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APICE

WP5: LOCAL ADAPTATION PLAN

Local Adaptation Plan of the Port of Thessaloniki

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INTRODUCTION

This document is the **Local Adaptation Plan** in the frame of the **Common Mediterranean strategy and local practical Actions for the mitigation of Port, Industries and Cities Emissions** (APICE) project. The purpose of this Plan is to define a roadmap for the Port Authority of Thessaloniki and stakeholders to ensure that air emissions generated by sources associated with port activities and affects the city of Thessaloniki will decline even with anticipated future port growth over the next years. The actions identified in this Plan are meant to address the bellow primary emissions mitigation objectives:

1. Develop a **knowledge-based approach** for air pollution mitigation and sustainable development of port activities, managed by spatial planning policies at local level, which includes the territory around the port and the centre of city of Thessaloniki
2. **Reduce maritime-related air quality impacts** on human health and the environment from criteria air pollutants
3. Merge **environmental** and **socio-economic needs** of port-cities policies
4. **Support eco-friendly changes** in shipping practices and ownership of shared emission abatements options
5. Mainstream the LAP raising **policy makers awareness.**

Stakeholders

The integration of the Local Adaptation Plan is based in three procedural elements:

- the **stakeholder consultation process** which took place at the two Local Working Tables,
- the **Delphi Method** (Criteria Assess and Measure Evaluation process) and
- the **evaluation process** conducted by the scientific project team (*Aristotle University of Thessaloniki - Department of Physics - Laboratory of Atmospheric Physics, University of Western Macedonia – Mechanical Engineering – Environmental Technology Laboratory, Decentralized Administration of Macedonia and Thrace - Department of Environmental and Spatial Planning*).

An important part of developing this Local Adaptation Plan was seeking and incorporating input and feedback from **agencies** and **key stakeholders** such as:

- *Department of Environmental and Spatial Planning – DAMT,*
- *Department of Environment – Municipality of Thessaloniki,*
- *Organization of Planning and Environmental Protection of Thessaloniki - OR.TH.,*

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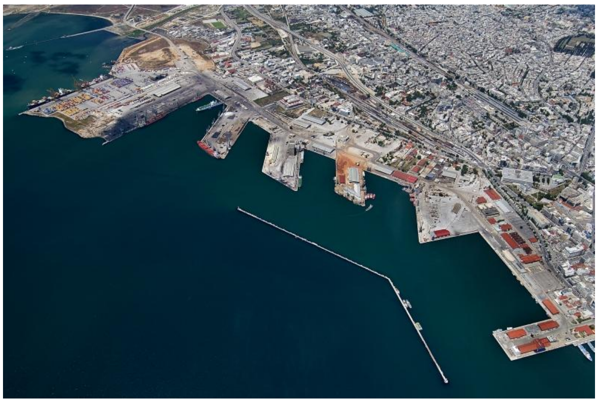
- *Department of Environment and Spatial Planning – RCM,*
- *Aristotle University of Thessaloniki - Separate Divisions*.

These groups, along with the Port Authority of Thessaloniki, comprised the **Working Group**, which oversaw the development of this Plan. Several face-to-face meetings and calls were held to scope, draft, and further refine the list of actions to reduce air emissions as provided within this Plan. The above key stakeholders recognize that the development of this Plan is only the first step in achieving future emissions reductions that build upon those already occurring. The key will be transitioning from the promising strategies contained herein to actual implementation of the specific actions needed to achieve further emissions reductions.

Port infrastructures and future development



The Port of Thessaloniki is fully organized and secure, with experienced personnel, modern and productive equipment, investment plans under implementation and the vision to serve as a hub transit trade center of the Balkan Region. Through the port of Thessaloniki, the year of 2011, 13,708,313 tones of cargo had transported and approximately 2,000 vessels arrived.

The development of the Thessaloniki's Port is a key target achieved through both the evolution of infrastructure and the new innovative practices.

The future plans with respect to extensive port infrastructures are:

- the **extension of the 6th pier** (container Terminal)
- the **construction of a marina**
- the **improvement** and functionality of the **rail network**

The upgrading and expansion of the technological infrastructures of the Thessaloniki Port Authority S.A. along with the use of state-of-the-art software packages and the development of specialized applications will allow the company to increase its productivity, to simplify and achieve quality services to its customers.

The participation of Thessaloniki Port Authority to research contributes to the **transfer of know-how** and to the follow-up of modern safe and quality ship service trends while **improving** the **performance** of the port activities (Programs SPIN, TRAPIST IONAS, e-LOGMAR-M, NAYTILOS, EFFORTS, FREIGHTWISE, MIRTO). Such **research programs** (GREENPORTh and GILDA.NET) contribute to the development of the port's environmental protection policy and to the acquisition of significant know-how in the new transaction of Information and Communication Technologies in the transportation field.

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The main port related activities studied within APICE, which release pollutant emissions in the atmosphere, are the ship and vessel traffic, the operation of the port vehicles and the processes of loading/unloading and pilling goods and materials in the port. Table 4 presents the emissions from these activities which were calculated for a reference domain with 100x100km^2 extend centered over Thessaloniki. According to Table 1, cargo shipping is the major emission source for all pollutants. The in-port storage processes like loading, unloading and pilling of goods/materials can be identified as the second in rank PM emission source.

Table 1 Pollutant emissions from the maritime and harbor activities under the responsibility of the Thessaloniki Port Authority S.A. (reference year 2010, reference area: 100x100km^2)

ACTIVITIES OF SHIPS AND VESSELS							
Emissions (tn/y)	**CO**	**NOx**	**SOx**	**NMVOCs**	**NH_3**	**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
Total	**943.82**	**7069.13**	**4410.30**	**127.04**	**0.92**	**222.80**	**222.80**
IN-PORT STORAGE							
Emissions (tn/y)	**CO**	**NOx**	**SOx**	**NMVOCs**	**NH_3**	**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							
Emissions (tn/y)	**CO**	**NOx**	**SOx**	**NMVOCs**	**NH_3**	**PM10**	**PM2.5**
Vehicles operating in the port	-	-	-	-	-	**0.181**	**0.043**

**total emissions: "on-route"+"maneuvering"+"hotelling".*

Mitigation objectives

Port of Thessaloniki represents a significant potential for the **economic development**, but also has a potential negative **environmental impact** due to multiple emission sources. The presence of competing activities in coastal areas can lead to **potential conflicts** which need to be **managed by** the institutional actors like **Port Authority** and **official stakeholders**.

This plan establishes a strategy for reducing port-related emissions while allowing the continuation of port development and job creation and economic activity associated with that development. The plan introduces anti-air pollution measures and best practices that applied

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mainly in the USA and Australia including all suggestions and opinions that were exchanged with EU partners within the project APICE. In addition, some of **the proposed measures** have a direct and **measurable impact** on reducing air pollution while for other measures cannot be quantified their contribution on air pollution mitigation despite their **positive impact**. The main issues for specific port-related emissions that this plan will address are **ships, diesel powered equipment, bulk cargo management, rail, diesel road vehicles** and **inventorying/monitoring/communicating tools**. The above port-related issues and parameters are further specified in the next section that details the proposed measures for air pollution mitigation.

Within the framework of environmental protection and sustainable development, Thessaloniki Port Authority S.A. was the first port of the Mediterranean to receive the "**Port Environmental Review System**" certification for environmental issues **by the European Sea Ports Organisation (ESPO)** and the **ECOPORTS Foundation**. Moreover, in harmonization with the community directive 2000/59/CE and the MARPOL 73/78 Convention, Thessaloniki Port Authority implements a ship's waste receipt and management plan. Port Authority acknowledges the significance of environmental issues related to air, soil and water quality as well as resource consumption and endeavors to achieve long-term sustainable development by minimizing air, land and water emissions in all its operations.

The main goal of Thessaloniki Port Authority, regarding air pollution, is to reduce emissions up to 20% and take compensatory actions for the greenhouse gas (GHG) emissions up to 25% annually.

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Dry bulk cargo management

Dry bulk cargo is a commodity cargo that is transported unpackaged in large quantities. It refers to material granular, particulate form, as a mass of relatively small solids, such as grain, coal, or gravel. This cargo is usually dropped or poured, with a spout or shovel bucket, into a bulk carrier ships hold, railroad car, or tanker truck/trailer/semi-trailer body and sometimes stored in the port specific areas until the upload. Dry bulk cargo management is classified as an important measure which faces the air quality problems from the airborne particles. The generation of dust from handling dry bulk materials and blowing of dust from piles causes significant environmental impact close to the port city areas of Thessaloniki.

The cargo is accommodated in the Terrestrial Zone of Thessaloniki's port in an area extending on a total surface of approximately 1,000,000m^2 with quay length of 4,000m and depth up to 12m. Cargo 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)
- Dry 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

The storage of cargo takes place in:

- Warehouses: 85,000 m^2 (out of which 21,500 m^2 and a reefer warehouse of 4,000 m^2 are located in the Free Zone)
- Sheds: 12,000 m^2
- Outdoor Storage Areas: 500,000 m^2
- Silo of 20,000 tones

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Table 2 Total dry bulk cargo for the port of Thessaloniki (year 2011)

DRY BULK CARGO (tones)			
	IN	OUT	TOTAL
Cereals	93.544,00	74.613,00	168.157,00
Cattle feed/Fodder/Oil Seeds	134.494,00	4.441,00	138.935,00
Coal	479.241,00	-	479.241,00
Ores	1.215.519,00	703.155,00	1.918.674,00
Fertilizers	56.768,00	-	56.768,00
Other dry bulk	544.912,00	286.270,00	831.182,00
	2.524.478,00	**1.068.479,00**	**3.592.957,00**

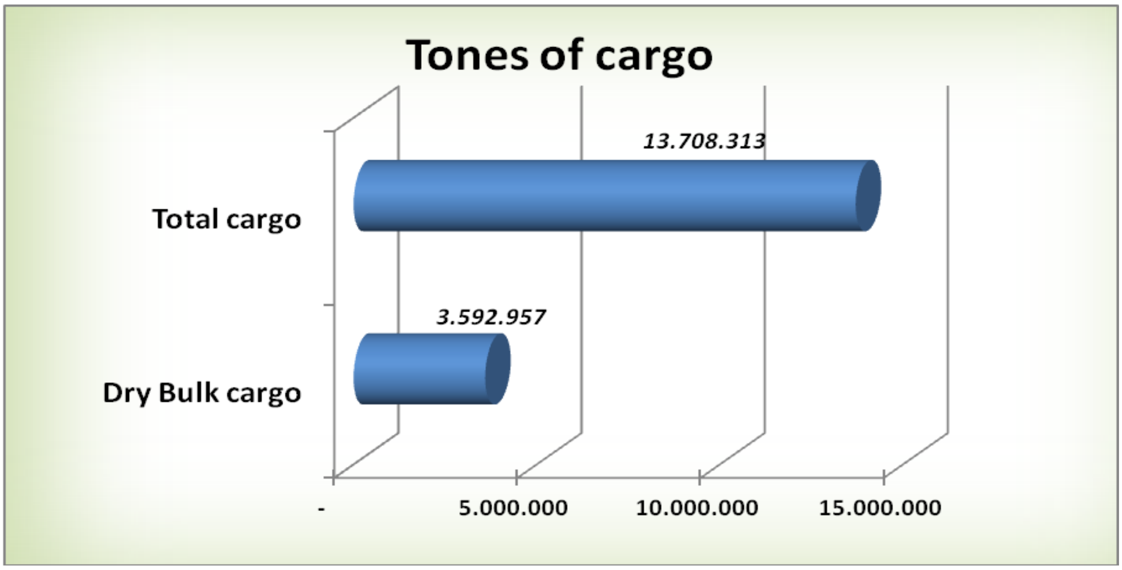

Figure 1 Statistical data of cargo in Thessaloniki port (year 2011)

Specifically, in Thessaloniki's port, the problems with airborne particles generated mainly at piers 5 and 6, where the dry bulk cargo is stored. The average residence time of dry bulk storage in the port of Thessaloniki area is ten days. The intense weather sometimes aggravates the air quality of the close port area at the western part of Thessaloniki city center.

Wetting of dry bulk

In order to reduce airborne particles emission mainly to the close port areas a wetting system is proposed. The proposed **wetting system** will consist of special sprinklers properly installed at specific locations to completely cover the selected area. The sprinklers will operate scheduled, according to the daily needs and depending on the prevailing weather conditions. Water will be supplied from the hydraulic network of the port and the positions will be stable and properly configured for the reception of water cannons. In some cases the wetting system will use **chemical wetting** that creates a protective crust above the cargo for greater protection when permitted due to chemical reactions. For chemical stability reasons, most of dry bulk cargo is proposed to be wetted with water rather than with chemical (foam).

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The proposed system is totally **applicable** and suitable for the Thessaloniki's port needs and has reasonable **installation cost (12,000€)** and **low maintenance cost (500€/y)**.

Chemical wetting is based in advanced **powerful polymer emulsion** that produces highly effective **dust control**, **erosion control** and **soil stabilization**. This technology should provide bonding, cohesion, versatility, cost-effectiveness and environmental compliance and overall performance. Also, the choice of the chemical product should be based on internationally recognized scientific and engineering evaluators of environmental performance and should have international verifications.

It should be noted that the chemical impregnation, even the extended wetting with water and the interaction between the loads can cause distortion. Also, because of the chemical reactions or poor ventilation may result: sweating load and change of humidity, molding, self-heating and possible spontaneous combustion, oxidation of metal parts, etc causing extends environmental and other problems. For all the reasons above, the wetting measure should be used in a very careful and sophisticated manner. Only authorized and well qualified employees should manage the wetting systems and, a consultation (approval) from a specialist in chemical sciences should follow.

On a local scale (in and near the port area of Thessaloniki) and for the reference year 2020, **the dry bulk wetting is expected to reduce significantly the PM10 and PM2.5 maritime/harbor emissions** by -31% and -14% respectively. In the figure below, the results of the change (%) in the mean PM10 concentration values are presented when implementing the wetting system. The results are based on the implementation of a modeling system that consists of the meteorological model WRF and the photochemical model CAMx. The system was implemented using the meteorology of the year 2011, while the reference year for the pollutant emission data used was 2020. According to Figure 2, the use of the wetting system could be characterized as more beneficial for the port and neighboring areas. In and near the port area, the decrease of PM10 mean concentration in the summer month reaches -4.5%, whilst in winter is about -1%.

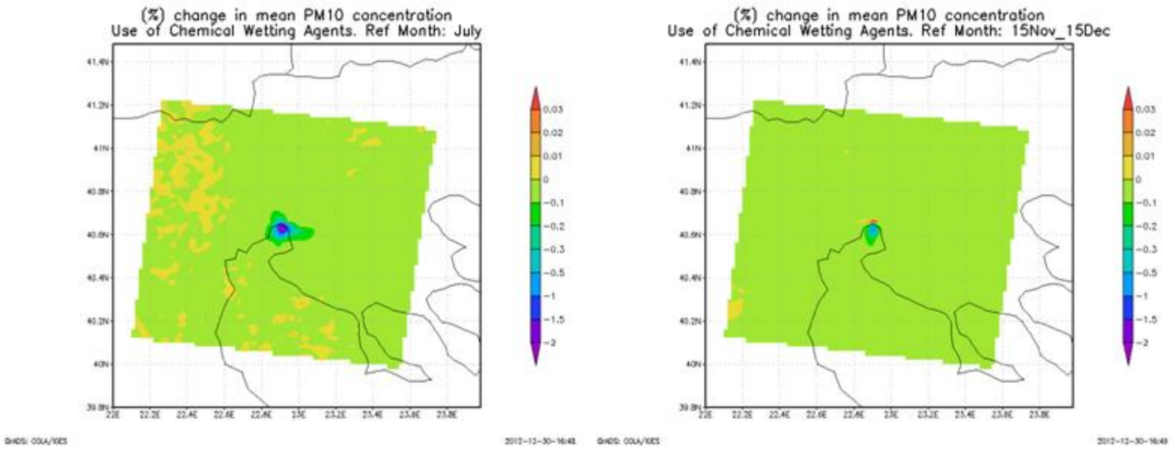

Figure 2 Change (%) in the mean PM10 concentration values implementing the "Use of Wetting Agents" mitigation action during July and 15 of November to 15 of December periods

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The dry bulk cargo management requires proper and well operational practices of loading/uploading. The proposed practices refer to both storage and time residence of the bulk cargo in the region of the port and to the permissive conditions of dry bulk cargo handling, as mentioned bellow:

- **direct loading of bulk cargo to the means of transport** (trucks, railway etc) in order to achieve the minimum stay of cargo at the ports' region
- **maintaining pile size/volume consistent with customer demand, transportation schedules and materials cost** to reduce the amount of material exposed to weather conditions
- **suspending unloading and handling operations during unfavorable weather conditions** (precipitation, wind) that could, otherwise, increase run-off or blowing dust
- **using enclosed conveyors or chutes and telescoping arm loaders** to reduce spillage and dust
- **minimize the distance between the working face and trucks/trains being loaded to reduce the area that has to be swept/cleaned**
- **regularly inspecting dry bulk storage piles, facilities and handling equipment** to ensure proper operation is maintained
- **scheduling regular mechanized sweeping of the bulk storage and access/egress areas**
- **wash down or spray the underside and tires of trucks transporting dry bulk materials on to public roads** to reduce dust
- use of **modernized loading/uploading technologies** (hopper, silo/elevator, loading boom etc)

The success of the proposed processes depends on the organization and management of transports, loading schedules and operational procedures, accuracy of cargo ships arrivals, proper function of the customs office and coast guard and the good cooperation between all the above factors.

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The Local Plan includes standards that achieve real emissions reductions, a nested set of implementation strategies, investment in the development and integration of new/cleaner technologies into port operations and the creation of a comprehensive air quality monitoring system within the ports' region in order to help in the control of the ports' operational activities.

One way to protect and assess air quality was through the development of an **air quality monitoring station**. Air quality samples are generally collected for one or more of the following purposes:

- To **judge compliance** with and/or progress made towards meeting ambient air quality standards
- To **activate emergency control procedures** those prevents or **alleviate air pollution episodes**
- To **observe pollution trends** throughout the port region
- To **provide a data base** for research evaluation of effects: urban, land-use, and transportation planning, development and evaluation of abatement strategies, and development and validation of diffusion models

For all the above reasons, the monitoring station can be an essential tool for achieving the environmental objectives of the Port Authority, who will be responsible for the station **installation** which is estimated to cost **approximately 50,000€**. The cost of **maintenance and calibration** is proposed to be outsourced and estimated at **6,000€ per year**.

The operation of the monitoring station may assist towards the publication of air quality information according to the national legislation (*Common Ministerial Decision 77921/1440/1995*) concerning the access to environmental information. The **management of the monitoring station** and the publication of air quality information may be under the responsibility of a **newly established working committee** which will consist of official and scientific staff of the Environment Departments of the Thessaloniki Port Authority, Municipality of Thessaloniki, Regional Unit of Thessaloniki and the Decentralized Administration of Macedonia-Thrace.

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Reducing the dependency on trucks by enhancing the use of rail and the implementation of short sea shipping is a goal that many ports should achieve. Consider a long term, operational change to increase the amount of cargo leaving or reaching the Port on rail versus truck. The **extensive and effective use of rail will reduce trucks** from the port of Thessaloniki, which will result in changes both in the traffic within the ports' area and in the loading/unloading cargo process. It is estimated that an effective and complete **rail operation could decrease 40% to 50% the use of trucks** as a mean of cargo and container transport.

Presently, moving goods with locomotives generates less pollution than with trucks per tone of freight moved over the same distance. It is estimated that the cargo moving from or to the port of Thessaloniki by rail is approximately 2,000,000 tones in the year of 2011 representing 15% of the total freight.

Compared to trucking and rail efficiency numbers, train has an efficiency of approximately 400 ton-miles per gallon (diesel) whereas trucks around 130 ton-miles per gallon. These efficiency indicators relate in direct proportion to air pollution caused by the transport of port cargo.

An analysis of the costs involved with rail and truck freight transportation is illustrated bellow (Table 3). The focus to the costs that are currently not reflected in the rates, or private costs, when is decided the mean of transport freight over one of the two modes. A direct comparison of the public and external costs can be difficult because of the wide variety of vehicles, operating environments, different types of freight and hauling distances. Also, the methods used to measure these costs vary widely and can often result in very different numbers. The costs discussed previously were analyzed both in aggregate and in the context of shipments that are competitive between the two modes, depending on the data used in the analyses. Similar methodologies were employed to quantify both truck and rail costs for a valid comparison. These results show that truck freight transportation imposes a higher cost than rail transportation.

Table 3 Summary of costs for truck-rail competitive freight shipments (cents per ton-mile)

Mode	Private Cost	Public Cost	External Cost	Total non-private costs	%
Truck	7.69	0.25	0.86	1.11	14.4%
Rail	2.68	0.00	0.25	0.25	9.3%

- *In economic terms, private costs are the costs that are borne directly by the user.*
- *Public costs are costs that are borne by the public through taxes or other fixed-rate fees, and are used to provide an indirect but essential part of a particular good or service.*
- *External costs generally include environmental costs imposed on non-users. Air pollution, noise, and the cost to society of accidents are typically categorized as external costs.*

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Setting performance requirements is becoming more and more common practice in the management of railway infrastructure. The recent development of EN50126, the European Standard for Reliability, Availability, Maintainability and Safety of Railway Systems, shows the changing attitude towards maintenance of railway assets. Maintenance of railway assets is not regarded anymore as something that needs to be done, but more and more as a professional business delivering very important products for rail operations by **improving the most important operational indicators**:

- **Availability**: the time that the infrastructure is available for operations per calendar period.
- **Reliability**: the time that the infrastructure is available for operations during the operation periods agreed.
- **Safety**: this aspect is covered in design criteria, maintenance thresholds (e.g. geometry control limits), inspection and failure response strategies (e.g. inspection frequencies and speed restrictions).

The improvement and extensive use of rail transportation system is a constant target of the Port Authority. Despite the **high cost** for the rail infrastructure improvements that is required and the **difficulties in the organizational collaboration between all related agencies and actors**, the use of rail system can deliver significant environmental effects on air quality.

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Ships are generally powered by large diesel engines operating on low quality fuel oil of relatively high sulfur content (average around 2.7% sulfur by mass). These large slow revving diesel engines produce more NO_x and particle emissions per unit of power output than smaller automotive diesel engines. The sulfur content of marine fuels is emitted as SO_2, leading to secondary formation of very fine aqueous sulfate particles. The shipping industry provides a market for low quality residual oil produced during oil refining and so contributes to the overall economics of oil as a fuel source.

Ships use diesel powered electrical generators on board for lighting, air conditioning, control systems, fuel and water systems, bow thrusters and cargo handling. Ships also use oil fired boilers for fuel heating, cargo heating and to produce steam to supply turbines for cargo and ballast pumping. Cruise ships have relatively high electrical loads to supply the needs of passengers. Container vessels also use electricity to run refrigerated containers. Oil tankers tend to use fairly inefficient steam driven pumps to deliver cargo, driven by oil fired boilers.

Table 4 presents the calculated emissions from shipping in each operation mode (cruising, maneuvering and hotelling) for a reference domain with 100x100km^2 extend centered over Thessaloniki. 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 NH_3 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. For all pollutants, the total cruising emissions represent the highest share of total emissions from all operation modes (cruising, maneuvering and hotelling).

On a more local scale (in and near the port of Thessaloniki), the comparison of ship hotelling and maneuvering emissions shows that the hotelling of ships is a more important emission source for CO, NMVOCs and PM in relation to ship maneuvering. The highest CO and NMVOCs hotelling emissions are emitted from ferries. PM hotelling emissions are emitted mainly from Containers and General Cargo ships. NO_x and SO_x emissions released from the maneuvering of ships, mostly of Containers and General Cargo ships, are greater than those from hotelling.

Table 4 Pollutant emissions (tn/year) from shipping in the area of Thessaloniki (reference area: 100x100km^2; reference year 2010)

		CO	NOx	SOx	NMVOC	NH_3	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**

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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**

Speed reduction on approach or departure from port

Slowing the speed of ships as they approach or depart the port, results in overall less fuel use and reduces overall emissions. Reduced vessel speeds demand less power from the main engine, which in turn reduces emissions and fuel consumption. **A 10% speed reduction may reduce emissions by approximately 20%. A 20% speed reduction may reduce emissions by approximately 35%**.

Port boundaries at sea are defined by an arc centered on a defined point at the port entrance. For Thessaloniki, **the radius of the arc is 4 nautical miles**. The **Restricted Speed Zones** are administered by the Maritime Safety (General) Regulation 2009 and begin at the harbor entrance. They exist for operational safety within the confined harbor waters.

Reducing vessel speed within a specified geographical limit reduces fuel consumption and emissions. The Port Authority of Thessaloniki should impose **speed reduction to 6 knots within 10 nautical miles** from the coast. Speed restrictions should be in force within the port limits. Also, for vessels with a length over 12 meters the maximum speed could be 6 knots. For vessels with a length under 12 meters, the maximum speed could be 12 knots.

Costs of reduced vessel speed include the cost to shippers for operating their vessels for a longer period due to the reduced speed. Increased costs will be offset by reduced fuel costs within the reduced speed zones due to reduced fuel consumption. Alternatively, shippers may choose to cruise at higher speeds outside the vessel speed reduction zones to make up for lost time. Current global deliberations around greenhouse gas emissions from shipping are also considering the use of slow steaming and optimized schedules for reduction of greenhouse gas emissions.

Low sulfur fuel

The two potentially effective options to reduce emissions from ships are the use of **low sulfur fuel** and shore power. For low sulfur fuel, there is a range of options for the level of fuel sulfur and the extent of the area in which the fuel sulfur is controlled. Reducing fuel sulfur significantly **reduces particles as well as sulfur dioxide emissions**.

The EU has directed that **from 2010 fuel of sulfur content 0.1% or less by mass must be used at berth in European Union ports from January 1, 2010**. The sulfur limit is detailed in Article 4b, EU fuel sulfur directive 2005 (EU, 2005) and a subsequent amendment. The terminology “at berth” covers ships alongside, buoys or anchored and whether or not they are working cargo. The rule covers all grades of fuel oil and all types of combustion machinery including main and auxiliary boilers. Ships need not comply with this 0.1% limit while maneuvering but must comply as soon as possible after arrival in port and comply till as late as possible before departure. The Bunker Delivery Note (BDN) from the fuel supplier must clearly indicate the actual sulfur content of the fuel. The requirement also applies to all vessels while operating on inland waterways.

Meanwhile, the **MARPOL Annex VI amendments** in 2008 introduced requirements for lower sulfur content in fuels globally, but also more stringent limits in the Emission Control Areas. In order to ensure regulatory consistency the European Commission presented a proposal in July 2011 to amend Directive 05/33/EC1 aligning EU legislation with the latest IMO requirements. In addition, the alignment with the international standards will be accompanied at EU level by a set of dedicated measures, which are further elaborated in the Commission Staff Working Paper published on 16 September 2011. The proposal includes **limits for sulfur content in marine fuels** used in Member States’ territorial seas outside ECAs: 3.5% from 1 January 2012, **0.5% from 1 January 2020**. The latter date could be changed to 1 January 2025 subject to assessment by the IMO of the availability of marine fuel to comply with the maximum sulfur content of fuel of 0.50%.

Port police of Thessaloniki is responsible for the enforcement of all the above requirements at least in respect of vessels flying their flag and vessels of all flags while in their ports.

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The implementation of ship emission reduction measures has been driven largely by either regulation or the provision of incentives to reward changed practices. Some identified **ship emission mitigation practices** include:

- **low sulfur fuel within a 10 nautical miles distance from the coast**: Required use of low sulfur fuel in ship main engines, auxiliary engines and auxiliary boilers within a 10 nautical miles distance of the coast. The required sulfur content will drop to 0.1%
- **continuous emission monitoring equipment on board.**

There is a limit to how far the sulfur content of Residual Oil (RO) used by ships can cost-effectively be reduced. Low sulfur RO down to 1% sulfur content is available. Higher quality marine diesel fuels with sulfur content as low as 0.1% (i.e. distillates such as Marine Diesel Oil-MDO and Marine Gas Oil-MGO) are produced, at a greater cost. If ships were required to use fuel other than heavy fuel oil in or near port, they would have to either bring MDO or MGO with them.

For any given engine, using MGO fuel with sulfur content of 0.1% may **reduce particles by 80-90%, SO_2 by 80-90% and NO_x by 5-6%.** Alternatively, using RO with 1% sulfur content may only reduce particles by 20% and SO_2 by 50-60%.

Low sulfur MGO costs at least 50% more than conventional RO. There would also be **capital costs** for ship owners to modify on-board systems to allow use of low sulfur fuel in auxiliary engines and auxiliary boilers of **5,000€ - 25,000€ per boiler**.

There is a significant risk of problems with fuel changeover in main engines and thus loss of propulsion while on-route. The international experience being developed regarding fuel changeover and operation on low sulfur fuels whilst cruising will provide more detailed information on this measure in the near future.

Shore power (future action)

Shore power, also referred to as **cold ironing**, involves switching off auxiliary engines at berth and supplying the ships with electricity from shore. The rate of uptake of the shore power option is limited by the high capital cost required for both ports and ship owners. The emissions benefits at berth also depend on the contribution of auxiliary boilers to total emissions. Use of shore power has the significant added benefit of protecting adjacent premises from the noise from the generators.

The feasibility of installation of shore power depends on the physical space on the wharves, the available electrical supplies and the number of relevant cruise vessels that have shore power capability or can be reasonably converted. The maximum auxiliary engine power generation indicates the peak electrical loading which would need to be supplied from the shore. The maximum electricity demand for any individual vessel at these berths is 11 MW, which would require a large substation. The greatest cost benefit for installing shore power at berths and connections on ships would be obtained for frequent visitors with high auxiliary engine energy production per visit.

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The cost of installation of the shore power facility may be approximately **3 million €** or more **per berth** if new substations need to be installed. The cost of installation of the facility **per ship** is of the order of **0.4 million €.** The high capital investment for ports and ship owners is a barrier and reduces the overall cost-effectiveness of this option when considered against the emissions savings. However, the current purchase cost of electricity is less than the cost of fuel to run ship auxiliary generators, depending on the means used to generate the shore power and the required fuel sulfur content. Also, there will be reduced auxiliary engine maintenance costs.

On a local scale (in and near the port area of Thessaloniki) and for the reference year 2020, **the cold ironing is expected to reduce significantly pollutant emissions** according to the following: -80% for CO, -46% for NOx, -15% for SO2, -82% for NMVOCs, -19% for PM10 and -55% for PM2.5. The implementation of a modeling system that consists of the meteorological model WRF and the photochemical model CAMx has revealed that the expected changes in mean PM10 and PM2.5 concentrations, which are the key pollutants within APICE, due to the cold ironing emission control are expected to be very small (<-1%). However, this may not be the case for the gaseous pollutants like SOx, NOx and CO.

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Trucks operation mode, traffic and handling

The growth in freight traffic has resulted in growth in the associated environmental impacts. **Diesel truck emissions are responsible for the primary environmental impact of truck freight transport**.

Diesel trucks have served freight needs very well for over 40 years because of their durability, reliability and relative efficiency. Since 1970, with the focus on air pollution and the setting of air quality standards, heavy-duty diesel engines have become less harmful for the environment. Despite this progress, the air pollution from diesel trucks is still a health concern and contributes to continuing air quality problems. Trucks release unburned hydrocarbons, carbon monoxide (CO), sulfur oxides (SO_x), nitrogen oxides (NO_x), particulate matter, and other toxic compounds. Although diesel trucks account for only a small amount of hydrocarbon emissions and carbon monoxide emissions, they do **contribute large amounts of NO_x and particulates**.

Trucks that serve port terminals are a vitally important link in Thessaloniki's port operations. In Thessaloniki, **the majority (85%) of cargo and containers are moved via trucks** and tractor-trailers. More than **11 million tones of cargo moved the 2011 by truck**. While delivery vans and small trucks (light trucks) account for a significant portion of activity, tractor-trailer trucks (heavy trucks) move a large volume of goods.

A **broad based mitigation strategy** like the proposed measures bellow could be beneficial for addressing diesel road trucks emissions.

Operational actions

All trucks accessing the Port of Thessaloniki maritime terminals to pick up or drop off cargo should behave in a manner that favors the increase of roadway capacity and the reduction of congestion. It is estimated that more than **100,000 trucks of all types per year entering the port of Thessaloniki** for loading and unloading.

The Port Authority and stakeholders should begin an initial phase of truck-related emissions reductions with a range of **operational actions**, such as:

- The development of an **appointment system for trucks** serving the terminals, including a **fast lane** in order to **decrease total truck turnaround time**
- The development of a **Port truck parking areas** to **reduce idling emissions**. Consider including rest stop amenities as part of the parking area to encourage use
- The conduct of a **study of freight movement, modal splits, and short sea shipping.**

Idle reduction programs

Idle reduction programs aim to decrease the amount of time vehicles spend in idle mode as part of their overall operation. Idle reduction could be implemented through local anti-idling rules as well as educational programs. Anti-idling rules stipulate areas where idling is not permitted or regulate the duration of idling. Educational programs relating to engine warming and advocate fuel cost savings associated with switching off an engine after a certain period of idling.

One hour of idling is estimated to produce 1-5 grams of PM_{10} and 140 grams of NO_x, based on a post-1995 diesel truck. Idle Free BC, a program hosted by the BC Climate Exchange in British Columbia, Canada, has estimated that **vehicle idling reduction programs** have the potential to **reduce approximately 20% of annual fuel budgets**.

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Technological improvements on Diesel powered port equipment

Thessaloniki Port use a wide range of **diesel powered equipment** (cranes, forklifts, loaders, derricks, small locomotives and trucks, platforms, etc) to move cargo. There is a range of technologies that have been developed to reduce emissions from diesel engines, and which are applicable to landside freight handling and port operations.

The cargo handling equipment of the Thessaloniki's Port Authority consists of:

Cargo handling equipment	Energy usage
44 rail-mounted power driven cranes	Electric powered
4 cranes for containers	Electric powered
1 transtainer	Electric powered
1 Gottwald HMK 260 EG mobile harbor crane	Diesel powered
2 mobile cranes	Diesel powered
78 forklifts	Diesel powered
24 Loaders	Diesel powered
17 straddle carriers	Diesel powered
5 front lifts	Diesel powered
4 tractors	Diesel powered
Numerous other cargo handling equipment (derricks, platforms, etc)	Electric and diesel powered

There are suggested some practices like accelerated fleet turnover and idle reduction programs to reduce emissions during the use of cargo handling equipments. Although, it is highlighted the available technologies aiming in reducing particulate, VOC and NO_x emissions through chemical and physical processes to change the composition of the exhaust from cargo handling equipment. These technologies reduce the operating cost of the vehicle however the capital cost of installation is high. Two equipment emissions improvement technology options that were discussed during the stakeholders' consultation are presented below.

Diesel Oxidation Catalyst (DOC)

A **diesel oxidation catalyst (DOC)** device can be connected to the exhaust of a diesel engine or vehicle to reduce the emissions of CO, VOCs by converting them to CO_2 and water. DOC technology is proven and installed in many locations throughout the world. The installation of a DOC is able to **reduce CO and VOCs emissions by up to 90%** by oxidising CO to CO_2 and combusting VOCs to CO_2 and water. **Particulate emissions can be reduced by up to 30%** using this technology. DOCs are a cost effective method of emission reduction, costing around 3,000€ depending on the size of the engine and the configuration of the exhaust. They are relatively easy to install and are largely maintenance free.

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A **diesel-electric hybrid** conversion can also significantly reduce the emissions from diesel powered equipment use. The Hybrid Diesel Electric equipments use a combination of a heavy duty battery rack and a small diesel generator. Apart from the reduction in air emissions and fuel consumption, hybrid diesel electric equipments also have the co-benefit of reducing noise levels at port facilities. The conversion to a diesel electric hybrid engine can **reduce emissions of NO_x by 50-90%, particulate matter by 50-90%, SO_2 by 40-60%** as well as reducing fuel consumption by 40-60% each. Since this technology is innovative and “fresh” in industry, current costs of hybrid diesel electric cannot be accurately estimated and expected to be fairly high particularly if there are an integrated purchase of equipment and not a retrofitting intervention.

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Within APICE project and due to consultation actions the key stakeholders emerged and revealed their intentions on mitigation practices regarding air quality in the urban area of Thessaloniki. Therefore, the key stakeholders view the Local Adaptation Plan as a **roadmap for future regional/local air quality environmental plans and urban master plans** in the region of Thessaloniki.

In this framework, the Thessaloniki Port Authority understands the Local Adaptation Plan as a tool for both achieving the environmental objectives and validating the **upcoming Port Master Plan**. Also, future actions on the field of urban or port infrastructure and strategic investments should be analyzed and evaluated in the light of the Local Adaptation Plan in order to ensure their sustainability and environmental utility.

Furthermore, the stakeholders realized the need of transitioning from the promising strategies to actual implementation of the specific actions needed to achieve further emissions reductions and remark that the **work procedure developed** within the project can be really useful, in order to **define and communicate different air quality measures and other environmental aspects on urban areas**.

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SUMMARY - CONCLUSIONS

This Plan has outlined a comprehensive approach for reducing emissions over the next years from maritime-related activities associated with the Port Authority of Thessaloniki and the official stakeholders. These actions aim in reducing air quality impacts on human health and the environment, into attainment with applicable air quality standards. A suite of measures for reducing emissions are included for different sectors of maritime activities (ships, diesel powered equipment, bulk cargo management, rail and diesel road vehicles).

As the proposed measures illustrate, this Plan builds upon a basic set of emissions reduction activities undertaken by the Port Authority and the key stakeholders. The list of proposed measures (

Table 5) highlights the dedication of the Port Authority and stakeholders to move above and beyond the current status with a range of actions to be implemented. The proposed future actions will ensure the sustainable development of the port and this Plan could be a potent think-tank as the Port authority has initiated the procedures for contracting the elaboration of the Port Master Plan.

In conclusion, the bundle of measures for different sectors of maritime activities presents a path for reducing maritime-related emissions which, when implemented, will result in achieving the environmental goals of the Port as well as improving the air quality of the city of Thessaloniki.

Table 5 Proposed measures and estimated goals and costs

Proposed measures		Estimated cost	Main benefits
Solid bulk cargo management	Wetting of solid bulk	Installation of the wetting system: 12,000€ Maintenance of the wetting system: 500€/year	Decrease of airborne particles PM10 and PM2.5 emissions
Solid bulk cargo management	Loading/uploading management	Implementation details needed prior to calculation	Decrease of airborne particles PM10 and PM2.5 emissions
Air quality monitoring and policy awareness		Installation of the monitoring station: 50,000€ Maintenance of the monitoring station: 6,000€/year	- compliance with air quality standards - avoid air pollution episodes - observe pollution trends - provide a data base
Improvement of the rail system operation		Implementation details needed	Decrease of CO, NOx, SOx, NMVOCs and PM

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Proposed measures		Estimated cost	Main benefits
		prior to calculation	emissions
Ship best practices	Speed reduction on approach or departure from port	Not quantifiable	Decrease of CO, NOx, SOx, PM and NMVOCs emissions
	Low sulfur fuel	- 50% more than conventional RO - to modify on-board systems: 5,000€ - 25,000€ per boiler	
	Shore power (Future action)	Installation of the shore power facility: 3 million € Installation of the facility per ship: 0.4 million €	
Trucks operation mode, traffic and handling	Operational actions	Not quantifiable	Decrease of CO, NOx, SOx, NMVOCs and PM emissions
	Idle reduction programs	Reduce approximately 20% of annual fuel budgets	
Diesel powered port equipment emissions improvement	Diesel Oxidation Catalyst (DOC)	Installation of the DOC technology: approximately 3,000€	Decrease of CO, NOx, SOx, NMVOCs and PM emissions
	Hybrid Diesel Electric	- Reduce fuel consumption by 40-60% - The installation cost cannot be accurately estimated	

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