



Overview of the AIRUSE LIFE+ project



Xavier Querol, IDAEA-CSIC on behalf of the AIRUSE team



THE AIRUSE PROJECT AIMS

- Characterizing similarities & differences in PM sources & contributions across S-EU (**5 cities**)
- Once the main sources of PM₁₀ and PM_{2.5} are identified, the strategic goal of the AIRUSE project is **to develop, test and propose specific and non specific measures** to abate urban ambient air PM in S-EU, **to meet AQ standards & to approach WHO guidelines.**

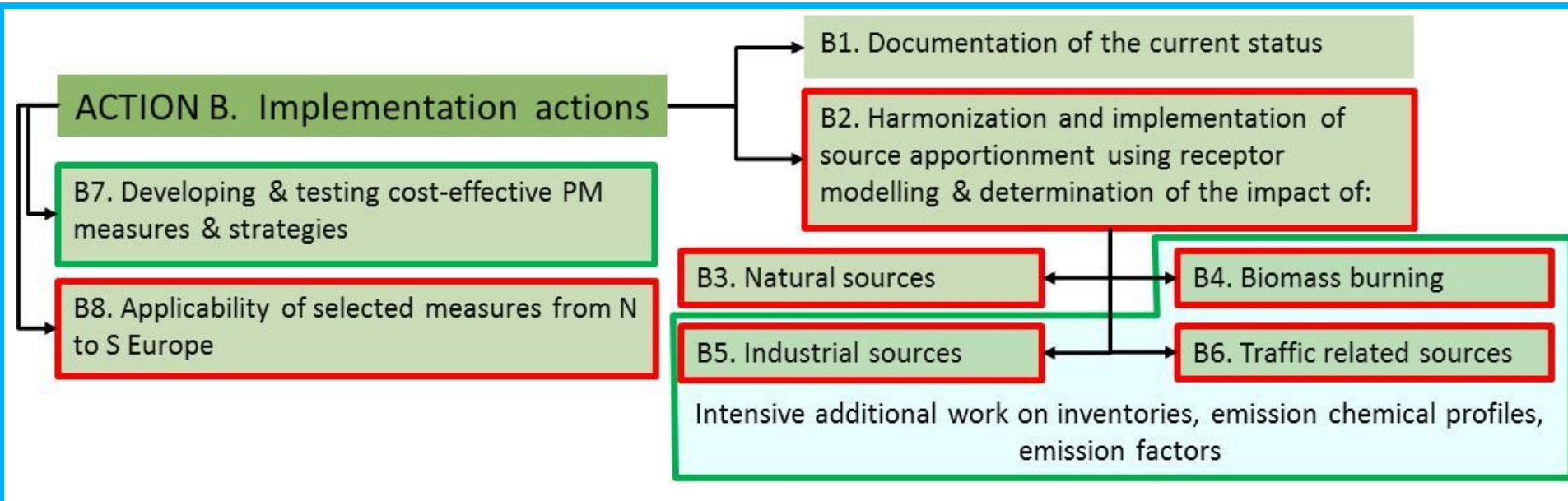
Specific PM mitigation measures

- Street washing & dust suppressants for road dust and deposited African dust
- Biomass burning
- Industrial emissions (channelled and fugitive)
- Strategies from other European countries (LEZ, eco-efficient vehicles, labelling, shipping, biomass burning...)

SPECIFIC TECHNICAL REPORTS FOR THESE TOPICS AT
<http://AIRUSE.EU>



AIRUSE STRUCTURE: ACTIONS & TASKS



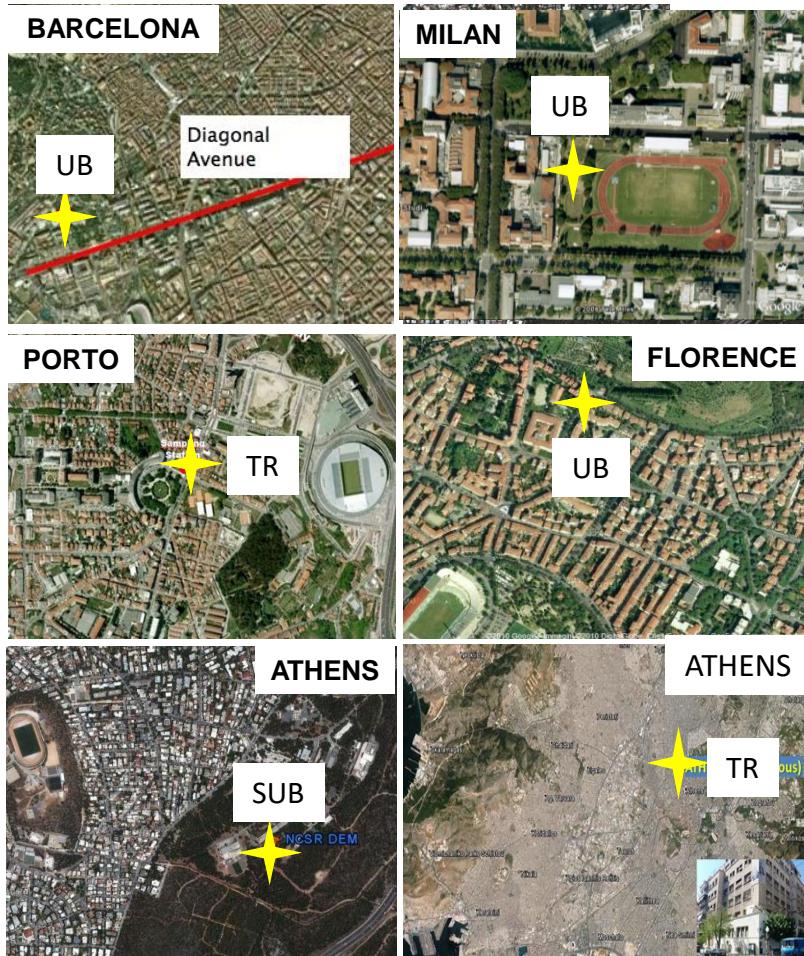
AIRUSE-1 presentation

AIRUSE-2 presentation

AXA-AIRUSE guide on measures



HARMONIZED 2013 PM10 & PM2.5 SOURCE APPORTIONMENT



Long term measurements		BCN-UB	FI-UB	MLN-UB	POR-TR	ATH-SUB	
Daily	PM10	Mass	122	226	379	123	197
		Elements	122	226	241 [§]	123 [*]	197 [†]
		Ions	122	226	337	123	197
		ECOC	122	226	348	123	197
		CC	122	226	89	123	197
		Levogluconan			324		243
Daily	PM2.5	Mass	126	243	378	126	243
		Elements	126	243	361 [§]	126	243
		Ions	126	243	374	126	243
		ECOC	126	243	370	126	243
		Levogluconan	126	243	356	126	888
Hourly	PM2.5-10	Elements	716	504		504	888
	PM2.5	Elements	714	504		504	197

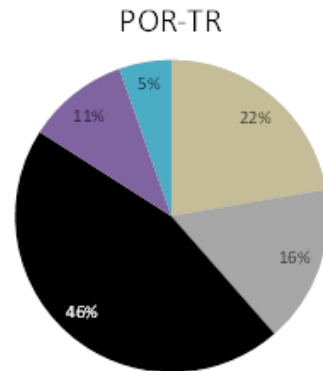


^{*}intercomparison between PIXE and ICP on Teflon filters
[†]intercomparison between Teflon (PIXE) and quartz (ICP) filters
[§]intercomparison between PIXE and XRF on Teflon and MCE filters

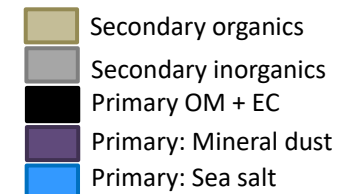
1047 PM10 samples
1116 PM2.5 samples



2013 PM10 & PM2.5 SOURCE APPORTIONMENT



Primary: 62%
Secondary: 38%



PM2.5



PM10 (annual mean)

PM10 (days of exceedance)

1. Road Traffic is the main source contributing to PM10: 29-36%	36-42% (ATH-SUB 8%)
1.1. Vehicle exhaust + traffic related NO ₃ ⁻ : 10-27% (ATH 14%)	28-30% (ATH 5-14%)
1.2. Non-exhaust vehicle emissions: 8-11% (ATH-TR 19%)	6-14% (ATH 3-26%)
2. Regional OC and/or SO₄²⁻ dominated pollution: 10-26% (POR-TR 10%)	BCN-MLN-ATH 9-19% , 2-6%
3. Local dust : 8-19% (5% MLN)	1-4% (POR-TR 27%)
4. Biomass burning very relevant in POR, FI, MLN (14-24%), ATH (7-11%), negligible in BCN	POR,FI, MLN (25-35%), ATH-T 11%, <1 BCN-ATH
5. Industry BCN-MLN 9-11% , 4-5% , ATH <1%	BCN 17% , <1-4%
6. Non traffic-NO₃⁻ 4-11%	11-22% , 1-3% POR,ATH-SUB
7. Shipping 4-5% in coastal sites	3-5% in coastal sites
8. African dust ATH-SUB 14% , 1-5%	1% (ATH 5- 52%)
9. Sea salt POR 13% , 3-7%	1-3% (ATH-SUB 7%)
10. Anthropogenic dust (Local dust + Non exhaust) 14-28%	11-33%

PM2.5 (annual mean)

PM2.5 (days of PM10 exceedance)

1. Road Traffic is the main source contributing to PM2.5: 22-39%	28-38% (ATH-SUB 11%)
1.1. Vehicle exhaust + traffic related NO ₃ ⁻ are the main causes: 17-34%	25-36% (ATH 10-19%)
1.2. Non-exhaust vehicle emissions are also relevant: 5-9% (BCN&FI 1-2%)	1-9%
2. Regional OC and/or SO₄²⁻ dominated pollution: 19-37% (POR 13%)	BCN-MLN-ATH 11-24% , 2-6%
3. Local dust : POR 16% , 2-6%	POR 22% , 1-2%
4. Biomass burning very relevant in MLN, FI & POR (18-21%), less in ATH (10-19%) , <2%BCN	POR-FI-MLN 26-33% , ATH 2-17%, <2%BCN
5. Industry 5-12% , ATH <1%	BCN 18% , <1-3%
6. Non traffic-NO₃⁻ 5-8% (POR, ATH 2-3%)	BCN, FI, ATH & MLN 10-14% (1-3% POR, ATH)
7. Shipping 5-7% in coastal sites	5-10% in coastal sites
8. African dust : ATH 2-6% , <1%	ATH-SUB 45% , ATH-TR 4%, 1%
9. Sea salt POR 5% , 1-3%,	<1%-2%
10. Anthropogenic dust (Local dust + Non exhaust) reaches 10-21% , BCN 7% , FI 4%	POR 25% , 2-9%



Annual average source apportionment

Road traffic

29-36% of PM10

50-70% of NO₂

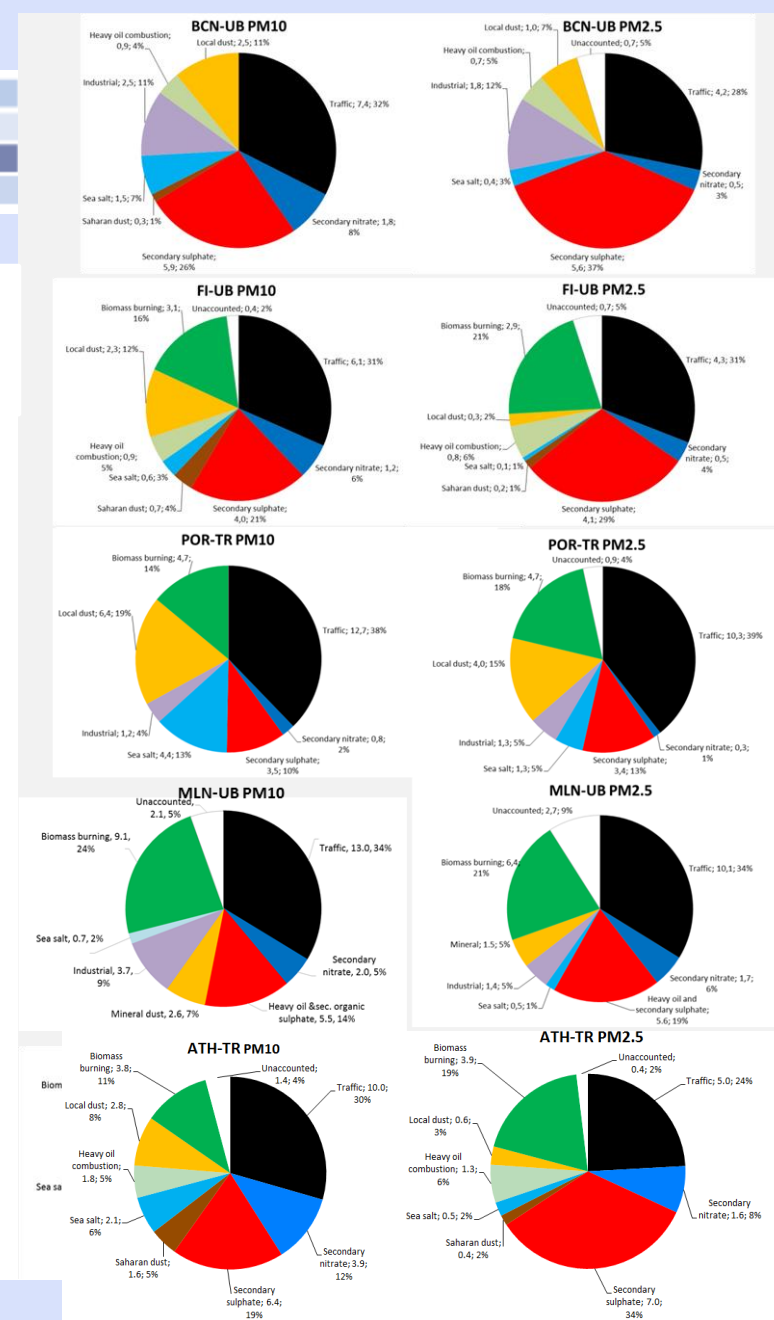
1st source at all sites

22-39% of PM2.5

1st source at MLN, POR, ATH and FI
2nd source, after SSO, at BCN

Biomass burning

20% PM2.5 FI, POR, MLN and ATH





CONTRIBUTIONS TO THE MEAN OF DAYS >50 (40 BCN) $\mu\text{gPM}_{10}/\text{m}^3$ (> $35\mu\text{g}/\text{m}^3$ PM_{2.5} MLN)

Road traffic

36-42% of PM₁₀
1st source at all sites

28-38% of PM_{2.5}
1st source at all sites

Biomass burning

Similar levels to traffic in FI, POR and MLN





Air quality measures for road traffic

0. Air quality plans should be devised at the scale of the metropolitan area

ii. Measures to reduce number of urban vehicles circulating

iii. Measures favoring renewal and transformation of urban vehicle fleets
(LEZ, CAs, taxes,..)

iv. Urban distribution of goods (urban freight distribution) & taxis

v. Urban re-design: priority pedestrians and green areas

vi

vii

i. Improving public transport

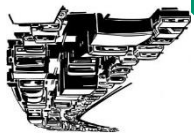
vi. Remediation measures

vii. Other non-technological measures



Air quality measures for road traffic

1. Measures to reduce the number of circulating vehicles

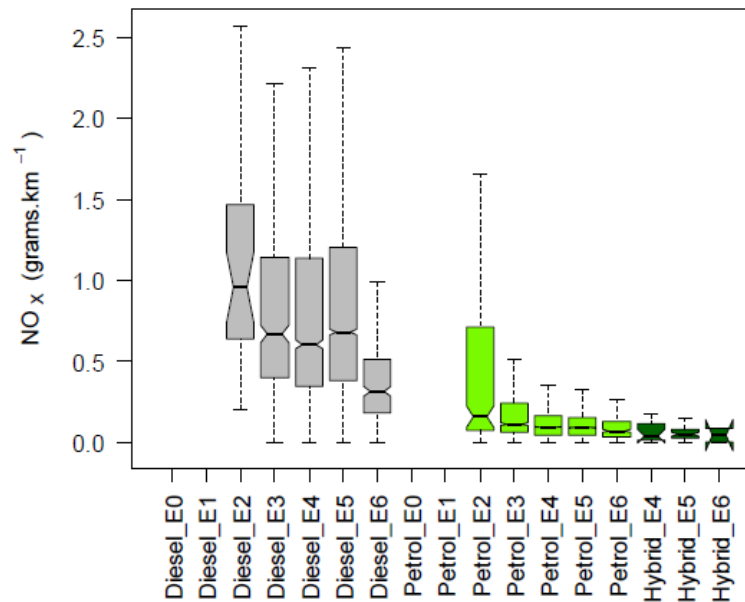




Air quality measures for road traffic

Real World driving emissions: Why shall we reduce number of cars?

Passenger cars, Spring/ Summer 2015



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Routes to Clean Air - Air Quality Conference - IAQM
Friday 23rd October 2015

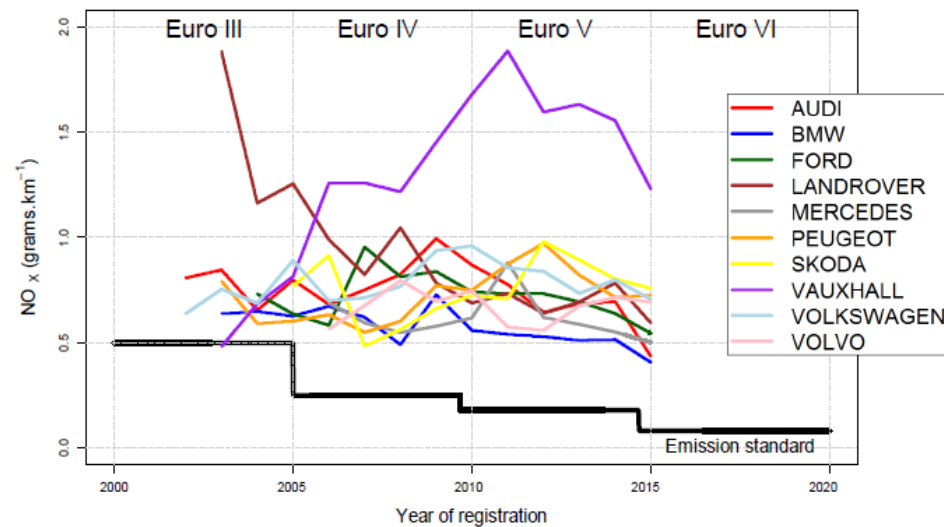


Air quality measures for road traffic

Real World driving emissions: Why shall we reduce number of cars?

Manufacturer comparison

Euro VI



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Air quality measures for road traffic

1. Measures to reduce the number of circulating vehicles



- 1.1. Public transport
- 1.2. Congestion charges
- 1.3. Parking restrictions

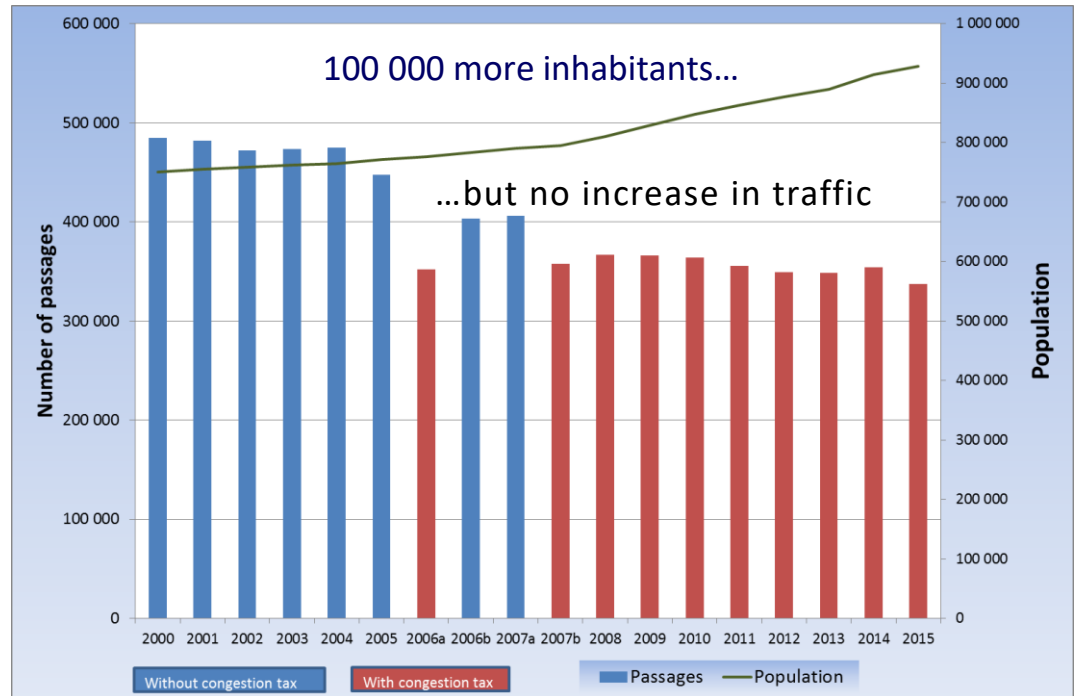
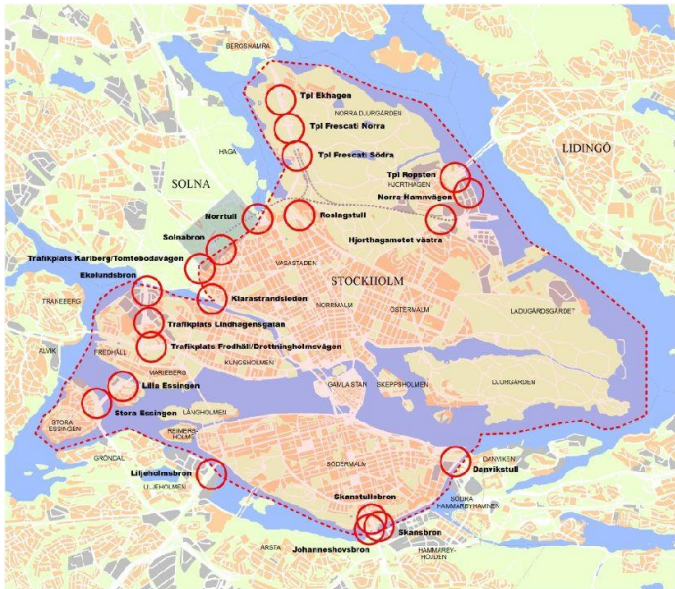




Air quality measures for road traffic

1. Measures to reduce the number of circulating vehicles

- 1 to 3.5 Euro for every passage
- Max 11 Euro per day
- Also foreign vehicles pay



>30 stations with APNR

Courtesy of Christer Johansson



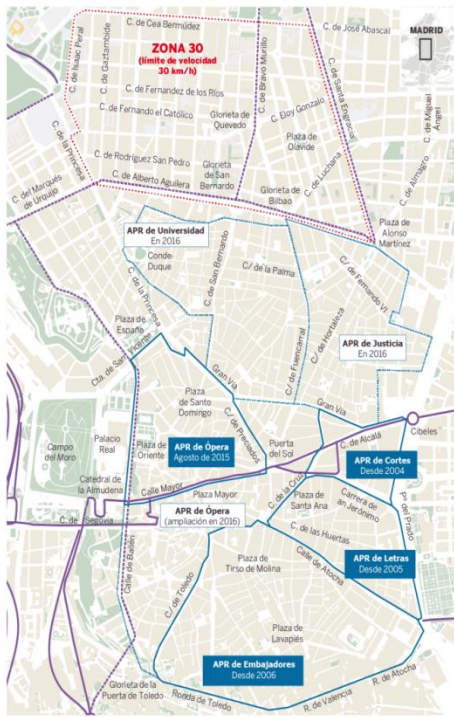
Air quality measures for road traffic

1. Measures to reduce the number of circulating vehicles

AYUNTAMIENTO DE MADRID

El Ayuntamiento de Madrid anuncia que restringirá el tráfico en gran parte de Centro en 2018

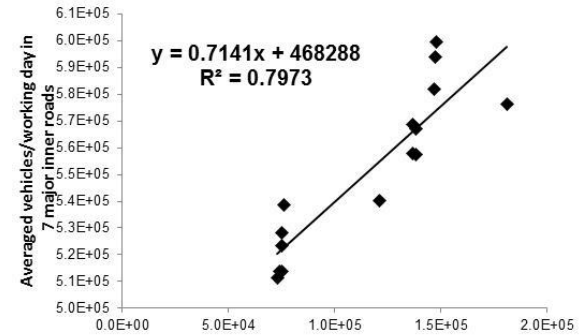
El gran Área de Prioridad Decidional de Centro "podrá ser una o dos" en función de si se parte o no por Gran Vía



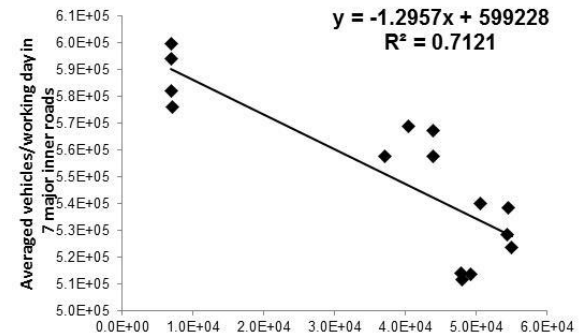
Fuente: Ayuntamiento de Madrid. EL PAÍS

BARCELONA-2001-2015

Querol et al., 2017. Non technological measures for urban air quality



Parking free places in the city of Barcelona



Payment or resident restricted parkings in Barcelona



Air quality measures for road traffic

2. Measures to renovate the fleet of circulating vehicles



**LEZ: Positive for BC
Ineffective for NO₂**



If we reduce vehicles by 30%, the 70% that will access have to be clean!!!!

+ plug-in-mobility





Air quality measures for road traffic

- LEZs
- Congestion Charge
- Other restrictions

2. Measures to renovate the fleet of circulating vehicles

NOW: CLEAN AIR ZONES (CAZS) IN UK

- **Must apply to ALL vehicle types**
- **Strict in application**
- **Also motor pets and motorbikes**
- **Use real world driving criteria**
- **Germany LEZ more efficient**

LOW EMISSION ZONES

15 MEMBER STATES, 280 CITIES:

- DE, NL, UK, NO, SE, DK, CZ, AT, HU, IT

AT (3)

Autopistes Tirol

CZ (1)

Praga

DE (50)

Augsburg, Berlín, Bochum, Bonn, Bottrop, Bremen, Dinslaken, Dortmund, Duisburg, Düsseldorf, Essen, Frankfurt, Freiburg, Gelsenkirchen, Halle (Saale), Hannover, Heidelberg, Heilbronn, Herrenberg, Ilsfeld, Karlsruhe, Köln (Colonia), Krefeld, Leipzig, Leonberg, Leonberg, Ludwigsburg, Magdeburg, Mannheim, Markgröningen, Mühlacker, Mühlheim, München, Münster, Neu-Ulm, Neuss, Oberhausen, Osnabrück, Pfinztal, Pforzheim, Pleidelsheim, Pleidelsheim, Recklinghausen, Ratisbona, Reutlingen, Schwäbisch-Gmünd, Stuttgart, Tübingen, Ulm, Wuppertal

DK (5)

Aalborg, Aarhus, Frederiksberg, Copenhagen, Odense

GB (3)

Londres, Oxford, Norwich

IT (42)

Roma, Milán, Livorno, Pisa, Módena, Nápoles, Palermo, Parma, Pavia, Pisa, Reggio Emilia, Rimini, Torino, Trento, Varese, Verona, Lodi, Lucca, Montove, Mezzocorona, Mondovi, Nichelino, Novara, Novi Ligure, Orbassano, Perugia, Piacenza, Prato, Ravenna.....

NL (13)

Ámsterdam, Breda, Delft, La Haya, Eindhoven, Leiden, Maastrich, Rijswijk,

Rotterdam, Hertogenbosch, Schiedam, Tiburg, Utrecht

NO (3)

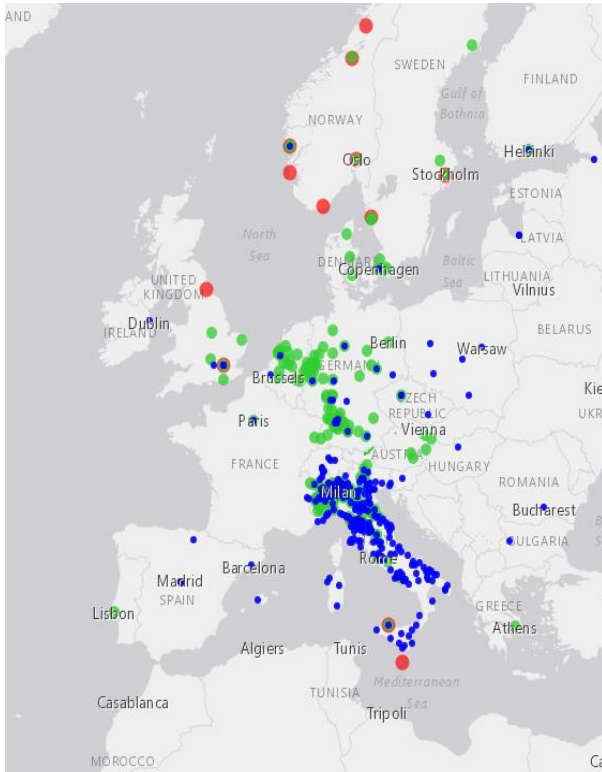
Oslo, Bergen, Trondheim,

SE (6)

Estocolmo, Gotemburgo, Helsinburg, Lund, Malmo, Molndal

FR

Paris: Testing in 2012



<http://es.urbanaccessregulations.eu/>



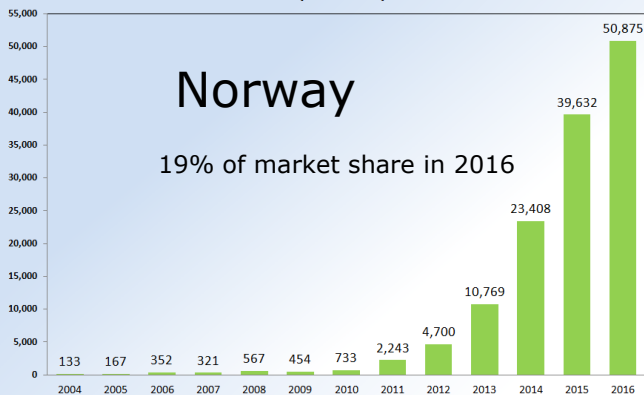
Air quality measures for road traffic

2. Measures to renovate the fleet of circulating vehicles

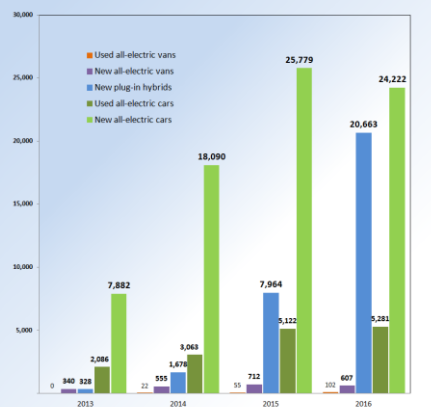
Registrations of light-duty plug-in electric vehicles in Norway by year (2004-2016)

Norway

19% of market share in 2016



Registrations of plug-in electric vehicles in Norway by type of vehicles and origin (2013-2016)



- 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

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

2016 with 5% of all passenger cars on Norwegian roads being a plug-in

- Starting with advantages and support to commercial vehicles with high km/day in cities
- Motorbikes in BCN



Air quality measures for road traffic

3. Urban freight distribution & taxis

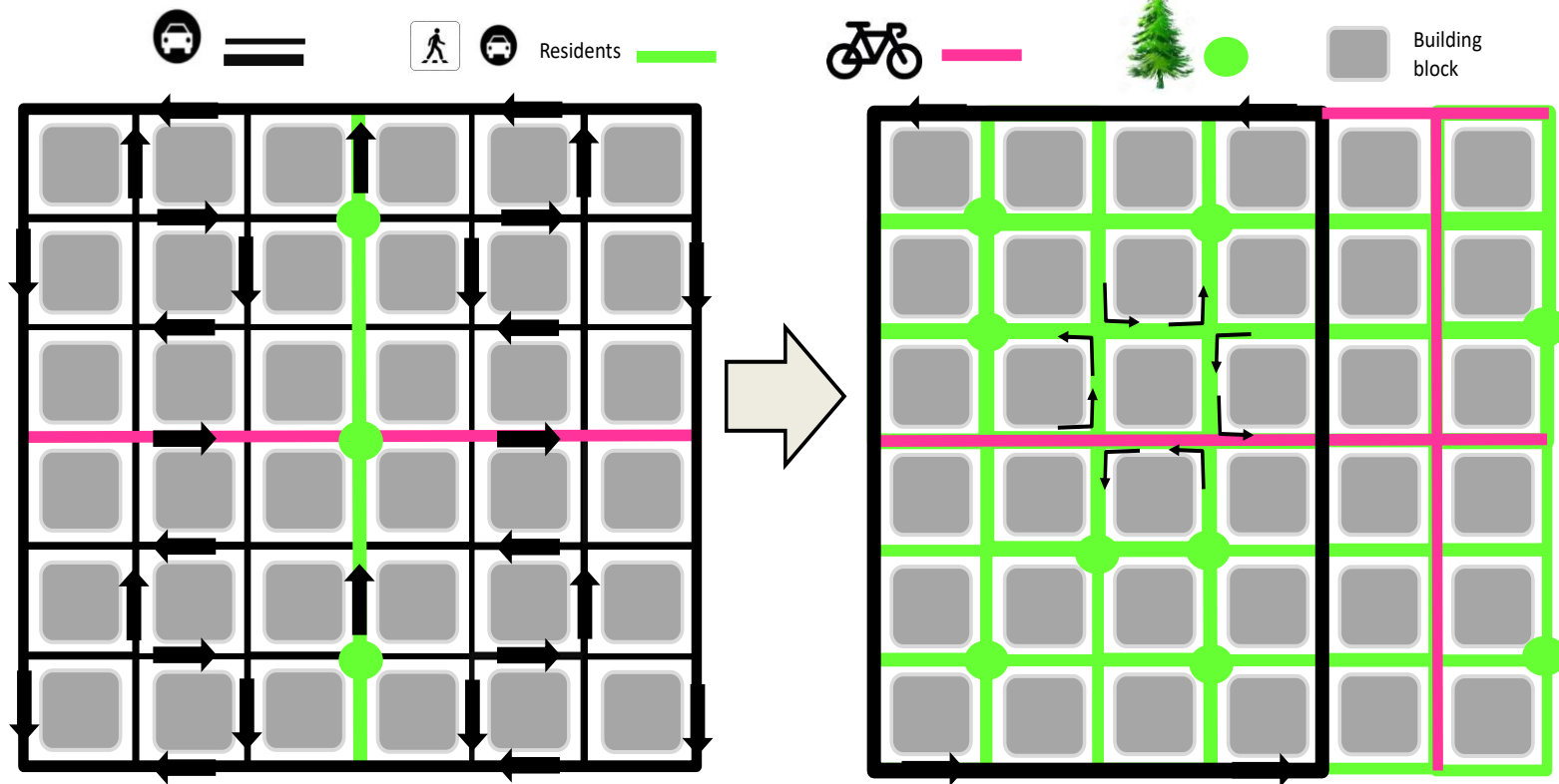
- Preferential electrification & hybridation, 1 vehicle UFD = 12 private cars due to kmtrage
- Restrictions from 7 to 11 am (unfavorable meteo & traffic density)
- Intelligent logistics (nocturnal, micro-platforms
- Strict regulations AND INFORCEMENT of minimum volume available for storing goods
- Avoiding circulation of free taxis
-



Air quality measures for road traffic

4. Reducing traffic space and increasing biking, pedestrian and greens

SUPERBLOCKS-BARCELONA



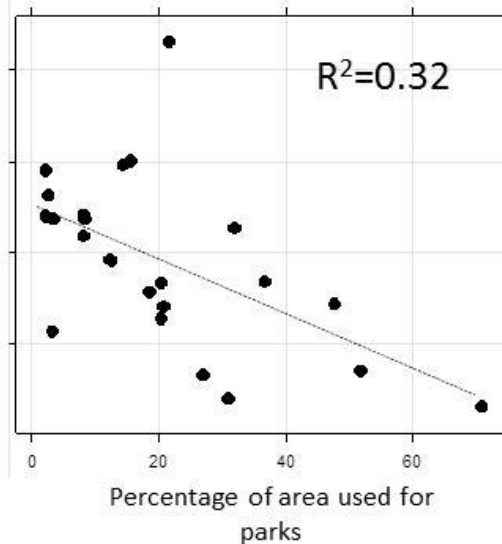
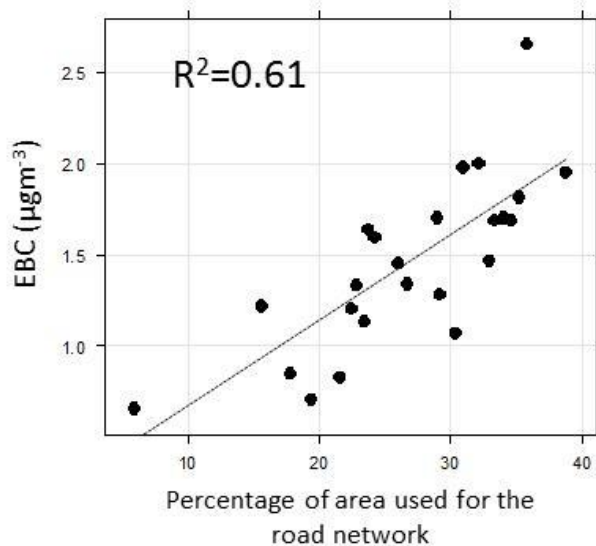


Air quality measures for road traffic

Real-time indoor and outdoor measurements of black carbon at primary schools of Barcelona

Reche et al., 2015.. *Atmos. Environ. Under review.*

A main contribution of road traffic emissions on indoor and outdoor Elemental Black Carbon (EBC) levels was evidenced

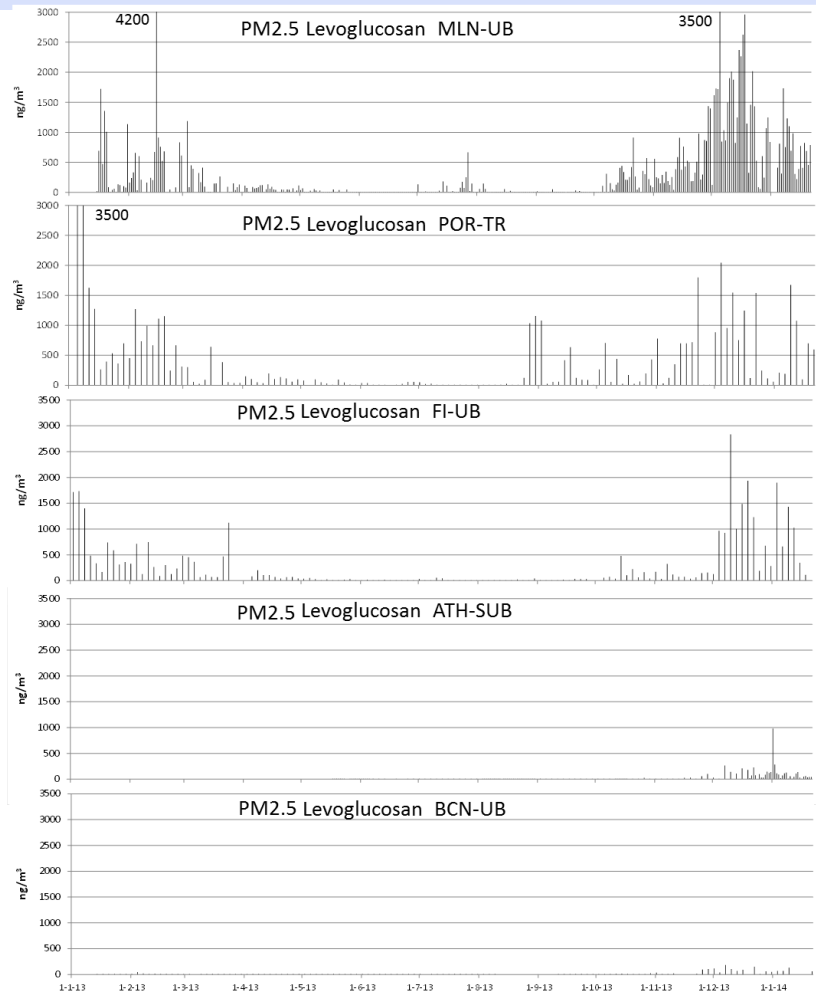


High correlation between average EBC levels at different districts of the city of Barcelona and the percentage of surface area used for the road network

BREATHE



Biomass burning profiles – biofuels and appliances



Biomass burning appliances



1

Traditional brick fireplace



2

Traditional cast iron wood stove



3

Eco-labelled chimney-type wood stove



4

Pellet stove

Biofuels



Cork oak (*Quercus suber*)



Holm oak (*Quercus ilex rotundifolia*)



Pine (*Pinus pinaster*)



Fagus sylvatica



Black poplar (*Populus nigra*)



Portuguese oak (*Quercus faginea*)



Quercus pyrenaica



Olive (*Olea europaea*)



Golden wattle (*Acacia longifolia*)



Eucalypt (*Eucalyptus globulus*)



Briquettes



4 types of pellets



Olive pit



Shell of pine nuts



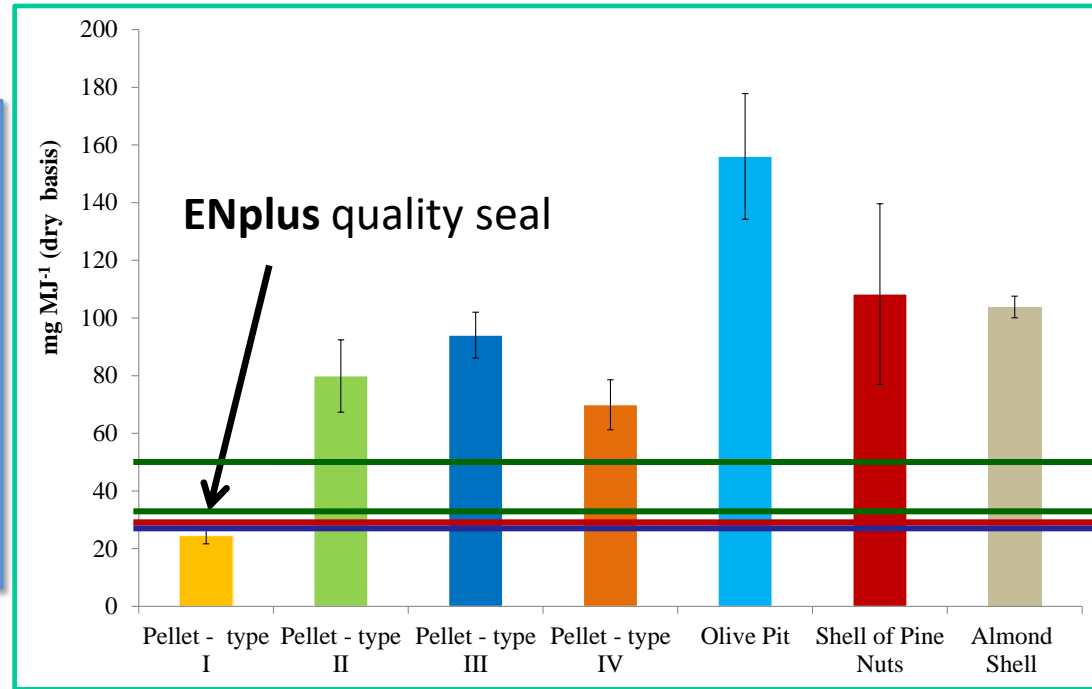
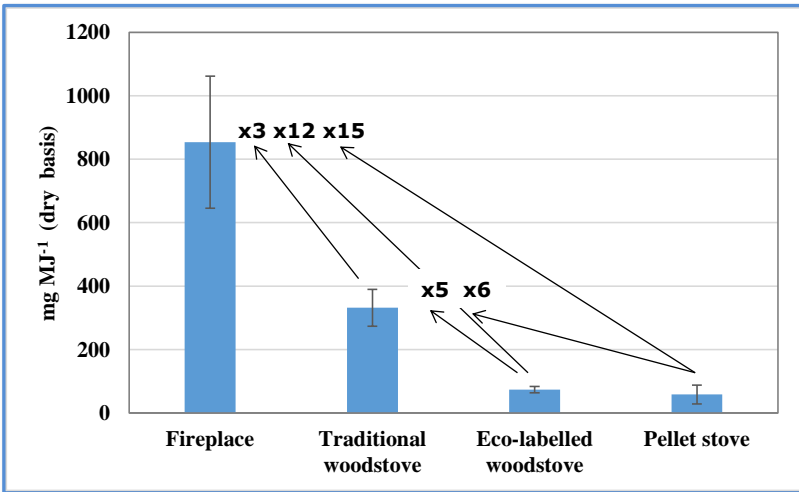
Almond shell

agro-fuels



Biomass burning profiles – biofuels and appliances

PM EMISSION FACTORS



1 kg of biomass = ca. 18 MJ

50 mg MJ⁻¹ in Denmark & Switzerland WITHOUT CONDENSABLES

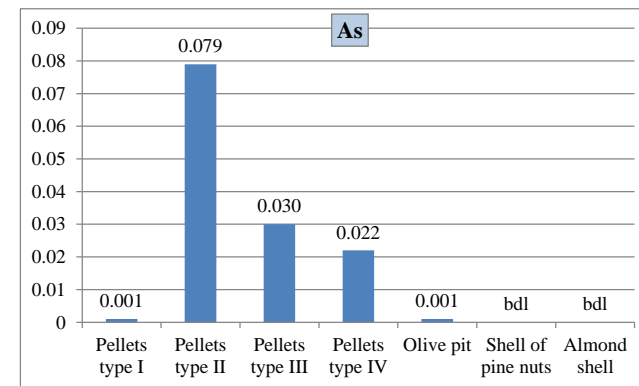
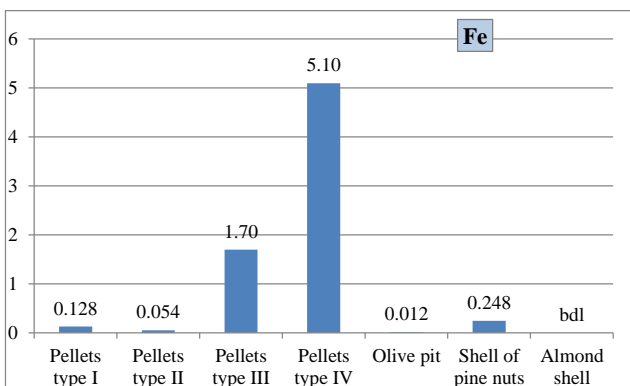
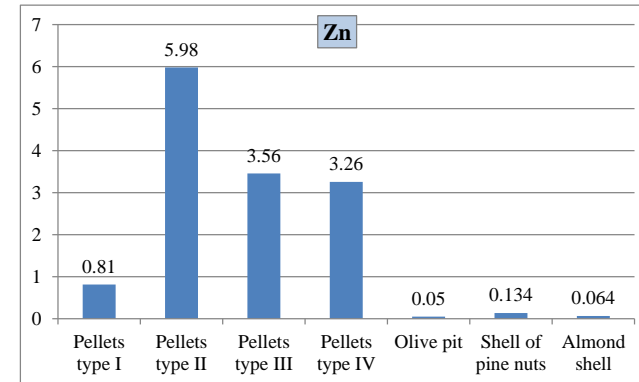
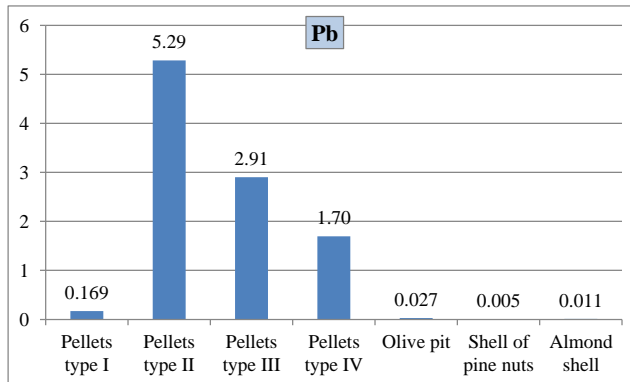
35 mg MJ⁻¹ wood fuels & 25 mg MJ⁻¹ for pellets in Austria WITHOUT CONDENSABLES

27 mg MJ⁻¹ in Germany WITHOUT CONDENSABLES



Biomass burning profiles – biofuels and appliances

PM10 mass fractions of trace elements (wt%)



Standards need to be established in the EU for elemental composition of commercial wood pellets and chips to avoid the inclusion of extraneous materials. Only Germany has standards containing extensive trace element limits.



Biomass burning profiles – biofuels and appliances

Recommendations on biomass burning

- Traditional residential combustion appliances, such as fireplaces and woodstoves, should be replaced by certified equipment rather than installing flue gas depollution technologies
- Emission requirements for the eco-labelling or certification of small-scale combustion appliances must be mandatory in all countries
- The market of firewood sales should be regulated; chemically treated material should not be allowed in any quality class of pellets; all pellets sold at the market must have quality certification
- Also transport and storage should be regulated to control moisture



ACKNOWLEDGEMENTS

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Thank you very much for your attention!!!

<http://airuse.eu>

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