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# WP5.4. Design of Scenarios Supporting Coast Development Strategies

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# Design of Scenarios Supporting Coast Development Strategies


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## February 2013


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## Table of Contents



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# Mitigation Scenarios

Emissions scenarios describe future releases into the atmosphere of gaseous and particulate pollutants and provide inputs to photochemical models. They are based on assumptions about the patterns of socioeconomic growth, the technology development and other factors. They constitute an appropriate tool with which to analyse how driving forces may influence future emission outcomes. They assist in air quality analysis, including air quality modeling, and the assessment of impacts, adaptation, and mitigation. These scenarios have been widely used in the public policy debate on air quality for awareness raising, understanding driving forces, and for the evaluation of mitigation options.

Within APICE, emission mitigation measures (and corresponding emission scenarios) relevant with the maritime and harbor activities were studied for each port-city with the use of Chemical Transport Models (CTM) in order to estimate the expected change in pollutant emissions and air concentrations in comparison to those of a base future emission scenario (more details on the base future emission scenario for each study area can be found at: http://www.apice-project.eu/content.php?ID1=49&ID2=58&ID=58&ID3=49&lang=ENG). The mitigation measures studied were decided mainly after discussions between the governmental bodies, port authorities and scientific groups with a view to increase the territorial knowledge framework and provide indications to undertake environmental-addressed actions towards mitigation strategies as drivers for the sustainable eco-environmental growth of the coastal areas. Following is a presentation of the emission mitigation measures or emission scenarios selected for each study area with a discussion on the related impact on air quality.



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# Barcelona

18 mitigation measures were examined for Barcelona aiming to the reduction of port emissions for the reference year 2015:

1. Promotion of LNG as fuel for ships: It is considered that ferries passengers will use this fuel in the future, considering traffic forecast by 2015. The expected reduction in emissions is about -85% for NOx and -100% for PM10.
2. Cold ironing: It is considered for 10% of cruise passenger, with forecast data for 2015. The expected decrease in emissions is about -6.5% for NOx and PM10.
3. LNG as fuel for tug boats: It is considered that half of the tug boats use LNG, with 2015 data projection. The expected reduction in emissions is about -42% for NOx.
4. Measures regarding trucks: Both NOx and PM10 emissions are expected to decrease by about -8%.
5. Measures regarding trains: NOx and PM10 emissions are expected to decrease by about -3% and -4% respectively.
6. Conversion cargo handling machinery to natural gas: The expected reduction in NOx emissions is about -35%.

Table 1 shows the reduction in the total maritime and port annual emissions of the base future scenario due to the mitigation measures.

**Table 1.** % Change in the maritime and port annual emissions of the base future scenario due to mitigation measures (Reference domain: Port area, Reference year: 2015).

| Mitigation Action | NOx | PM10 |
|---|---|---|
| 18 mitigation actions[1] | -12% | -13% |

[1]The actions are described in text above.

The impact of several future emission scenarios, including the aforementioned mitigation actions, on the air quality of the city of Barcelona was studied using the MM5-CHIMERE modeling system, as described in several works (e.g. Jiménez-Guerrero et al., 2012), including both anthropogenic and natural emissions (biogenic NMVOCs, wind-blown dust and sea salt aerosol). The system was applied over two nested domains covering (1) the entire Catalonia (120 x 120 km2 at a resolution of 2 km) and (2) the Barcelona Metropolitan Area (40 x 40 km2 at a resolution of 0.5 km) (Figure 1). 30 vertical layers up to 100 hPa were used for the simulation of the meteorological conditions and 16 layers up



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to 500 hPa in the CHIMERE configuration. Modeling system simulations were performed for a summer month (August 2011) and a winter month (December 2011).

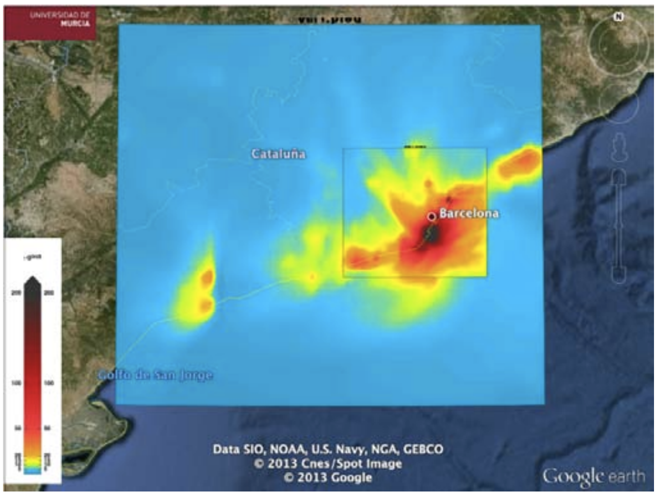


**Figure 1:** One-way nested domains of study simulated with CHIMERE: Catalonia and Barcelona Metropolitan Area. Shaded colours represent the maximum summertime concentrations of sulphur dioxide highlighting the impact of the Barcelona port on the levels of this pollutant.

CHIMERE results are based on the 0.5 km resolution simulations, and cover three different emission scenarios: (a) base-case future scenario: the forecast of the emissions for the port in the year 2015, including the trend scenario of emissions predicted by the Catalonia Government for emissions different from the maritime sector, (b) an analogous scenario to (a), where the emissions for the port include the mitigation measures as defined in APICE and (c) the plan scenario as defined by the Catalonia Government for the year 2015, where the port emissions include the mitigation actions defined in APICE. Further explanations are provided in the document "APICE Plan Barcelona" (http://www.apice-project.eu/index.php?lang=SPA).

Figure 2 presents the change in PM air quality in Barcelona for a summer period (using the meteorology of August 2011) because of the mitigation measures selected. When comparing the APICE mitigation scenario to 2015 base case scenario, values around -10.2% as maximum reductions are found (very similar reductions, -11.3%, are found in the case of PM2.5 concentrations). For the whole modeling domain, we observe a reduction in PM10 (PM2.5) levels around -6.1% (-6.3%) for this mitigation scenario. Analogous results are observed in the APICE mitigation + Plan scenario for 2015 (where reductions from other emitting sectors are included), where the maximum reductions downwind the port area are -12.8% and -11.9% for PM10 and PM2.5 (-5.7% and -5.4% respectively for the whole modeling domain). The above indicate that most of the concentration reduction comes from the mitigation measures in the port and not from the rest of planned emissions for the other emitting activities.



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Analogous results are found for Barcelona in the winter month (simulations using the meteorology of December 2011). The maximum decreases in mean PM levels (Figure 3) are over the coastal areas, and especially over the Barcelona port, where reductions in the order of -10.3% are found as maximum reductions in the scenario including the APICE mitigation measures when compared to the base case scenario for 2015. The results are similar for PM2.5 concentrations, where reductions by -9.9% are modeled as maximum decreases. When considering the mean in the modeling domain, we can observe a reduction in PM10 (PM2.5) levels around -5.6% (-5.2%) in this APICE mitigation + Trend scenario. Similar results are observed in the APICE mitigation + Plan scenario, where the maximum reductions are located near the port: -10.6% and -10.1% as maximum reductions of PM10 and PM2.5, respectively (-5.2% and -4.9% as mean for the modeling domain). As also found for the summer period, the local mitigation actions significantly impact $SO_2$ and $NO_2$ concentrations in the port and surrounding areas.

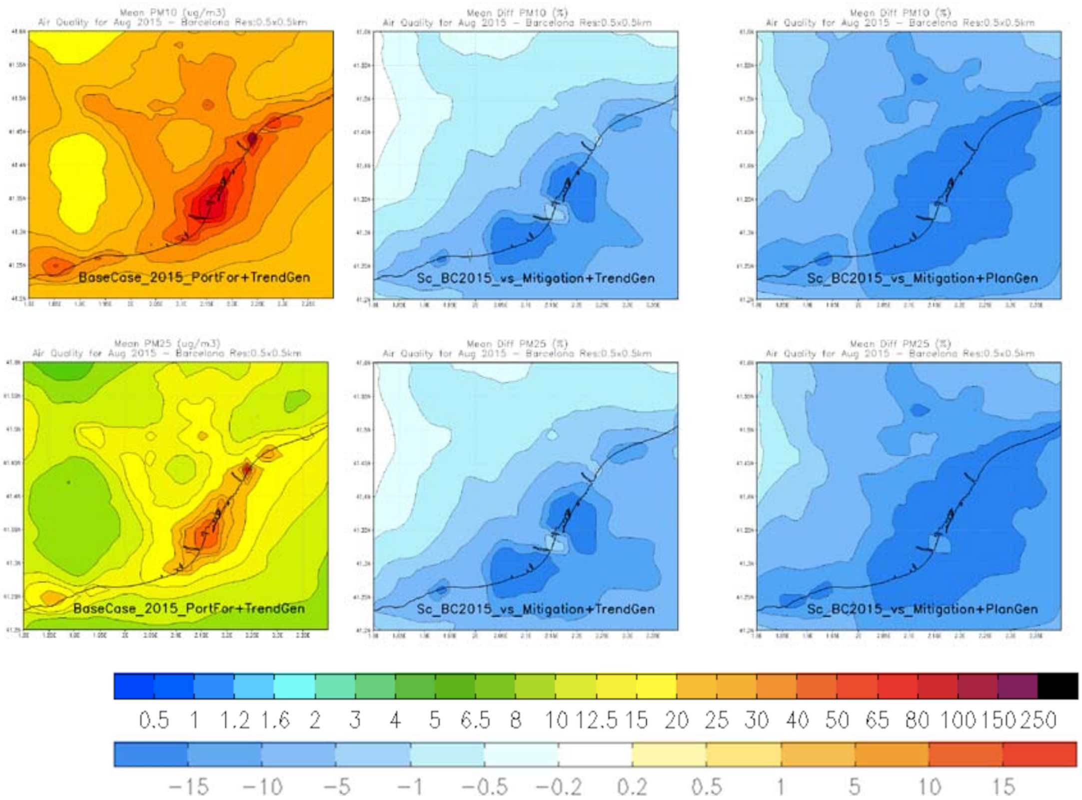


**Figure 2:** Left: Base-case concentrations of PM10 (top) and PM2.5 (bottom) over the Barcelona domain for summertime 2015; Middle: the relative difference (%) due to the APICE mitigation measures + Trend scenario; Right: the relative difference (%) due to the APICE mitigation measures + Plan scenario.



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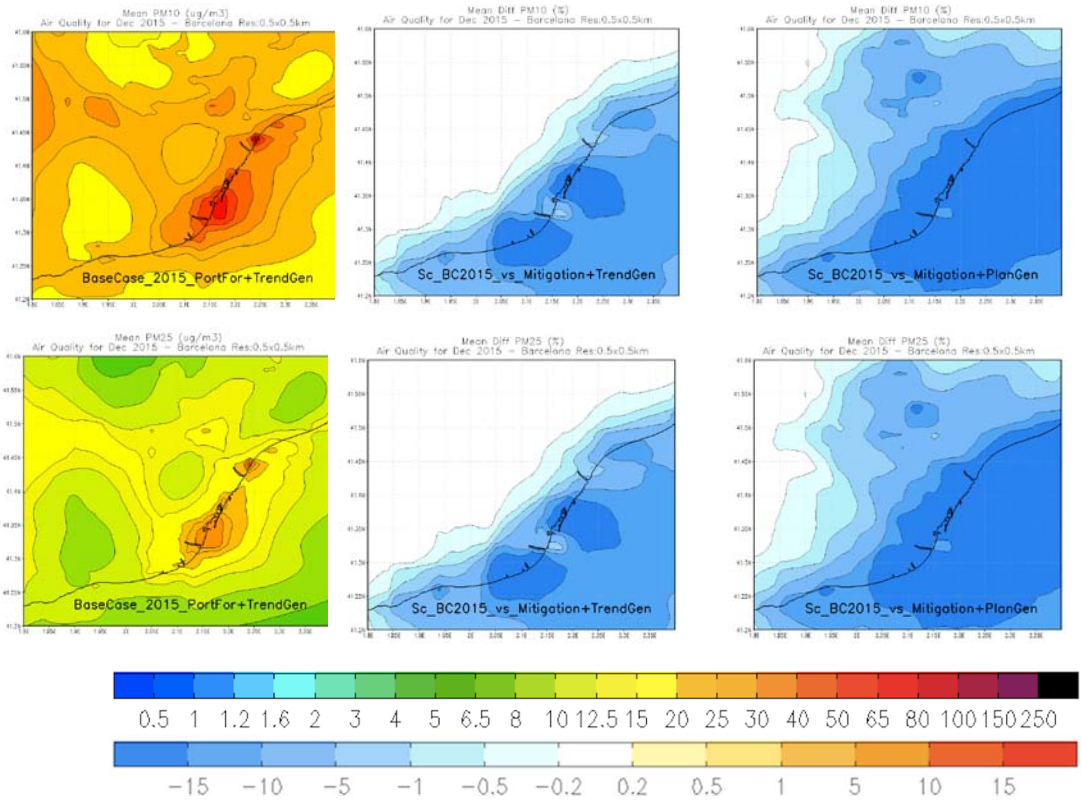


**Figure 3:** Left: Base-case concentrations of PM10 (top) and PM2.5 (bottom) over the Barcelona domain for wintertime 2015; Middle: the relative difference (%) due to the APICE mitigation measures + Trend scenario; Right: the relative difference (%) due to the APICE mitigation measures + Plan scenario.



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# Genoa

The mitigation measure considered for Genoa was the Cold ironing for two different areas of the port, namely the VTE cargo terminal, located at the western edge of the harbour area, and the Ferry Terminal, sited very close to the city center. The contribution of VTE and Ferry Terminal emissions to total harbor emissions is around 10%, while the abatement of the harbor emissions in the area close to the electrified quays is very high (till 80%). The advantage of a very high mitigation at local level can be added to the contemporary mitigation of noise from harbour. Table 2 presents the change in future time ship and vessel annual emissions in the port area due to the cold ironing measure.

**Table 2:** % Change in future time ship and vessel annual emissions due to emission mitigation measure (Reference domain: Port area, Reference year: 2020)

| Mitigation Action | CO | NOx | $SO_2$ | NMVOCs | PM10 | PM2.5 |
|---|---|---|---|---|---|---|
| Cold ironing (ferry and container terminals) | -35% | -38% | -35% | -34% | -35% | -35% |

The emission scenarios were studied with an integrated air quality forecasting system that was implemented at the University of Genoa. Meteorological fields were obtained from the mesoscale model WRF-ARW, whereas air quality simulations were performed using the photochemical model CAMx. By means of subsequent nesting procedures, meteorological and pollutant concentration fields were obtained up to resolutions of 1 km. Initial and boundary conditions needed to drive WRF simulations were provided by the global model GFS, operational at the National Center for Environmental Prediction. Large-scale anthropogenic emissions data were provided by the Aristotle University of THessaloniki (AUTH) after processing the 2005 European emission dataset of The Netherlands Organization with the MOdel for the Spatial and tEmporal diStribution of emissionS (MOSESS) (Markakis et al., 2013). Finally, natural emissions were computed from the WRF outputs using the Natural Emission Model (NEMO) developed by AUTH (Markakis et al., 2009; Poupkou et al., 2010). Figure 4 shows the environmental impact of the mitigation measure on the air quality of Genoa as simulated for the base future time emission scenario using the meteorology of the year 2011. The role played by meteorological conditions (mainly prevailing wind directions) on the impact of mitigation action is clear while looking to Figure 4. Pollutant emitted from the port is carried mainly to N/NW, then the central and eastern part of the city area will be less affected by this intervention, while local consistent effects are expected in western side of the city.



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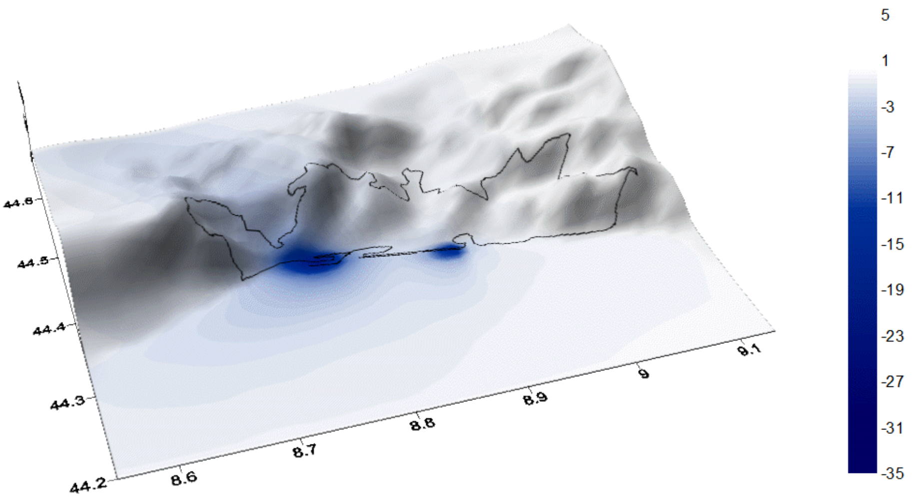


**Figure 4:** % Difference in PM2.5 concentrations between the future time scenario with mitigation action and the 2020 base future scenario (summer month).



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# Marseille

The following mitigation emission scenarios were studied for Marseille having as reference time period the year 2025:

1. Cold ironing: It is applied to passenger ships in rotation between Marseille and Corsica Island. It involves one terminal and three ships of the CNM Company (scenario name "Cold ironing").
2. Build a new cruise terminal: The aim of this scenario is to move the current terminal cruise closer to the historical city center to allow a direct access to the places of interest (scenario name "New terminal cruise").
3. Use of liquefied natural gas (LNG) in shipping: It is applied to passenger and cruise ships for cruising, maneuvering and hotelling phases. This scenario is named "LNG passenger".

The expected changes in the maritime emissions at the scale of the Marseille urban area for each mitigation action examined are reported in the Table 3.

**Table 3:** % Change in the maritime annual emissions of the base future scenario due to mitigation measures (Reference domain: Marseille urban area, Reference year: 2025).

| Mitigation Action | CO | NOx | $SO_2$ | NMVOCs | PM10 | PM2.5 |
|---|---|---|---|---|---|---|
| **Cold ironing** | -3% | -2% | -1% | -3% | -3% | -3% |
| **New cruise terminal** | -0% | -0% | -0% | -0% | -0% | -0% |
| **LNG passenger** | -78% | -57% | -75% | -78% | -78% | -78% |

As the studied scenarios considered very local mitigation actions or a translation of maritime emissions, the ADMS Urban model was used to allow a better evaluation of these actions. This urban model was used over a domain including the Eastern port of Marseille, with an adaptive spatial resolution, narrowed close to the main pollutant sources and over the areas including an emission scenario. Receptor points were computed with a height of 1.5m. Meteorological data were taken from a meteorological station located in Marseille. The main emission sources as road traffic, industry and maritime activity, were modeled as explicit sources. CHIMERE model was used with a spatial resolution of 3km over the regional area, meteorological data from the WRF model and the local emission inventory to include background concentrations for PM10 and PM2.5.

PM10 and PM2.5 concentrations for the "Base future" scenario were computed for a winter and a summer month, using meteorology for February and August 2011 respectively (Figure 5). As the highest PM concentrations were identified during the winter time, the evaluation of mitigation



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actions focused on this period. Seasonal variations were due to lower emissions of primary particles as from the central heating and better dispersion conditions during the summer time.

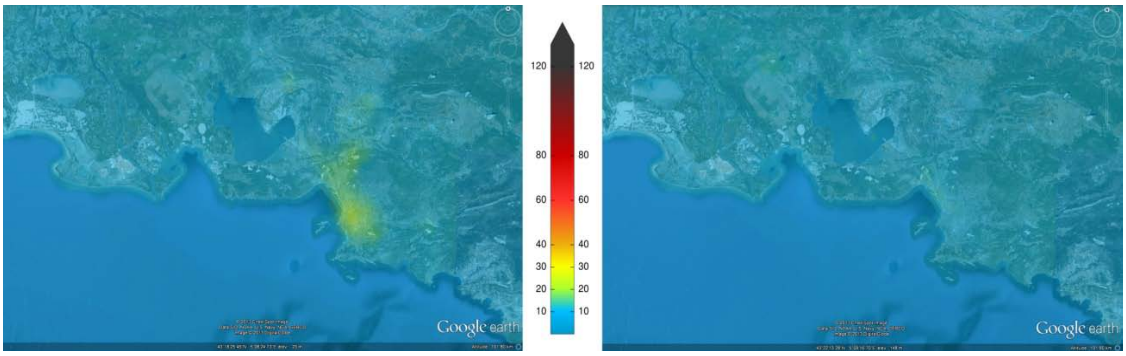


**Figure 5:** PM2.5 concentrations for the “Base future” scenario during winter (left) and summer (right) periods using the CHIMERE model.

Figure 6 displays the expected changes on the PM10 and PM2.5 concentrations as a result of the implementation of the mitigation emission scenarios selected for Marseille for a winter period (using the meteorology of February 2011). The use of LNG as fuel for passenger ships has shown a significant decrease for PM concentrations at the port scale. The impact of the cold ironing action is lower with an improvement located very close to the terminal involved. The new cruise terminal building should significantly reduce concentrations in the northern part of the port with a translation of the emission inside the new terminal. Also, all the local mitigation actions significantly impact NO2 concentrations in the port and surrounding areas.



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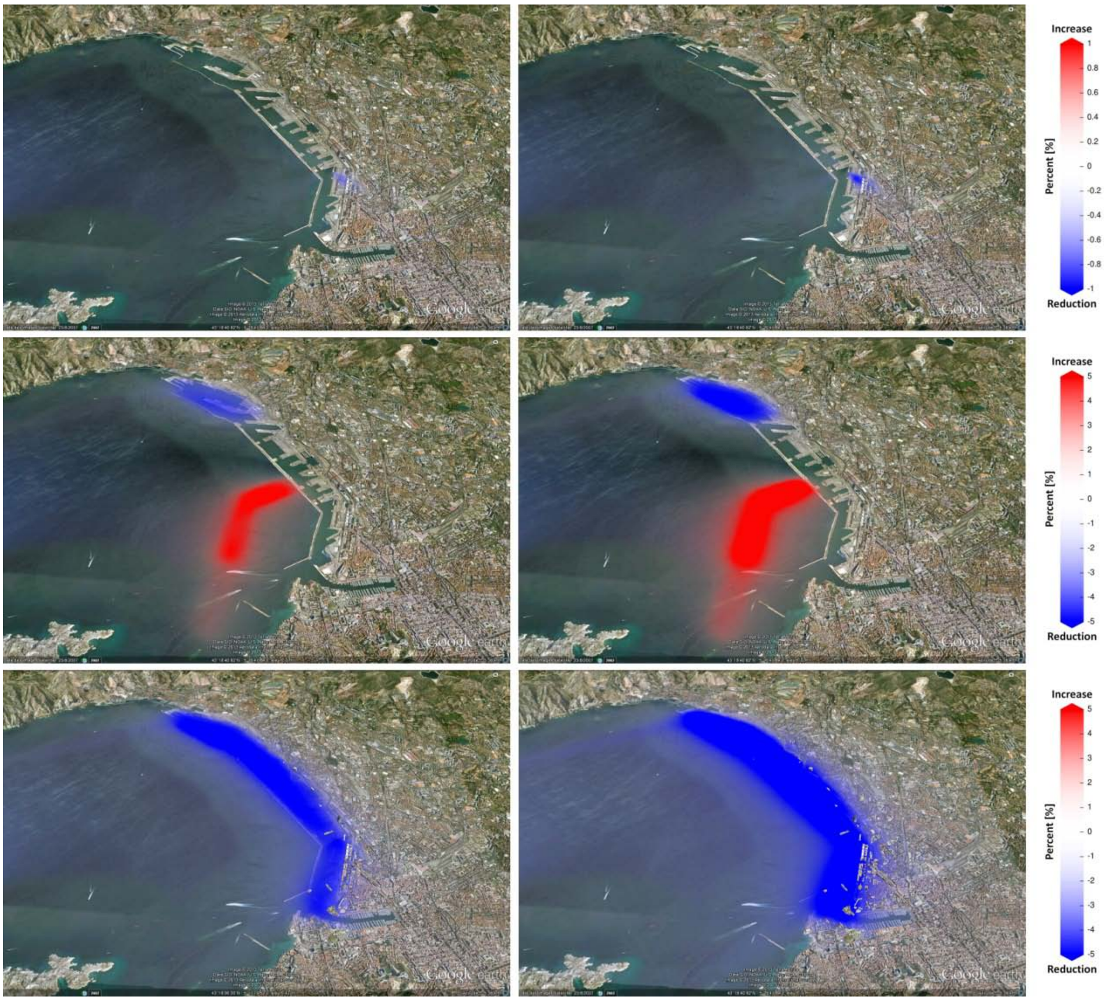


**Figure 6:** Relative difference between the "Base future" and the "Cold ironing" scenario (top), the "New cruise terminal" scenario (middle) and the "LNG passenger" scenario (bottom) for the PM10 (left) and PM2.5 (right) concentrations during the winter period over the urban domain for Marseille.



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# Thessaloniki

The following mitigation actions were studied for Thessaloniki for the year 2020:

1. Cold ironing: It was considered for all types of ships.
2. Use of wetting agents (chemical and water): The aim of the measure is the reduction of the port storage pile PM emissions.

Table 4 reveals that the implementation of both measures is expected to contribute to significant decreases in future PM maritime/harbor emissions in the area of the port. Over the whole study domain centered over Thessaloniki with a 100 x 100km2 extend, the reduction of the PM maritime/harbor emissions due to both mitigation actions was estimated to be small (-4.4% for PM2.5 and -8.1% for PM10).

**Table 4:** % Change in the maritime/harbor annual emissions of the base future scenario due to mitigation measures (Reference area: Port area, Reference year: 2020)

| Mitigation Action | CO | NOx | $SO_2$ | NMVOCs | PM10 | PM2.5 |
|---|---|---|---|---|---|---|
| **Cold ironing** | -80% | -46% | -15% | -82% | -19% | -55% |
| **Use of wetting agents** | 0% | 0% | 0% | 0% | -31% | -14% |

In order to assess the impact of the mitigation actions on the air quality of Thessaloniki, simulations were performed using the WRF-CAMx modeling system (Skamarock et al., 2008; ENVIRON, 2010) applied over a 2km spatial resolution grid for Thessaloniki. There were 17 vertical CAMx layers extending up to 10 km above ground level. CAMx simulations were performed for a summer period (month of July using the WRF meteorology for July 2011) and a winter period (the period from 15 November to 15 December using the corresponding WRF meteorology for the year 2011). CAMx runs were based on the 2km resolution anthropogenic emission data of: a) the base future emission scenario and b) the base future emission scenario reduced in order to account for the mitigation actions selected. 2km spatial resolution natural emission data (biogenic NMVOCs, wind-blown dust and sea salt), as calculated with the use of NEMO driven by the WRF meteorology for the year 2011, were also used. The chemical boundary conditions for the Thessaloniki grid were taken from the results of CAMx having been applied over the Balkan Peninsula for the present time emission scenario.



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Figure 7 shows the differences in the mean PM10 and PM2.5 concentrations of the 2020 year base future scenario due to the implementation of both mitigation actions. The differences are small. The maximum decreases in mean PM levels are identified in and near the port area where PM10 values decrease by -4.4% and -2.4% and PM2.5 concentrations are reduced by -0.9% and -0.5% during the summer and winter period respectively. Controlling PM emissions from port storage piles with the use of wetting agents (chemical and water) improves better the PM air quality near the port area than the implementation of the cold ironing.

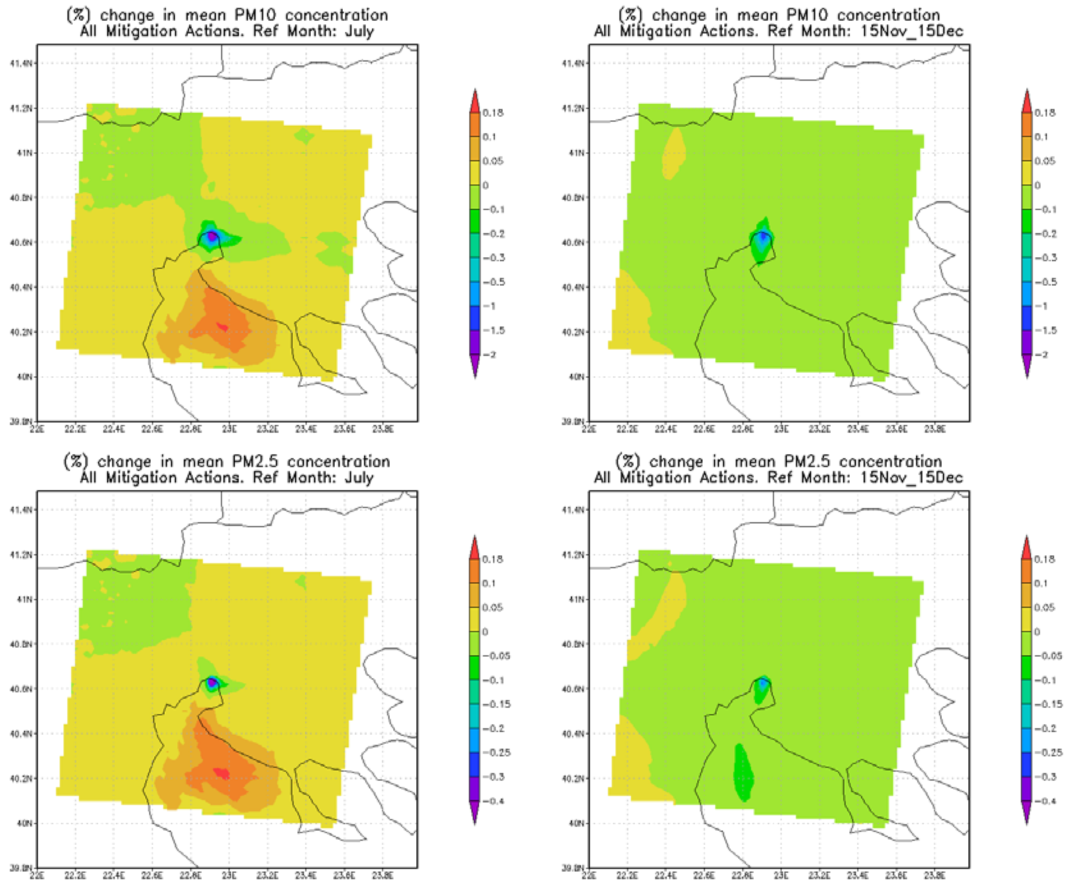


**Figure 7:** Difference (%) in the mean PM10 (top panel) and PM2.5 (bottom panel) concentrations implementing the “Cold ironing” and the “Use of wetting agents” mitigation actions for the summer and winter periods studied.



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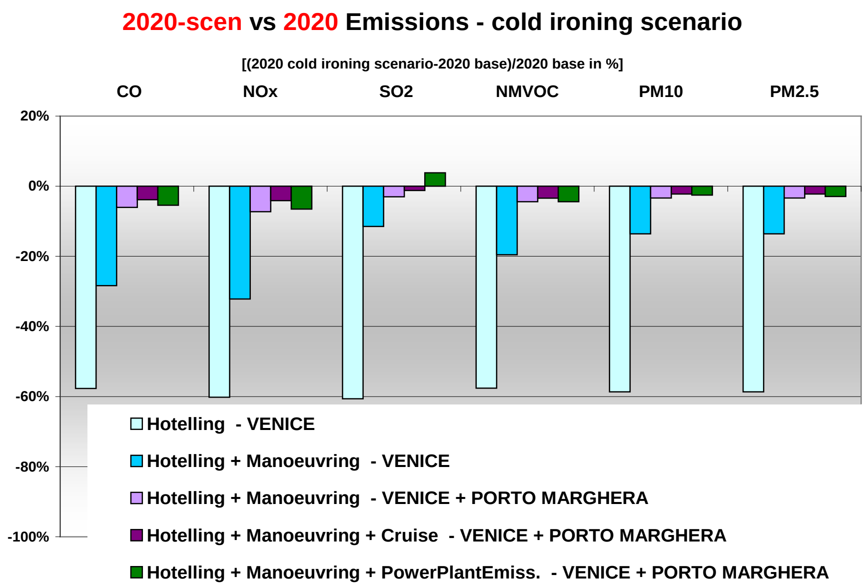
# Venice

One emission mitigation scenario was examined for Venice accounting for the following 2 mitigation actions:

1. Cold ironing: It was considered for the cruise vessels hotelling in Venice at the Marittima Terminal, with a total amount of 6195 hours of power supply in a year and a local production of electricity by the near coal power plant in Fusina (Porto Marghera),
2. Limitation of 0.1% for the sulfur content in ship fuels: The measure was considered for all the passenger ships arriving and departing from the terminal inside the historical city of Venice in maneuvering and cruising phases. The emission estimation calculation has considered an obligation to switch from Bunker Fuel Oil (BFO) to Marine Gas Oil/Marine Diesel Oil (MDO/MGO) in order to reach the limit.

The changes in the emissions of the future reference year 2020 due to each of the mitigation actions examined are reported in Figure 8.



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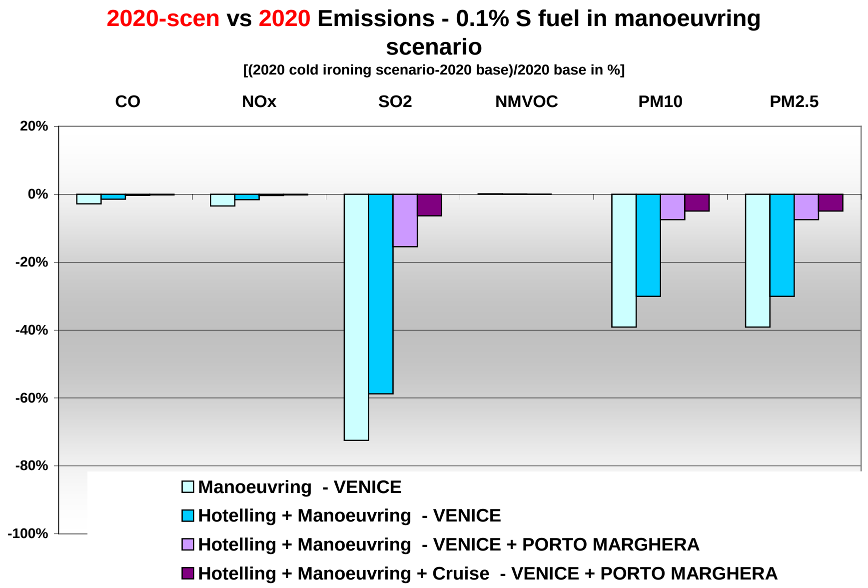


**Figure 8:** % Change in future time emissions due to emission mitigation measures in Venice.

The modeling chain implemented was constituted by COSMO-LAMI (Limited Area Model Italy) meteorological model and the photochemical air quality model CAMx, which was run for two periods: from June to August 2011, and from mid-November to mid-December 2011. The main CAMx grid had an extent of about 250 km and a 4 km resolution, whereas the nested one covered the urban area of Venice with an extent of 30 km and a resolution of 1 km. In the CAMx domain there were 10 vertical layers extending up to 3 km above ground level. The gaseous and PM chemical boundary conditions were provided by the CHIMERE outputs of the Prev'air System (http://www.prevair.org/fr/index.php). Natural emissions (biogenic NMVOCs, wind-blown dust and sea salt) have been calculated during the CAMx simulations, starting from land use and the meteorological data provided as input to the model. CAMx runs were based on: a) the base future emission scenario, with the emission data coming from the projection to the year 2020 of the Veneto Regional Emission Inventory by GAINS-Italy model and the port emissions estimated by the EMEP/EEA methodology on the ship movements foreseen for the development scenario at 2020 and b) the base future emission scenario reduced in order to account for the mitigation actions selected.

Figure 9 illustrates the expected impact of both mitigation actions on the PM2.5 mean levels of the 2020 year base future scenario in the Venice area for a summer month (using the meteorology of the corresponding month for the year 2011). Model runs for a winter period were not performed since the mitigation actions selected consider the passenger ship traffic that has non negligible contribution only in summer. The maximun decrease occurs in the cell of the Passenger Terminal in which cold ironing has been modeled. The map for PM10 (not shown here) is very similar with that presented in Figure 9 and reveals differences in concentration values that are not detectible.



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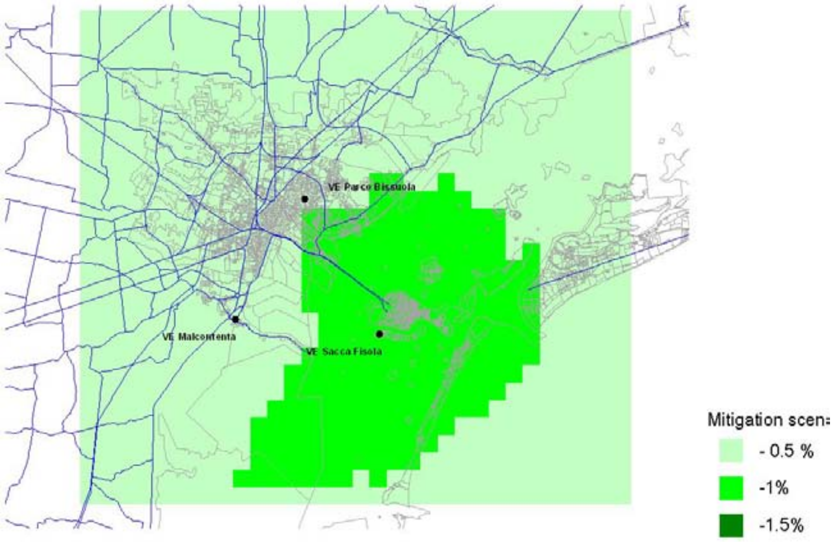


**Figure 9:** Difference (%) in the mean PM2.5 concentrations between the future mitigation scenario and the future base scenario for the summer period studied.



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# Conclusions

A summary table for the effect of the different emission mitigation scenarios on the future PM maritime emissions and PM air quality in the study areas is presented below. Table 5 shows the differences in the mean PM2.5 and PM10 levels of the base future scenario at the monitoring sites and in the whole modeling domain because of the emission mitigation actions examined in each study area.

For Barcelona and Genoa, the estimated decreases in mean PM concentrations are moderate in the summertime; down to -12.7% and -11.6% for PM2.5 and PM10 respectively in Barcelona and -23% and -21% for PM2.5 and PM10 in Genoa. For Thessaloniki and Venice the maximum reductions are expected to be rather small; -0.9% and -4.4% for PM2.5 and PM10 in Thessaloniki and -1.5% for both PM2.5 and PM10 in Venice. In wintertime, the mitigation measures could have a moderate impact on the PM air quality in Barcelona and Marseille. The maximum decreases are -11.2% and -10.6% for PM2.5 and PM10 respectively in Barcelona; -8.5% and -6.1% for PM2.5 and PM10 in Marseille when considering the "LNG passenger" scenario. For Thessaloniki, the air quality improvement seems to be rather small.

As shown in Table 5, PM2.5 maritime/harbor annual emissions are cut down by -35% and -69% in the port areas of Genoa and Thessaloniki respectively because of the mitigation actions. Also in the Marseille urban study domain, the use of LNG as fuel in passenger and cruise shipping may seriously reduce PM2.5 maritime annual emissions by -78%. The mitigation actions are expected to result in a moderate reduction (-13%) of PM10 emissions in the Barcelona port area and in a moderate decrease (-10%) of PM2.5 and PM10 emissions in the port of Venice.

Based on the above, it can be concluded that the mitigation actions studied for each Mediterranean port-city are more effective in terms of the maritime and harbor emission reductions that they induce mainly in local scale while their impact on the air quality is estimated to be more limited.



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**Table 5**: The effect of emission mitigation actions on the PM emissions and concentrations in the study areas for a future reference year[1].

| City | Mitigation actions | % Decrease in maritime and port annual emissions[2] | | % Difference of mean concentration at the monitoring sites | | % max increase / % max decrease of mean concentration in the modeling domain[3] | |
|---|---|---|---|---|---|---|---|
| | | PM10 | PM2.5 | PM2.5 (PM10) (summer month) | PM2.5 (PM10) (winter month) | PM2.5 (PM10) (summer month) | PM2.5 (PM10) (winter month) |
| **Barcelona** | 18 actions (see the text above) | -13 | - | Port site: -11.3 (-10.2)<br>Urban site: -1.7 (-1.6) | Port site: -10.3 (-9.9)<br>-Urban site: -1.3 (-1.5) | 0.0 / -12.7[4]<br>(0.0 / -11.6)[4] | 0.0 / -11.2[4]<br>(0.0 / -10.6)[4] |
| **Genoa** | Cold ironing | -35 | -35 | Port site: -1 (-1)<br>Urban site: <-1 (<-1) | - | 0.0 / -23%<br>(0.0 / -21%) | - |
| **Marseille** | Cold ironing | -3 | -3 | - | Port site: -0.1 (-0.1)<br>Urban site: 0.0 (0.0) | - | 0.0 / -1<br>(0.0 / -0.7) |
| **Marseille** | New cruise terminal | 0 | 0 | - | Port site: +0.9 (+0.6)<br>Urban site: 0.0 (0.0) | - | 8.4 / -5.5<br>(5.8 / -3.9) |
| **Marseille** | LNG passenger | -78 | -78 | - | Port site: -6.0 (-4.2)<br>Urban site: -1.0 (-0.7) | - | 0.0 / -8.5<br>(0.0 / -6.1) |
| **Thessaloniki** | Cold ironing and use of wetting agents (chemical and water) for storage piles | -50 | -69 | Port site: -0.9 (-4.4)<br>Urban site: -0.07 (-0.4) | Port site: -0.4 (-2.4 )<br>Urban site: -0.03 (-0.1) | 0.2/-0.9<br>(0.2/-4.4) | 0.01/-0.5<br>(0.01/-2.4) |
| **Venice** | Cold ironing and 0.1% sulfur content in passenger ship fuels | -10% | -10% | Malcontenta[5]: -0.5 (-0.5)<br>Sacca Fisola[5]: -1.4 (-1.4)<br>Parco Bissuola[5]: -0.5 (-0.5) | - | 0.0/-1.5<br>(0.0/-1.5) | - |

[1] Future reference year: 2015 for Barcelona; 2020 for Genoa, Thessaloniki and Venice; 2025 for Marseille.
[2] Reference area: the port area for Barcelona, Genoa, Thessaloniki and Venice; the urban area for Marseille.
[3] Modeling domain extend: 100 x 100 km2 for Marseille, Thessaloniki and Venice; 40 x 40 km2 for Barcelona; 40 x 30 km2 for Genoa.
[4] % changes of mean concentration refer to scenario (b) (Trend scenario + APICE mitigation measures).
[5] Malcontenta: Commercial port in Porto Marghera; Sacca Fisola: Historical city near Passenger Terminals; Parco Bissuola: Urban background.

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# References


1. ENVIRON, 2010. User's guide CAMx - Comprehensive Air Quality Model with extensions, Version 5.30, ENVIRON International Corporation, 415.899.0700, December 2010.
2. Jiménez-Guerrero, P., Montávez, J.P., Gómez-Navarro, J.J., Jerez, S., Lorente-Plazas, R., 2012. Impacts of climate change on ground level gas-phase pollutants and aerosols in the Iberian Peninsula for the late XXI century. Atmospheric Environment, 55, 483-495, doi:10.1016/j.atmosenv.2012.02.048.
3. Markakis, K., Giannaros, T., Poupkou, A., Liora, N., Melas, D., Sofiev, M., Soares, J., 2009. Evaluating the impact of particle emissions from natural sources in the Balkan region, European Aerosol Conference 2009, 6-9 September 2009, Karlsruhe, Germany.
4. Markakis, K., Katragkou, E., Poupkou, A., Melas, D., 2013. MOSESS: A new emission model for the compilation of model-ready emission inventories. Application in a coal mining area in Northern Greece. Environmental Modeling and Assessment (accepted).
5. Poupkou, A., Giannaros, T., Markakis, K. Kioutsioukis, I., Curci, G., Melas, D., Zerefos, C., 2010. A model for European biogenic volatile organic compound emissions: Software development and first validation. Environmental Modelling and Software, 25, 1845-1856.
6. Skamarock, W.C., Klemp, J.B., Dudhia, J. et al., 2008. A detailed description of the advanced research WRF version 3, NCAR/TN-475+STR, NCAR Technical Note, June 2008, Boulder, Colorado, USA.




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