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WP5.2. Assessment of air emissions sources in the Port of Thessaloniki and future scenario





Assessment of air emissions sources in the Port of Thessaloniki and future scenario

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1. Identification of the present time risk activities and vulnerability systems in terms of emissions

A. Introduction

The port of Thessaloniki is a European port and the natural gateway for the economic activities of the inland markets beyond Greece (<http://www.thpa.gr/index.php?lang=en>). It serves the growing needs of those countries for the import and export of raw material, consumer products and capital equipment. Thessaloniki's port has a total quay length of 6,200m and a sea depth down to 12 meters. It has 600,000 m² of indoor and open storage area and modern mechanical equipment for the secure and prompt handling of all kinds of cargo, general, bulk and containers.

The port includes the following areas: container terminal, conventional cargo and passenger terminal.

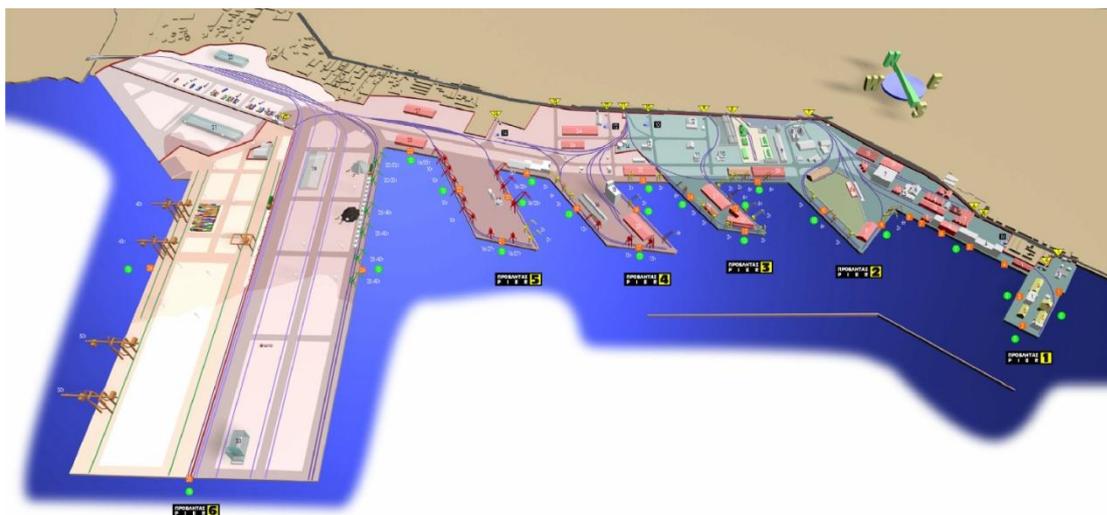


Figure 1.1. Port area of Thessaloniki

Container Terminal

The containers are handled through a specially arranged area located in the western part of pier 6. The 550 m long and 340 m wide Container Terminal can berth ships with a draught of 12 m. Being part of the Free Zone, it covers a surface area of 254,000 m² with an on-site storage capacity of 4,696 TEUs in ground slots. Four cranes are used for container loading-unloading services.

Conventional Cargo

Conventional cargo is accommodated in the Terrestrial Zone of Thessaloniki's port in an area extending on a total surface of approximately 1,000,000 m² with quay length of 4,000m and depth up to 12m. Cargos of all origins and destinations, including the above, are handled in the Free Zone. Such as:

- General Cargo (steelwork products, metal sheets, timber, marble, pallet cargo, tobacco, fruits, etc)
- Solid Bulk Cargo (minerals, ores, coal, solid fuel, cereals, feed stuffs, fertilizers, cement, scrap)
- Liquid Bulk Cargo with pipelines (spirits, chloroform, asphalt, chemicals, mineral oils, wine)
- Ro-Ro vehicles.

Passenger Terminal

The passenger port of Thessaloniki meets the needs of passenger sea transport (coastal and cruise). It is located between Pier 1 and 2 and includes 5 docks in total. The port basin provides sufficient space and depth for cruise ship maneuvering. The cruise terminal is well protected from weather conditions (winds, undulation etc.) providing a safe berthing for cruise ships.

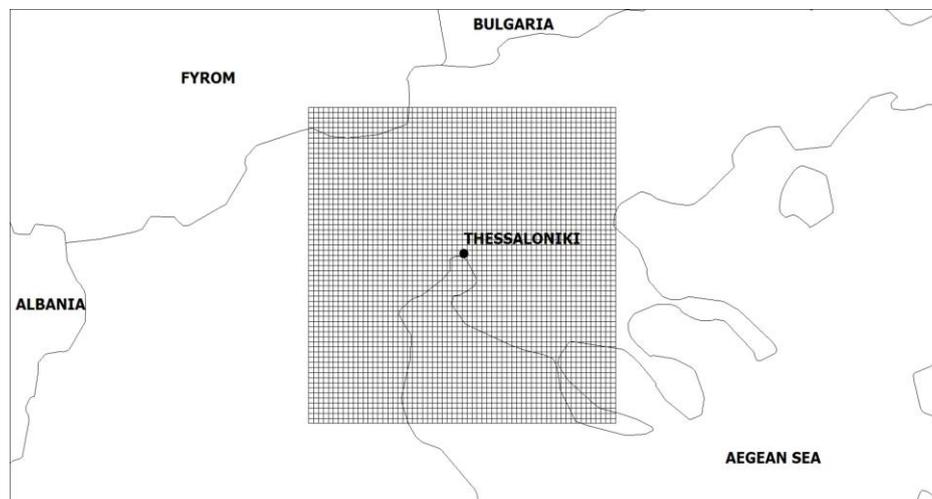


Figure 1.2. APICE study area for Thessaloniki.

The Thessaloniki area that has been studied within APICE is that presented in Figure 1.2. Thessaloniki and its port are located almost in the center of the domain. In this area, the maritime activities presenting risks regarding air emissions are the following:

1. Passenger ships: Ferries, other passenger
2. Cargo ships: General cargo, container and other cargo vessels
3. Tugs
4. Harbor operations: Loading, unloading, piling of goods/materials and vehicles operation in the port (e.g trucks)
5. Inland waterways vessels: Small and medium vessels e.g. pleasure crafts
6. Fishing boats.

From the activities listed above, the first four ones are under the responsibility of the Thessaloniki Port Authority S.A.

The methodology of EEA (2006) was mainly used for the estimation of emissions from ships and vessels. In addition, emission factors were selected from Cooper and Gustafsson (2004). Shipping emissions were estimated for three operating modes: a) on-route (cruising), b) maneuvering, and c) hotelling (in port). It should be noticed that according to an amendment of the directive 2005/33/EC (FEK 173B – 30/08/2007), all ships in the area of Greece have to change their marine fuel used before entering into the port (during maneuvering and hotelling mode) with fuel with a sulphur content not exceeding 0,1 % by mass. The AP-42 emission factors (US EPA) have been estimated for the determination of emissions from the harbor operations. Emissions from vehicles operation concern particulate emissions which occur whenever vehicles travel over the paved roads of the port due to resuspension of the loose material on the road surface. More details on methodologies used in the “Emission Inventory Methodology Description” Final Report which is available on the APICE website.

B. Maritime emissions in the Thessaloniki area studied within APICE

Table 1.1a presents the emissions because of the maritime and harbor activities in the Thessaloniki domain. Cargo shipping is the major contributor to total emissions of all pollutants except for NH₃. Passenger ships do not play a significant role in maritime emissions because of the low passenger traffic in the port of Thessaloniki. The second larger contributor to the total emissions of all pollutants except for NH₃ is the fishing boats (their operation it is not under the responsibility of the Thessaloniki Port Authority SA).

Regarding PM₁₀, 221 tn/year are emitted by cargo ships and 58 tn/year by the fishing boats. The in-port storage processes like loading, unloading and piling of goods/materials can be identified as the third in the rank PM₁₀ emission source (~37 tn/year). Concerning PM_{2.5}, the third most important emission source, after the cargo ships and the fishing boats, is the inland waterways emitting PM_{2.5} amounts that are comparable with those released in the atmosphere by in-port storage processes.

Table 1.1.b presents the calculated emissions from shipping in each operation mode; cruising, maneuvering and hotelling. Emissions are shown for different types of ships. The most important source for NO_x, SO_x and NMVOCs total emissions is the Containers while for PM and NH₃ is the General Cargo ships. The emissions from the Containers and the General Cargo ships are generally comparable. CO is emitted mainly by the Other Cargo Vessels.

According to Table 1.1.b, for all pollutants, the total cruising emissions represent the highest share of total emissions from all operation modes (cruising, maneuvering and hotelling). This result is valid also for all cargo ships. However, ferries emissions are the largest during hotelling for all pollutants apart from SO_x which are the largest during the cruising mode. CO and NMVOCs emitted from the Other Passenger ships are the highest during hotelling while the emissions for all the other pollutants are the highest while “on-route”.

C. Maritime emissions in the port area of Thessaloniki

The main activities studied within APICE that take place in the port area (or near the port) of Thessaloniki and which release pollutant emissions in the atmosphere are the ship maneuvering and hotelling, the operation of the port vehicles and the processes of loading/unloading and pilling goods and materials in the port.

According to Tables 1.1a and 1.1b, among these activities, the hotelling of ships is the major emission source for CO, NMVOCs and PM2.5. The highest CO and NMVOCs hotelling emissions are emitted from ferries. PM2.5 hotelling emissions are emitted mainly from Containers and General Cargo ships. The largest NOx emissions are released from the maneuvering of ships, mostly of Containers and General Cargo ships; however, the NOx ship maneuvering emissions are comparable with those emitted from ship hotelling. The highest SOx emissions are also released from the maneuvering of ships, mostly of Containers and General Cargo ships. Finally PM10 are emitted mostly from the in-port processes relevant with the loading, unloading and pilling of goods/materials (~37 tn/year).

Table 1.1a. Pollutant emissions (in tn/year) from the maritime activities in the Thessaloniki area studied within APICE (reference year 2010)

ACTIVITIES OF SHIPS AND VESSELS							
	CO	NOx	SOx	NMVOCs	NH3	PM10	PM2.5
Passenger ships*,**	60.67	36.80	10.38	12.73	0.009	1.62	1.62
Cargo ships*,**	881.02	7022.23	4399.48	113.92	0.904	220.79	220.79
Tugs**	2.13	10.10	0.44	0.39	0.004	0.39	0.39
Inland waterways	26.78	72.87	-	9.58	0.011	7.59	7.15
Fishing Boats	315.75	3738.86	118.28	57.37	1.301	57.72	57.72
Total	1286.35	10880.86	4528.58	193.99	2.23	288.11	287.67
IN-PORT STORAGE							
	CO	NOx	SOx	NMVOCs	NH3	PM10	PM2.5
Loading**	-	-	-	-	-	6.2	0.94
Unloading**	-	-	-	-	-	14.7	2.23
Pilling**	-	-	-	-	-	16.3	2.47
Total	-	-	-	-	-	37.2	5.64
IN-PORT TRAFFIC LOAD INDUCED BY PORT ACTIVITIES							
	CO	NOx	SOx	NMVOCs	NH3	PM10	PM2.5
Vehicles operating in the port**	-	-	-	-	-	0.181	0.043

*total emissions: "on-route"+"maneuvering"+"in port".

**activities under the responsibility of the Thessaloniki Port Authority S.A.

Table 1.1b. Pollutant emissions (in tn/year) from shipping in the Thessaloniki area studied within APICE (reference year 2010)

		CO	NOx	SOx	NMVOC	NH3	PM10	PM2.5
On-route (Cruising)	Other Passenger ships	1.14	13.83	6.73	0.21	0.01	0.52	0.52
	Ferries	0.41	4.71	2.40	0.07	0.00	0.19	0.19
	General Cargo	5.85	2536.94	1612.47	40.59	0.37	90.61	90.61
	Container	5.33	2896.73	1829.41	46.35	0.33	81.64	81.64
	Tugs	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Other Cargo Vessels	840.99	1308.27	842.79	21.98	0.20	36.42	36.42
	Total	853.72	6760.48	4293.8	109.20	0.91	209.38	209.38
Maneuvering	Other Passenger ships	0.42	1.97	0.09	0.08	0.001	0.08	0.08
	Ferries	0.64	2.78	0.13	0.12	0.001	0.12	0.12
	General Cargo	0.16	53.98	34.28	0.86	0.004	0.57	0.57
	Container	0.18	76.82	48.37	1.23	0.005	0.64	0.64
	Tugs	2.13	10.10	0.44	0.39	0.004	0.39	0.39
	Other Cargo Vessels	14.99	23.68	15.58	0.45	0.002	0.25	0.25
	Total	18.52	169.33	98.89	3.13	0.017	2.05	2.05
Hotelling (in port)	Other Passenger ships	20.37	4.73	0.41	4.75	-	0.25	0.25
	Ferries	37.76	8.81	0.63	7.52	-	0.47	0.47
	General Cargo	0.28	28.73	3.72	0.46	-	4.13	4.13
	Container	0.48	74.44	9.55	1.19	-	4.64	4.64
	Tugs	0.00	0.00	0.00	0.00	-	0.00	0.00
	Other Cargo Vessels	12.76	22.66	3.32	0.81	-	1.89	1.89
	Total	71.65	139.37	17.63	14.73	0.00	11.38	11.38

Total	Other Passenger ships	21.92	20.53	7.23	5.03	0.01	0.84	0.84
	Ferries	38.81	16.30	3.16	7.71	0.00	0.77	0.77
	General Cargo	6.29	2619.64	1650.46	41.91	0.37	95.31	95.31
	Container	5.99	3047.99	1887.32	48.77	0.33	86.92	86.92
	Tugs	2.13	10.10	0.44	0.39	0.01	0.39	0.39
	Other Cargo Vessels	868.75	1354.61	861.69	23.24	0.20	38.56	38.56
	Total	943.88	7069.17	4410.30	127.05	0.92	222.80	222.80

Figures 1.3 and 1.4 present the spatial distribution of the annual PM emissions from the maritime activities in the Thessaloniki area studied within APICE. According to the Figure 1.4, the highest PM10 emissions appear in the port because of the processes of loading/unloading and piling goods and materials in the port. PM2.5 emissions are maximum along the routes of the cargo ships (mainly of Containers and General Cargo ships).

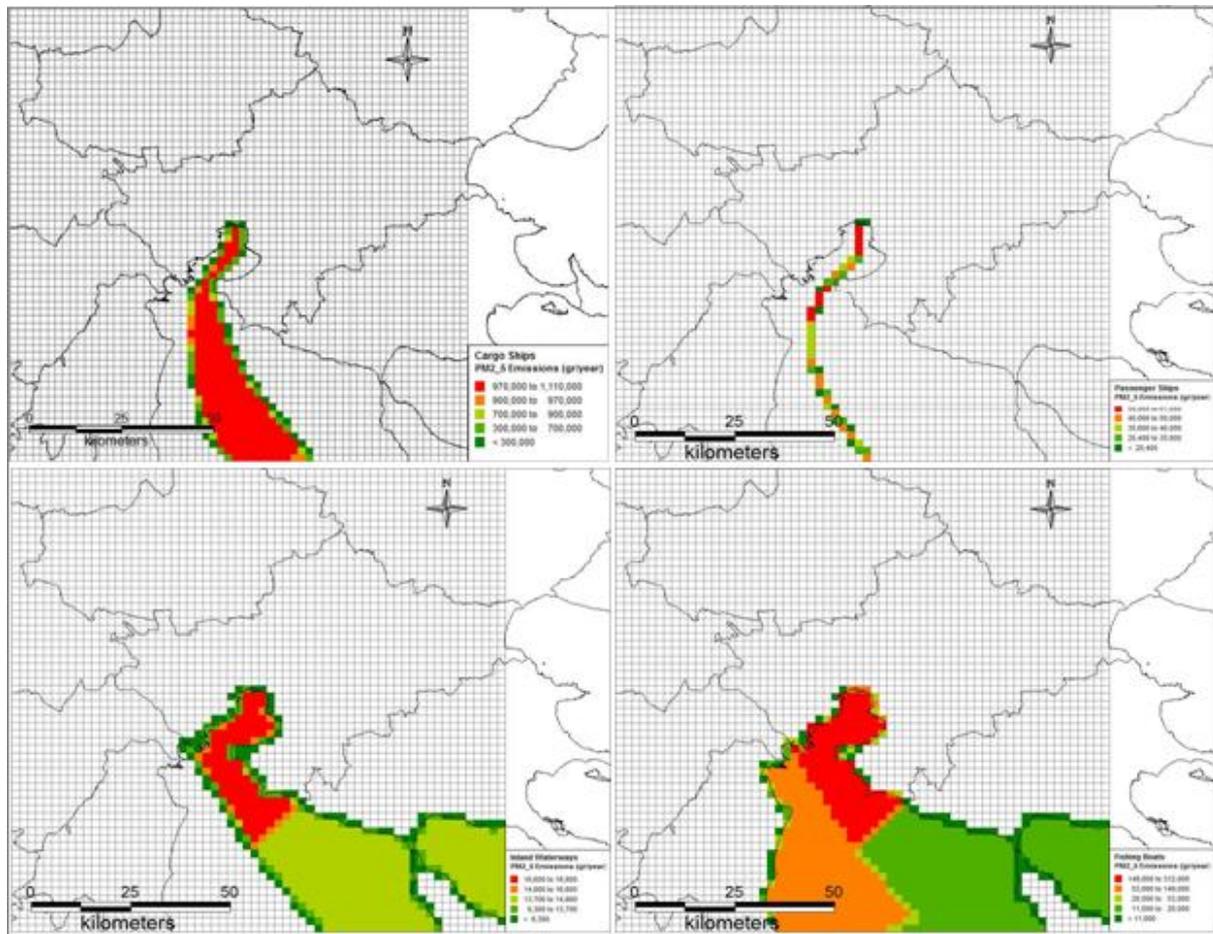


Figure 1.3: Annual PM2.5 emissions from cargo ships, passenger ships, inland waterways and fishing boats (ship emissions presented for all transport modes: on-route, maneuvering and hotelling) (reference year 2010).

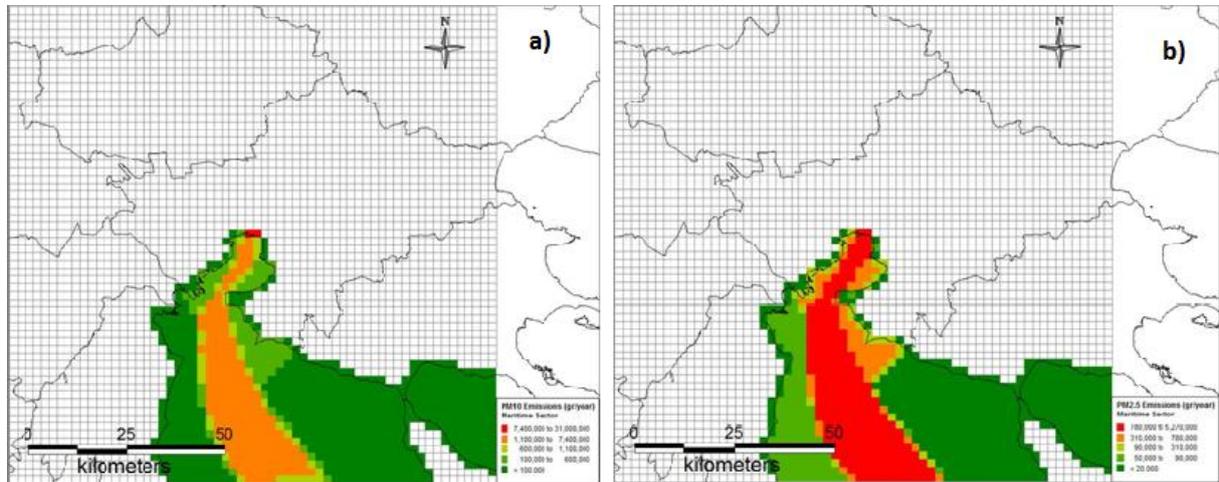


Figure 1.4.: Annual a) PM10 and b) PM2.5 emissions for the maritime sector (reference year 2010).

Table 1.2 shows the time frame of the pollutant emitting activities relevant with the presence of the port in Thessaloniki. The data were provided by the Port Authority of Thessaloniki.

Table 1.2. Time frame of the pollutant emitting activities relevant with the presence of the port in Thessaloniki

IN-PORT ACTIVITIES OF SHIPS AND VESSELS		
	Mean Diurnal Duration	Mean Frequency
Passenger ships hotelling	10 hours	One time per week
Passenger ships hotelling	2 hours	4 time per week (mainly in the summer period)
Cruise ship facilitation	9 hours	20 times per year
Load/unload ships	24 hours (for container vessels)	2 container vessels per day
	16 hours for dry bulk and general cargo vessels	About 4 vessels per day
Outdoor storage	12 hours	Every day
ON-ROUTE AND MANEUVERING ACTIVITIES OF SHIPS AND VESSELS		
	Mean Diurnal Duration	Mean Frequency
Passenger ships	1 hour	One time per week (all year round)
		Four times per week (for the summer period)
		20 times per year
Cargo ships	1 hour	6 ships per day
TRAFFIC LOAD INDUCED BY PORT ACTIVITIES		
	Mean Diurnal Duration	Mean Frequency
Vehicles operating in the port	Operation time per truck in the port (about 45 minutes)	About 220 trucks per day
Passenger cars (transit vehicles)	Operation time about 2 hours	35 cars per day
Heavy and light duty vehicles (transit vehicles)	Operation time about 16 hours	19 heavy duty vehicles per day

D. Seasonal Variability of the maritime emissions in the Thessaloniki area studied within APICE

All the maritime and harbor activities display a seasonal variability. According to the Figure 1.5, particulate matter emissions are maximum in the summer season. In addition, in all seasons, the cargo ships are the most significant source of PM10 emissions while fishing boats and harbor operations are following. The same applies also for the PM2.5 emissions except for the third most important source activity which in all seasons is the inland waterways.

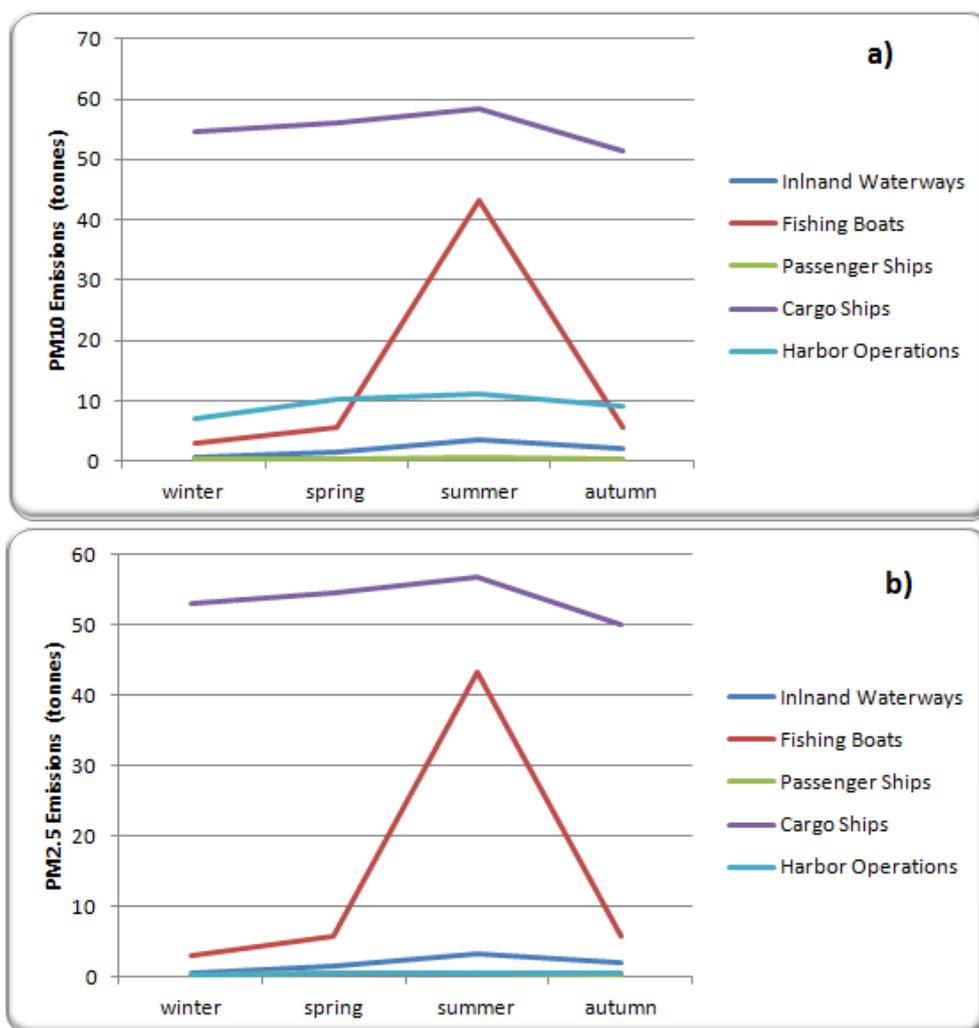


Figure 1.5.: Seasonal variability of a) PM10 and b) PM2.5 emissions for each maritime activity (reference year 2010).

2. Identification of the future time risk activities and vulnerability systems in terms of emissions

In this section, the future emissions of the maritime activities in the Thessaloniki area studied within APICE will be presented. The reference year for the future emissions is 2020. The emissions for the year 2020 for the maritime sector were estimated according to activity data provided by the Thessaloniki Port Authority SA and considering only the port evolution without taking into account any modification in engine types, emission factors etc.

The projected emissions were based mainly on the port's authority Investment/Development Plans which include the extension of the 6th pier and the construction of a marina for pleasure crafts. The first project is going to be completed until the end of 2018. More particularly, the container terminal will be extended on the western part by 550m in length and by 365m in width. As a consequence, it is expected an increase of the storage capacity of the container terminal as well as an increase in cargo ship traffic. The second project is on-going and is expected to be completed on the second half of the year 2015. The marina will be able to host up to 216 pleasure crafts.

The air pollution from maritime transport is regulated by Annex VI of the Convention for the Prevention of Marine Pollution from Ships (MARPOL 73/78) governed by the International Maritime Organization (IMO). So, in the identification of the future emissions, the reduction of the sulfur content of fuels used by ships in cruising mode to 0.5% m/m according to a revision of the MARPOL Annex VI has been taken into account.

A. Maritime emissions in the Thessaloniki area studied within APICE

Table 2.1a presents the future emissions because of the maritime and harbor activities in the Thessaloniki domain. Cargo shipping is the major contributor to the total emissions of CO, NO_x, SO_x, PM and NH₃. In 2020, the inland waterways are expected to be the most important NMVOCs emission source followed by the cargo ships. The second larger contributor to the NO_x, SO_x and NH₃ emissions is the fishing boats and to the CO emissions are the inland waterways.

Regarding PM₁₀, cargo ships are expected to be the first in the rank of the PM₁₀ emission source (~247 tn/year) followed by the inland waterways (~170 tn/year). Moreover, 66 tn of PM₁₀ per year will be emitted by the in-port storage processes like loading, unloading and pilling of

goods/materials. Concerning PM_{2.5}, the most important emission source is the cargo shipping (~247 tn/year) followed by the inland waterways (~160 tn/year) and the fishing boats (~37tn/year).

Compared to the 2010 emissions, the 2020 emissions from passenger ships increase by ~+35% for CO and NMVOCs, by ~+25% for NO_x, by ~+17% for PM and by ~+19% for NH₃ while they are reduced by ~-50% for SO_x (projections show an increase of passenger traffic in 2020). Emissions from cargo ships increase by +30% for CO, by ~+40% for NO_x, NMVOCs, NH₃ and by ~+12% for PM while they are reduced by ~-65% for SO₂. Projections give a steep increase of all pollutant emissions from the inland waterways due to the construction of the marina. On the other hand, emissions from fishing boats show a decline of approximately -35% in 2020. Emissions from tugs increase by +66%. PM emissions from loading, unloading and pilling of goods/materials increase significantly in 2020 (~78%).

Table 2.1.b presents the calculated future emissions from shipping in each operation mode; cruising, maneuvering and hotelling. Emissions are shown for different types of ships. The total emissions at the end of the Table 2.1.b reveals that the highest emission source for all the pollutants except for CO is the Containers (followed by the General Cargo ships). CO is emitted mostly by the Other Cargo Vessels.

According to Table 2.1.b, for all pollutants, the total cruising emissions represent the highest share of the total emissions from all ship operation modes (cruising, maneuvering and hotelling). This result is valid for all cargo ships. However, ferries emissions are the largest during hotelling for all pollutants apart from SO_x which are the largest during the cruising mode. CO and NMVOCs emitted from the Other Passenger ships are the highest during hotelling while the emissions for all the other pollutants are the highest while “on-route”.

B. Maritime emissions in the port area of Thessaloniki

The main activities studied within APICE that take place in the port area (or near the port) of Thessaloniki and which release pollutant emissions in the atmosphere are the ship maneuvering and hotelling, the operation of the port vehicles and the processes of loading/unloading and pilling goods and materials in the port.

According to Tables 2.1a and 2.1b, among these activities, the hotelling of ships is the major emission source for CO, NMVOCs and PM_{2.5}. The highest CO and NMVOCs hotelling emissions are emitted from ferries. PM_{2.5} hotelling emissions are emitted mainly from Containers and General Cargo ships. The largest NO_x emissions are released from the maneuvering of ships, mostly of Containers and General Cargo ships; however, the NO_x ship maneuvering emissions are comparable with those emitted from ship hotelling. The highest SO_x emissions are also released from the maneuvering of ships, mostly of Containers and General Cargo ships. Finally PM₁₀ are emitted mostly from the in-port processes relevant with the loading, unloading and pilling of goods/materials (~67 tn/year).

In 2020, the emissions within the port area of Thessaloniki show an increase for all the pollutants. PM₁₀ emissions from the in-port processes relevant with the loading, unloading and pilling of goods/materials increase by +78%. Emissions from containers ships increase by approximately 70% during hotelling and maneuvering mode for all the pollutants. Tugs emissions increase also by ~ 66% during maneuvering mode. Moreover, in both operational modes, all pollutant emissions from ferries show an increase of 50% while from passenger ships have a small increase in 2020 (~5%).

Table 2.1a. Pollutant emissions (in tn/year) from the maritime activities in the Thessaloniki area studied within APICE (reference year 2020)

ACTIVITIES OF SHIPS AND VESSELS							
	CO	NOx	SOx	NMVOCS	NH3	PM10	PM2.5
Passenger ships*	82.04	46.34	5.25	17.02	0.011	1.90	1.90
Cargo ships*	1139.80	9882.42	1517.28	160.13	1.245	247.50	247.50
Tugs	3.55	16.83	0.73	0.65	0.007	0.65	0.65
Inland waterways	607.55	1634.15	-	215.89	0.249	170.17	160.22
Fishing Boats	205.63	2434.91	77.03	37.36	0.847	37.59	37.59
Total	2038.56	14014.64	1600.29	431.04	2.36	457.80	447.86
IN-PORT STORAGE							
	CO	NOx	SOx	NMVOCS	NH3	PM10	PM2.5
Loading	-	-	-	-	-	11.1	1.69
Unloading	-	-	-	-	-	26.0	3.93
Pilling	-	-	-	-	-	29.4	4.45
Total	-	-	-	-	-	66.5	10.07
IN-PORT TRAFFIC LOAD INDUCED BY PORT ACTIVITIES							
	CO	NOx	SOx	NMVOCS	NH3	PM10	PM2.5
Vehicles operating in the port	-	-	-	-	-	0.1810	0.043

*total emissions: "on-route"+"maneuvering"+"in port".

Table 2.1b. Pollutant emissions (in tn/year) from shipping in the Thessaloniki area studied within APICE (reference year 2020)

		CO	NOx	SOx	NMVOC	NH3	PM10	PM2.5
On-route (Cruising)	Other Passenger ships	1.19	14.54	2.36	0.22	0.007	0.42	0.42
	Ferries	0.62	7.15	1.22	0.11	0.002	0.15	0.15
	General Cargo	6.79	2941.63	413.64	47.07	0.426	84.06	84.06
	Container	9.04	4910.74	690.53	78.57	0.560	110.72	110.72
	Tugs	0.00	0.00	0.00	0.00	0.000	0.00	0.00
	Other Cargo Vessels	1087.13	1621.35	242.09	27.30	0.243	35.70	35.70
	Total	1104.77	9495.41	1349.84	153.26	1.24	231.14	231.14
Maneuvering	Other Passenger ships	0.44	2.08	0.09	0.08	0.001	0.08	0.08
	Ferries	0.97	4.23	0.20	0.18	0.001	0.18	0.18
	General Cargo	0.18	62.97	40.81	1.01	0.005	0.66	0.66
	Container	0.30	129.86	84.15	2.08	0.008	1.08	1.08
	Tugs	3.55	16.83	0.73	0.65	0.007	0.65	0.65
	Other Cargo Vessels	19.04	28.96	20.64	0.55	0.003	0.31	0.31
	Total	24.48	244.93	146.62	4.55	0.025	2.96	2.96
Hotelling (in port)	Other Passenger ships	21.46	4.99	0.43	5.01	-	0.26	0.26
	Ferries	57.43	13.40	0.96	11.44	-	0.72	0.72
	General Cargo	0.33	33.52	4.42	0.54	-	4.82	4.82
	Container	0.81	125.83	16.61	2.01	-	7.84	7.84
	Tugs	0.00	0.00	0.00	0.00	-	0.00	0.00
	Other Cargo Vessels	16.20	27.57	4.39	1.01	-	2.32	2.32

	Total	96.23	205.30	26.81	20.01	0.00	15.96	15.96
Total	Other Passenger ships	23.10	21.60	2.88	5.30	0.01	0.76	0.76
	Ferries	59.03	24.78	2.37	11.73	0.00	1.04	1.04
	General Cargo	7.29	3038.12	458.87	48.61	0.43	89.54	89.54
	Container	10.15	5166.43	791.29	82.66	0.57	119.64	119.64
	Tugs	3.55	16.83	0.73	0.65	0.01	0.65	0.65
	Other Cargo Vessels	1122.36	1677.88	267.13	28.86	0.25	38.32	38.32
	Total	1225.48	9945.64	1523.27	177.80	1.26	249.95	249.95

Figures 2.1 and 2.2 present the spatial distribution of the future annual PM emissions from the maritime activities in the Thessaloniki area studied within APICE. According to the Figure 2.2, in 2020, the highest PM10 emissions are expected to be in the area of the harbor of Thessaloniki because of the processes of loading/unloading and piling goods and materials in the port. On the other hand, PM2.5 are expected to be higher in the greater area of Thessaloniki gulf due to the increase of inland waterways.

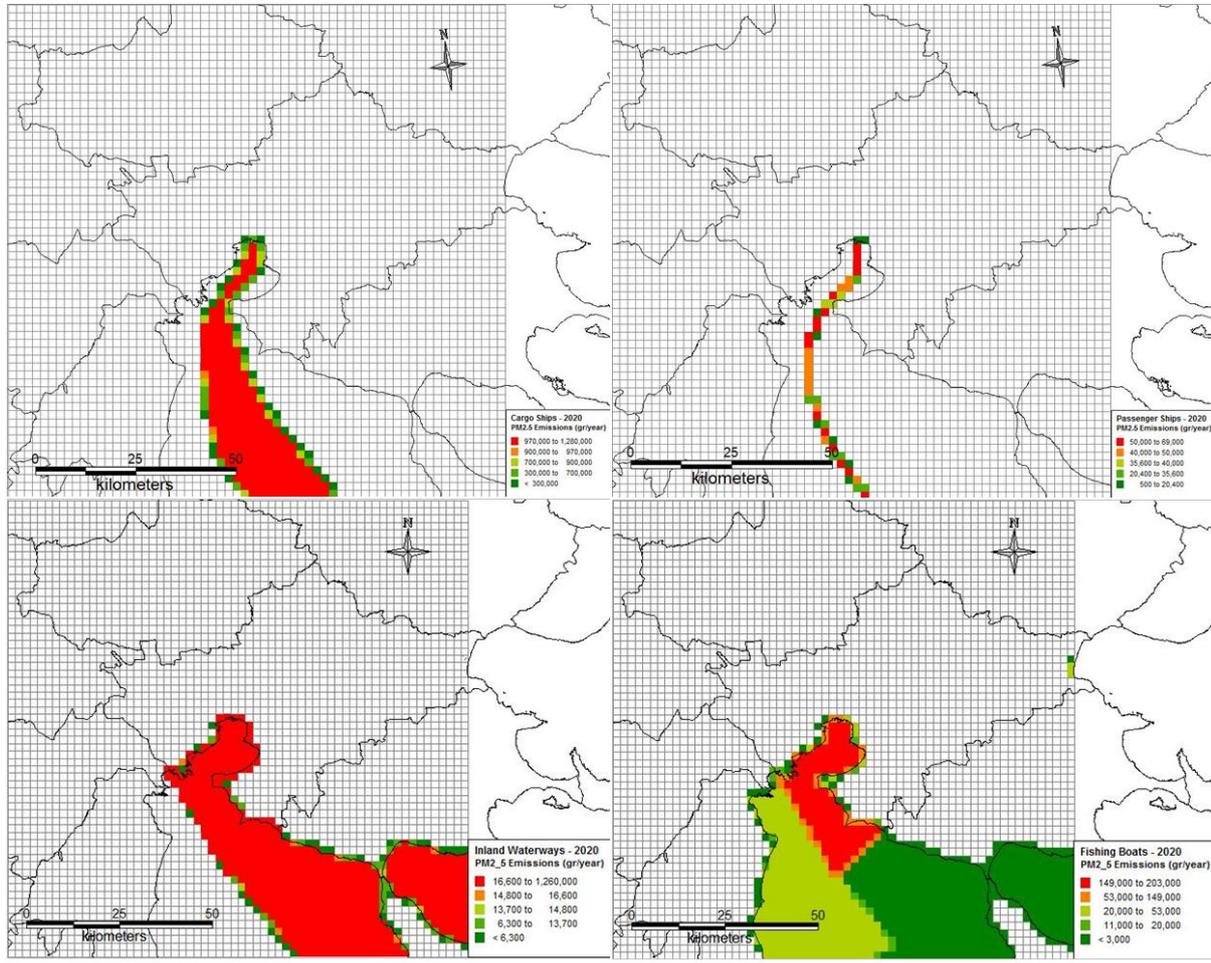


Figure 2.1: Annual PM2.5 emissions from cargo ships, passenger ships, inland waterways and fishing boats (ship emissions presented for all transport modes: on-route, maneuvering and hotelling) (reference year 2020).

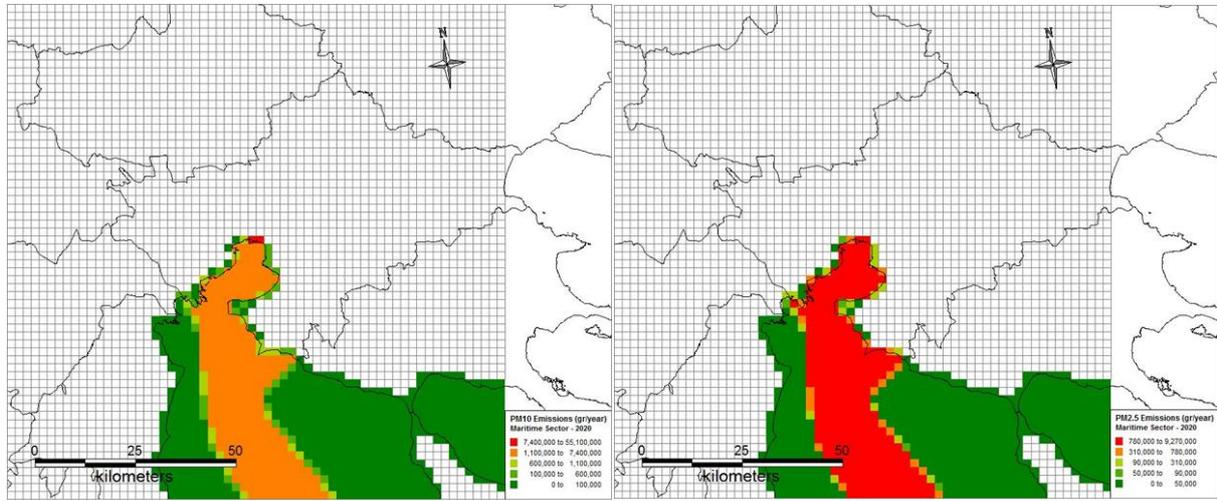


Figure 2.2.: Annual PM10 and PM2.5 emissions for the maritime sector (reference year 2020).

C. Seasonal Variability of the maritime emissions in the Thessaloniki area studied within APICE

Future emissions have a similar seasonal variability to present emissions. During summer, the emissions are the highest for all maritime activity. In summertime, the PM10 emissions from the inland waterways are the highest. The second larger contributor to PM10 emissions is the cargo shipping and they are followed by fishing boats and harbor operations. In summer season, the most important PM2.5 emission source is the inland waterways, followed by the cargo ships, fishing boats, the harbor operations and the passenger ships.

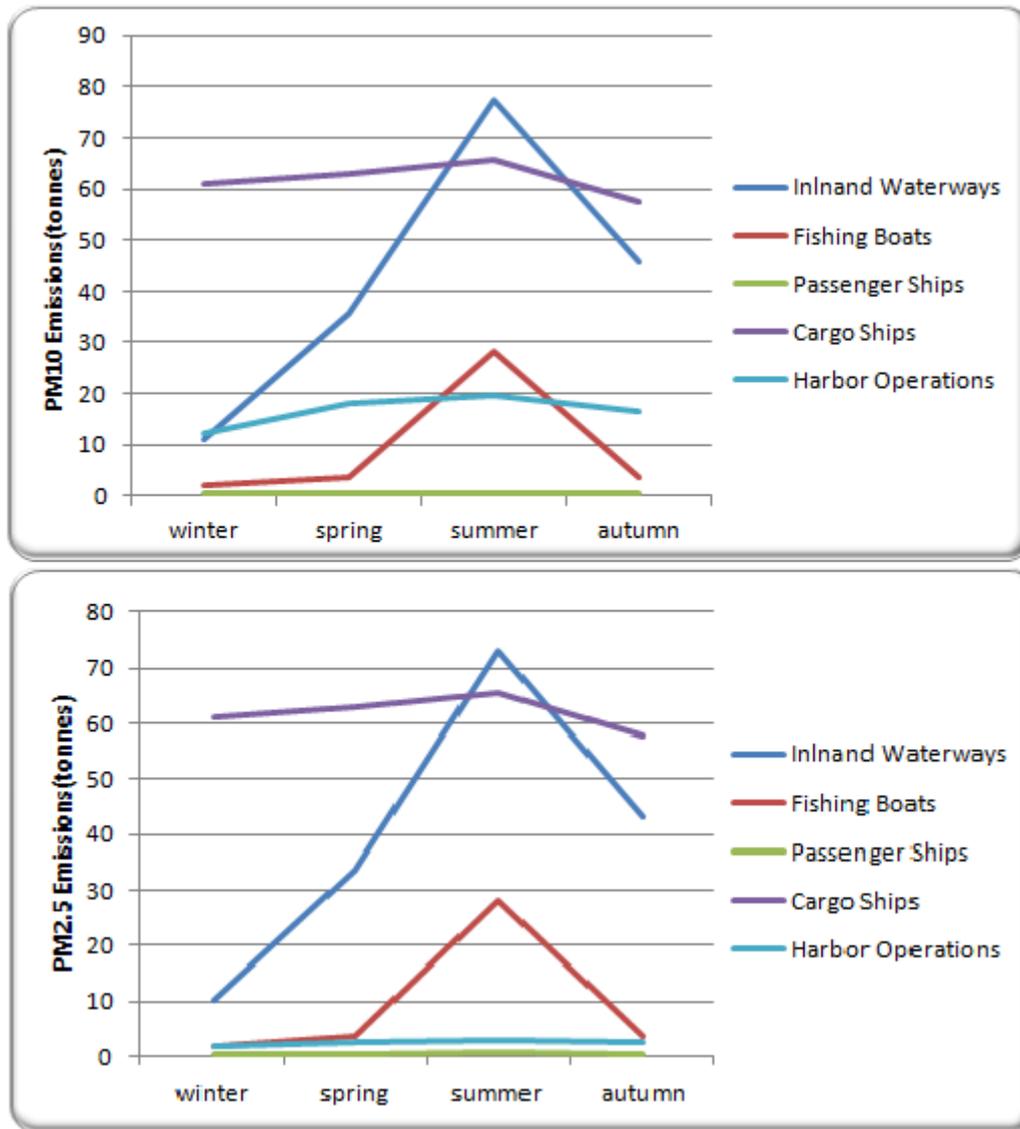


Figure 2.3.: Seasonal variability of a) PM10 and b) PM2.5 emissions for each maritime activity (reference year 2020).

3. Involvement of stakeholders in the activities relevant with the presence of the port in Thessaloniki

The following table shows the stakeholders involved in the activities relevant with the presence of the port in Thessaloniki which have been presented in Tables 1.1 and 2.1. The information was provided by the Thessaloniki Port Authority S.A.

Table 3.1. Maritime/Harbor activities in the port of Thessaloniki and stakeholders involved

Activities	Stakeholders
Passenger ships	Port Police of Thessaloniki
Loading/unloading ships	Thessaloniki Port Authority S.A
Outdoor storage	Thessaloniki Port Authority S.A
Vehicles operating in the port	<ol style="list-style-type: none"> 1. Thessaloniki Port Authority S.A 2. Port Police of Thessaloniki 3. Department of Environmental and Spatial Planning of the Region of Central Macedonia

4. Conclusions

Following are the conclusions for the most risky maritime/harbor activities for Thessaloniki in terms of pollutant emissions:

A. Whole Thessaloniki area studied within APICE

In present time, on an annual basis, the cargo shipping is the major contributor to the total emissions of pollutants (except for NH₃). The second larger contributor to the total emissions of pollutants is the fishing boats. For all pollutants, the total cruising emissions represent the highest share of the total emissions from all operation modes (cruising, maneuvering and hotelling). This result is valid also for all cargo ship types (General Cargo, Container, Other Cargo Vessels). Concerning PM₁₀ and PM_{2.5}, which are key species within APICE, the most important emission source is the General Cargo ships; however, the emissions from General Cargo ships and the Containers are generally comparable.

In 2020, on an annual basis, PM₁₀ and PM_{2.5} will be mostly emitted by the cargo ships while the second emission contributor will be the inland waterways. This can be explained by the increase in the number of cargo ships as well as by the high increase in the number of pleasure crafts. Despite the increase in the number of ships, the increase in the future shipping emissions is relatively small because of the reduction of the sulfur content in fuels used by ships. Cargo shipping will be the major contributor to the total emissions of CO, NO_x, SO_x and NH₃. The inland waterways are expected to be the most important NMVOCs emission source.

Emissions show a seasonal variability and the majority of PM emissions are estimated during the summer season. In summer season, the major present time PM emissions source is cargo shipping. This is expected to change in the future when PM₁₀ and PM_{2.5} emissions from the pleasure crafts are expected to be dominant.

B. In the port area of Thessaloniki

In present time, on an annual basis, the hotelling of ships is the major emission source for PM_{2.5}, CO and NMVOCs. PM_{2.5} hotelling emissions are emitted mainly from Containers and General Cargo



ships. PM10 are emitted mostly from the in-port processes relevant with the loading, unloading and piling of goods/materials. The largest NOx and SOx emissions are released from the maneuvering of ships; however, the NOx ship maneuvering emissions are comparable with those emitted from ship hotelling. The above results are similar also for the future time emissions.

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