Air4EU

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IER

Emissions & Data Needs

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Review of methodologies and data needed for the generation of emission inventories

An emission inventory which is able to provide accurate emissions with a high resolution in space, time and substances is a prerequisite for the operation of dispersion and chemistry transport models (CTMs). The generation of emission data firstly requires the development of a detailed source inventory that leads to an identification of major sources. Furthermore the generation of emission maps requires a geographic source and emission allocation and the analysis of temporal emission variations. Within AIR4EU, methodologies of emission data generation were reviewed and recommendations were derived how to assess and reduce uncertainties. Results contributed to the project deliverables and were compiled in the Milestone Report 6.4. The focus was on selected issues that are relevant for the AIR4EU scope and priorities:

- Calculation of emissions, spatial and temporal disaggregation (mobile/stationary sources, substantial disaggregation, scenarios, applications, quality assessment, uncertainty analysis)
- Data review for selected topics: PM/benzene from two-wheelers, PM from residential wood combustion, non-exhaust emissions from road traffic, NO_2/NO_x ratio of road traffic emissions

Recommendations for the generation of emission data

Recommendations of good practice for emission modelling were defined on regional/continental, urban/agglomerate and local/hotspot scale. Uncertainties in emission data are strongly related to uncertainties in the source specific input data for emission calculations (activities, emission factors) as well as in the usage/availability of spatial allocation data and temporal profiles. Recommendations for the usage of specific data such as activity rates or literature sources for emission factors are in most cases not reasonable as there is always an individual data choice depending on a review of the current state of knowledge and on national methodologies and data bases. Examples of issues that are addressed:

- **General recommendations:** transparent documentation, archiving, completeness, cross checking, external review, data harmonisation, source categorisation, uncertainty analysis
- **Calculation of annual emissions:** level of detail for key sources, bottom-up versus top-down, scenarios, use of specific/local/industrial information, NMVOC/NO_x/PM speciation
- **Spatial/temporal disaggregation:** distinguish point/area/line sources, use of GIS, industrial data for point sources/ effective emission height, digitised road net for traffic, statistics/land use for area sources, temperature dependence of temporal variation, use of monitoring data for validation/evaluation

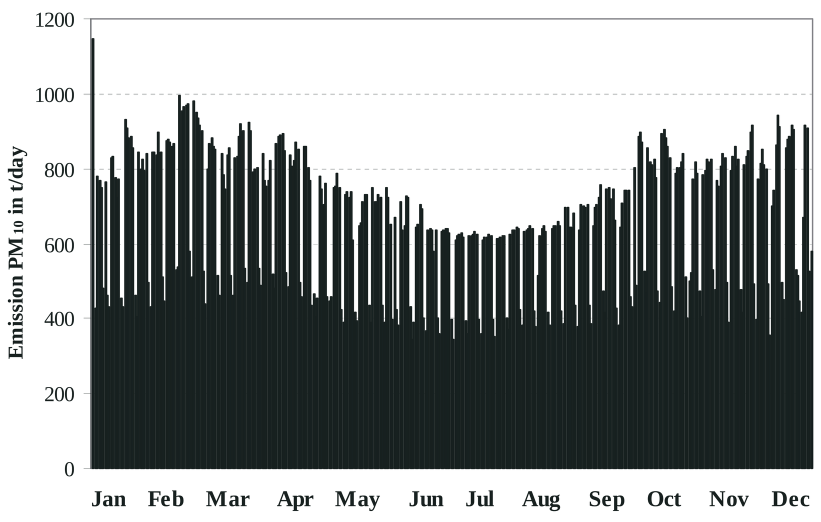

Fig. 1: Example of national emission data in temporal resolution: daily PM_{10} emissions in Germany in the year 2000

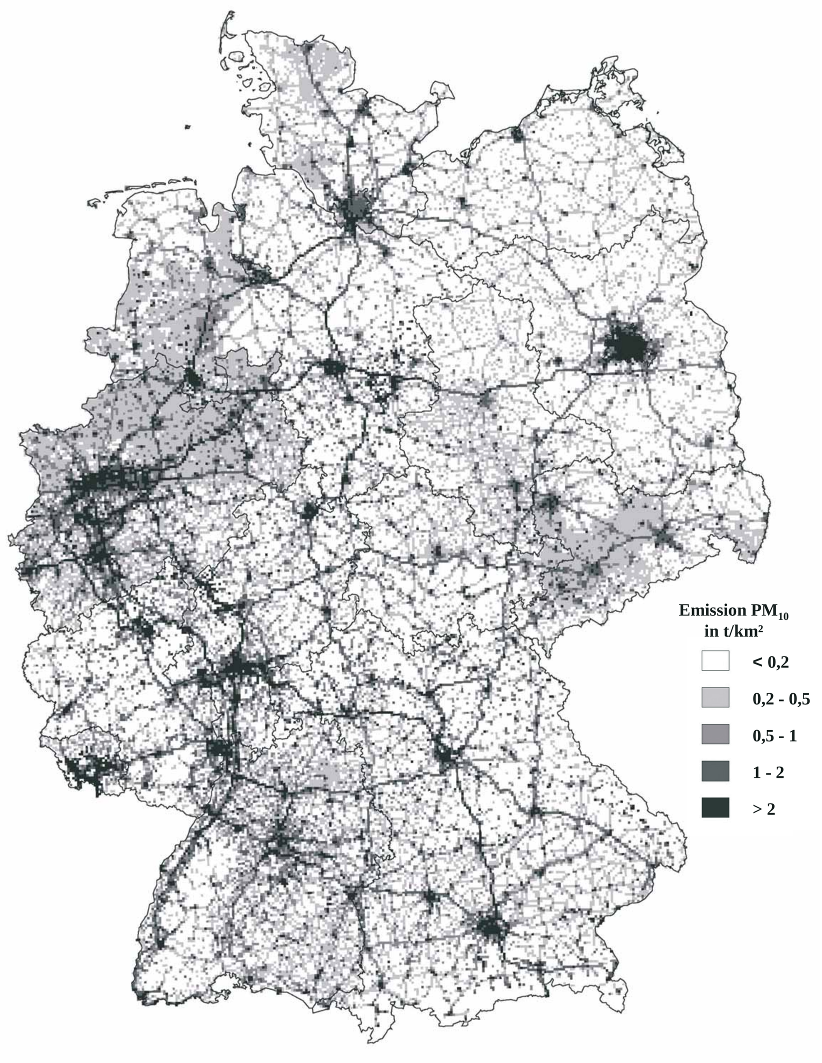

Fig. 2: Example of meso-scale emission data on national scale: annual PM_{10} emissions in Germany in the year 2000 (2 km x 2 km resolution)

Special topics considered in Air4EU

NO_2/NO_x ratio of road traffic emissions

Average NO and NO_x concentrations near roads in Europe decreased during the last decade while NO_2 concentration remained stable or even increased. One reason for this development is an increase of the direct NO_2 emissions. Since the implementation of oxidation catalysts as a standard equipment of diesel passenger cars (PC) and the resulting additional NO oxidation to NO_2, the NO_2/NO_x ratio became higher in the exhaust of diesel vehicles. In addition, numerous buses and other heavy duty vehicles (HDV) were equipped with CRT-systems (diesel particulate filter) generating NO_2 for soot oxidation. Figure 3 shows selected technology specific NO_2/NO_x ratios. For diesel engines without oxidation catalyst or a catalysed PM filter the average NO ratio is usually > 90 %. Engine-out NO_x portion contain typically some 5% of NO_2, but even higher than 20% of NO_2 may exist in raw exhaust at some running conditions. The engine-out NO_2/NO_x ratio depends on the engine design, calibration and the operating conditions (e.g. exhaust temperature, load). Diesel engines have a higher NO_2/NO_x ratio than gasoline engines. The implementation of oxidation catalysts results in NO_2/NO_x ratios of 20%-50%. Even higher values are produced from vehicles equipped with diesel particulate filters, especially the passive regenerating CRT-systems for HDV. The expected combination of diesel particulate filters (CRT or PM cat) with NOx removal (e.g. SCR) - as a result of EURO VI limit values - might reduce NO_2/NO_x ratios to the level of pre-EURO vehicles.

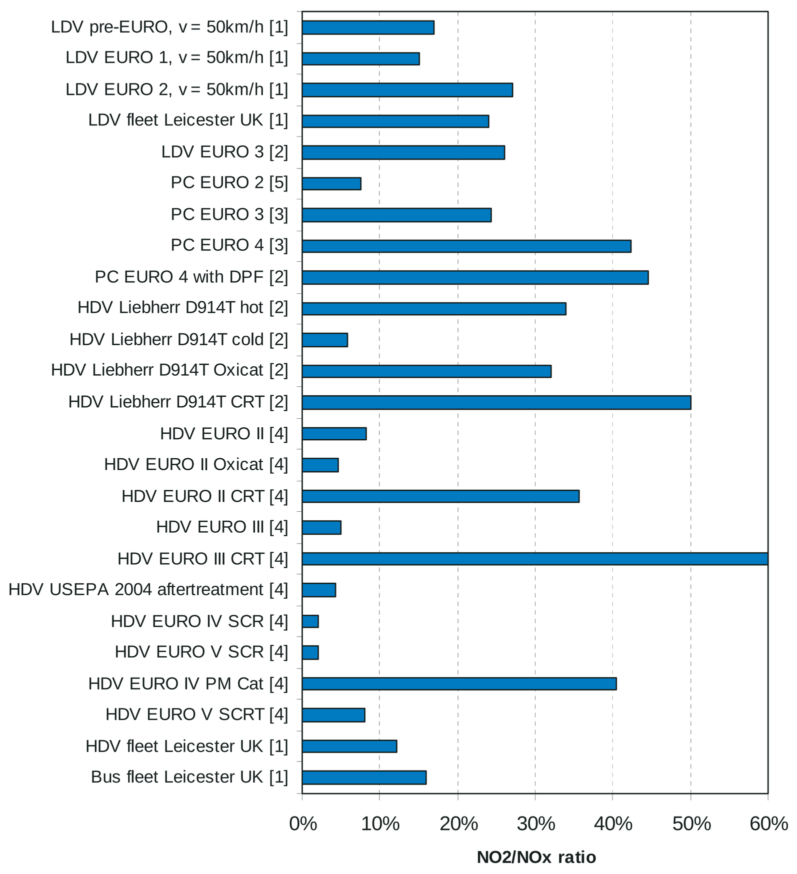

Fig. 3: Measured average source and technology specific NO_2/NO_x ratios for diesel vehicles
[1]: Latham et al. 2001
[2]: Czerwinski et al. 2006
[3]: Petit 2006
[4]: DC 2006
[5]: AQEG 2006

Non-exhaust emissions from road traffic

Non-exhaust emissions from mobile sources are caused by the abrasion of brakes, tyres and road pavement and by the traffic induced suspension of road dust. Suspended particles can have various sources such as atmospheric deposition, dirt from side walks, trees etc. and sand or salt for ice control. Non-exhaust particulate matter mostly has an aerodynamic diameter of at least 1-2 µm as it is mechanically formed (exhaust particles have diameters < 1 µm). In the Air4EU case study „Assessment of non-exhaust PM by road traffic in urban areas“ different approaches were tested for road dust suspension on Magna Grecia road in Rome (Figure 4).

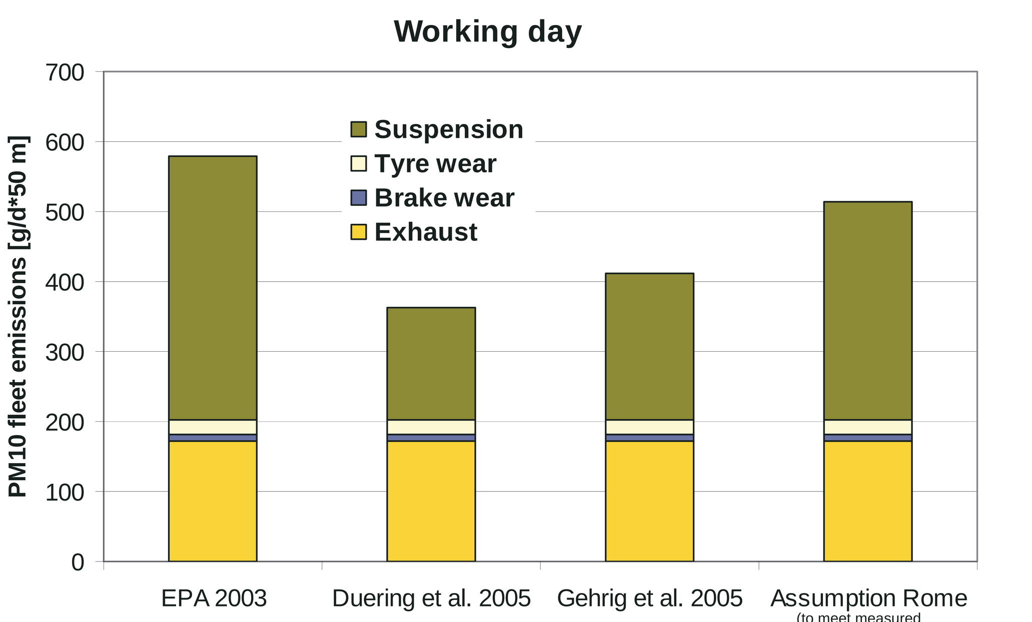

Fig. 4: Calculated PM_{10} emissions from road traffic on Magna Grecia 2003: comparison of different approaches for dust suspension

Tab. 1: Non-exhaust PM_{10} emission factors for road traffic

ROAD CLASS / TRAFFIC SITUATION	VEHICLE CATEGORY	EMISSION FACTOR [g/km] PM_{10}	LITERATURE
road dust suspension:			
urban streets	PC/ LDV	0.030	Hüglin et al. 2000
urban streets	HDV	0.450	Hüglin et al. 2000
urban street (Hornsgatan) in winter	urban fleet	0.209	Johansson 2002
Switzerland, mean value	PC/ LDV	0.031	BUWAL 2001
Switzerland, mean value	HDV	0.475	BUWAL 2001
Switzerland, mean value	motorcycles	0.016	BUWAL 2001
Switzerland, mean value	mopeds	0.008	BUWAL 2001
highways	PC/ LDV	0.082	Fitz & Bufalino 2002
urban streets	PC/ LDV	0.098	Fitz & Bufalino 2002
interstate roads	PC/ LDV	0.129	Fitz & Bufalino 2002
other rural roads	PC/ LDV	0.064	Fitz & Bufalino 2002
tyre and brake wear, road dust suspension:			
urban streets (mean values) Nordic countries	average fleet (4% HDV)	0.205	Omstedt et al. 2005
highways, rural roads	PC/ LDV	0.022	Düring et al. 2005
highways, rural roads	HDV	0.2	Düring et al. 2005
urban streets (mean values)	PC/ LDV	0.05	Düring et al. 2005
urban streets (mean values)	HDV	0.45	Düring et al. 2005
highways, rural roads	PC/ LDV	0.04	Gehrig et al. 2003
highways, rural roads	HDV, coaches	0.2	Gehrig et al. 2003
highways, rural roads	public-transit buses	0.334	Gehrig et al. 2003
urban streets	PC/ LDV	0.054	Gehrig et al. 2003
urban streets	HDV, coaches	0.541	Gehrig et al. 2003
urban streets	public-transit bus	0.438	Gehrig et al. 2003

Emissions from two-wheelers

PTW (powered two-wheelers such as scooters, mopeds and motorcycles) have so far not been playing a dominant role in transportation and have therefore been included only recently in EU-wide emission standards (Euro 1-3). However, in urban traffic their contributions to total emissions are remarkably high. A comparison of Swiss fleet emissions from two wheelers and passenger cars in urban areas (in tons per year) shows that CO and HC emissions caused by PTW are higher by a factor of 2.7 and 16, respectively (Vasic & Weilenmann 2006). Exhaust benzene and PM_{10} emissions were calculated within the Air4EU case study „Assessment of non-exhaust PM by road traffic in urban areas“ for Magna Grecia road in Rome (Figures 5 and 6). Although two wheelers amount to only 20% of the total fleet, their emissions are comparatively high (especially for benzene).

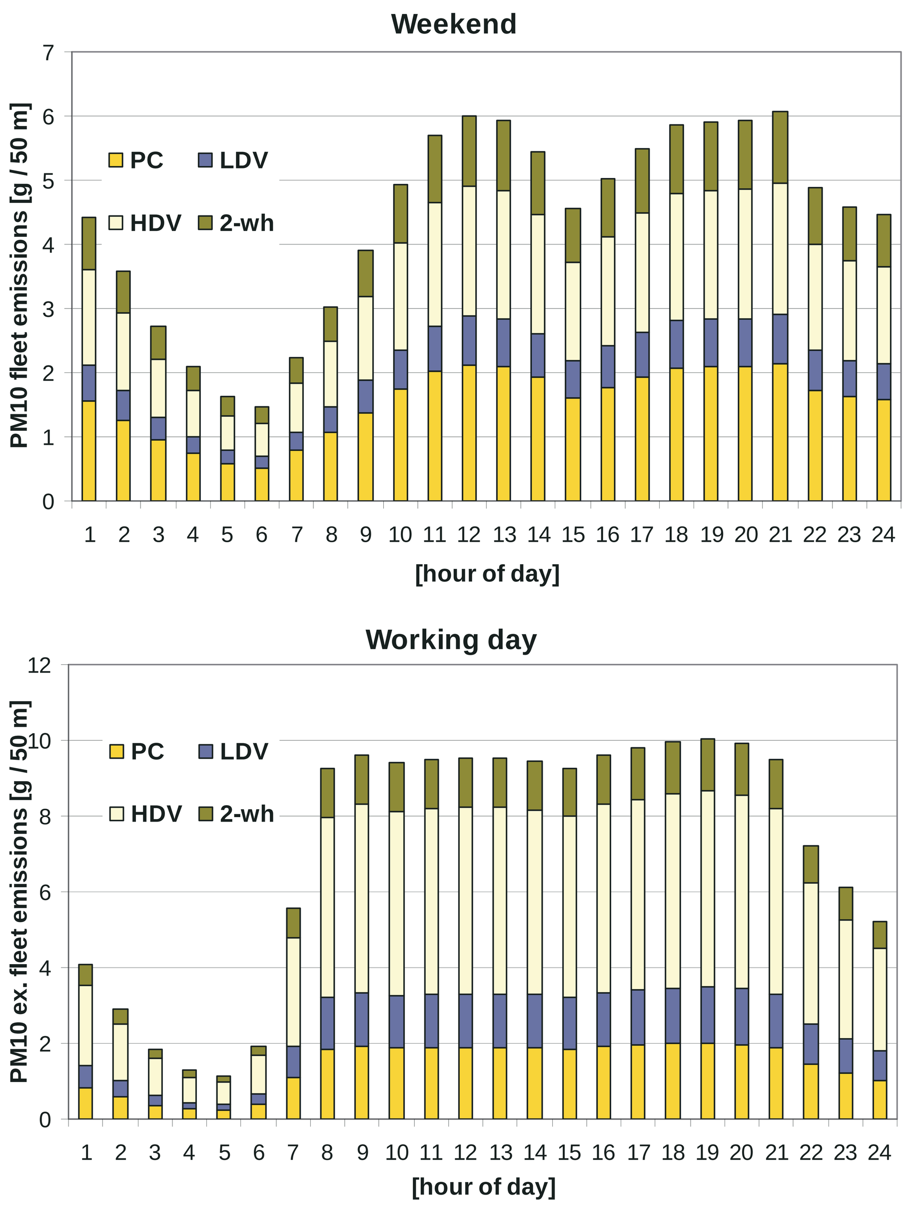

Fig. 5: Calculated PM_{10} emissions from road traffic exhaust on Magna Grecia

PM emissions from residential wood combustion

Wood combustion plays a major role in air quality for large areas in middle and northern Europe. High oil and gas prices will result in an increasing use of wood as alternative fuel. Several recent studies can be found where emission measurement data were analysed and assessed and particle size factors were derived from selective measurements at wood combustion plants. Table 2 shows collected examples of these studies that originate from UK, Switzerland, Austria, Germany and the USA. For an accurate emission calculation the plant inventory and the activity rates have to be determined and representative emission factors have to be derived from available data for single plants.

Tab. 2: PM_x emission factors for residential wood combustion

LITERATURE	YEAR OF REFERENCE	PROCESS	EMISSION FACTOR [kg/TJ] PM	PM10	PM2.5	PM1.0
EPA 1995	1996	open fireplace; dry wood 13 MJ/kg; no flue gas cleaning; measurement from a single fire place	1330	1330		
EPA 1995	1996	conventional wood stove; no flue gas cleaning	1176	1176		
	1996	catalytic wood stoves; combustor/converter	753	753		
	1996	non catalytic stoves; baffles/secondary combustion chamber	784	784		
	1996	pellet stoves; wood/sawdust pellets	250	250		
	1996	masonry heater, dry wood	215	215		
Gullett et al. 2003		woodstove; oak, 22% moisture; no flue gas cleaning	769			
		fireplace; oak, 20-28% moisture; no flue gas cleaning	428			
		fireplace; pine 11% moisture; no flue gas cleaning	215			
		fireplace; artificial log, 1% moisture; no flue gas cleaning	1277			
Fisher et al. 2000		wood stoves (catalytic and non catalytic)	748			
Houck et al. 1997		open fireplace <25 kW; dry wood 13 MJ/kg	907			
Houck et al. 2001		woodstove; wax-sawdust fire log, 3% moisture; no flue gas cleaning	416-708			
Fine et al. 2002	2001	masonry fireplace; yellow poplar, 33% moisture; no flue gas cleaning			667	
	2001	masonry fireplace; mockernut hickory 12% moisture; no flue gas cleaning			472	
	2001	masonry fireplace; soft wood (sweetgum, pine) ;12-14% moisture; no flue gas cleaning			199	
McDonald et al. 2000		woodstove; mixed hardwoods, oak; 10-15% moisture; no flue gas cleaning	247			
		fireplace; softwood (pine) 10% moisture; no flue gas cleaning	379			
		fireplace; hardwood (oak, mix) 15% moisture; no flue gas cleaning	407			
Spitzer et al. 1998	1997/98	various measurements at wood stoves in Austria, no flue gas cleaning	90 - 148			
Baumbach et al. 1999	1999	wood stove, 9 kW; log (beech, fir), briquettes	44 (31-56)	43	41	39
	1999	chimney stove, 6 kW; log (beech)	67	66	65	60
	1999	pellet stove, 8.5 kW; pellets, softwood	11	11	11	10
	1999	average value of measurements	46	45	43	41
Struschka et al. 2003	2000	slow-combustion stoves, tiled stoves, chimneys, bathroom boilers (<15 kW), untreated wood	102	101	98	94
	2000	boiler: 4-25 KW; untreated wood	23	22	18	17
	2000	boiler: 25-50 KW, untreated wood	175	162	138	124
	2000	average values for wood combustion in small residential plants in Germany (source inventory)	116	112	104	98
Wieser & Gaegauf 2000	2000	batch, space heating; log 16% moisture	28 (18-38)			
	2000	storage heater (soapstone), wood 16% moisture	96			90
	2000	automatic pellet stove, wood 8% moisture	21			10
	2000	automatic chip stove (stoker), wood 60% moisture	135			26
Wieser 2001	2001	chimney stove, 6-7 kW; log (beech) 16-20 % moisture	24.5-111			
	2001	storage heater (soapstone), 6-3 kW, log (beech) 16-20% moisture	93-241			
	2001	boiler, 25-70 kW, log (beech – softwood 20% moisture)	16-39			
	2001	pellet stove 12 kW, wood 8% moisture	54			
	2001	pellet boiler, 16 - 25 kW, wood 8% moisture	20			
	2001	underfeed stoker (dry wood chips), 70 kW; wood chips 60% moisture	79			
	2001	underfeed stoker (dry wood chips), 120 kW; dry chips 35% moisture	109			
	2001	advancing grate furnace, 325 - 800 kW; wood chips 60% moisture	42-55			
	2001	dual-chamber furnace, 200 kW; wood waste (joiner's workshop) 10% moisture	64			
Purvis et al. 2001	2001	wood stove conventional, log (oak) 34.2% moisture	757 (457-1140)	88	79	
	2001	wood stove conventional, log (fir), 22-30% moisture	508 (282-734)	81	63	
	2001	wood stove modern, log(oak) 34.2 % moisture; secondary air	514	81	66	
AEAT 2004	2001	open fireplace <25 kW, wood	750	707		
	2003	advanced closed fireplace <25 kW, wood	310	295	288	
	2003	conventional stoves <25 kW, wood	310-400	223	194	
	2003	modern low emission stoves <25 kW, wood/pellets	30 (4-65)	23	14	
	2003	conventional manual feed boiler <50 kW, wood	250	229		
	2004	modern low emission boilers <50 kW, wood/pellets	34 (20-43)	34	27	
	2004	conventional manual feed boiler 50-1000 kW, wood	180	180	150	
	2004	modern auto- feed boiler 50-1000 kW, wood/pellets	32- 43	38		
	2004	large boiler 1-50 MW, wood, with abatement plant	2	2		
DMU 2006	2004	wood combustion in Denmark	715	679	643	

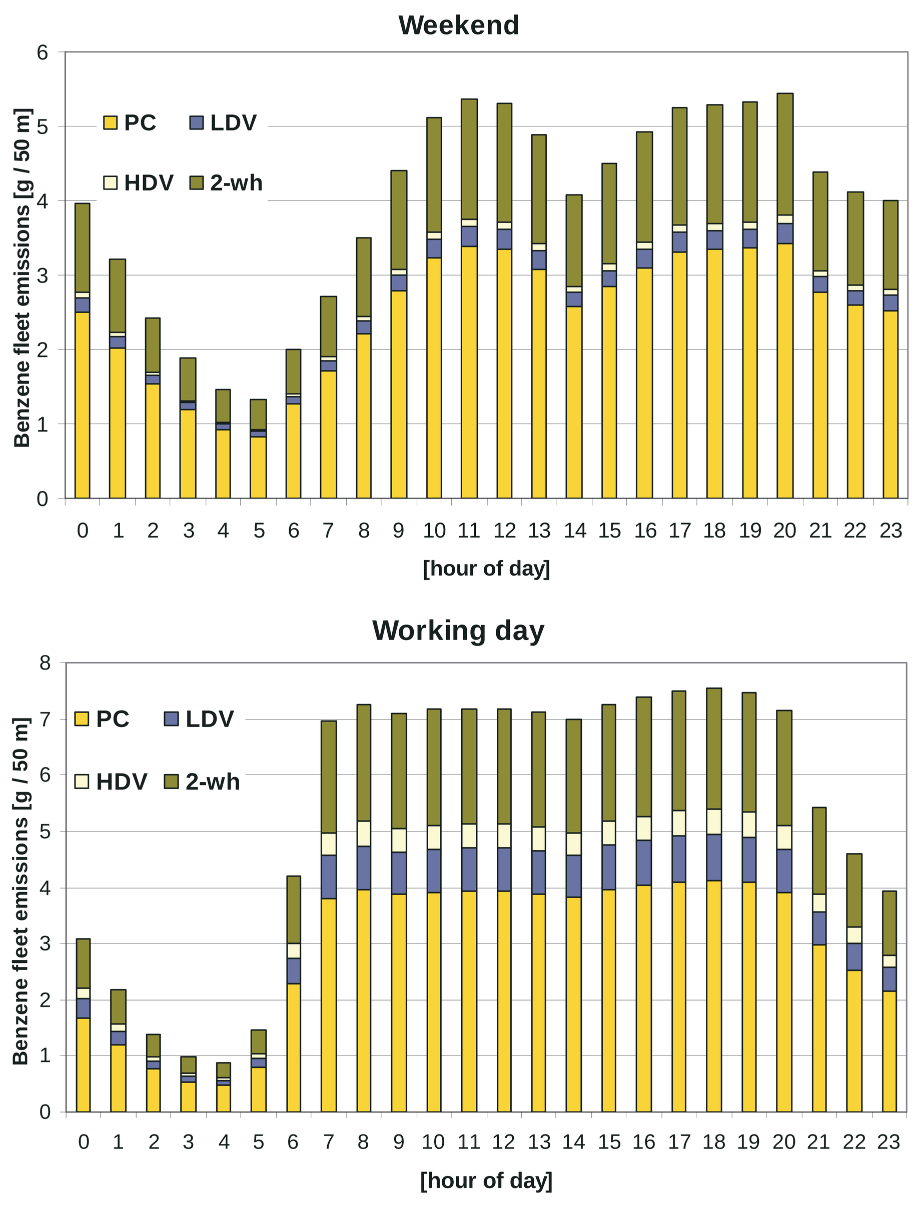

Fig. 6: Calculated benzene emissions from road traffic exhaust on Magna Grecia

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