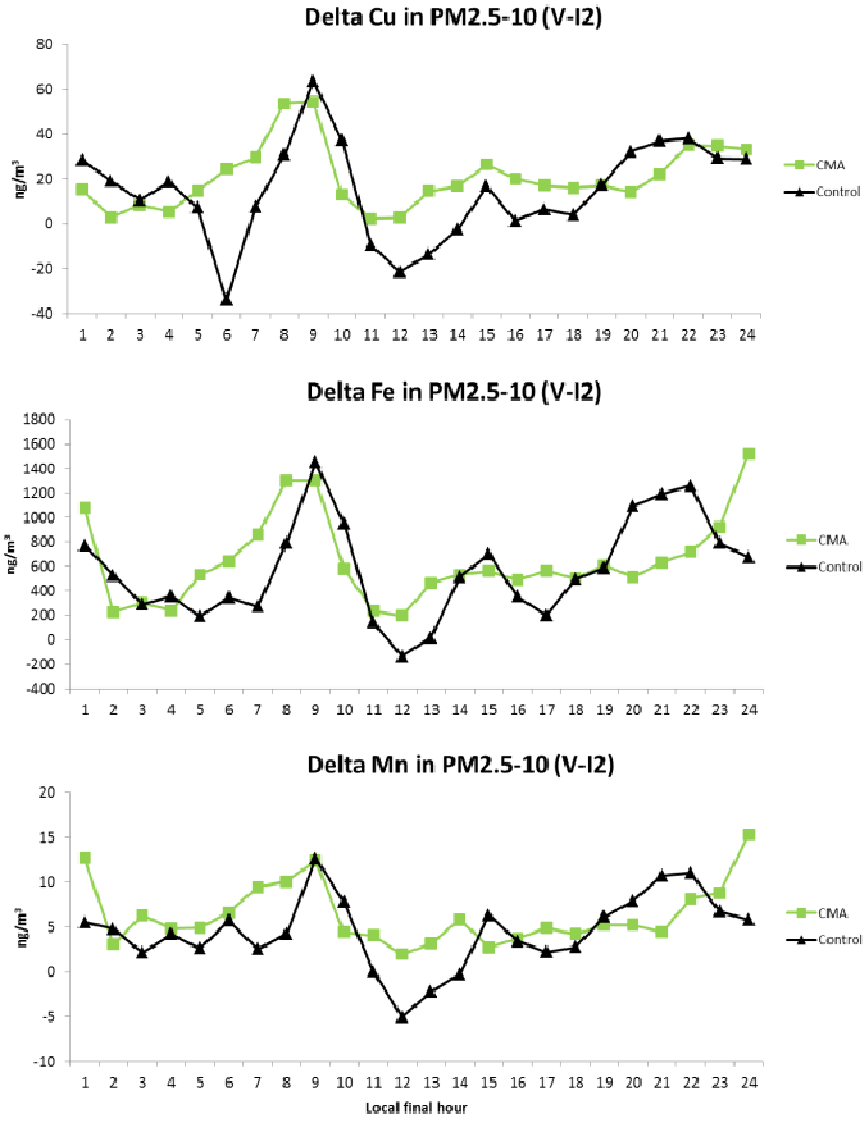


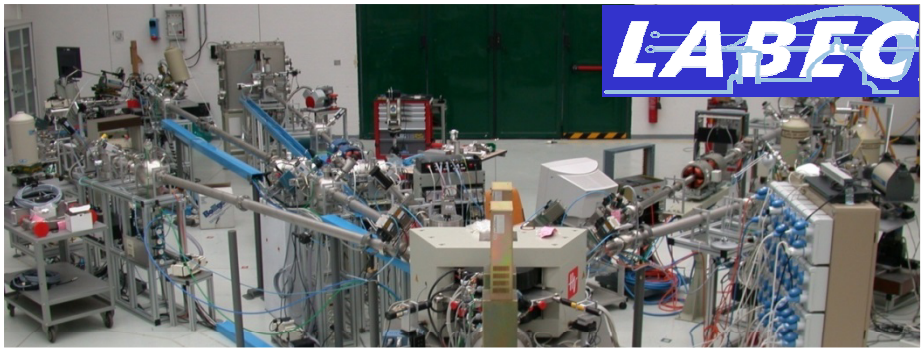




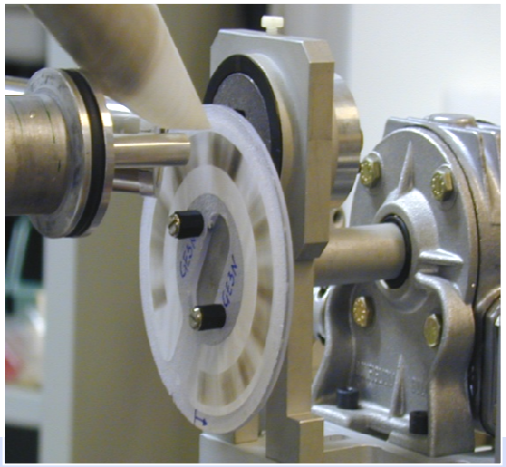


B7: MEDIDAS ESPECÍFICAS PARA EVITAR RESUSPENSIÓN





3MV accelerator (INFN, Florence)



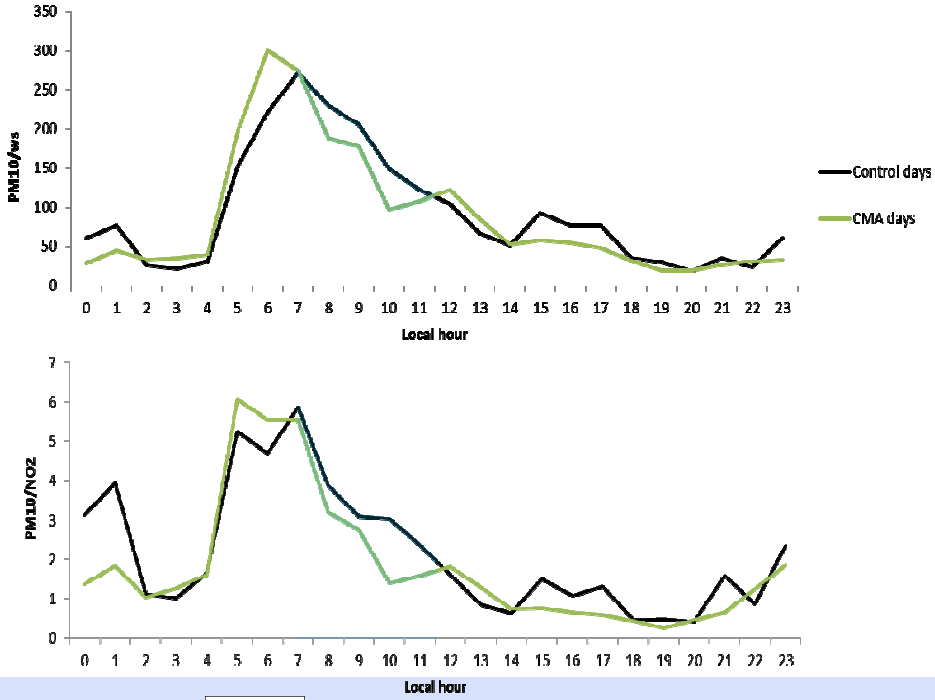
AIRUSE

Industrial (ceramic) paved road

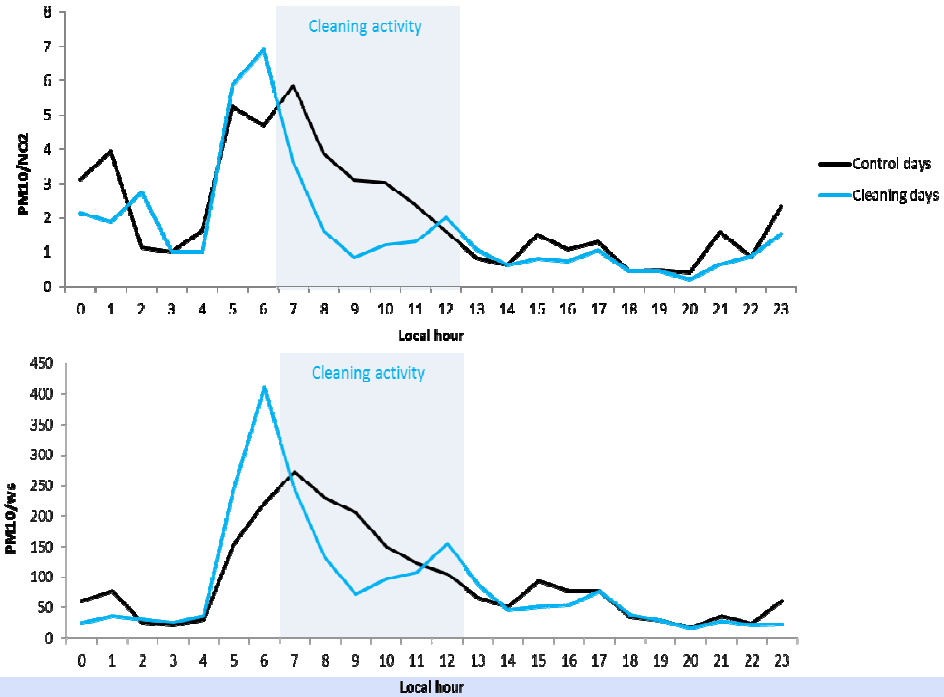
- 250 companies (tiles, spray-dried granules, pigments..)
- 17% of the worldwide supply
- consumes 12 Mt/year of clay

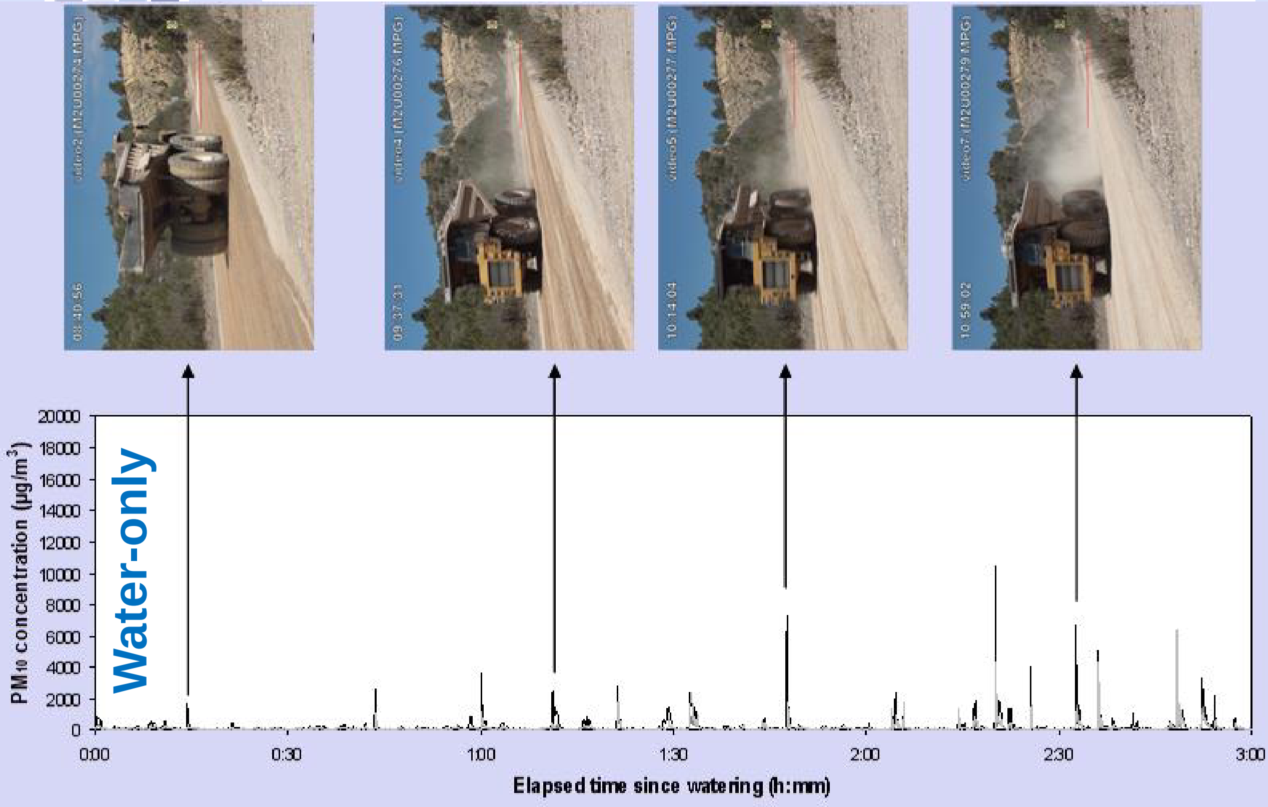
Industrial paved road

CMA
8% reduction

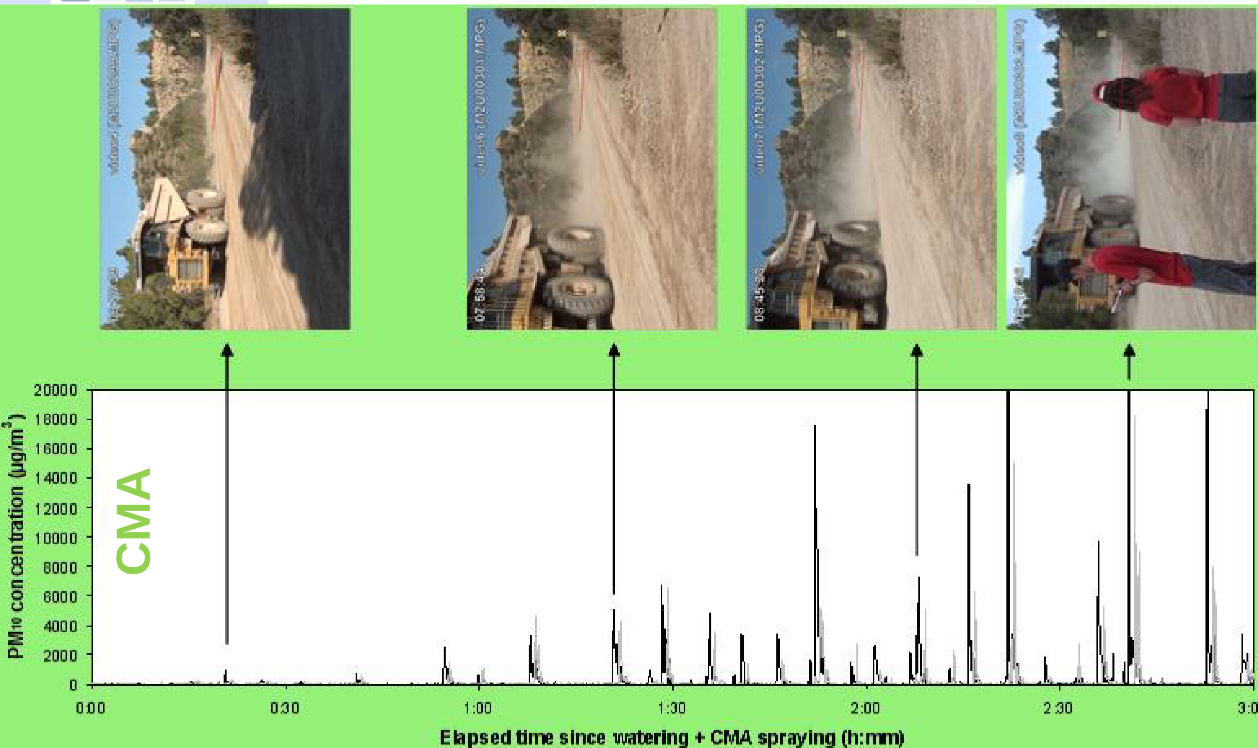


Water-only
18% reduction





http://airuse.eu/media/watering.mp4



Conclusiones

- Street washing revealed the highest efficiency in reducing mobility of particles.
- The effect is short lived (<8hours), and should be performed before rush hours
- Sweeping, CMA and $MgCl_2$ do not offer evidence of efficiency in our environments (S.Europe)
- Polymers need further testing in paved roads

Acknowledgements:

B8: ESTRATEGIAS Y ACTUACIONES DEL N Y CENTRO DE LA UE: EVALUACIÓN Y ADAPTACIÓN

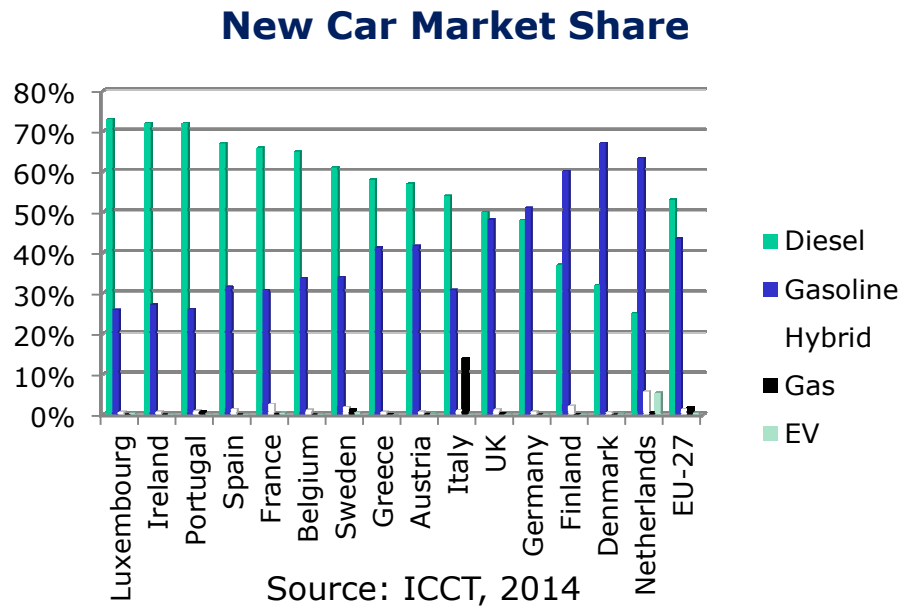
10 reports on evaluation efficiency of specific measures

1. Street cleaning – **draft completed**
2. Dust suppressants – **draft completed**
3. Low Emission Zones - **draft completed**
4. Discourage diesel cars – **draft completed**
5. Encourage use of EVs, HEVs and gas vehicles – **draft completed**
6. Eco-efficient car labels – **draft completed**
7. Traffic NOx abatement measures – **draft completed**
8. Shipping
9. Biomass burning - agricultural and domestic sectors
10. Air quality/climate change synergies/interferences

Led by R.M. Harrison & C. Hollman
University of Birmingham

Diesel vehicles

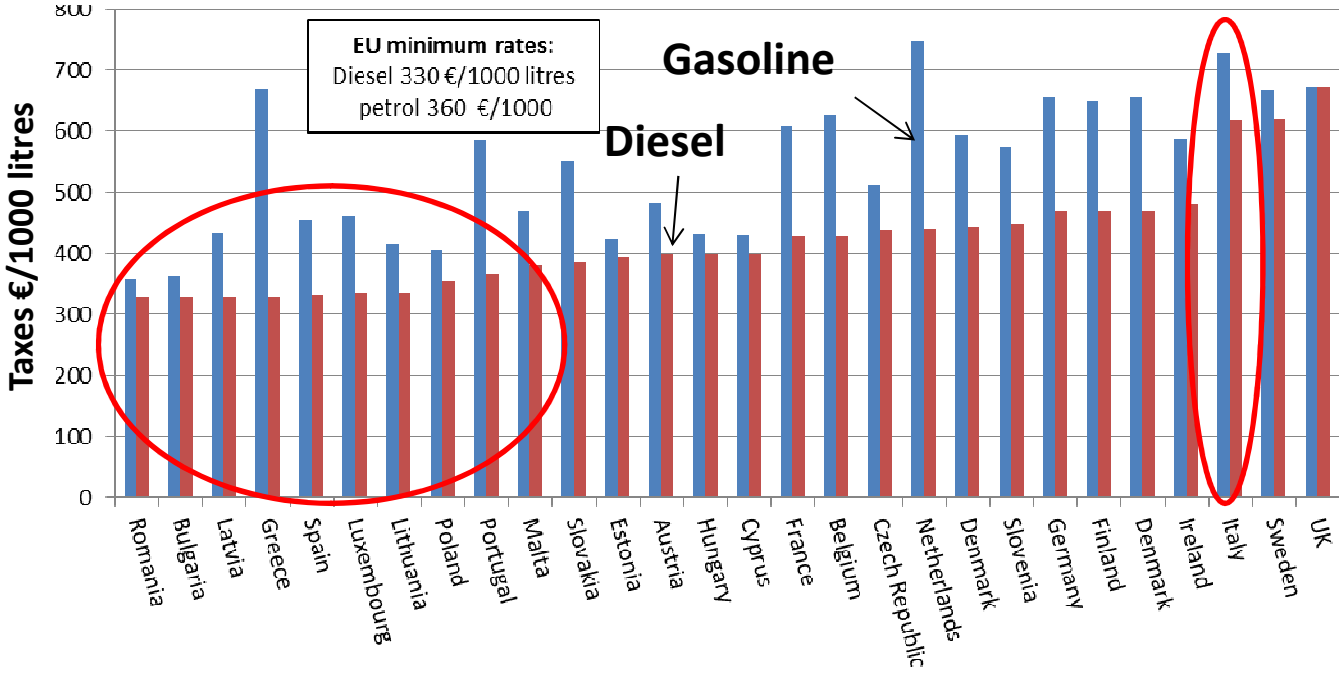
- HIGH real-world NOx emissions. Euro 6 NOx 7 times the type approval limit (ICCT, 2014)
- Car NOx emissions not improved for over 20 years
- Some Euro VI buses continue to have high in-use NOx emissions, depending on exhaust temperature (Carslaw et al, 2014)
- EU Diesel market share increased from 36% (2001) to 55% (2013)



Solutions: Encouraging the use of cleaner cars

- Discouraging diesel cars
- Low Emission Zones (LEZs)
- Encouraging BEVs, HEVs PHEVs and gas vehicles
- Mandatory eco-label

Discouraging Diesel cars



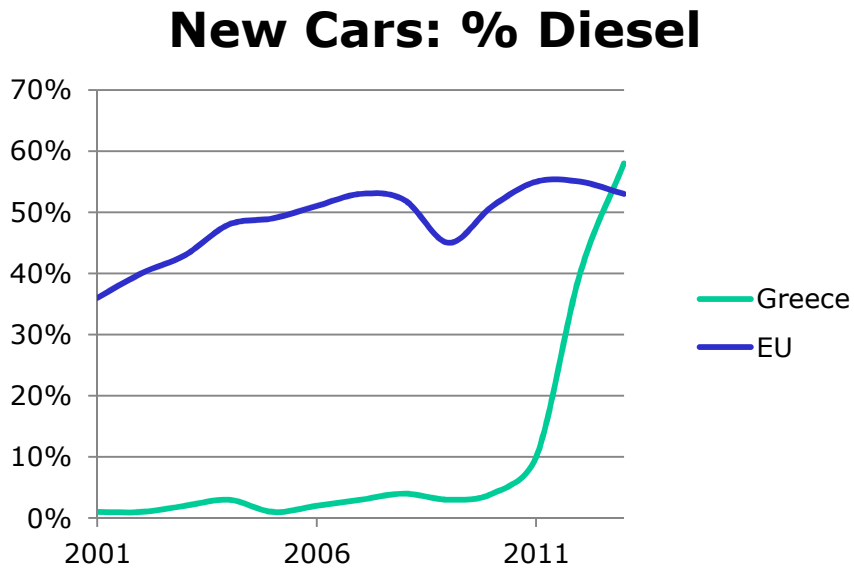
Discouraging Diesel cars

- Car purchase and/or ownership taxes - CO_2 based in most MS
- Diesel taxation and pump prices – lower than gasoline in most MS
- **Favours purchase and use of diesel cars**
- Gap between type approval and real world CO_2 emissions increased 7% (2001) to 23% (2011)
- **Diesel Benefits overstated**

Banning Diesel Cars

Greece

- 1991 until 2011 – diesel cars banned in Athens and Thessaloniki
- Diesel 20% cheaper than gasoline
- Rapid increase in diesel car sales since ban lifted



London

2014: Attempts to ban diesel cars from London LEZ dropped due to public opposition

France

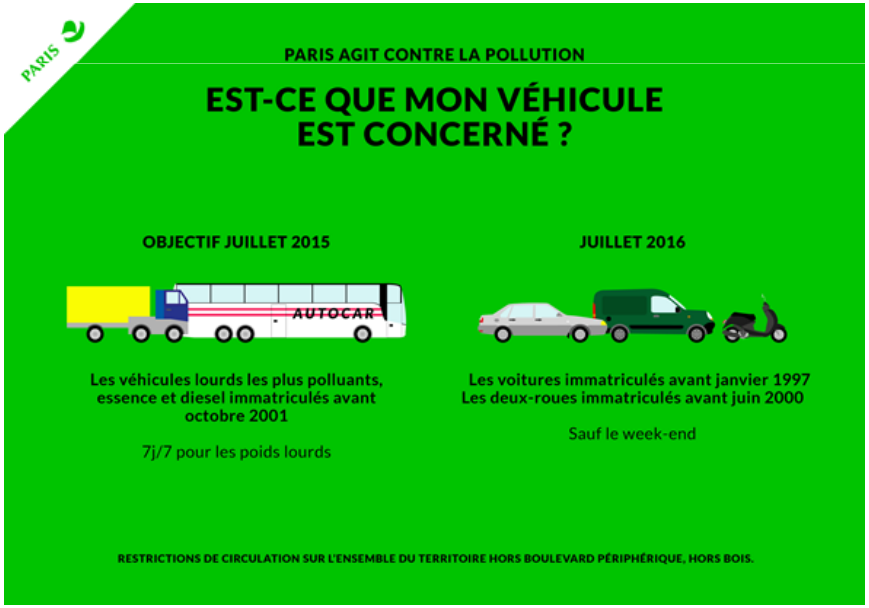
9th February 2015: Mayor Anne Hidalgo presented plan to Council to

"ban most diesel vehicles from the city by 2020"

This is a LEZ and includes gasoline vehicles

Only current French LEZ:

- Mont Blanc tunnel



LEZs

Country	Number of LEZs	Applicable vehicles	National Framework/ legislation
Austria	3	HDVs	Yes
Czech Republic	1	HDVs	-
Denmark	6	Vehicles > 3.5 tonnes	Yes
France	1	HDVs	No
Germany	>70	All except motorcycles	Yes
Hungary	1	HDVs	No
Italy	>130	Various	No
Netherlands	14	HDVs	Yes
Portugal	1	Cars & HDVs	No
Sweden	8	Vehicles > 3.5 tonne	Yes
UK	2	Various	No

At mid 2014

Efficacy of LEZs

- Difficult to determine
- Confounders e.g. weather, other policy measures, recession

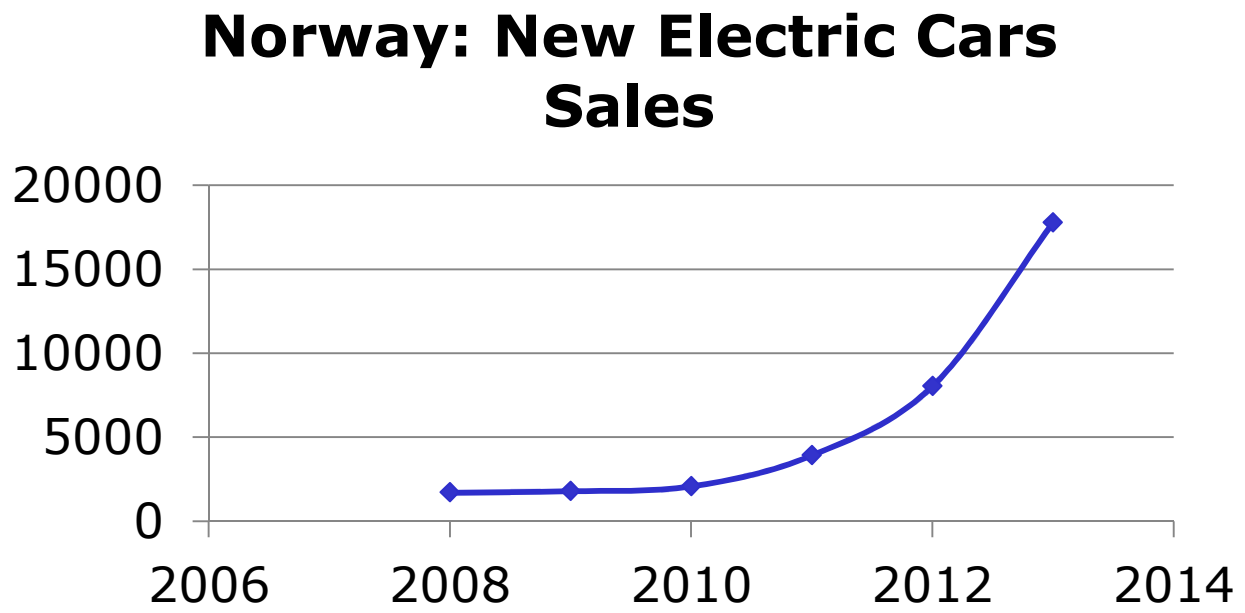
- Little evidence of impact on PM10 and NO2 concentrations outside Germany
- EC/BC reduced

German LEZs

- PM_{10} ≤7%↓
- Munich (LEZ + HDV ban) PM_{10} ca.13%↓
- NO_2 ≤10%↓
- But not all robust studies
- Early phases studied

- **LEZs apply to cars as well as HDVs**
- **Generally more stringent than elsewhere**

Electric car market in Norway



Norway 5.8%; Netherlands 5.4%; EU-28 0.4% (2013)

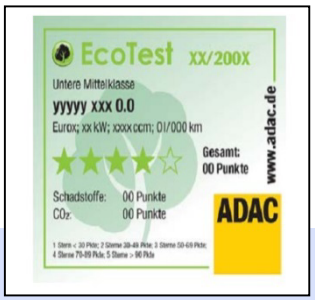
Electric car market in Norway

- Long term fiscal incentives from 1990s
- Incentives added sequentially until the market responded
- The price difference between battery EV and petrol car can be €1,000

- Exempt from
  - vehicle registration tax
  - road tolls
  - VAT (normally 25%)
- Bus lane access
- BEVs -reduced annual tax
- Reduced rates on the main coastal ferries

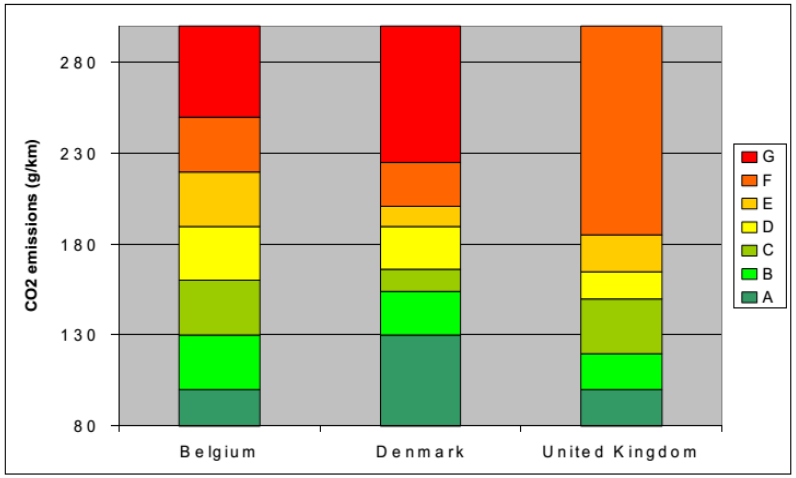
Ecolabels

- EU CO_2 label applied differently in each MS
- Many use A-F / G classes
- Can rank same car very differently
- Motoring organisations have separate eco-labels include NOx/PM



Comparison of the CO_2 emission bands (gasoline cars) used in the energy efficiency rating systems

Source: ADAC, 2005



Vehicle Eco-Label

Recommendations

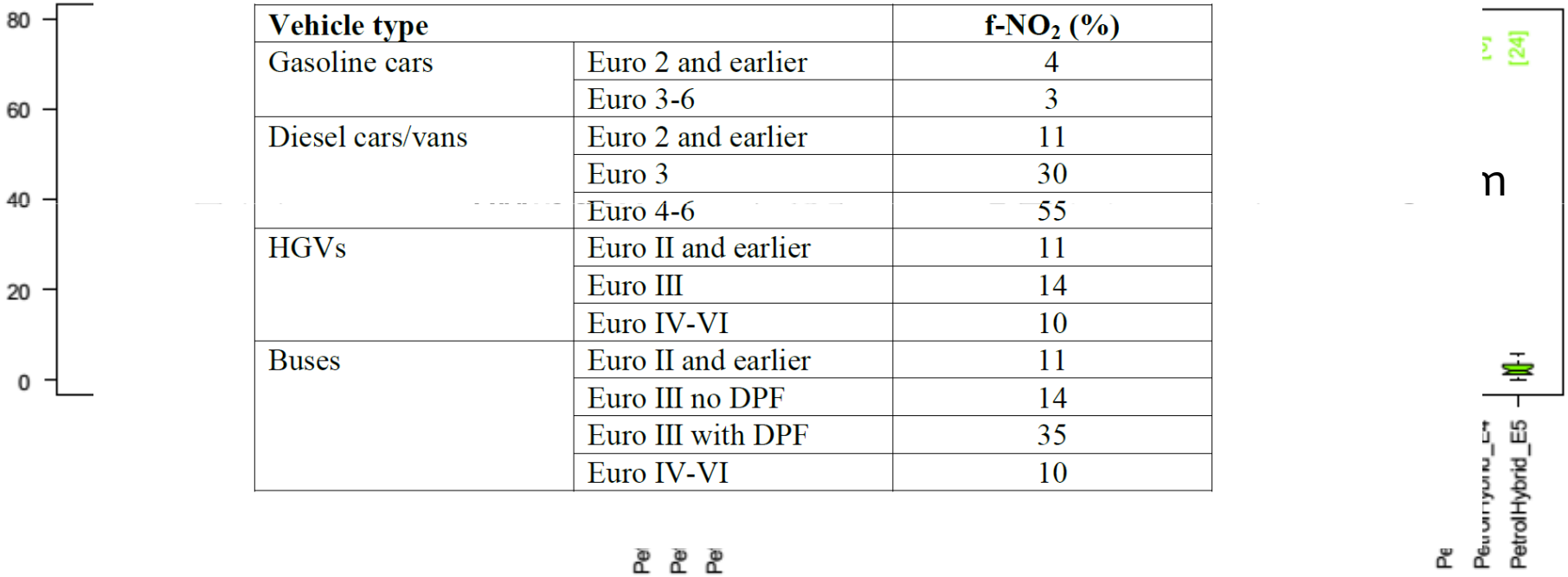
- Mandatory EU wide scheme
- NOx, PM and CO_2 emissions, with no weighting
- Apply to new & used vehicles
- To take account of real-world emissions
- 'Well to tank' to enable ICEs and EVs to be compared
- Based on domestic appliances label (A to G rating) with running costs.
- Updated on annual basis by allocating a fixed percentage of models to each band
- Long term public education is required to support the eco-label

NOx emission technologies

Diesel car PM & NO2 Emissions

Table 1: Recommended Primary NO_2 emission percentages for different vehicle types (f-NO_2) (Grice et al., 2009)

Vehicle type		f-NO_2 (%)
Gasoline cars	Euro 2 and earlier	4
	Euro 3-6	3
Diesel cars/vans	Euro 2 and earlier	11
	Euro 3	30
	Euro 4-6	55
HGVs	Euro II and earlier	11
	Euro III	14
	Euro IV-VI	10
Buses	Euro II and earlier	11
	Euro III no DPF	14
	Euro III with DPF	35
	Euro IV-VI	10



- **Average Euro 6 NOx seven times the type approval limit (ICCT, 2014)**
- **Some Euro VI buses continue to have high in-use NOx emissions, depending on exhaust T (Carslaw et al, 2014)**

NOx emission technologies

- World Harmonized Light duty test Procedure (WHLP) has been developed, also Real driving emissions (RDE) tests will be introduced for passenger cars with Euro 6c standards in 2017 and 2018
- NOx emissions for Euro 6 cars are typically lower than from earlier generations, but they remain on average many times the emission limit
- A number of measures for HDVs have resulted in Euro VI long distance trucks having low NOx emissions
- More information is needed on urban bus and distribution vehicle emissions during operation
- There is evidence that SCR can reduce NO2 as well as NOx emissions significantly, but this needs to be kept under review as the technology develops, and appropriate emission limits legislated if necessary.
- Retrofitting pre Euro VI urban buses and distribution trucks with 'low NO2 SCRT' devices may offer a relatively cost-effective way of achieving the ambient NO2 limit value

Conclusions

- Influencing motorists away from diesel unlikely until fiscal incentives change
- Promoting cleaner vehicle technologies requires long term consistent policies
- LEZs need to be stringent and include cars to be effective
- Public information on air quality implications of fuel choice required¡

Additional considerations (1)

Non-exhaust contribution to PM mass

- from wear of brakes, tyres, road surface
- from resuspension of surface dusts

These will soon exceed exhaust emissions considerably, but

- wear emissions can be influenced by choice of materials
- it may be possible to trap brake dust on the vehicle
- resuspension is influenced by the aerodynamics of the vehicle

There is current research on quantifying these emissions, but none on reducing them

Additional considerations (2)

Cooking aerosol

Some measurement methods (generally Aerosol Mass Spectrometry) show an appreciable contribution of cooking aerosol to $PM_{2.5}$ concentrations

There is a pressing need for:

- Better methods of quantification of cooking particles
- Research on mitigation measures

Additional considerations (3)

- National Emissions Ceilings are an important tool, but air quality Limit Values and Exposure Reduction targets are the best protection for human health.

- More research is needed on the differential toxicity of particles of different composition and size distribution, and from different sources.

AGRADECIMIENTOS

LIFE+ AIRUSE & MAGRAMA

Spain	**GenCat, Barcelona and Madrid City Councils**
Italy	**ARPA-Lombardia, Regione Lombardia, Regional Government of Tuscany, ARPA Toscana**
Portugal	**Porto City Council, North Regional Coord. & DeveloP. Comm. (CCDR-N)**
Greece	**Ministry of Environment, Energy and Climate Change**

¡GRACIAS POR SU ATENCIÓN!

xavier.querol@idaea.csic.es

GRACIAS A MARTÍN BASTOS POR ORGANIZAR LAS JORNADAS Y POR SU CONTRIBUCIÓN A LA MEJORA DE CALIDAD DEL AIRE, SU SABER HACER Y SU CALIDAD HUMANA

IN MEMORIAM DE MIGUEL LAVADO