Emissions of ships in Liguria ports: trend, COVID & NECA Area implementation

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Liguria region

a narrow strip of heavily populated land between the sea and the mountains with many highways, three large harbours including the largest Italian port, an airport, two big power stations, a refinery, a steel mill

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Liguria Region evaluation tools

➤ **multi-years emission inventory 1995-2021 at municipal level managed by** *E²Gov* **system**

➤ **emission projections implemented with 2021 base year and projections up to 2030 managed by** *Projection* **model of** *E²Gov* **system**

➤ **air quality monitoring system and models**

➤ **case studies in Horizon 2020 projects:**

  ➤ **ClairCity engaged citizens to better understand their environmental behaviours (2016-2020)**

  ➤ **ICHANGE citizen science initiatives (living labs) which are using sensors with an impact on their environmental footprint (2021-2025)**

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E²Plan - Tool for AQP & CF

Regional and national application

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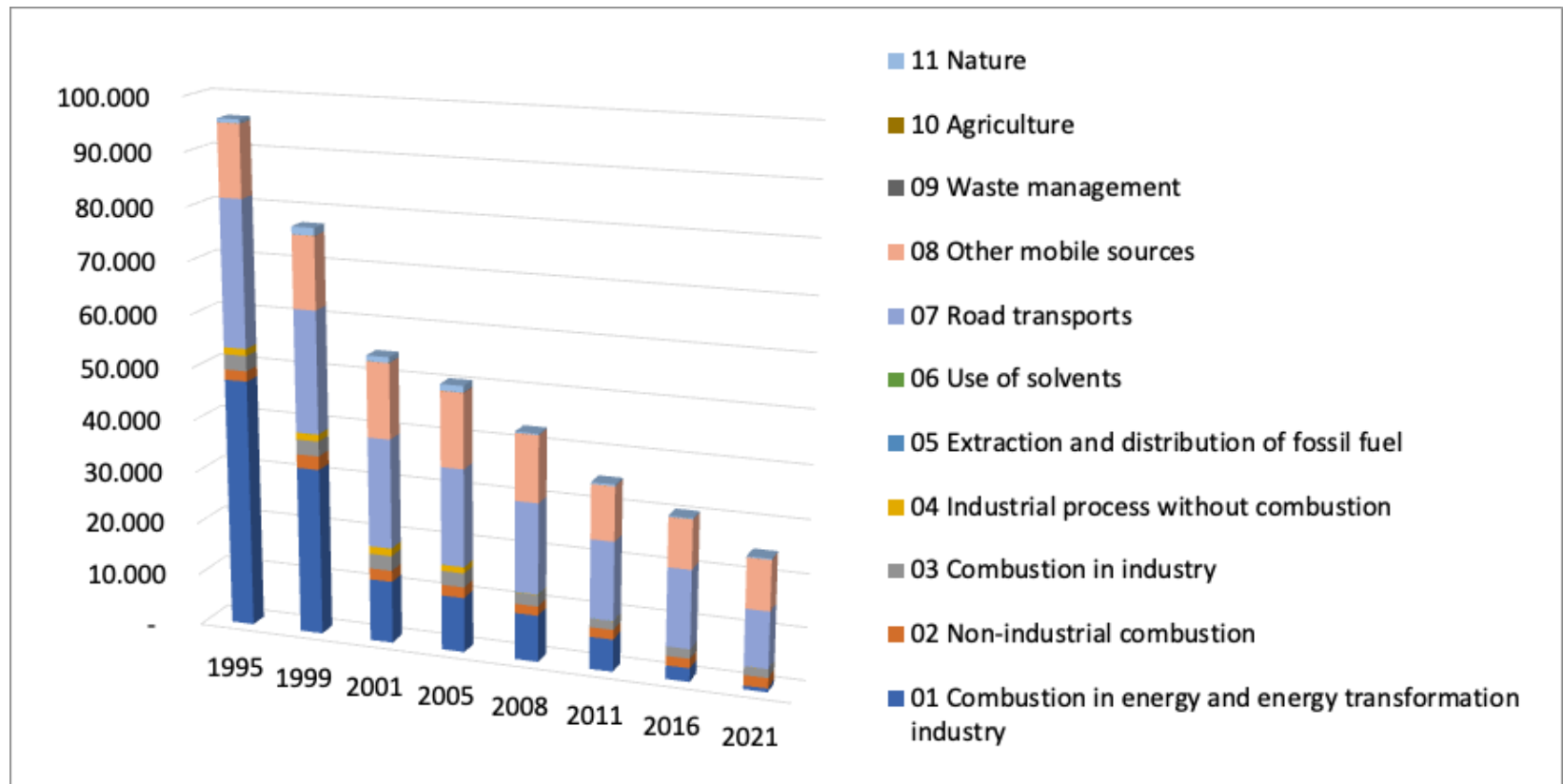(*carlo.trozzi@techne-consulting.com)
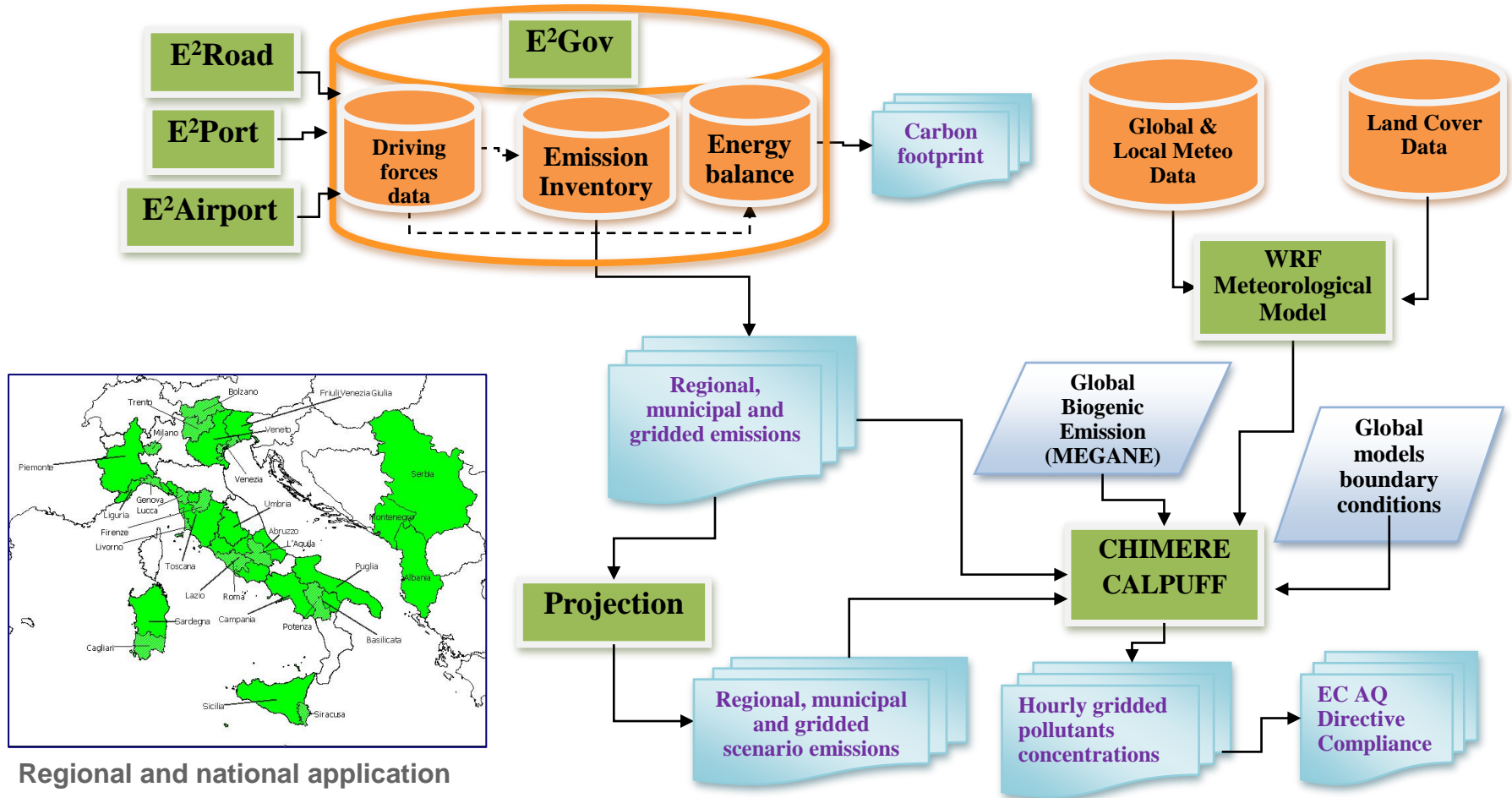
Regional emissions inventory

- **Sources:**

  - **Structure, sources that is possible and useful geolocate and evaluated by direct census and emission factors:**

    - **Point - stationary sources whose emissions exceed fixed thresholds (i.e. 5 tons/year of NO_x or PM_{10} , SO_x, NMVOC)**

    - **Line - the main roads, railways, seaways, canalways**

    - **Area - the main ports, airports, landfills, storage areas**

  - **Diffuse (statistic) sources not included in the previous classes estimated at municipal or sub-municipal level by statistical or direct census data and emission factors**

- **This level of detail is necessary to evaluate the effect of specific measures on air quality at a local dimension and to define air quality management plans with specific source oriented and spatially oriented measures**

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Liguria region NO$_x$ emission inventory 1995-2011

Legend:
- 11 Nature
- 10 Agriculture
- 09 Waste management
- 08 Other mobile sources
- 07 Road transports
- 06 Use of solvents
- 05 Extraction and distribution of fossil fuel
- 04 Industrial process without combustion
- 03 Combustion in industry
- 02 Non-industrial combustion
- 01 Combustion in energy and energy transformation industry

$\mathcal{E}^2Port$ emission models for ships in ports

Techne consulting $\mathcal{E}^2Port$ model was applied for ships in port emissions estimates.

The model uses Tier3 methodology, based on installed engine power and time spent in the different navigation phases in port (hotelling and manoeuvring) for each ships movement

Data on ships movements by ship were provided by port authorities

Engine power was obtained from the $\mathcal{E}^2Port$ database or, only where missing, from gross tonnage (GT) using GB power vs GT functions

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E2Port emission models for ships in ports

Emissions have been estimated for single ships movement from installed main and auxiliary engines (e), engine power (P), load factor (LF) and total time spent (T), in hours, for each navigation phase (p) and emission factors (EF) of pollutant (i) for engine type j and fuel type m

$$E_{Trip,i,j,m} = \sum_{p} \left[T_P \sum_{e} \left(P_e \times LF_e \times EF_{e,i,j,m,p} \right) \right]$$

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Emission Factors

Table 3-15 Tier 3 emission factors for pollutants and Specific Fuel Consumption for Diesel engine types/fuel combinations and vessel trip phases (cruising, hotelling, manoeuvring) in g/kWh

EMEP/EEA air pollutant emission inventory guidebook 2023

Engine	Phase	Engine type	Fuel type	CO (g/kWh))	NOx Tier 0 (g/kWh)	NMVOC (g/kWh)	TSP, PM₁₀, PM₂.₅ (g/kWh)	BC (g/kWh)	SFOC (gfuel/kWh)
Main	Cruise	High-speed diesel	BFO	0,693	8,53	0,440	1,13	0,0114	214
			MDO/MGO	0,693	8,53	0,440	0,188	0,00584	205
			LNG	1,44	0,732	0,127	1,80E-04	3,60E-06	178
		Medium-speed diesel	BFO	0,614	10,8	0,269	1,01	0,0114	185
			MDO/MGO	0,614	10,8	0,269	0,180	0,00584	177
			LNG	1,44	0,732	0,127	1,80E-04	3,60E-06	154
		Slow-speed diesel	BFO	0,451	17,7	0,238	1,02	0,0114	187
			MDO/MGO	0,451	17,7	0,238	0,180	0,00584	178
			LNG	1,44	0,732	0,127	1,80E-04	3,60E-06	156
	Manoeuvring Hotelling	High-speed diesel	BFO	2,70	11,7	1,233	1,34	0,0646	318
			MDO/MGO	2,70	11,7	1,233	0,367	0,0330	304
			LNG	6,15	1,25	1,242	5,41E-04	1,08E-05	265
		Medium-speed diesel	BFO	2,39	14,8	0,753	1,23	0,0646	275
			MDO/MGO	2,39	14,8	0,753	0,361	0,0330	263
			LNG	6,15	1,25	1,242	5,41E-04	1,08E-05	229
		Slow-speed diesel	BFO	1,75	24,3	0,666	1,24	0,0646	277
			MDO/MGO	1,75	24,3	0,666	0,361	0,0330	265
			LNG	6,15	1,25	1,242	5,41E-04	1,08E-05	231
Auxiliary	Cruise	High-speed diesel	BFO	1,81	9,94	0,997	1,16	0,0389	283
			MDO/MGO	1,81	9,94	0,997	0,290	0,0199	271
			LNG	4,88	0,928	0,887	2,70E-04	5,41E-06	236
		Medium-speed diesel	BFO	1,61	12,6	0,609	1,06	0,0389	245
			MDO/MGO	1,61	12,6	0,609	0,284	0,0199	234
			LNG	4,88	0,928	0,887	2,70E-04	5,41E-06	204
	Manoeuvring Hotelling	High-speed diesel	BFO	1,10	8,53	0,649	1,03	0,0206	235
			MDO/MGO	1,10	8,53	0,649	0,221	0,0105	224
			LNG	2,92	0,566	0,380	1,80E-04	3,60E-06	196
		Medium-speed diesel	BFO	0,974	10,8	0,397	0,93	0,0206	203
			MDO/MGO	0,974	10,8	0,397	0,215	0,0105	194
			LNG	2,92	0,566	0,380	1,80E-04	3,60E-06	169

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load factors

The Guidebook reports the load factors in Table 3-20

Table 3-20   Estimated % load of MCR (Maximum Continuous Rating) of Main and Auxiliary Engine for different ship activity

Phase	% load of MCR Main Engine	% time all Main Engine operating	% load of MCR Auxiliary Engine
Cruise	80	100	30
Manoeuvring	20	100	50
Hotelling (except tankers)	20	5	40
Hotelling (tankers)	20	100	60

EMEP/EEA air pollutant emission inventory guidebook 2023

In the last years _E²Port_ **uses more detailed load factors from an ICF study for US EPA derived from a survey conducted through interviews with ship captains, engineers chief and pilots**

Table 2-7: Auxiliary Engine Load Factor Assumptions

Ship-Type	Cruise	RSZ	Maneuver	Hotel
Auto Carrier	0.15	0.30	0.45	0.26
Bulk Carrier	0.17	0.27	0.45	0.10
Container Ship	0.13	0.25	0.48	0.19
Cruise Ship	0.80	0.80	0.80	0.64
General Cargo	0.17	0.27	0.45	0.22
Miscellaneous	0.17	0.27	0.45	0.22
OG Tug	0.17	0.27	0.45	0.22
RORO	0.15	0.30	0.45	0.26
Reefer	0.20	0.34	0.67	0.32
Tanker	0.24	0.28	0.33	0.26

U.S. Environmental Protection Agency
Current Methodologies in Preparing Mobile Source Port Related Emission Inventories. Final Report. April 2009
Prepared by: ICF International

IMO Marpol NOx Code

The current Marpol 73/78 Annex VI legislation on NO$_x$ emissions, formulated by IMO (International Maritime Organisation) is relevant for diesel engines with a power output higher than 130 kW, which are installed on a ship constructed on or after 1 January 2000 and diesel engines with a power output higher than 130 kW which undergo major conversion on or after 1 January 2000.

The Marpol Annex VI, as amended by IMO in October 2008, considers a three tiered approach as follows:

➢ **Tier I: 1 January 2000**

➢ **Tier II: 1 January 2011**

➢ **Tier III: 1 January 2016 (For ships operating in a designated NO$_x$ Emission Control Area [NECA] Outside a designated NECA, Tier II limits apply)**

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NOx emission reduction
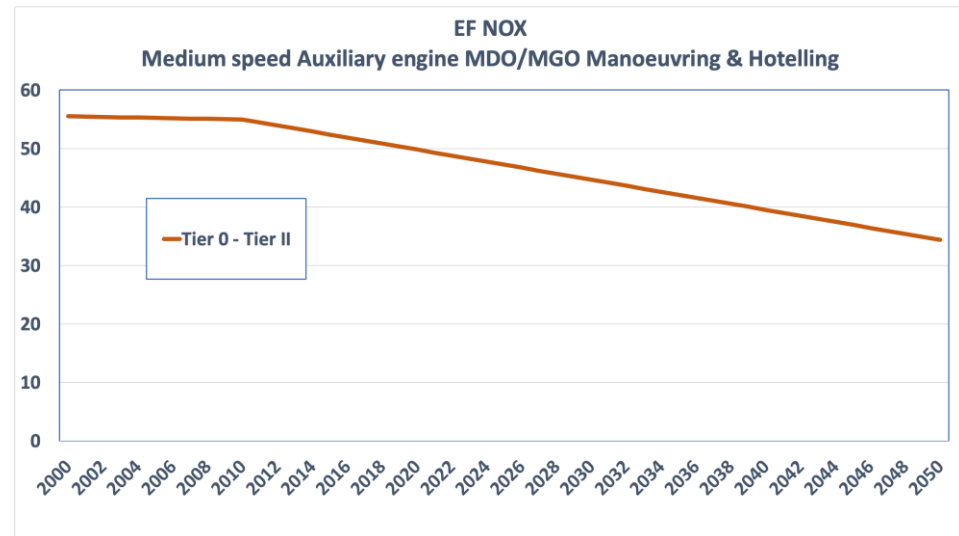
NO$_x$ emissions for Tier I, II and III engines:

$$EF_{NOx\ TierX} = EF_{NOx\ Tier0} \cdot (1 - R_f)$$

Table 3-6   NOx Tier reduction (%) from NOx Tier 0

Engine type	NOx Tier I	NOx Tier II	NO$_x$ Tier III
High-speed diesel	13.1	30.2	85.3
Medium-speed diesel	2.36	23.2	90.6
Slow-speed diesel	18.3	36.1	88.7

EMEP/EEA air pollutant emission inventory guidebook 2023

An approximate life cycle for a marine engine is assumed to be 25 years, which is equivalent to an annual replacement rate of 4%.

EF NOX
Medium speed Auxiliary engine MDO/MGO Manoeuvring & Hotelling
— Tier 0 - Tier II

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COVID effect on ships traffic in 2021

The year **2021** was an **anomalous year** as regards emissions from ships in port as a result of the **effects of the pandemic** on **passenger traffic** and especially for **cruise traffic**, the year was, in particular, characterized by the **prolonged hoteling in port** of Ro - RO ships and especially cruise ships as a result of the lack of operations at sea

This prolonged time was, however, associated with **reduced energy consumption on board** as a result of the inactivity of a series of services linked to the presence of passengers (heating and/or lighting of cabins and common areas, catering services, other on-board services)

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COVID period load correction

In this work, the loading percentages of Passenger ships were discussed by direct contacts with the managers of MSC Cruise and fixed to 2/3 of usual load when ship is "freezed" in port with no passenger on board
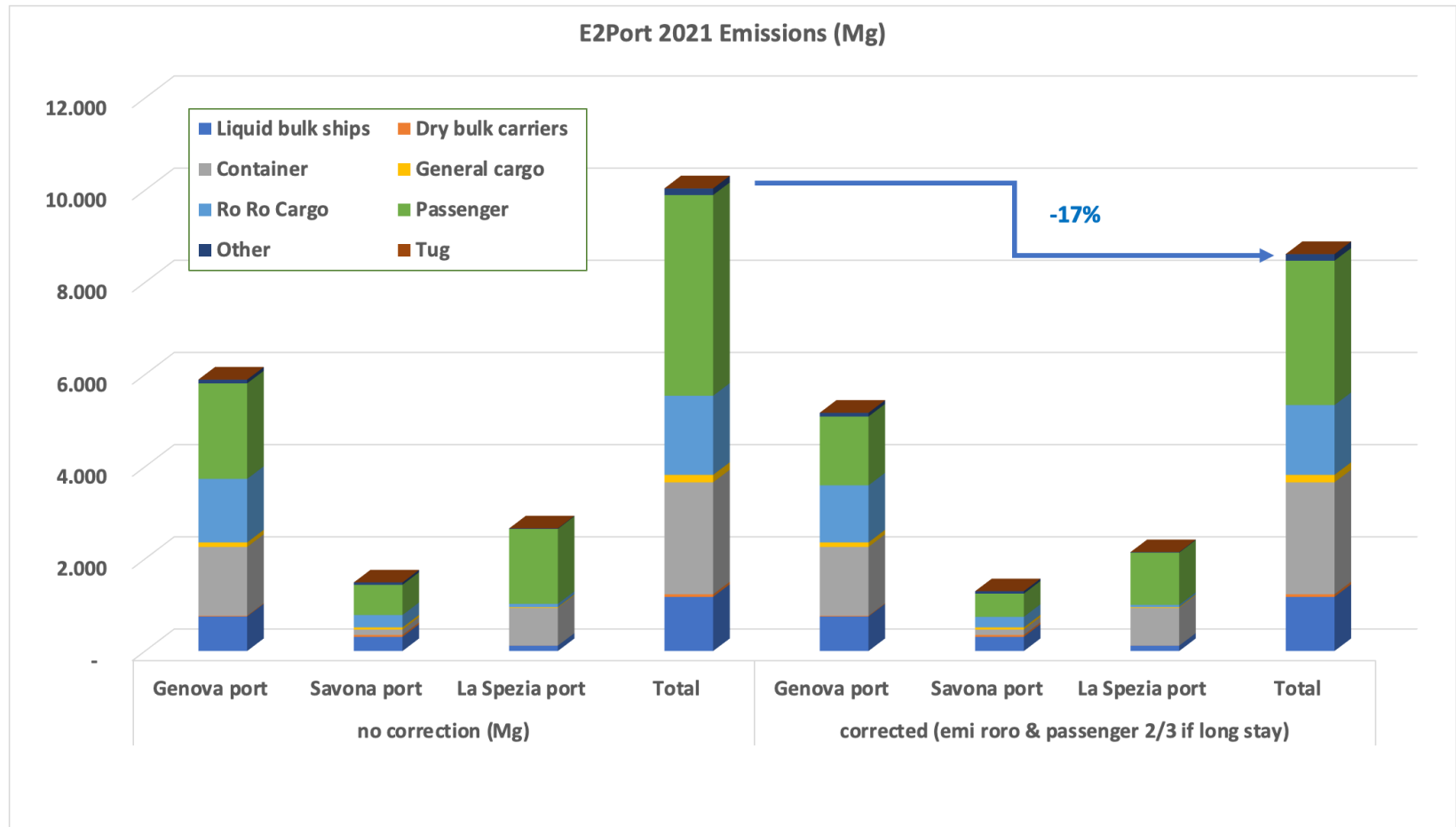
As a result, a change has been introduced to the calculation of the engine load percentage which reduces the load by one third in the event of prolonged stops, i.e. stops during more than 120 hours. The correction was applied to cruise ships and Ro-Ro ships

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COVID period emissions correction

E2Port 2021 Emissions (Mg)

Legend: Liquid bulk ships, Dry bulk carriers, Container, General cargo, Ro Ro Cargo, Passenger, Other, Tug

-17%

no correction (Mg): Genova port, Savona port, La Spezia port, Total

corrected (emi roro & passenger 2/3 if long stay): Genova port, Savona port, La Spezia port, Total
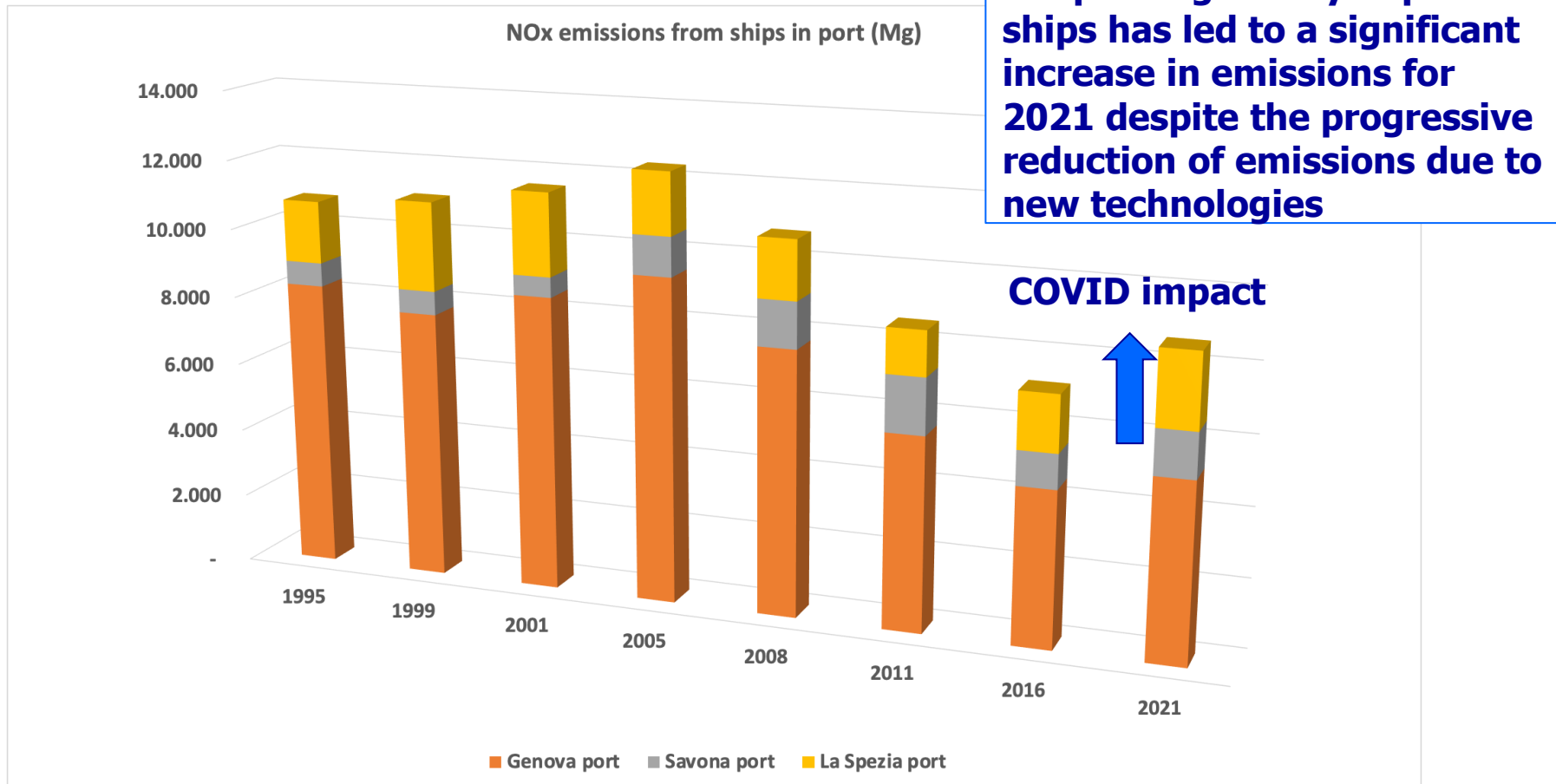
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COVID stop emissions correction

the prolonged stay in port of ships has led to a significant increase in emissions for 2021 despite the progressive reduction of emissions due to new technologies

NOx emissions from ships in port (Mg)

COVID impact

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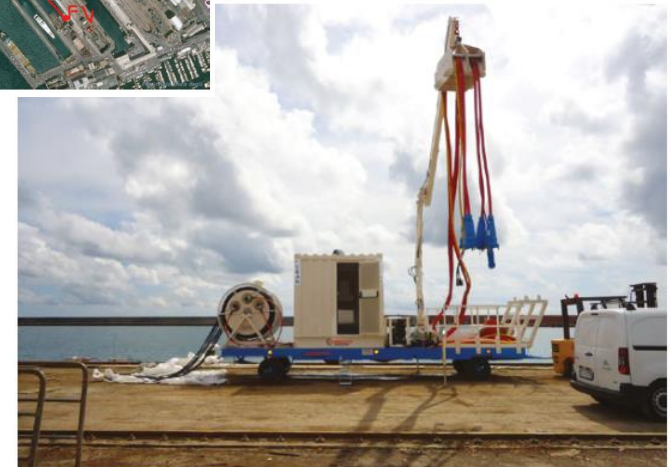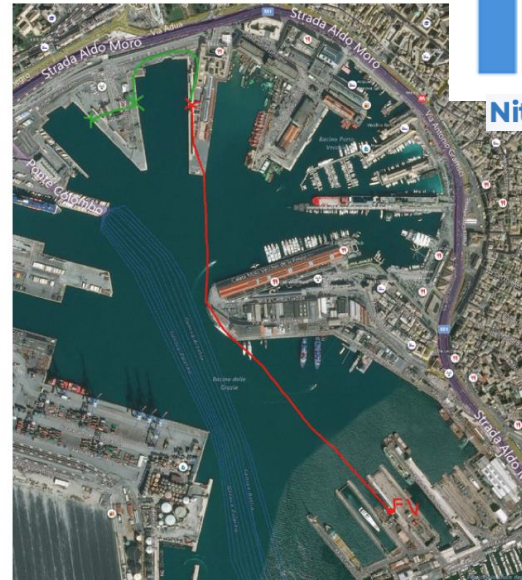(*carlo.trozzi@techne-consulting.com)

Regional scenarios definition

➢ **activity scenarios** defined associating to selected activities, specific activity drivers at national, regional, zone, line, area and units of point source level

➢ **technology scenarios** defined associating to selected activities and pollutants, specific technology drivers at national, regional, zone, line, area and units of point source level

➢ **new sources scenarios** defined introducing new specific source (new plant, new road, …) or source category (for example new fuel)

➢**emissions scenarios** obtained as combination of activity, technology and new sources scenarios

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Scenario definition in regional plan

➢ **Baseline**: the current situation (2021 data);

➢ **WEM**: future situation without any policy actions beyond what is already decided including:

  ➢ **national** measures defined in the 'with measures' (adopted measures) NECD or energy/GHG strategies projection;

  ➢ **regional** measures adopted in regional air quality plans;

  ➢ all the other measures already adopted at **city level** by local planning actions;

➢ **WAM**: added policy interventions to the WEM, same time horizon; including:

  ➢ **regional** planned measures in the 'with additional measures' in regional plans;

  ➢ all the other planned measures defined at **city level** by local planning actions or during the project

  ➢ eventual **"hot spot"** measures (single plant, road, port)

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Port emission projection drivers

- ➤ **End of the pandemic correction in Genoa, Savona & La Spezia port (stop in prolonged hoteling in port)**

- ➤ **Expected growth in cruise calls in Genoa port and La Spezia port**

- ➤ **IMO NOx Code Tier I-II**

- ➤ **Cold Ironing of Genoa PRA Container Terminal, Genoa Ferry/Cruise Terminal, Savona Cruise Terminal and La Spezia Port**
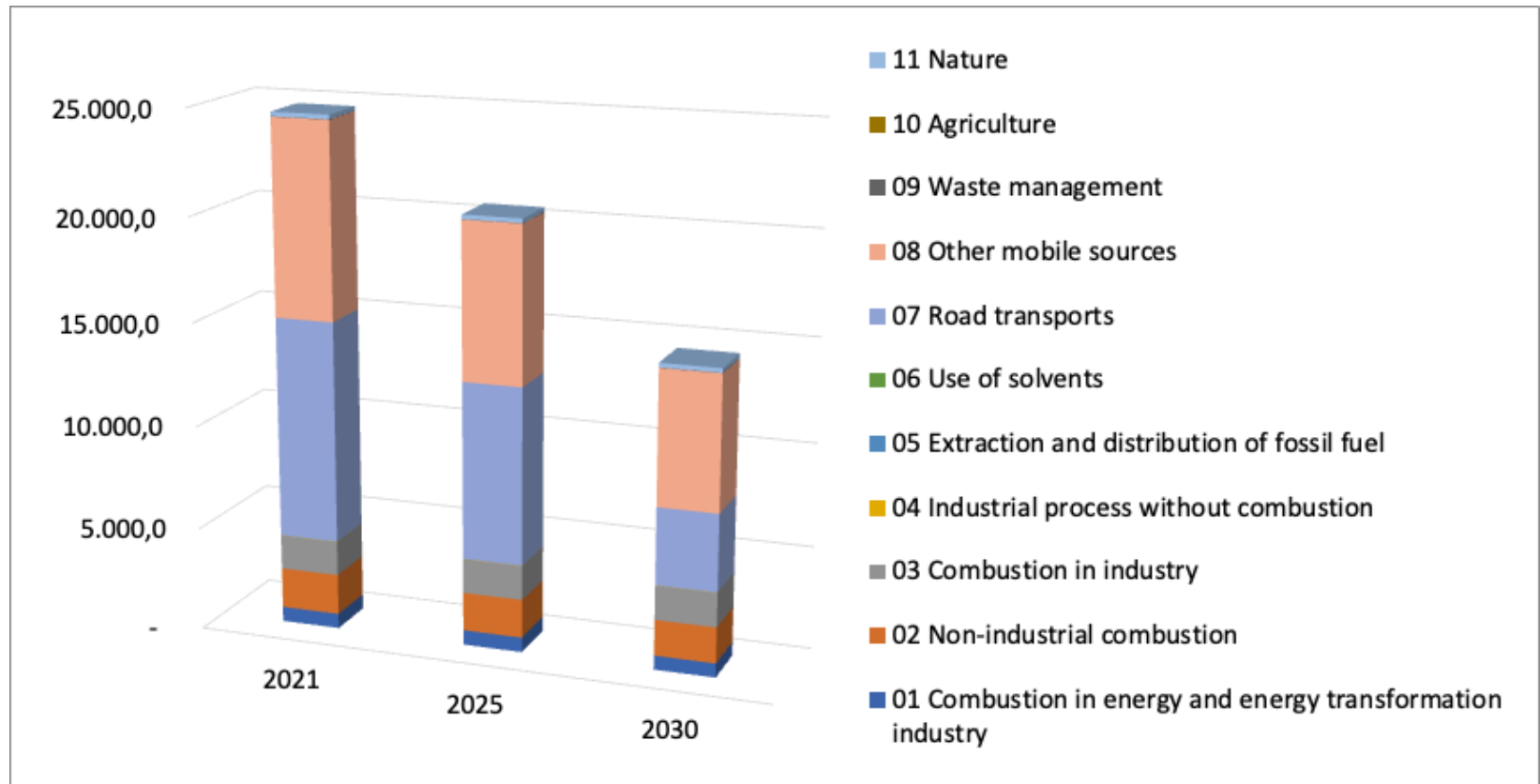
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Liguria region NO$_x$ emission projection WAM 2021-2030

Legend:
- 11 Nature
- 10 Agriculture
- 09 Waste management
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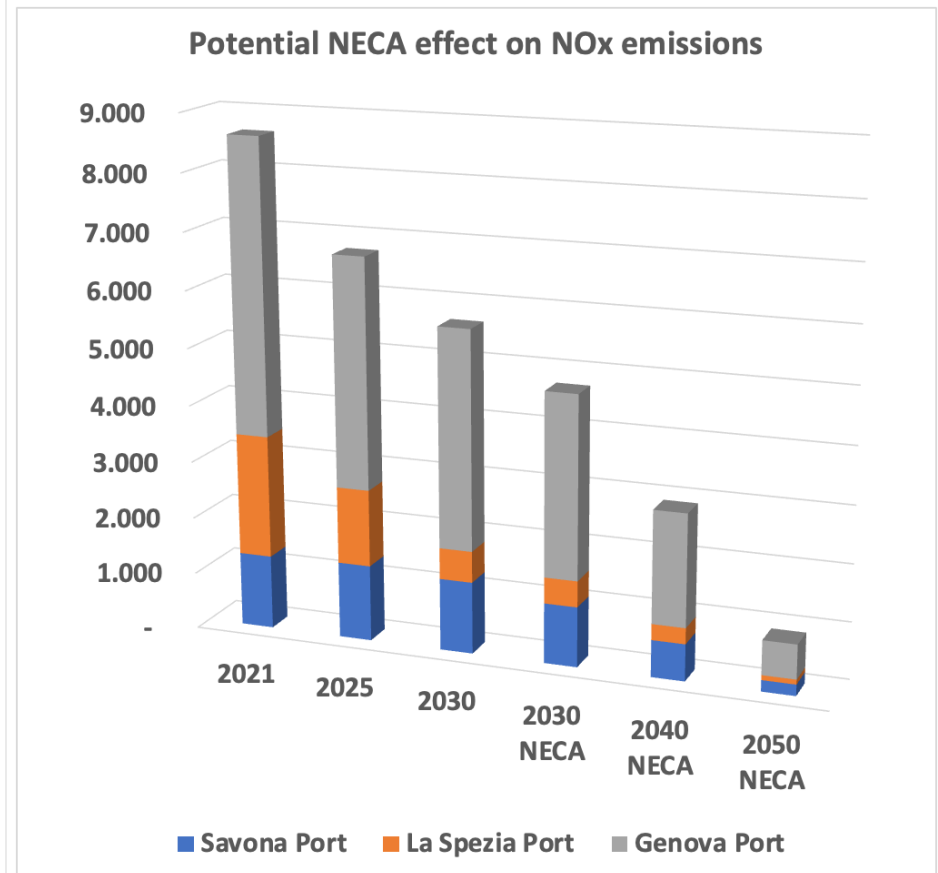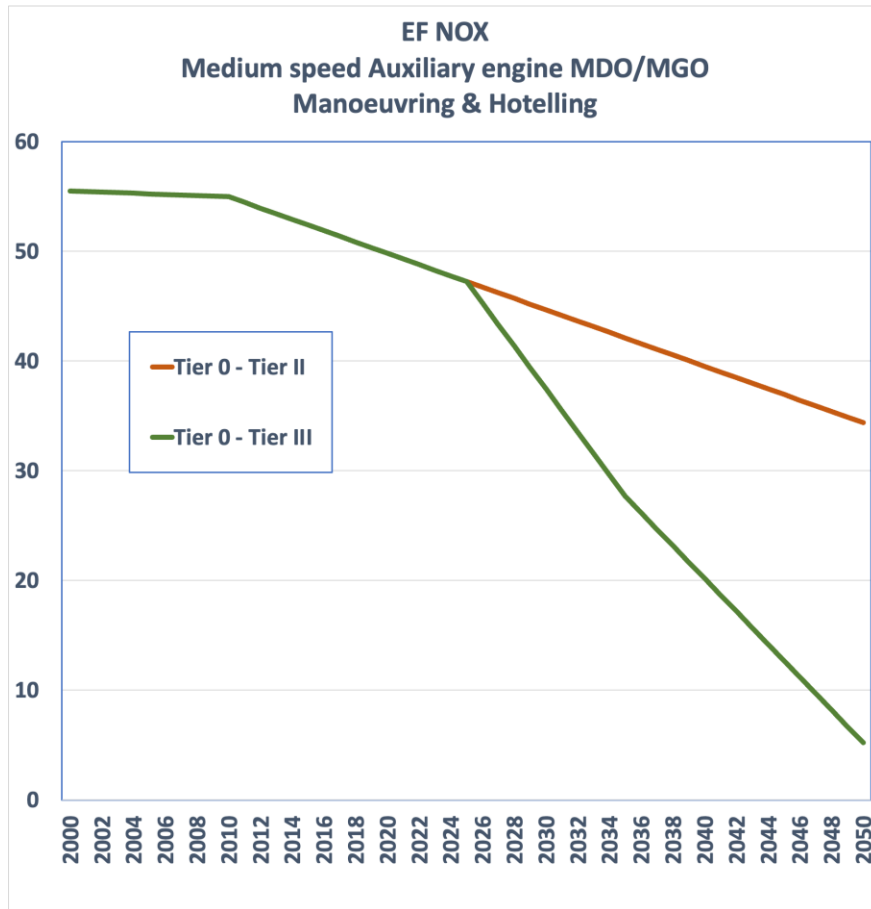
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Liguria ports NO$_x$ emission projection with NECA

2040 & 2050 only NECA reduction on 2030 no other drivers (i.e. cold ironing improvement)

Task force on emission inventories &projections - Expert Panel on Projections - 16 May 2024 Dessau (DE)

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Conclusions

➢ **The emission inventory of Liguria Region was realized for 2021 and time series are update from 1995 with updated emission factors**

➢ **Emissions from ships hoteling in ports in 2021 are corrected to take into account the long time stay due to COVID pandemic introducing reduced load of engines**

➢ **Emissions are projected for the whole regional inventory and in particular for ships taking into account the exit from pandemic period, IMO NOx code and cold ironing implementation**

➢ **IMO NECA introduction has been evaluated**

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Future activities

- ➤ **The emission projection are been used in input to CHIMERE air quality modelling in cooperation with Liguria Environmental Protection Agency (ARPAL)**
- ➤ **Base years, WEM and WAM air quality scenario are already modelled in last months in the frame of update of Regional Air Quality Management plan**
- ➤ **A new WAM+NECA air quality scenario will be evaluated with results from WAM+NECA emissions estimates in 2030**

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Thank you for the attention