Assessing the impacts and feasibility of emission reduction scenarios in the Po Valley to attain air quality standards recommended by WHO guidelines

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Agenzia Regionale per la Protezione dell'Ambiente

Regione Lombardia

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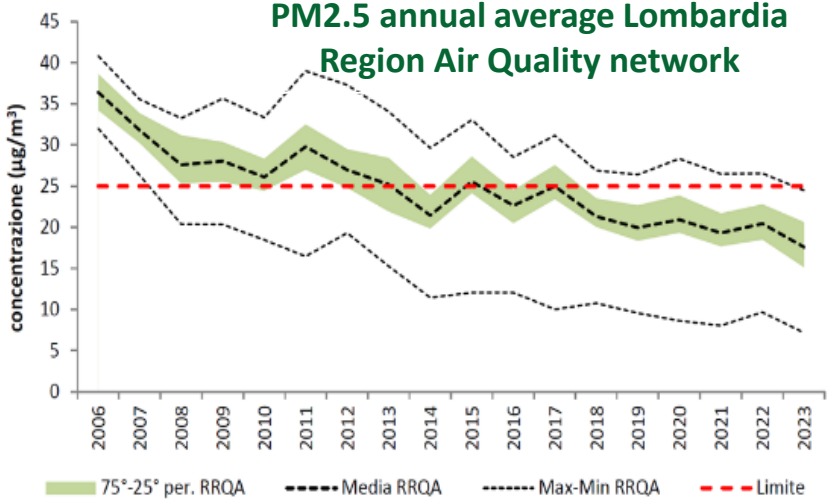
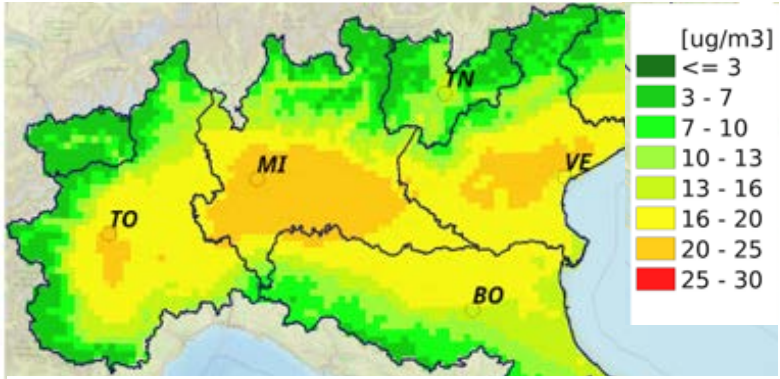
The framework

PM2.5 annual average Lombardia Region Air Quality network



PM2.5 2022 annual average

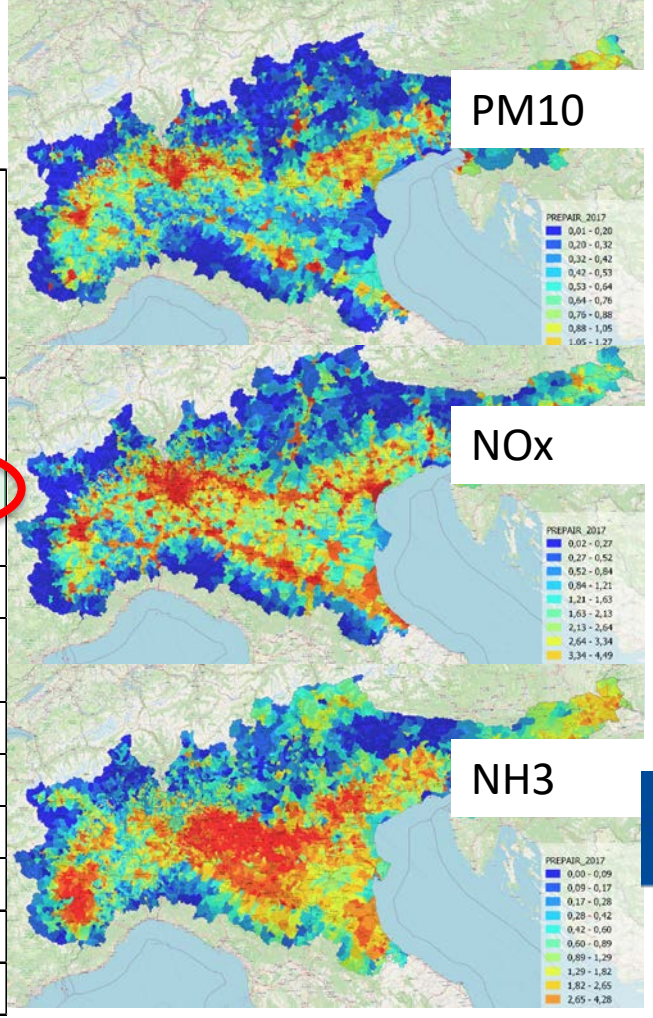


From: Life Prepair project, Air quality assessment 2022

- Po Valley is a plain sorrounded by mountains higher than 3000 a.s.l. with a population of more than 23 M of inhabitants with an annual GDP of 947 billions €
- Despite a progressive decrease during years, the concentrations of the main pollutants are still very far from the values recommended by WHO standard

Emissions share for Po Basin (2017)

Macrosectors	NH3	NMVOC	NMVOC without mac 10 and 11	NOx	PM10
1-Combustion in energy and transformation industries	0%	0%	0%	7%	1%
2-Non-industrial combustion plants	1%	5%	11%	11%	56%
3-Combustion in manufacturing industry	0%	1%	2%	15%	4%
4-Production processes	0%	4%	10%	3%	3%
5-Extraction and distribution of fossil fuels and geothermal energy	0%	3%	6%	0%	0%
6-Solvent and other product use	0%	23%	55%	0%	3%
7-Road transport	1%	6%	13%	48%	19%
8-Other mobile sources and machinery	0%	1%	2%	14%	3%
9-Waste treatment and disposal	1%	0%	0%	1%	0%
10-Agriculture	97%	24%		1%	5%
11-Other sources and sinks	0%	34%		0%	5%



Source:

LIFE 15 IPE IT 013

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Time series for primary emission Po Basin

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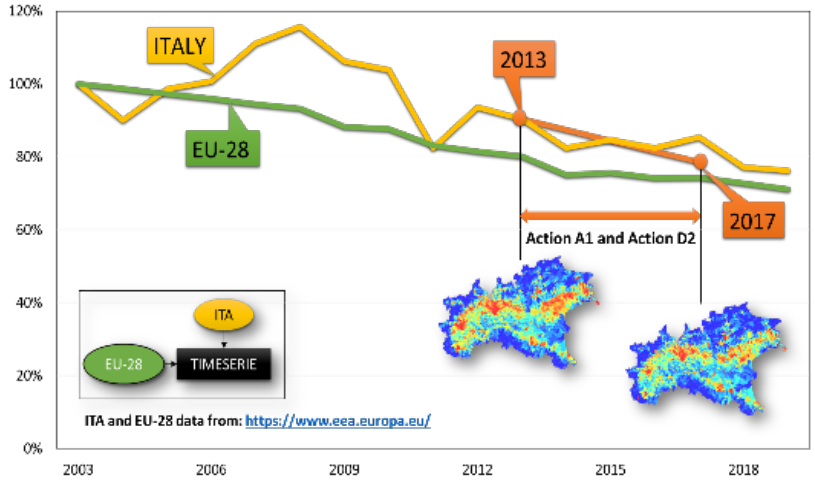
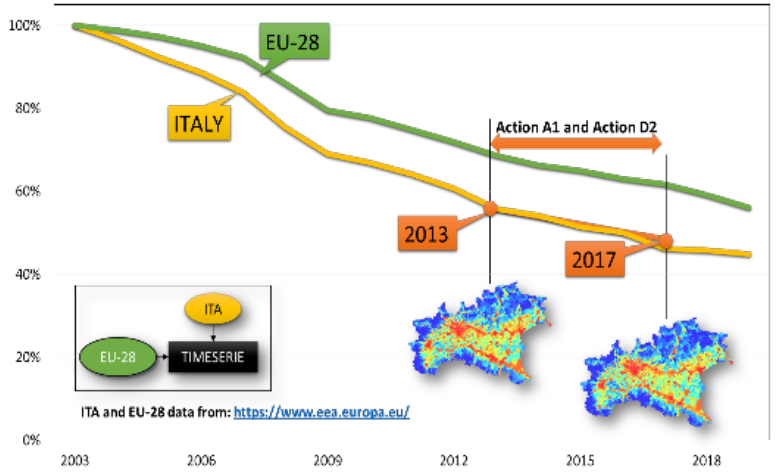
PM10

PM10 2013-2017:
EU28: - 7%
ITA: - 5%
PO VALLEY: -13%



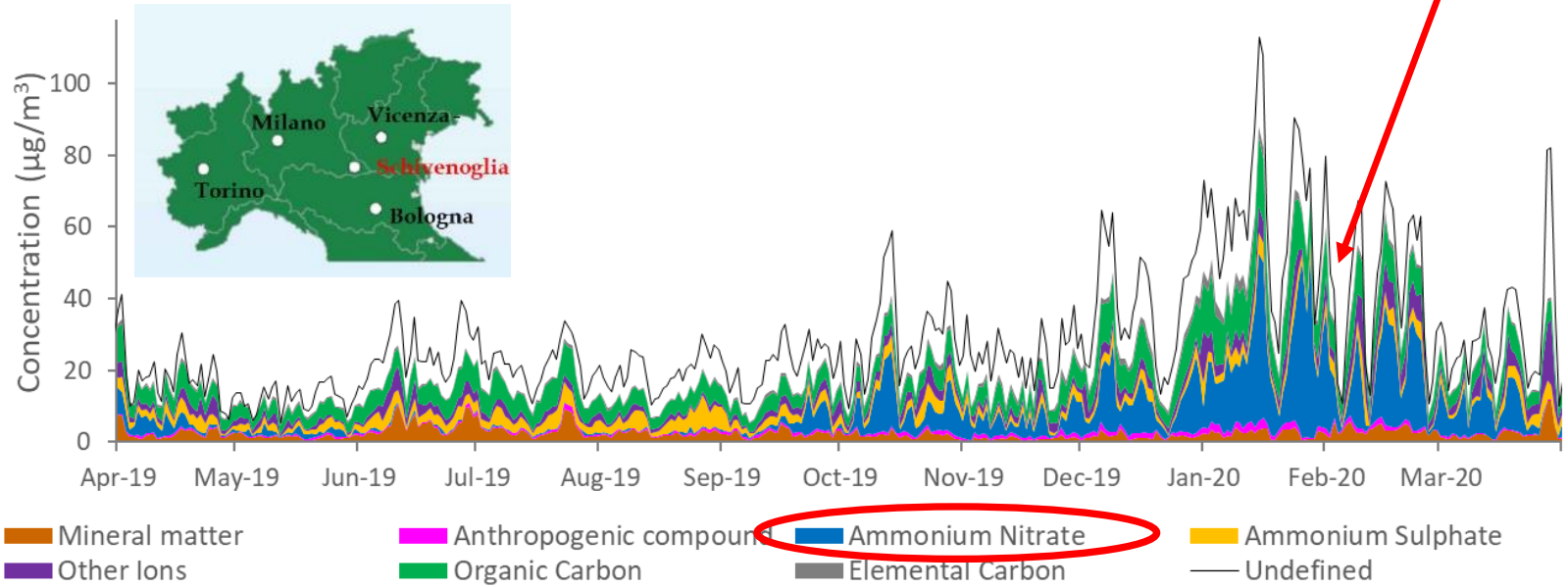
NOx

NOx 2013-2017:
EU28: -10%
ITA: -17%
PO VALLEY: -13%



On the base of the Report Life Prepair on emission dataset (actions A1 - D2) ITA and EU-28 data from: https://www.eea.europa.eu/

PM10 composition – average for Po Basin



During high pollution episodes, secondary inorganic aerosol can represent 40% - 50% of the total PM10 concentration (average on the basin) and even more of PM2.5

The sensitivity analysis

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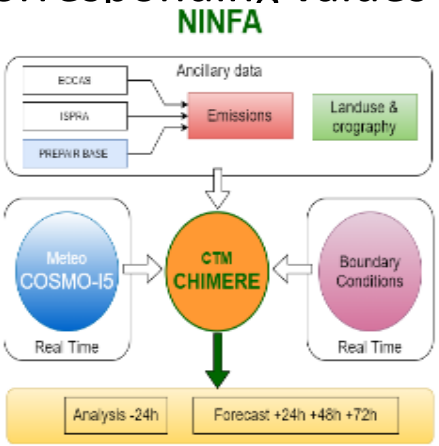
- During the Life Prepair project, to evaluate the feasibility of different possible targets, a sensitivity analysis has been performed decreasing emissions of all the main pollutants and precursors (NOx, VOC, NH3, PPM, SOx) on the whole basin (-10%, -50%, -80% with respect to 2017 emission)
- Scenario simulations are corrected taken into account monitoring station data
- The results of the simulations have been used to forecast the corresponding values in the air quality stations actually present



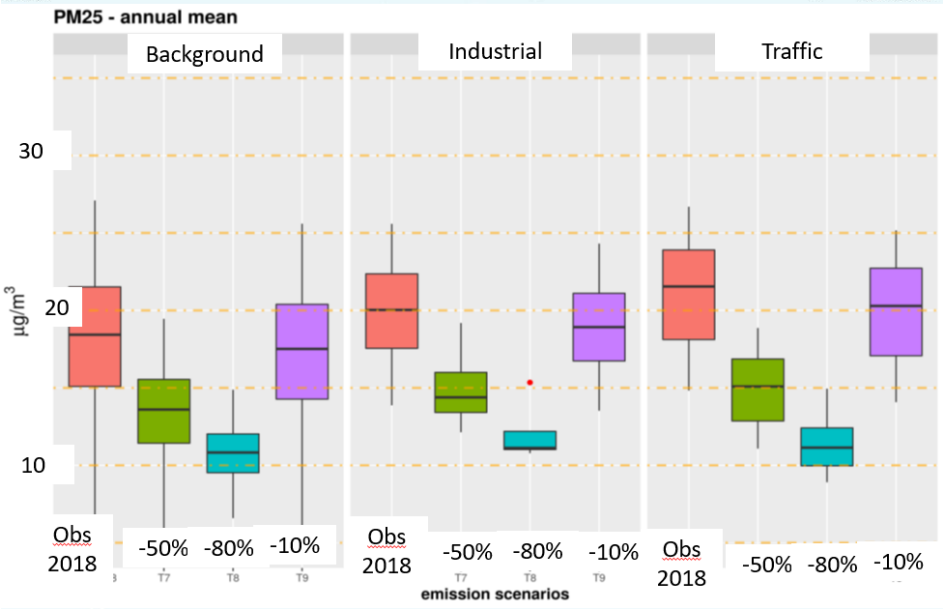
Emission Inventory (Prepair 2017)

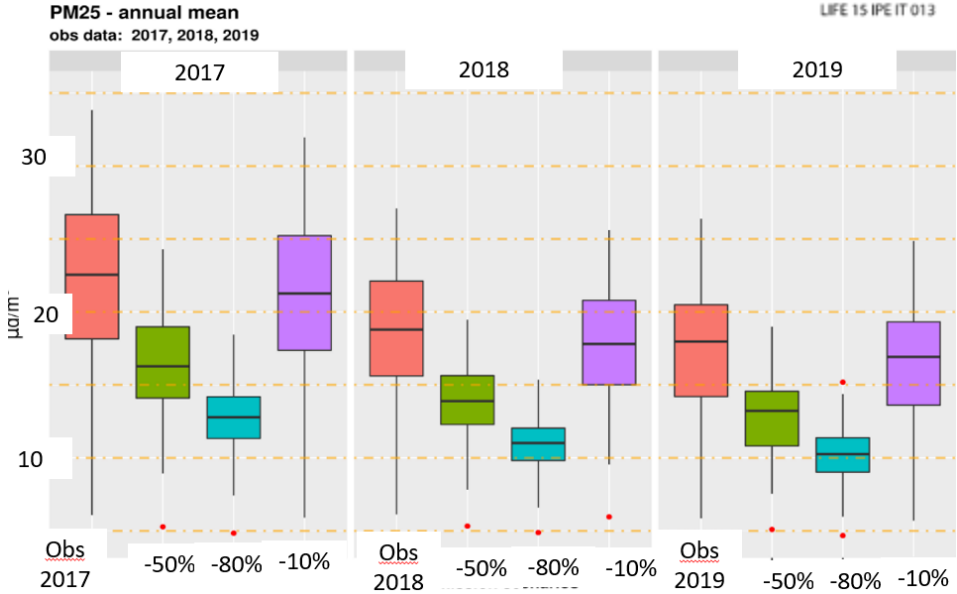
Boundary Conditions: Prevair 2018 Meteo : COSMO 2018

Vertical level: 9 up to 500 hp Hor. Resolution: 0.09*0.06 lat/lon (abo

https://www.lifeprepair.eu/index.php/sdm_downloads/evaluation_scenarios-2022_who

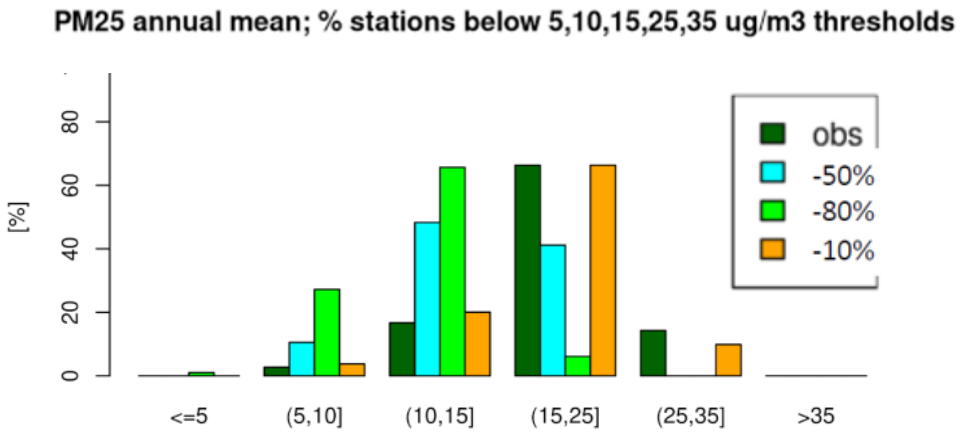
Evaluation of emission reduction scenarios on air quality in Po Valley – PM2.5 annual mean

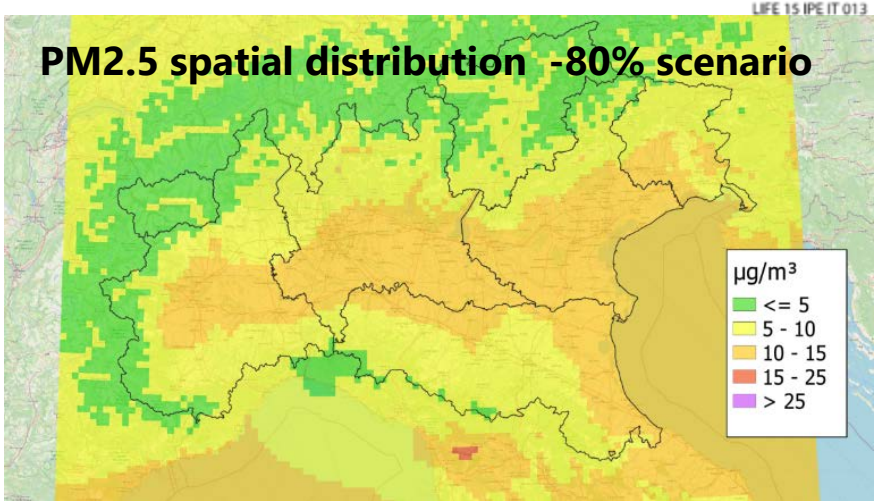




The gradient resulting from the sensitivity analysis was used to evaluate the effects of the reduction of the emissions on the concentrations measured by the stations of different types (background, industrial and traffic) and starting from the concentrations of different years on the whole Po Valley

Evaluation of emission reduction scenarios on air quality in Po Valley – PM2.5 annual mean





- The sensitivity analysis showed that also reducing of 80% the emissions of all the main pollutants and precursors, only 30% of the stations would remain below 10 µg/m3 and only a very little number would be below WHO air quality guideline
- This projection is not limited to the hot spot situations but it is the average for the whole territory

Evaluation of emission reduction scenarios on air quality in Po Valley – PM10 and NO2 annual mean

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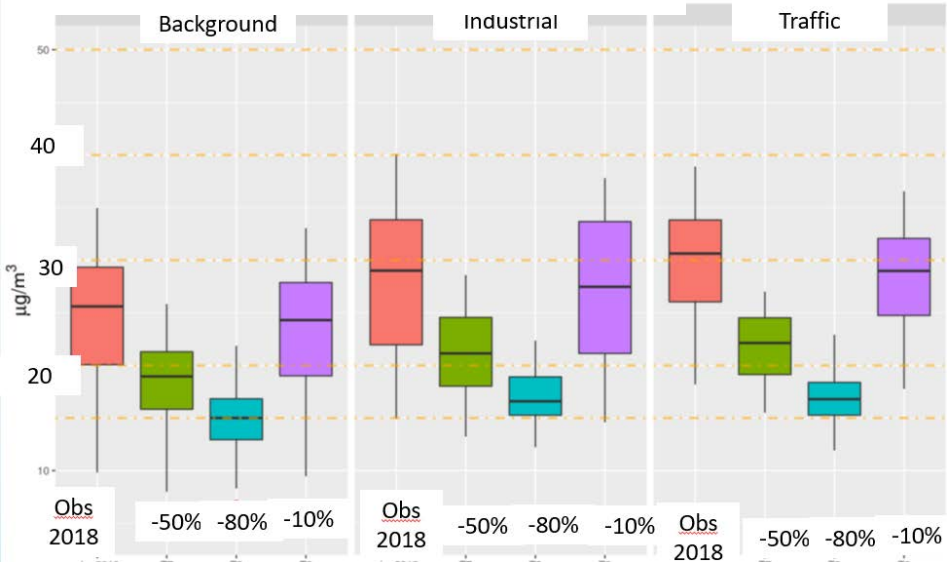
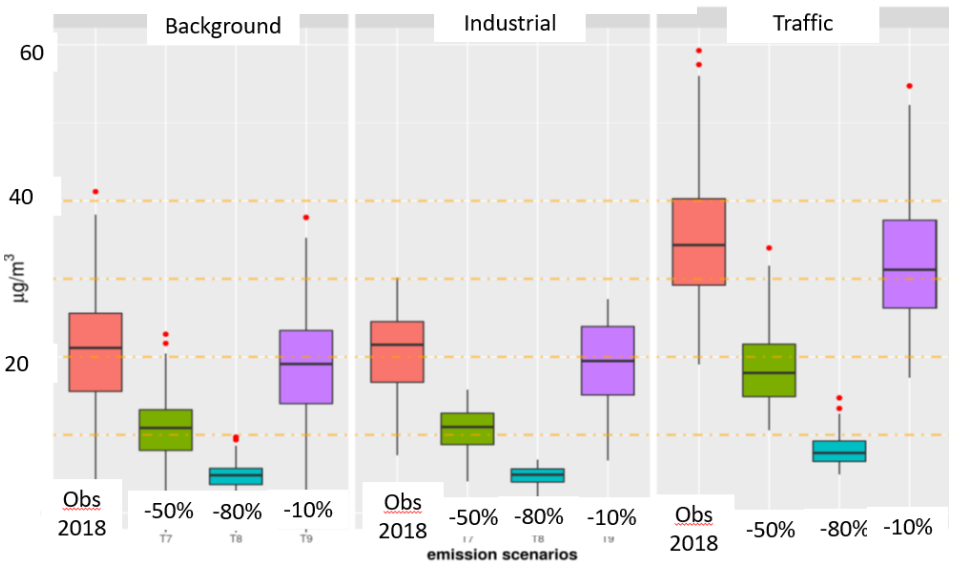
PM10 annual average



NO2 annual average



The same evaluation was performed for PM10 and NO2

PM10, PM2.5 and NO2 annual averages foreseen in the different reduction scenarios

Pollutant	Average time	Interim target 1		Interim target 2		Interim target 3		Interim target 4		AQG (air quality guidelines)		AAQ directives (actual limit)	
$PM_{2.5}$ µg/m³	y	35	R50	25	R50	15	R50	10	R50	5	R50	25	R50
			R80		R80		R80		R80		R80		R80
PM_{10} µg/m³	y	70	R50	50	R50	30	R50	20	R50	10	R50	40	R50
			R80		R80		R80		R80		R80		R80
NO_2 µg/m³	y	40	R50	30	R50	20	R50	—		10	R50	40	R50
			R80		R80		R80				R80		R80

- The green/red colored cells indicate respectively achievement/non achievement of selected target, while yellow means achievement at most monitoring stations.
- Reducing all the emissions of 50% (with respect to 2017 situation) would permit to achieve WHO interim target 3 for PM10 and NO2, but not for PM2.5
- Reducing all the emissions of 80% (with respect to 2017 situation) would permit to achieve WHO guidelines for NO2 and interim target 4 for PM10 at most of the monitoring stations; but just interim target 3 for PM2.5

The maximum reduction rate MRR (technological) scenario

Assuming like the base scenario (E0) the regional emission inventory of Lombardy updated to 2019, the MRR is calculated under the following assumptions:

1. Replacement of all vehicles, except heavy commercial vehicles, with electric vehicles
2. Replacement of heavy goods vehicles with Euro VI vehicles
3. Replacement of all wood-burning appliances with “5 stars” appliances
4. Conversion of all farms to use the most efficient technologies for NH3 emission reduction in all phases of manure management
5. Implementation of fertilizers that reduce ammonia volatilization

into the atmosphere

All other indicators such as the number of vehicles, distances traveled, electricity production, farms sizes, and areas to be fertilized, remain at their current levels

“5 stars” vs. Ecodesign standards for local space heaters

The National Decree 186/2017 defines emission standards for local space heaters.

5 stars class	PM emissions (mg/Nm³)
Pellets/chips Boilers	10
Pellets/chips Stoves and wood boilers	15
Fireplaces and Wood stoves	25

Best available technology at the moment of the adoption of the decree

Ecodesign regulation 2015/1185	PM emissions (mg/Nm³)
Pellets closed heaters	20
Pellets/chips Stoves and wood boilers	40
Open Fireplaces	50

Most efficient technologies for NH3 emission reduction

Housing

-10% Air conditioning and -20% Feed lanes, Bedding and Slatted Floors (Cattle)

-80% Air treatment (Swine/Sow/Laying Hens)

-90% Overlapping floors with ventilation (Broilers)

Storage

-90% Covered tanks or floating covers (Slurry)

-40% Covered storage in manure and at field (Solid)

Spreading

-90% Purified sewage, fertirrigation or deep injection (Slurry)

-60% Non-inversion cultivation incorporation or Incorporation within 4 h (Solid)

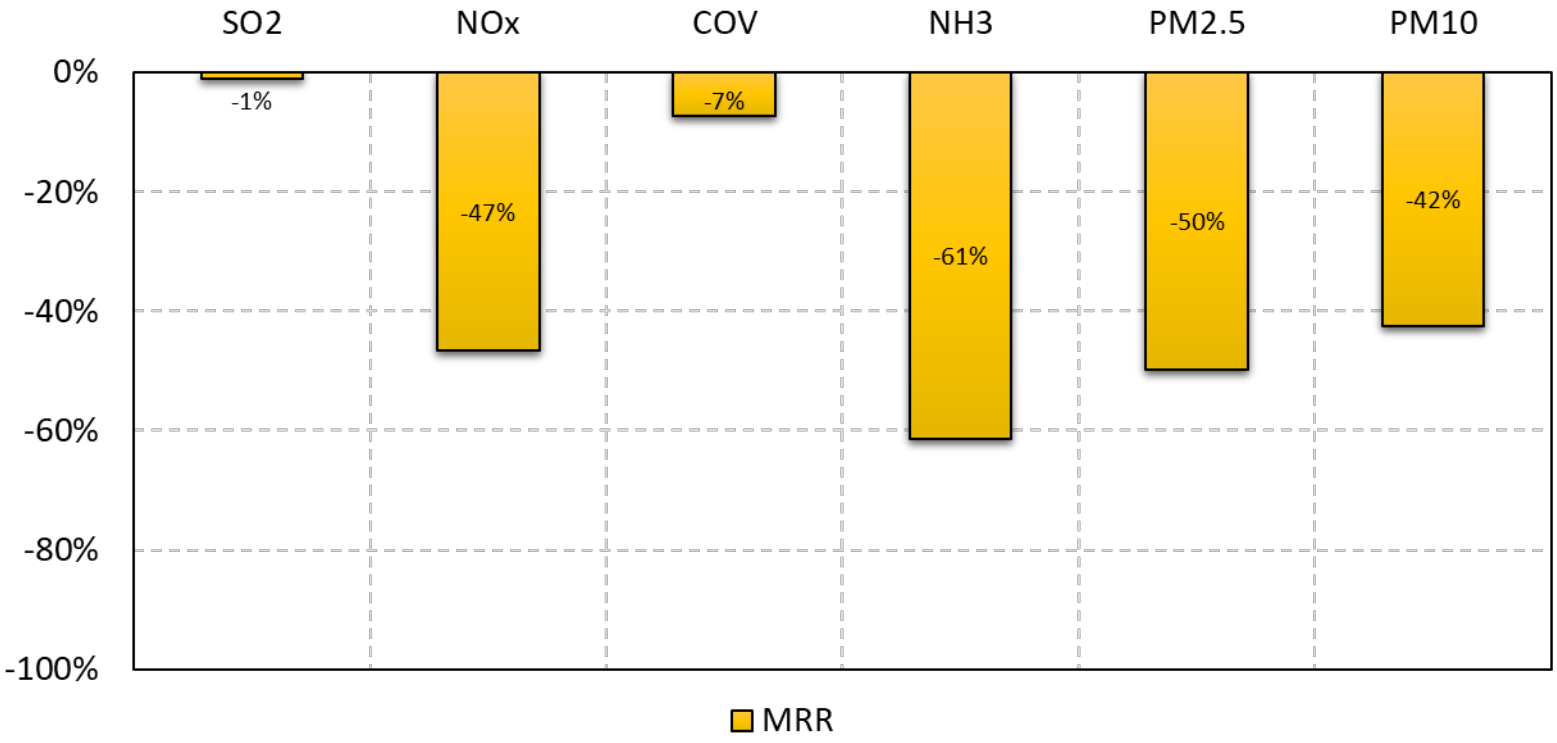
The maximum reduction rate MRR scenario (technological) in Lombardy

The maximum achievable emission reduction through the application of all available technological measures reaches these values:

	SO2 (t/y)	NOX (t/y)	COV (t/y)	NH3 (t/y)	PM2.5 (t/y)	PM10 (t/y)
E0	10476	99234	247628	90727	12122	14496
MRR	10363	52908	229341	35002	6092	8336
Var	**-1%**	**-47%**	**-7%**	**-61%**	**-50%**	**-42%**

The MRR scenario does not take into account the techno-socio-economic feasibility of completely replacing biomass appliances, vehicle fleets, breeding and manure management technologies in the livestock sector.

The maximum reduction rate MRR scenario (technological) in Lombardy



Activity level variations in addition to the MRR scenario

In addition to the MRR scenario, calculations were set up to evaluate an additional reduction by considering possible variations in activity indicators (e.g., reducing the number of cars or their mileage). These scenarios, referred to as the MRR + Indicators, are estimated using the following approach:

$$E_{MRR\_IND} = E_{MRR} \cdot (1 - r_n) \cdot (1 - r_{ind})$$

These scenarios involve the percentage reduction of two indicators:

a) r_n, represents the percentage reduction in the number of vehicles on the road, wood-burning appliances or number of animals.

b) r_{ind} represents the percentage reduction in average mileage for road transport, energy consumption of wood-burning appliances.

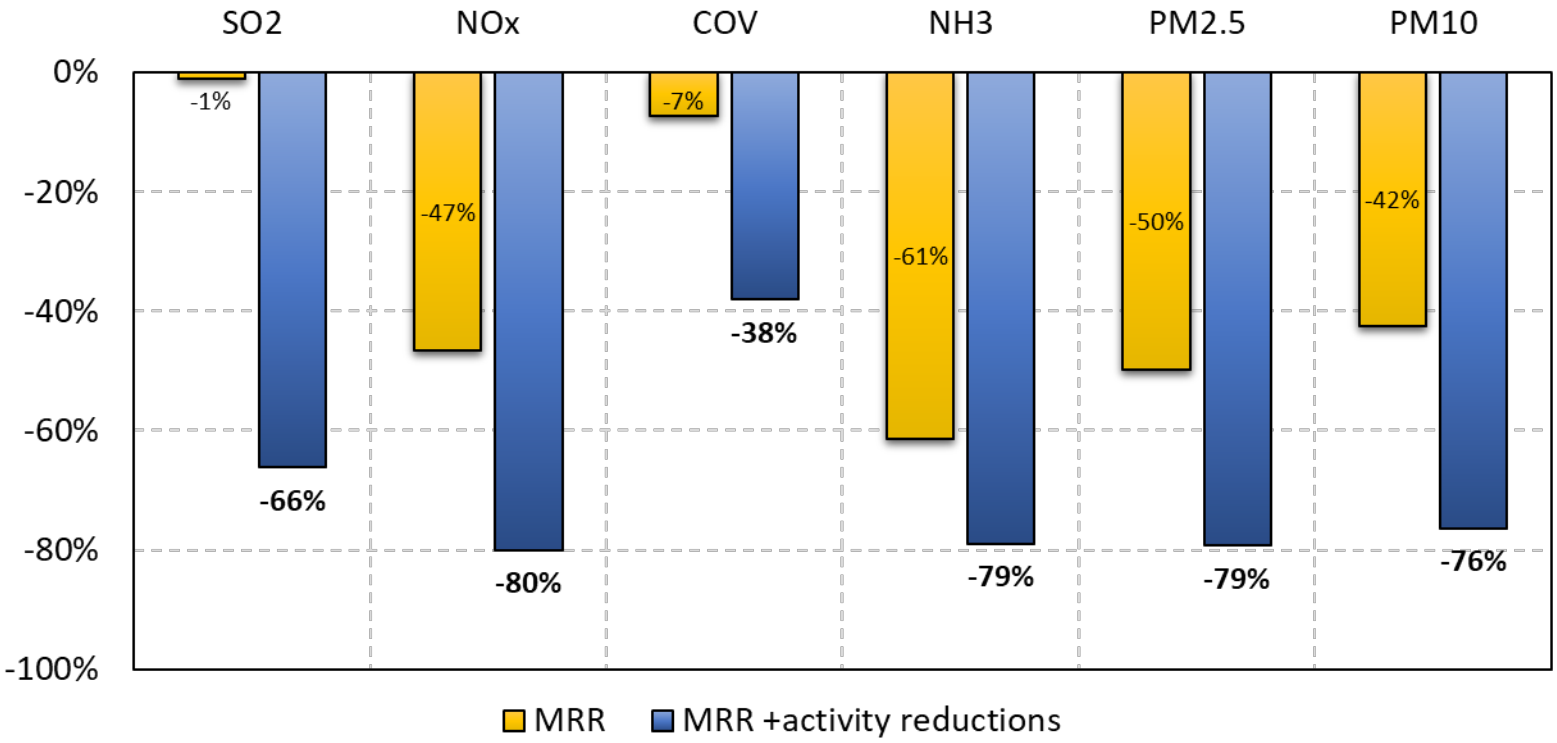
The MRR scenario with activity level variations

To achieve an 80% reduction in emissions within the Lombardy Region, in addition to MRR application, it would be necessary to implement drastic reduction in activities.

For example, achieving an 80% reduction could involve, among other possible choices:

a) removing 75% of vehicles and
b) removing 75% of methane domestic heating systems and 100% of biomass domestic heating systems (already with the best technologies) and
c) reducing pigs and cattle populations by 60% and
d) eliminating 75% of industrial activities

The MRR scenario with activity level variations in Lombardy



Conclusions 1/2

- Thanks to emission reductions of the last years, air quality is improving also in the Po Valley but WHO guidelines suggest values much lower than those measured in 2023 (the best year of whenever)
- In the framework of Life Prepair project a sensitivity analysis was performed to evaluate the feasibility of the different WHO targets
- In Po Valley also a reduction of 80% of 2017 emissions doesn’t guarantee the achievement not only of WHO AQG levels but also of the interim target 4 (in particular for PM2.5)
- Nevertheless, it was studied which would be possible measures to reduce emissions up to 80% in Lombardia.

Conclusions 2/2

- Maximum technological measures considered:
  - ✓ all cars and light duty vehicles electric and Euro VI heavy duty vehicles
  - ✓ best available technology applied to industry, agriculture and biomass LSH

  would lead to a reduction less than 80%
- A reduction of 80% of the emissions of all the relevant pollutants, would be possible applying all the described technologies AND
  - ✓ reducing 75% of the number of kilometres travelled by vehicles; of the industrial activities; of the use of natural gas boilers; ban the use of the wood reducing the number of cattle and pigs of 60%
- In conclusion, in the Po Valley a drastic change of the people behaviour could be not enough to achieve WHO AQG levels. If technology will not improve substantially, it would necessary also to discuss if an important reduction of industrial and agricultural activities is sustainable.