Methodologies for the Compilation of the Emission Inventories within APICE

A. Presentation of the Methodologies for Each Study Area

A.1 Barcelona

A.2 Genoa

A.3 Marseille

A.4 Thessaloniki

A.4.1 Short Description of the Methodologies for the Estimation of Emissions for all Source Sectors except for the Maritime Sector

The emission inventory for the greater Thessaloniki area includes 28 different anthropogenic activities, the emissions of which were either derived from existing national emission databases (e.g. for the industrial sector) and international emission databases (e.g. the distribution of fossil fuels sector emissions were taken from The Netherlands Organisation (TNO) database (Visschedijk et al., 2007)) or quantified using mainly the methodologies and emission factors of the EMEP/CORINAIR emission inventory handbook (EEA, 2006). The following list describes the basic statistical quantities and emission factors which were used for the determination of the pollutant emission fluxes for the anthropogenic activities for which activity information were available and as a result the calculation of emissions was possible. Emissions have been quantified using the anthropogenic emission model MOSESS (MOdel for the Spatial and tEmporal diStribution of emissionS) that has been developed by the Laboratory of Atmospheric Physics of the Physics Department of the Aristotle University of Thessaloniki (Markakis et al., 2011).

Central heating

The annual consumed quantities of wood, oil and gas fuels were used. The emission factors were differentiated to account for the combustion type e.g. fireplaces/stoves, single house boilers and medium size boilers.

Solvent and other product use

Glues and adhesives, domestic use of solvents: Population statistics multiplied with per capita emission factors.

Painting applications: The annual consumed quantities of paint in 4 different painting activities were used. Emission factors correspond to the emission of pollutant per mass of paint used. For wood coating operations the total area of wood coated in annual basis was used (emission factors are given per unit area coated). For vehicle painting the total area of small, medium and large cars was used. Emission factors correspond to the emission of pollutant per unit area of the painted cars.

Metal degreasing: The annual consumed quantities of solvent were used. Emission factors correspond to the emission of pollutant per mass of solvent used in the metal degreasing units.

Dry cleaning: The annual mass quantities of material cleaned in the dry cleaning units were used. Emission factors were differentiated to account for the cleaning machinery/method used and they correspond to the emission of pollutant per mass of material cleaned.

Foam processing: The annual consumed quantities of EPS blowing agent were used. Emission factors correspond to the emission of pollutant per mass of agent used in the foam processing units.

Printing: The annual quantities of ink consumed in 5 different activities of the printing industry were used. Emission factors were differentiated to account for the printing technique implemented and they correspond to the emission of pollutant per mass of ink consumed.

Oil extraction: The annual quantities of oil seeds processed were used. Emission factors correspond to the emission of pollutant per mass of oil seeds used.

Car dewaxing: The number of cars dewaxed after storage/transport was used. Emission factors correspond to the emission of pollutant per car dewaxed.

Wood preservation: The annual quantities of wood preserved were used. Emission factors correspond to the emission of pollutant per mass of wood preserved.

Road transport

The emissions were calculated using the annual registered fleet of cars, trucks, busses and 2-wheelers in the area. The annual mileage driven for those vehicles per driving mode, engine type and technology as well as the circulating speed per driving mode were also available (emission factors were calculated from those speed values). Emissions for the non-exhaust part as well as the evaporative emissions of NMVOCs were also calculated using the same statistics.

Non-road transport

Aviation: The annual quantities of jet-fuel for domestic and international flights and the LTOs per aircraft type were used. Emission factors correspond to the emission of pollutant per mass of fuel consumed. Emissions for LTO operations and the cruising mode of aircrafts were determined.

Agricultural/industrial/forestry/household machineries, railway transport: The registered fleet of machinery/vehicles per fuel type (gasoline or diesel) was used. The split in engine technology, engine power output and the annual hours of operation was also available. Emission factors correspond to the emission of pollutant per KWh of engine power output.

Waste treatment and disposal

Municipal waste, agricultural waste: The annual quantities of waste processed/burned were used. Emission factors correspond to the emission of pollutant per mass of waste processed/burned.

Agriculture

Manure management, grazing: The numbers of 7 different animal types were used. Emission factors correspond to the emission of pollutant per animal.

Animal husbandry: The numbers of 5 different animal types and the proportion of annual time that the animals spend in housing environment were used. Emission factors correspond to the emission of pollutant per animal.

Fertilizer application: The annual quantities of 10 different fertilizer types were used. Emission factors correspond to the emission of pollutant per mass of fertilizer used.

Legumes cultivation: The area of legumes cultivation was used. Emission factors correspond to the emission of pollutant per unit area of cultivation.

Natural emissions

The emissions originating from natural sources were calculated with the use of the emission model namely NEMO (Natural Emission MOdel) that has been developed by the Laboratory of Atmospheric Physics of the Physics Department of the Aristotle University of Thessaloniki (Markakis et al., 2009). Wind erosion dust, sea salt and biogenic NMVOCs emissions can be calculated using the WRF model meteorology. The methodology of the NATAIR project (NATAIR, 2007) is implemented for the calculation of wind erosion dust emissions employing the high resolution landcover database of USGS and the soil texture maps compiled specifically for this purpose (Webb et al., 2000). Sea salt emissions are calculated based on the original formulas of Monahan et al., 1986 and Martensson et al., 2003 modified by the researchers of the Finish Meteorological Institute (Dr. Mikhail Sofiev, personal communication). The methodology described in Poupkou et al., 2010 is implemented for the calculation of biogenic isoprene, monoterpenes and other VOCs biogenic emissions.

A.4.2 Description of the Methodologies for the Estimation of Emissions for the Maritime Sector

Inland waterways vessels

To calculate the emissions following equation was used:

$$E_{i,j} = F_j * HP_j * HRS_j * LF_j * EF_{i,j} * DF_j$$

where: E is the emission of the pollutant i and engine horsepower j, F is the registered fleet of vessels per horsepower class j, HP is the representative horsepower of the class j (in KW), HRS is the annual hours of operation of the vessel of horsepower j (in hours) and LF is the loading factor of the vessel of horsepower j (dimensionless). The emissions factor (EF_j) corresponds to the emission of pollutant i per KWh of horsepower of class j. Finally the DF_i is the age degradation factor which is calculated from a representative age value (in years) of each vessel of horsepower j.

Fish catching ships

To calculate the emissions the following equation was used:

$$E_i = F * C * T * EF_i$$

Where: E is the emission of the pollutant i, F is the registered fleet of vessels, T is the annual operating time of the vessel (in days). The emissions factor (EF_i) corresponds to the emission of pollutant i per mass of consumed fuel. The consumption of fuel is calculated from the provided gross tonnage of the vessels based on the relevant equations of the EMEP/CORINAIR handbook for fish catching ships.

Passenger ships

To calculate the emissions the following equation was used:

$$E_i = F * C * (D/SPD) * EF_i$$

Where: E is the emission of the pollutant i, F is the registered fleet of vessels, SPD is the representative speed of the vessel (in knots) and D is the distance cruised (in Km). The emissions factor (EF_i) corresponds to the emission of pollutant i per mass of consumed fuel. The consumption of fuel is calculated from the provided gross tonnage of the vessels based on the relevant equations of the EMEP/CORINAIR handbook for passenger ships.

Cargo shipping

To calculate the emissions 2 different methodologies were used. For the determination of PM and NH3 the following equation was used:

$$E_{i,j} = F_j * C_j * (D/SPD_j) * ET * EF_{i,j}$$

Where: E is the emission of the pollutant i of vessel type j, F is the registered fleet of vessel type j, SPD is the representative speed of the vessel type j (in knots) and D is the distance cruised (in Km). The emission factor ($EF_{i,j}$) corresponds to the emission of pollutant i per mass of consumed fuel of vessel type j. The consumption of fuel is calculated from the provided gross tonnage of the vessels based on the relevant equations of the EMEP/CORINAIR handbook for cargo ships. ET is the proportion of the fleet equipped with slow or medium speed engine.

For the remaining pollutants the equation used was:

$$E_{i,j} = F_j * (D/SPD_j) * ET * EF_{i.j}$$

Where: E is the emission of the pollutant i of vessel type j, F is the registered fleet of vessel type j, SPD is the representative speed of the vessel type j (in knots) and D is the distance cruised (in Km). The emissions factor ($EF_{j,j}$) is expressed in mass of pollutant i per operating time and it is calculated from relevant equations which include the engine power output of the vessel type j and the number of engines. ET is the proportion of the fleet equipped with slow or medium speed engine.

Harbor operations

To calculate the emissions the following equation was used:

$$E_{i,j} = Q * EF_{i,j}$$

Where: E is the emission of particles of material i handled in operation j (loading/unloading/storage) and Q is the quantities of material i in each operation j. The emission factor ($EF_{j,j}$) is expressed in mass of pollutant per mass of material i handled in operation j and it is a function of the relative humidity of the material i.

A.4.3 Anthropogenic Emission Inventory Results for Thessaloniki

The emission inventory results are presented in details in the Annex 4. Following, the most important emission sources are shown and the contribution of the maritime sector to the total emissions in Thessaloniki is identified.

For Thessaloniki, the three most important anthropogenic emission source sectors per pollutant are the following (results refer to a domain size of 100km x 100km with spatial resolution of 2km x 2km and reference year 2008) (Figure 4.1):

CO: 1) Road transport (62%), 2) Central heating (21.5%) and 3) Non-road transport (without ship/harbor activities) (9.8%).

NOx: 1) Road transport (36.2%), 2) Non-road transport (without ship/harbor activities) (32.9%) and 3) Ship/Harbor activities (20.7%).

SO2: 1) Industries (56.6%), 2) Ship/Harbor activities (35.6%) and 3) Extraction and distribution of fossil fuels and geothermal energy (7.3%).

NH3: 1) Agriculture (80%), 2) Road transport (16.5%) and 3) Waste treatment and disposal (2.5%).

NMVOCs: 1) Solvent use (34.4%), 2) Road transport (26%) and 3) Extraction and distribution of fossil fuels and geothermal energy (15.9%).

PM10: 1) Industries (55%), 2) Central heating (16.7%) and 3) Non-road transport (without ship/harbor activities) (11.5%).

PM2.5: 1) Industries (46.8%), 2) Central heating (21.8%) and 3) Non-road transport (without ship/harbor activities) (11.5%).

Focusing on the maritime sector (ship and harbor activities) being a key emission source sector within APICE, the percentage contribution to total anthropogenic emissions is 1.3% for CO, 20.7% for NOx, 35.6% for SOx, 0.5% for NMVOCs, 1.2% for PM10 and 1.3% for PM2.5.

Figure 4.1. Anthropogenic source sectoral contribution to pollutant emissions.

Figure 4.1 (*continuation*).

A.5 Venice

A.5.1 Short Description of the Methodologies for the Estimation of Emissions for all Source Sectors except for the Maritime Sector

The Veneto Region emission inventory is based on INEMAR (INventario di EMissioni in ARia - Air Emission Inventory) which is a database developed by a consortium of Italian Regions leaded by the Lombardy Region (Caserini et al., 2002 and Caserini et al., 2005). It is partially established using a bottom-up approach (industrial point sources, airports and harbours), and partially based on activity indicators and emission factors. The level of resolution of the data is the municipality and the emissions are available by SNAP activity and fuel.
INEMAR is mostly based on the CORINAIR methodology. The emission factors used are frequently taken from the CORINAIR Guidebook, however when specific surveys are available at local level the latter are preferred. PM10 and PM2.5 emissions are derived by granulometric distribution at SNAP activity from TSP emissions.
A short description of the estimation methodology applied to the 11 CORINAIR SNAP Sectors is presented in the following paragraphs. A more detailed description of methodology and emission factor used for ships and harbour activities is presented in a specific paragraph below.

Sector 1: Energy production

This sector is completely covered by point sources, for which emission data are given as stack emission measurements performed by ARPAV and/or by IPPC emission permits.

Sector 2: Central heating

These are area source emissions estimated using emission factors based on residential fuel consumptions . Data related to fossil fuels are provided by the Italian ministry of economic development as statistical reports on natural gas distributed and sales of gas oil, fuel oil and LPG at provincial level. For wood consumption has been used the results of a survey at regional level commissioned by ISPRA/ARPA Lombardy.

Sectors 3 and 4:Industries.

Emissions for these sectors are considered partially as point sources (in analogy to Sector 1) and partially as area sources estimated from emission factors. For the Sector 3 when measures aren't available, fuel consumption indicators are used, whereas for Sector 4 the emission factors principally used are based on throughput indicators.

Sector 5: Extraction and distribution of fossil fuels & geothermal energy

This sector is completely estimated as area sources, using different activity indicators, mainly regarding the losses from the natural gas distribution network and from the evaporative emissions by petrol stations.

Sector 6: Solvent and other product use

Also this sector is treated as area sources, and the emission factors are connected with the consumption of solvents. The reconstruction of this amount at local level is derived from the national total of solvents produced in reference year downloadable from the EUROSTAT Prodcom statistics. It is obtained as budget among production, import and export of paints and other products containing solvents. This consumption is downscaled using the ratio between the number of employees, at local and national level, taking into account only the SNAP activities connected to use of solvents.

Sector 7: Road transport

This is the only Sector not estimated by INEMAR but following a top-down approach by distributing at local level national emissions by means of surrogated spatial datasets (population, car fleet characterization, road network design).

Sector 8. Non-road transport

This sector comprehends harbours, airports and off road transport emissions. The methodology used for harbour emissions is described below in more detail.
For airports the detailed methodology of CORINAIR Guidebook has been followed starting from the aircraft traffic data for the three major Veneto Region airports (among them Venice airport)
The off-road emissions are calculated from fuel consumption of machines in agriculture and forestry and trains diesel fuelled; the statistics of consumptions have been collected from the Regional Agency for Agricultural Payments (AVEPA) and Trenitalia (the Italian railway company).

Sector 9: Waste treatment and disposal

The emissions are derived in a bottom up approach starting from a census of landfills and incinerators (some of which are treated as point sources with measured data). Landfills emissions are relevant mainly for GHGs.

Sector 10: Agriculture

This sector is relevant mainly for ammonia emissions; for this pollutant the most important contribution comes from animal husbandry and manure management. The emission factors for this subsector (10.09) are taken from EMEP/CORINAIR and IPCC methodology customized on the Italian reality of animal husbandry. Regarding the agriculture, the emissions from cultures with fertilisers are estimated using the national statistical institute (ISTAT) on utilised agricultural area (hectares) and the amount of fertilisers annually used. This estimation complies with EMEP/CORINAIR too. PM10 emissions coming from animal husbandry are based on the RAINS project (IIASA 2001) and on a study carried out by the University of Milan.

Sector 11. Natural emissions

In INEMAR this sector comprehends biogenic NMVOC and GHGs emissions, and other natural minor relevant emission activities (wild fire, pyrotechnics and smoke). For the APICE project purposes the natural emissions, other than the INEMAR estimations, specific processors for the estimation of sea-salt and windblown dust have been implemented. The methodologies used for the biogenic emissions considered are:

- NMVOC from forests and crops : the method implemented in INEMAR estimates the emissions of isoprene, monoterpens and other VOC (sequiterpens and oxygenated VOC), basing on the emission factors and the algorithms described in M. Karl et al., 2009, which starts from EMEP/CORINAIR methodology.
- Sea salt: the processor used implement the methodology described in Gong, 2003 and Monaghan et al., 1986. This is the same methodology used in the NATAIR project, and described in the final report http://natair.ier.uni-stuttgart.de/dataandpublicationsr.html .
- Windblown dust: the processor had been build following the NATAIR project methodology.

A.5.2 Description of the Methodologies for the Estimation of Emissions for the Maritime Sector

Harbour emissions for the Venetian study area takes account of both the huge Venice harbor and the smallest harbour of the near city of Chioggia.

For both the harbours, pollutant emissions are estimated only for shipping activities, whereas, since a lack of detailed activity data required, other harbour emissions (freight loading and unloading, handling equipments) are not considered.

The shipping activities emissions are referred for both Venice and Chioggia harbours to the calendar year 2008.
The two estimates were built up slightly differently due to a dissimilar availability of data activities provided by the two different Port Authorities.
As for the Venice harbour, shipping emissions derive by a bottom up estimation conducted by ARPAV-DAP VE in 2007 (ARPAV, 2007. By Rosa et al.) and related to year 2005. Ship movements during the whole year 2005 were supplied by Venice Port Authority, as well as the classification of every single ship on a restricted number of typologies. This classification allowed to apply a derived MEET methodology (Trozzi and Vaccaro, 1998) for ship emissions quantification starting from a restrict number emissions factors for ship typologies and operational phases such as cruising, hotelling, manuevering (EC, 2002).
Within APICE implementation, the 2005 bottom up estimation has been updated using the ship movements 2008 to 2005 ratio as coefficient of variation.
For Chioggia harbour, shipping emissions have been directly calculated applying the derived MEET methodology (Trozzi and Vaccaro, 1998) using ship movements referring to calendar year 2008.
Following a more detailed description of the algorithms applied, derived from the MEET methodology but using Emission Factors by European Commission (EC, 2002).
In the detailed MEET methodology (Trozzi and Vaccaro, 1998, chapter 3), the ships emissions are obtained as:

(eq. 1)

with:

i	pollutant (NOx, SOx, CO, VOC, PM, CO2);
j	fuel (Bunker fuel oil, Marine diesel oil, Marine gas oil, Gasoline fuel);
k	ship class for use in consumption classification (Solid Bulk, Liquid Bulk, General Cargo, Container, Passenger/Ro-Ro/Cargo, Passenger, High speed ferries, Inland Cargo, Sail ships, Tugs, Fishing, Other);
l	engines type class for use in emission factors characterization (Steam turbines, High speed motor engines, Medium speed motor engines, Slow speed motor engines, Inboard engines, Outboard engines, Tanker loading and offloading);
m	Operating mode (Cruising, Maneuvering, Hotelling, Tanker offloading, Auxiliary generators);
E_i	total emissions of pollutant I;
E_{ijklm}	total emissions of pollutant i from use of fuel j on ship class k with engines type l in mode m;
$S_{jkm}(GT)$	daily consumption of fuel j in ship class k in mode m as a function of gross tonnage (GT);
t_{jklm}	days operating of ships of class k with engines type l using fuel j in mode m;
F_{ijlm}	average emission factors of pollutant i from fuel j in engines type l in mode m (for SOx, taking into account average sulfur content of fuel)

And where the daily consumption of fuel is calculated as:

(eq. 2)

with:

C_{jk} (GT)	daily consumption at full power of fuel j in ship class k as a function of gross tonnage (GT);
p_m	fraction of maximum fuel consumption in mode m (see table 1)

Tab.1. Fraction of maximum fuel consumption in different mode (Trozzi and Vaccaro, 1998)

For the daily consumption of fuel at full power C_{jk} functions are listed in the MEET Report with the generic formula:

$$C_{j,k} = a_{j,k} + b_{j,k} \cdot GT$$

(eq. 3)

with a and b empirical coefficients explicitly listed in the MEET Report.
Emission Factors, to be used in eq. 1, are provided for the different engines types and fuels as well as operating mode in the MEET Report, too.
Starting from the ship movements databases provided by the Port Authorities, reporting the name of every ship entering the harbour during the year as well as the hour and the day of its arrival and departure, its gross tonnage and typology, the fuel consumptions were estimated using equation 3 and 2.
Since in the ship movements databases there was no data on fuel type and engine type, for the calculation of total emission rather than eq. 1 and the MEET Emission Factors depending on fuel, the simpler following equation was used:

$$E_{ikm} = S_{km}(GT) \cdot t_{km} \cdot F_{ikm}$$

(eq. 4)

where average emission factors F_{ikm} of pollutant i in ship class k and in mode m don't depend on fuel typology and engine type.
The necessary Emission Factors without the dependency on fuel were found in the study conducted by Entec UK Ltd on behalf of the European Commission: "Quantification of emissions from ships associated with ship movements between ports in the European Community" (EC, 2002). Since the European Commission document doesn't report any emission factor for CO, for this pollutant was used the value reported in EMEP/CORINAIR Emission Inventory guidebook 2006 (EEA, 2006).
The weighted emission factors obtained combining fuel and engine type are reported as range values in tables 3 and 4.
The Venetian Harbour emission inventory counted also tug boat emissions, using the same MEET derived methodology with the specific EC, 2002 emission factors (ship type: "B32 Towing/Pushing") and the assumption that every ship with Gross Tonnage over 2000 or 1200 thousands (depending on the access to the lagoon: "bocca di Lido" or "Malamocco" respectively) is assisted by a tug boat in the manoeuvring phase.
As a latest specification on Venetian application of ship emission calculation, there's to report that, since Venice and Chioggia harbours are both inside the Venice Lagoon and since the application of the emission estimation is limited to the area inside the lagoon, the Emission Factors used were only those of hotelling and manoeuvring mode, emission factor "at sea" were not taken into consideration at the moment.

A.5.3 Anthropogenic Emission Inventory Results for Venice

The emission inventory results are presented in details in the Annex 5. Following, the most important emission sources are shown and the contribution of the maritime sector to the total emissions in Venice is identified.
For comparison among pilot areas purposes, in the following are presented the total amount of emissions in a 100x100 km^2 area, centered on the Venice harbour (see figure 5.1). The results are displayed in form of tables, pie charts and maps.

Figure 5.1 : Veneto Region Domain

The Veneto Region territory, and particularly the plane area, is characterized by an continue urbanization, spread over a country with a rural connotation and with a fairly dense network of small and medium-sized firms. In this contest, the Venice area is peculiar for the high concentration of relevant anthropogenic sources: the most important industrial site of Veneto, Porto Marghera, in which are located coal and gas fuelled power plants, the oil refinery and relevant chemical industries; the commercial and tourist Venice harbour; the major airport of Veneto; the more busy highways connections; the most populate municipally of Veneto. Therefore, regarding the subdomain of 100x100 km^2, other than road transport and domestic heating emissions (especially for NOx, PM and CO), also energy production, ships and harbour activities and industries (SO2, NOx) play an important role, as is showed in the bar diagrams in Figure 5.2. The total amount of anthropogenic emissions for the seven major pollutant in Ktones is reported in the Annex 5.

For Venice, the three most important anthropogenic emission source sectors per pollutant are the following (results refer to a domain size of 100km x 100km with spatial resolution of 2km x 2km and reference year 2008) (Figure 5.3):

NOx: 1) Road transport (45.5%), 2) Industries (16.4%) and 3) Energy production (11.2%).
CO: 1) Central heating (47.2%), 2) Road transport (43.9%), and 3) Industries (4.8%).
SO2: 1) Energy production (46.5%), 2) Ship/Harbor activities (25.2%) and 3) Industries (19.8%).
NMVOCs: 1) Solvent and other product use (54.4%), 2) Road transport (18.5%) and 3) Central Heating (18.3%).
NH3: 1) Agriculture (97.7%), 2) Road transport (1.8%) and 3) Central heating (0.4%).
PM10: 1) Central heating (38.5%), Road transport (24.5%), and 3) Non-road transport (without ship/harbor activities) (11.3%).
PM2.5: 1) Central heating (41.5%), Road transport (24.9%), and 3) Non-road transport (without ship/harbor activities) (12.6%).

Focusing on the maritime sector (ship and harbor activities) being a key emission source sector within APICE, the percentage contribution to total anthropogenic emissions is 0.3% for CO, 6.4% for NOx, 25.2% for SOx, 0.4% for NMVOCs, 7.1% for PM10 and 8.2% for PM2.5.

Figure 5.2: Anthropogenic Emission by Sector

Figure 5.3: Pie chart of sector contribution for NOx, NMVOC, CO, SO2, PM and NH3 emissions

Figure 5.3: Pie chart of sector contribution for NOx, NMVOC, CO, SO2, PM and NH3 emissions (continuation)

The estimation of biogenic emissions is strictly connected with the meteorology. So the amount of emissions used in the regional model for the APICE purposes will be specifically calculate for the simulation period. For this reasons, the data shown in the specific table in the annex, for January and July 2008, are reported only for comparison. This results must be considered preliminary because the processor, recently prepared, have to be tested.

B. Summary Tables Describing Methodologies and Data Used for the Estimation of the Maritime Sector Emissions for Each Study Area

Inland waterways vessels

Table 1: Summary table for the inland waterways vessels

	Barcelona	Genoa	Marseille	Thessaloniki	Venice
Methodology				EEA, 2006	No estimation
Activity data				Fleet, engine horsepower	--
Emission factors				Emission per KWh (EEA, 2006)	--
Range of CO emission factors used				4 – 8.38 g/KWh[a]	--
Range of NOx emission factors used				6.3 – 14.4 g/KWh[a]	--
Range of SO2 emission factors used				254 – 271 g/KWh[a]	--
Range of NH3 emission factors used				0.002 g/KWh[a]	--
Range of NMVOCs emission factors used				0.95 – 3.82 g/KWh[a]	--
Range of PM10 emission factors used				0.3 - 2.22 g/KWh[a]	--
Range of PM2.5 emission factors used				0.28 - 2.09 g/KWh[a]	--

[a]depending on the engine type and horsepower of the vehicle/machinery.

Fish catching ships

Table 2: Summary table for the fish catching ships

	Barcelona	Genoa	Marseille	Thessaloniki	Venice
Methodology				EEA, 2006	No estimation
Activity data				Fleet, fuel consumption	--

Emission factors	Emission per fuel mass (Cooper and Gustafsson, 2004)	--
Range of CO emission factors used	5336 g/tn fuel	--
Range of NOx emission factors used	58362 g/tn fuel	v
Range of SO2 emission factors used	(20000 * S) g/tn fuel[a]	--
Range of NH3 emission factors used	15 g/tn fuel	--
Range of NMVOCs emission factors used	976 g/tn fuel	--
Range of PM10 emission factors used	976 g/tn fuel	--
Range of PM2.5 emission factors used	976 g/tn fuel	--

[a] S is the sulfur content of the fuel used.

Passenger ships

Table 3: Summary table for the passenger ships

	Barcelona	Genoa	Marseille	Thessaloniki	Venice
Methodology				EEA, 2006	Derived from MEET methodology (Trozzi, Vaccaro 1998)
Activity data				Fleet, fuel consumption	Ship movements, time spent in operation modes
Emission factors				Emission per fuel mass (Cooper and Gustafsson, 2004)	Emission per fuel mass (EC, 2002) and for CO EEA, 2006
Range of CO emission factors used				9206 – 120000 g/tn fuel[a]	7400 g/tn fuel
Range of NOx emission factors used				28000 – 44841 g/tn fuel[a]	46000-77000 g/tn fuel [c]
Range of SO2 emission factors used				(20000 * S) g/tn fuel[a,b]	46000-54000 g/tn fuel [c]
Range of NH3 emission factors used				26 g/tn fuel[a]	not estimated
Range of NMVOCs emission factors used				1671 – 23900 g/tn fuel[a]	2000-6200 g/tn fuel [c]
Range of PM10 emission factors used				1500 - 4228 g/tn fuel[a]	5000-9800 g/tn fuel [c]
Range of PM2.5 emission factors used				1500 - 4228 g/tn fuel[a]	5000-9800 g/tn fuel [c]

[a]depending on the vessel and engine type.
[b] S is the sulfur content of the fuel used.
[c] depending on the ship type and operational mode ("manoeuvring", "at sea", "in port")

Cargo shipping

Table 4: Summary table for the cargo shipping

	Barcelona	Genoa	Marseille	Thessaloniki	Venice
Methodology				EEA, 2006	Derived from MEET methodology (Trozzi, Vaccaro 1998)
Activity data				Fleet, operating time	Ship movements, time spent in operation modes
Emission factors				Emission per hour of operation (Cooper and Gustafsson, 2004)	Emission per fuel mass (EC, 2002) and for CO EEA, 2006
Range of CO emission factors used				2045 – 5063 g/tn fuel[a]	7400 g/tn fuel
Range of NOx emission factors used				61657 – 87136 g/tn fuel[a]	32000-92000 g/tn fuel [c]
Range of SO2 emission factors used				(20000 * S) g/tn fuel[a,b]	49000-54000 g/tn fuel [c]
Range of NH3 emission factors used				29 g/tn fuel[a]	not estimated
Range of NMVOCs emission factors used				919 – 1525 g/tn fuel[a]	1400-7800 g/tn fuel [c]
Range of PM10 emission factors used				2326 - 6667 g/tn fuel[a]	4400-10600 g/tn fuel [c]
Range of PM2.5 emission factors used				2326 - 6667 g/tn fuel[a]	4400 10600 g/tn fuel [c]

[a] depending on the vessel and engine type.
[b] S is the sulfur content of the fuel used.
[c] depending on the ship type and operational mode ("manoeuvring", "at sea", "in port")

Harbor operations

Table 5: Summary table for the harbor operations

	Barcelona	Genoa	Marseille	Thessaloniki	Venice
Methodology				Martin et al., 2007	No estimation
Activity data				Mass of handled material	--
Emission factors				Emission per mass of handled material (Martin et al., 2007)	--
Range of PM10 emission factors used				2.146E-04 g/tn material	--
Range of PM2.5 emission factors used				3.25E-05 g/tn material	--

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Annexes (excel files with the emission data for each study area will be annexed)

Annex1:

Annex2:

Annex3.

Annex4: Emission_Inventory_Thessaloniki.xls

Annex5: Emission_Inventory_Venice.xls