Towards zero pollution in Northern Italy cities

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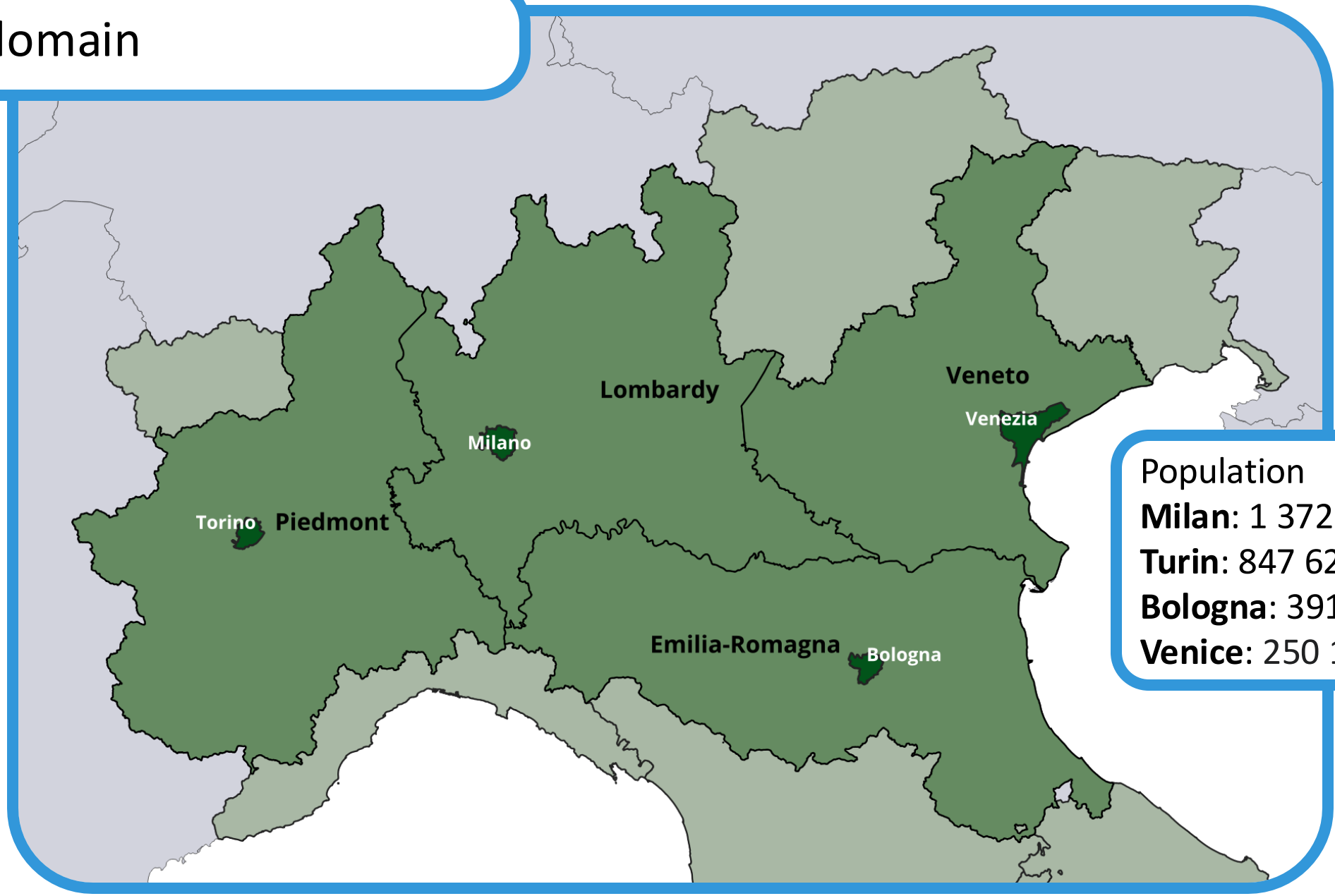
Zero pollution targets for 2030

- improving air quality to reduce the number of premature deaths caused by air pollution by 55%, relative to 2005;
- improving water quality by reducing waste, plastic litter at sea (by 50%) and microplastics released into the environment (by 30%);
- improving soil quality by reducing nutrient losses and chemical pesticides' use by 50%;
- reducing by 25% the EU ecosystems where air pollution threatens biodiversity;
- reducing the share of people chronically disturbed by transport noise by 30%;
- significantly reducing waste generation and by 50% residual municipal waste.

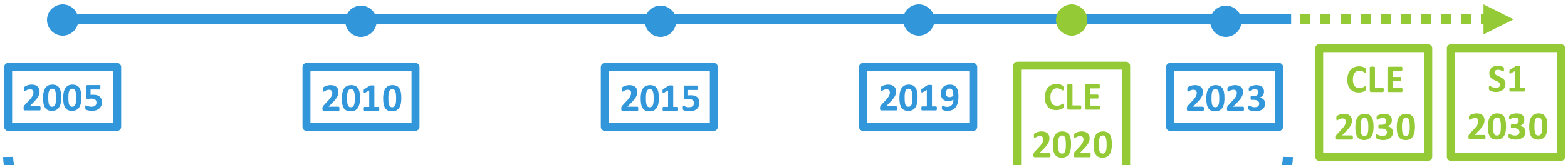
https://environment.ec.europa.eu/strategy/zero-pollution-action-plan_en

Study domain



Population
Milan: 1 372 843
Turin: 847 622
Bologna: 391 191
Venice: 250 141

Analysis from 2005 up to 2030

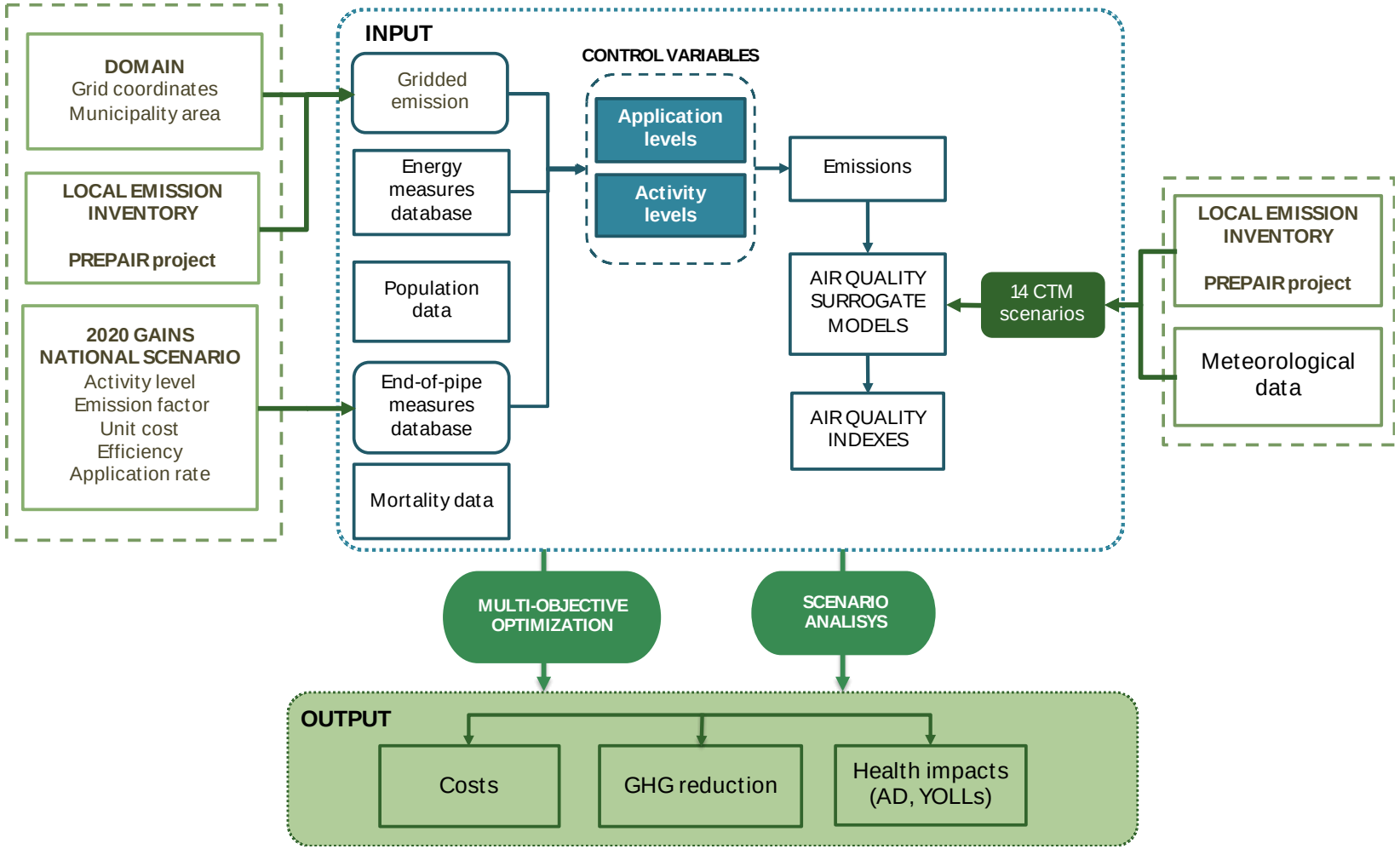


- Measured PM2.5 values in the main cities of the study domain
- Data available from EEA site and each regional environmental agency (ARPA)

- 2020 base case obtained by merging prepAIR* emission inventory and GAINS Outlook2017
- Projected to 2030 using the energy and climate national plan (PNIEC) and GAINS Outlook2017.
- Multi-objective optimization of PM2.5 and NO_2 concentration (300M€ over CLE2030)

* prepAIR LIFE 15 IPE IT 013 European Project

Integrated Assessment Model - MAQ



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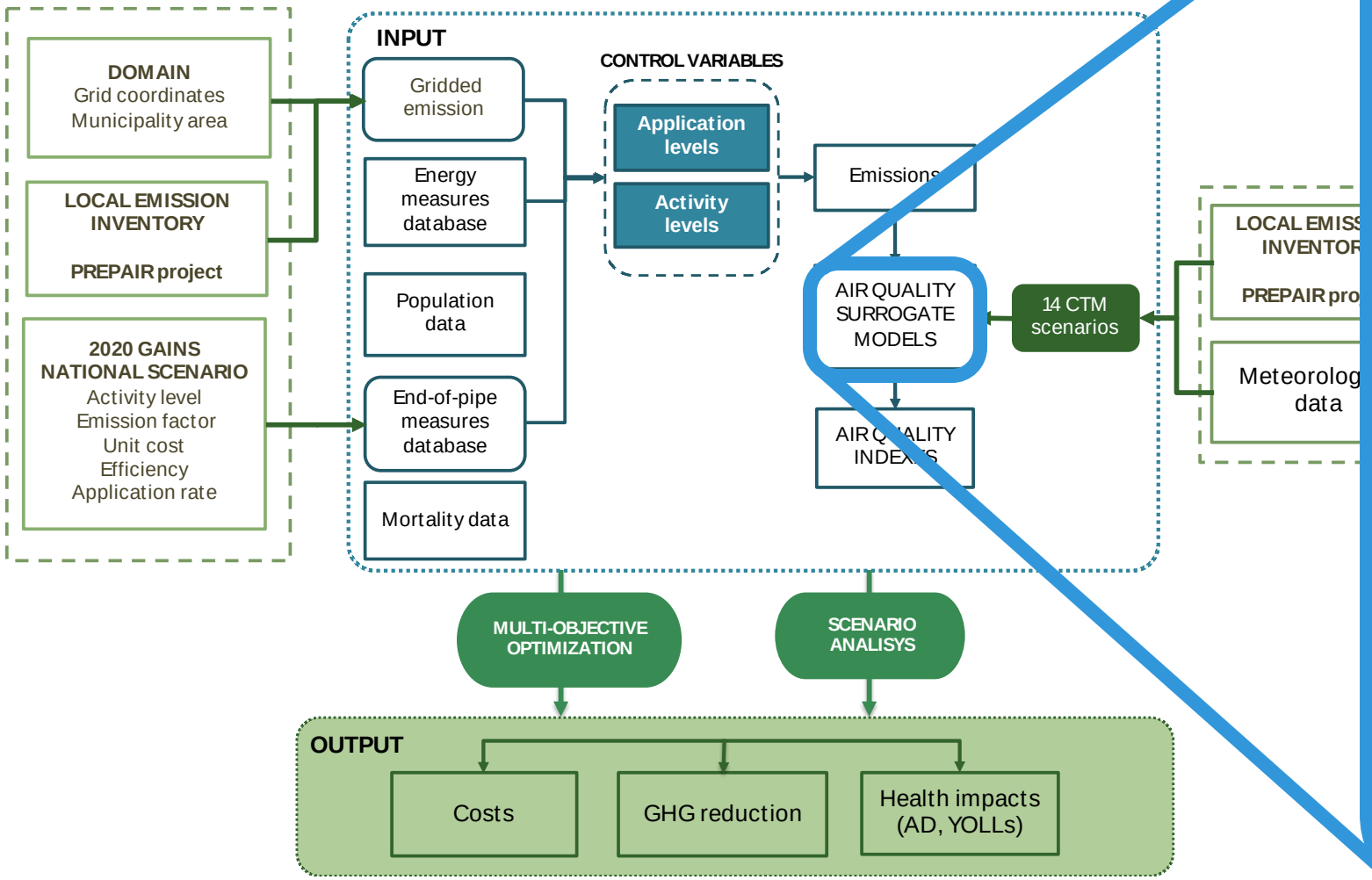
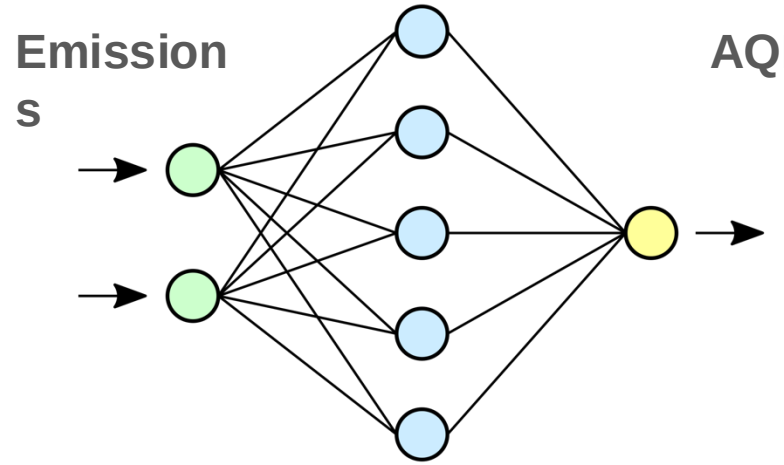
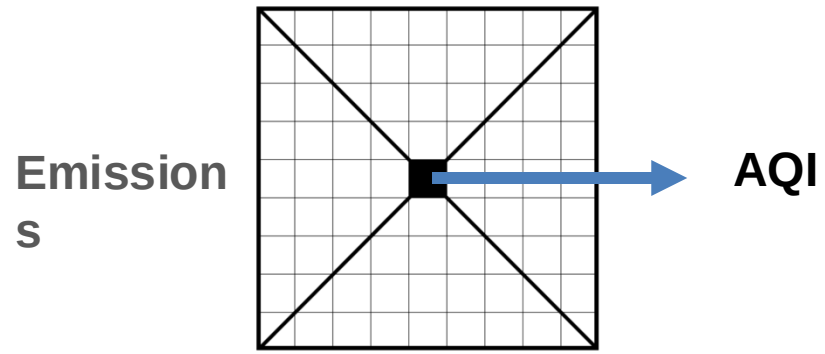


Air Quality surrogate models: ARTIFICIAL NEURAL NETWORKS





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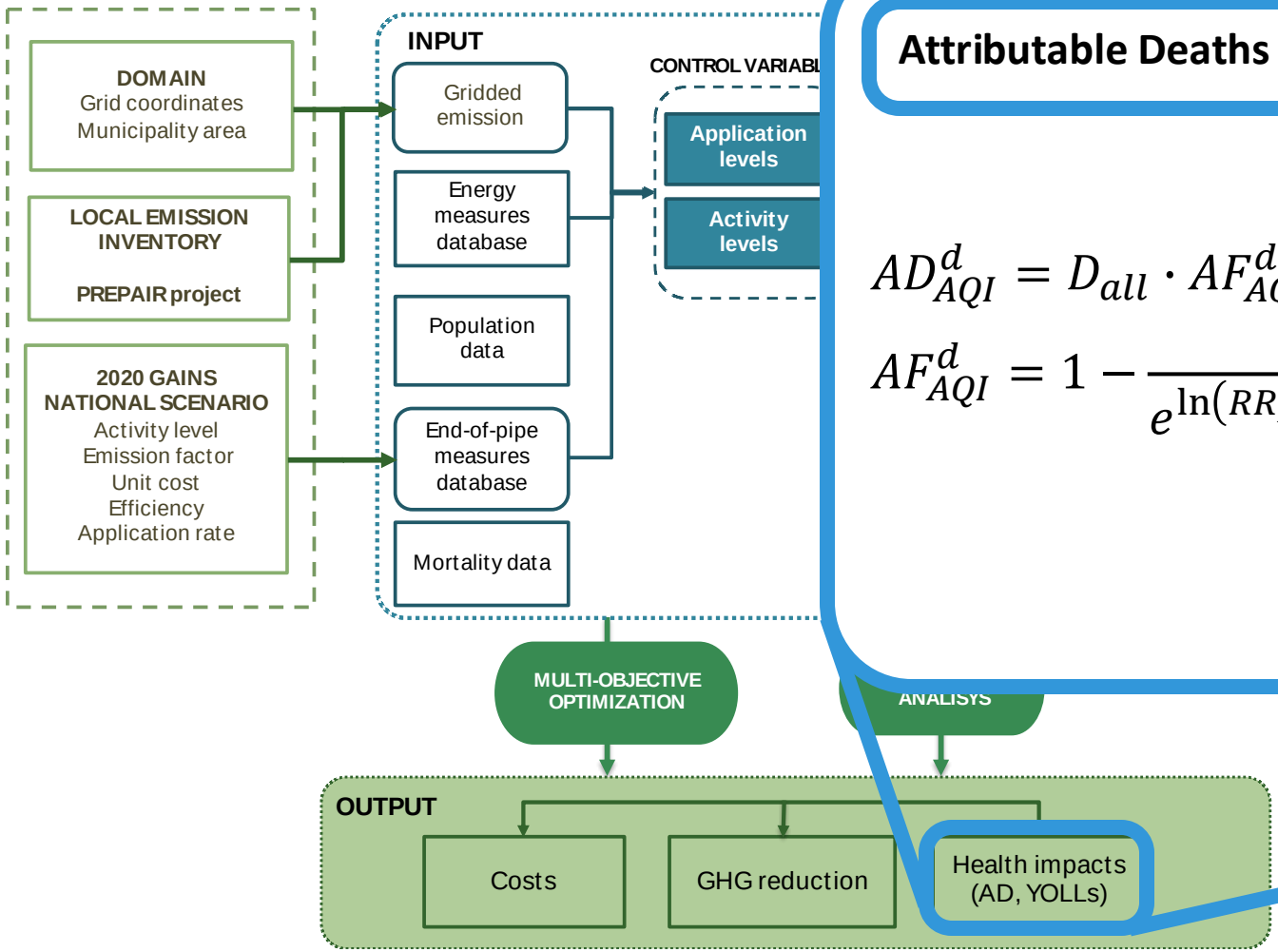

Attributable Deaths computation

$$AD_{AQI}^{d} = D_{all} \cdot AF_{AQI}^{d}$$

$$AF_{AQI}^{d} = 1 - \frac{1}{e^{\ln(RR_{AQI}) \cdot (AQI^{d} - AQI^{tr})}}$$

AQI treshold (WHO):

$PM2.5^{tr} = 5\ \mu g/m^3$

$NO_2^{tr} = 10\ \mu g/m^3$

Relative risk (RR)*	RR PM2.5	RR NO_2
Natural causes mortality	1.08 (1.06-1.09)	1.02 (1.011.04)

*J. Chen, G. Hoek, "Long-term exposure to PM and all-cause and cause-specific mortality: A systematic review and meta-analysis", Environ Int., vol. 143 . Huangfu, R. Atkinson, "Long-term exposure to NO2 and O3 and all-cause and respiratory mortality: A systematic review and meta-analysis," Environ Int., vol. 144.

Analysis from 2005 up to 2030

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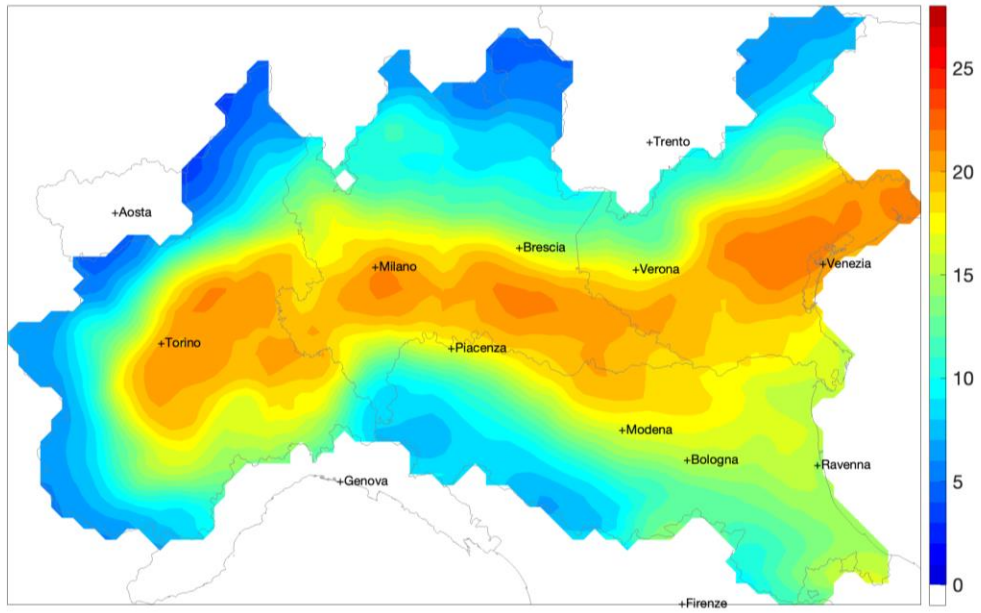
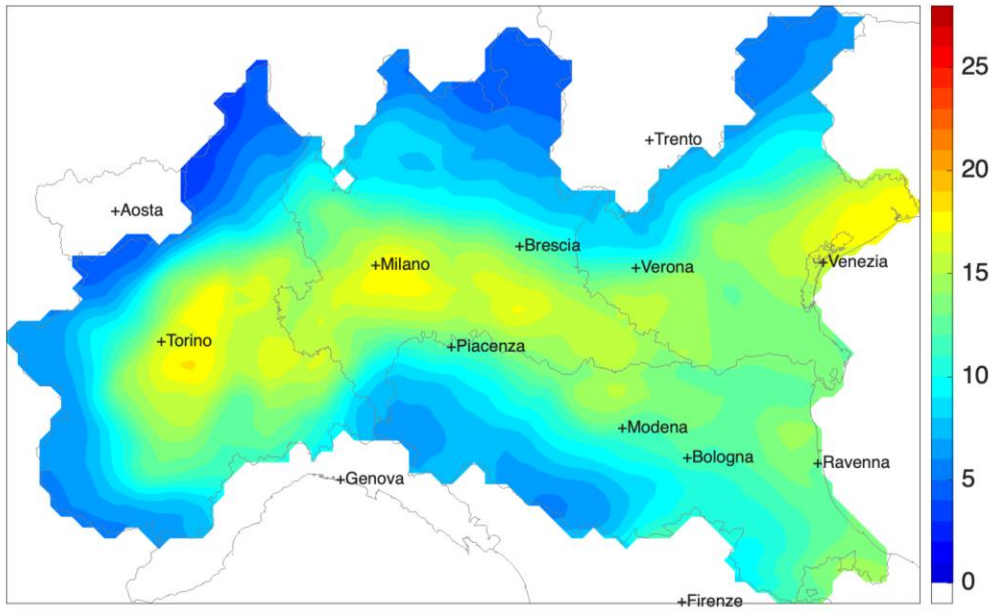
2005 — 2010 — 2015 — 2019 — CLE 2020 — 2023 — CLE 2030 — S1 2030



PM2.5 [µg/m³]



Problem formalization

$$\min_x J(x) = \min_x [AQI(x)\ , C(x,)]$$

$$\frac{\partial AQI(x)}{\partial x} = \frac{\partial AQI(x)}{\partial E(x)} \cdot \frac{\partial E(x)}{\partial x}$$

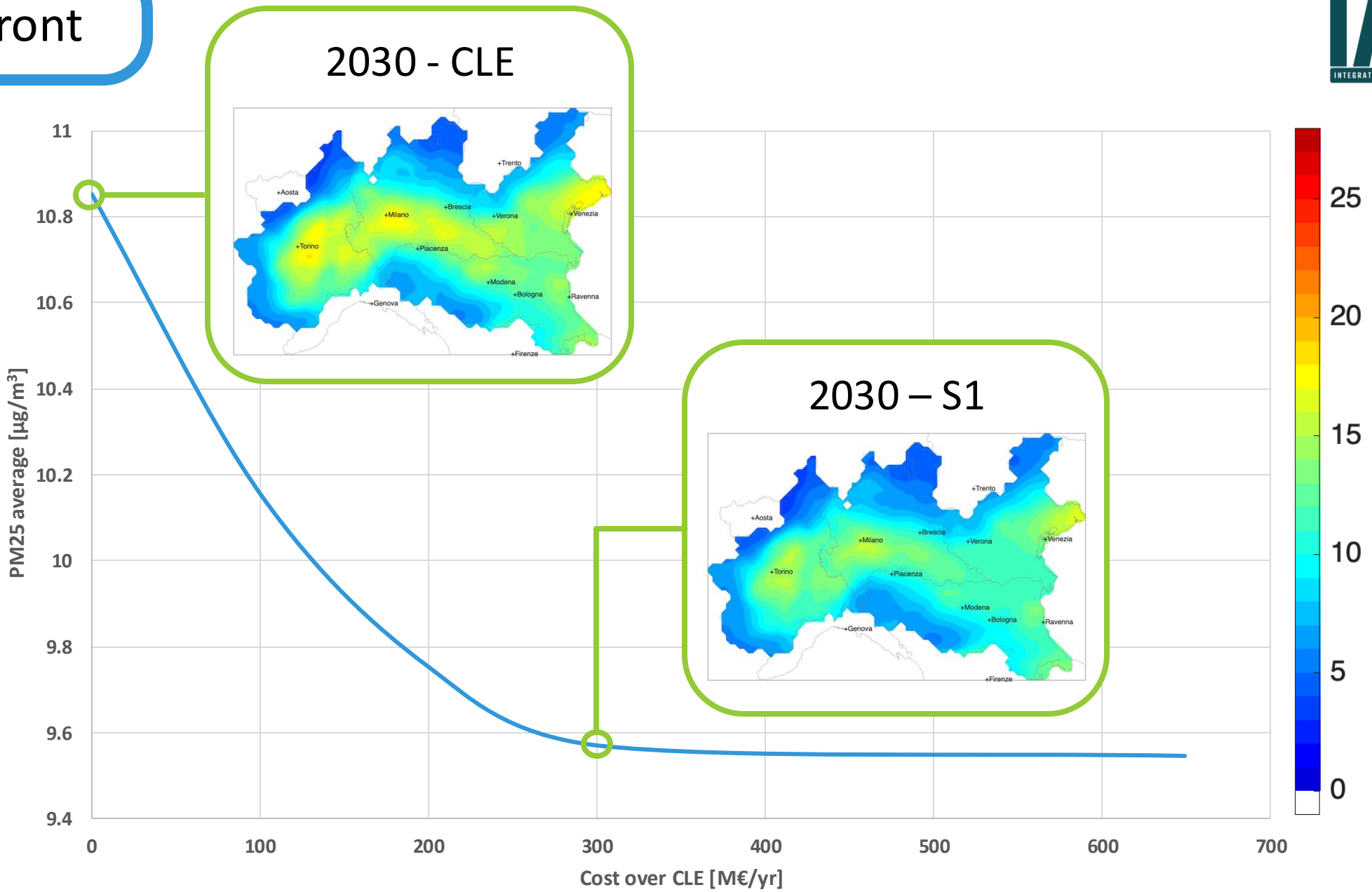
AQ SURROGATE MODEL:
Artificial Neural Network

$$E^{d,p}(x) = \sum_{k \in K} \left[A_k^d \cdot ef_k^p \cdot \left(1 - \sum_{t \in T_k} eff_t^p \cdot x_k^t \right) \right]$$

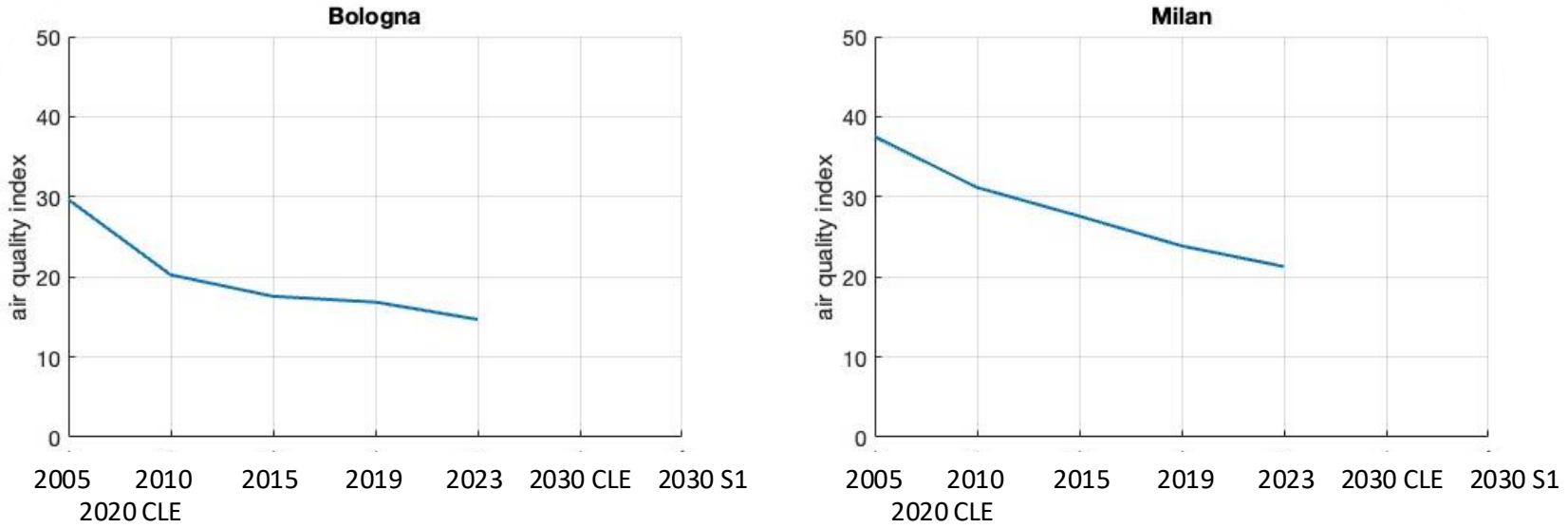
- k emission source
- A_k activity level
- ef unabated emission factor
- t end of pipe measure
- eff removal efficiency

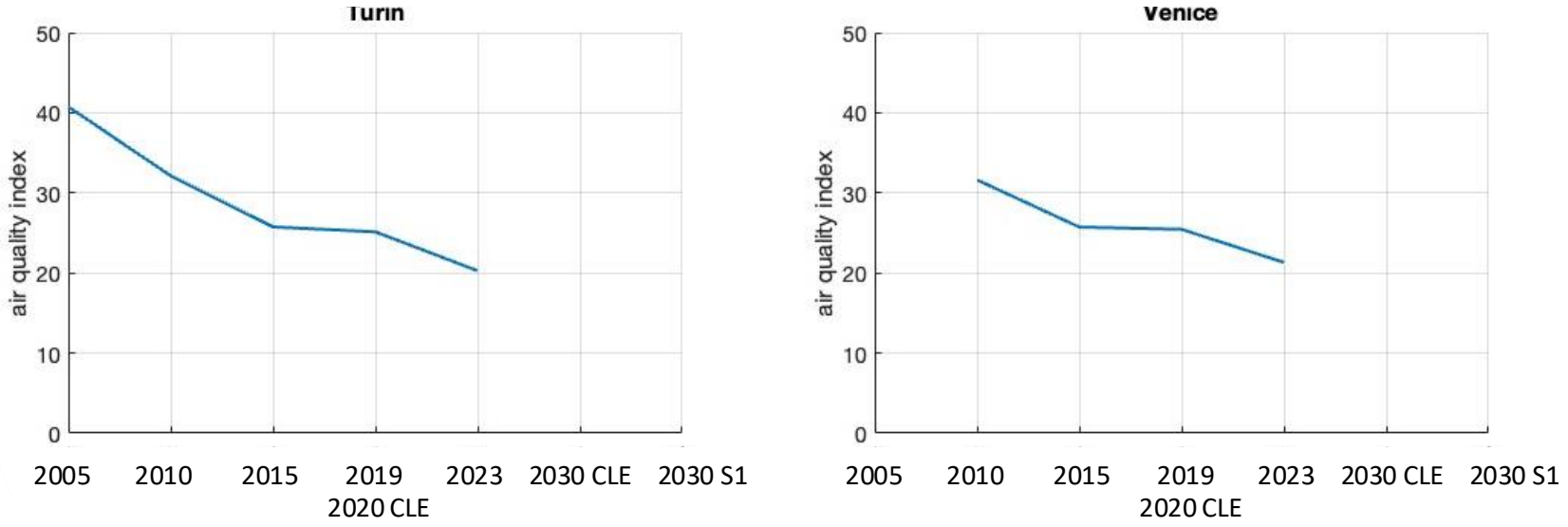
E. Turrini, C. Carnevale, G. Finzi, M. Volta. A non-linear optimization programming model for air quality planning including co-benefits for GHG emissions, Sci. Total Environ., 621 (2018), pp. 980-989

Pareto front



PM2.5 concentrations in the main Po Valley cities





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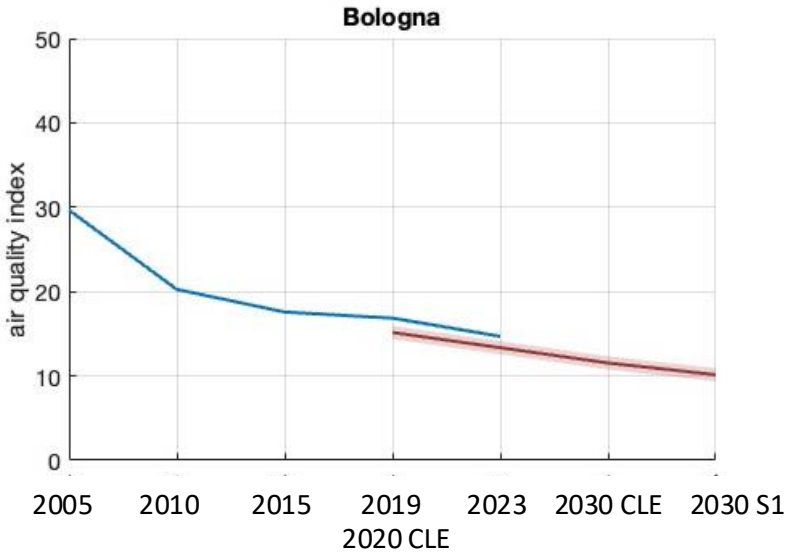

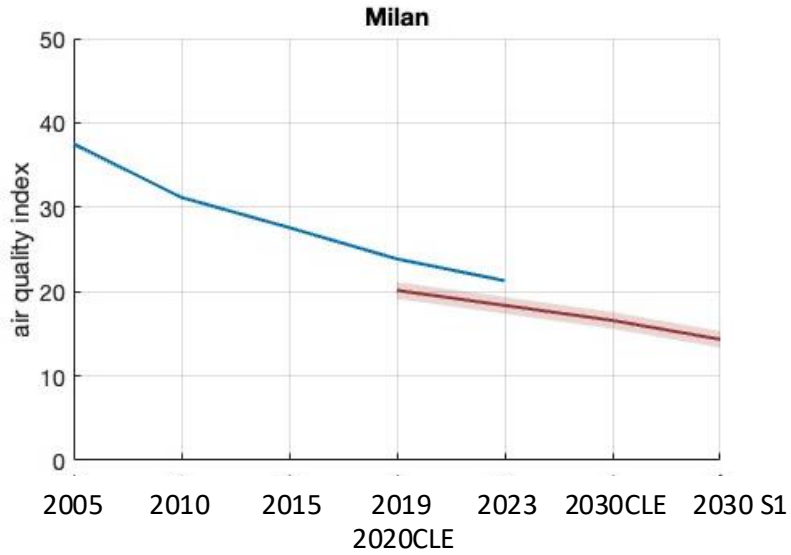

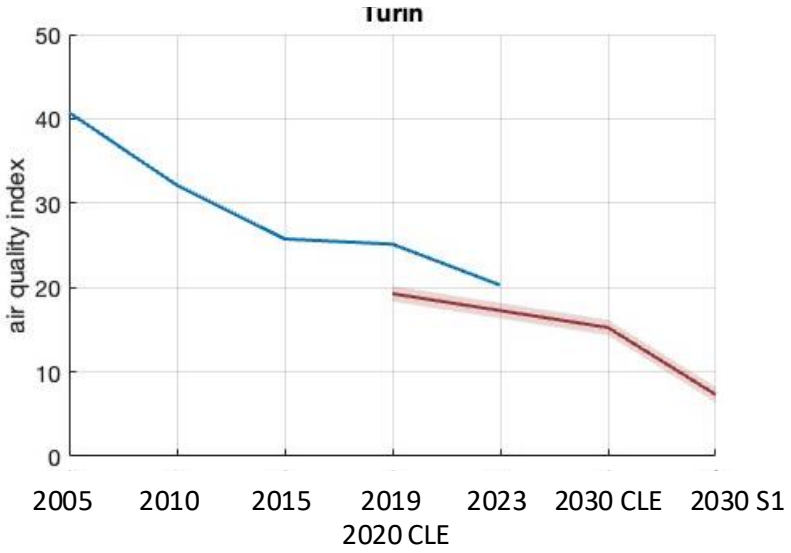

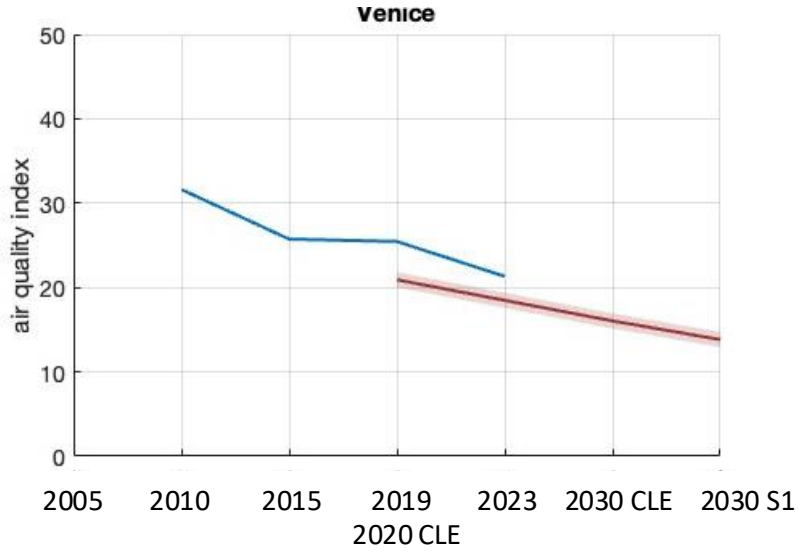

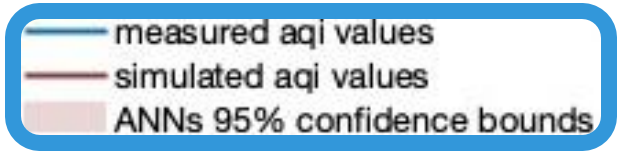

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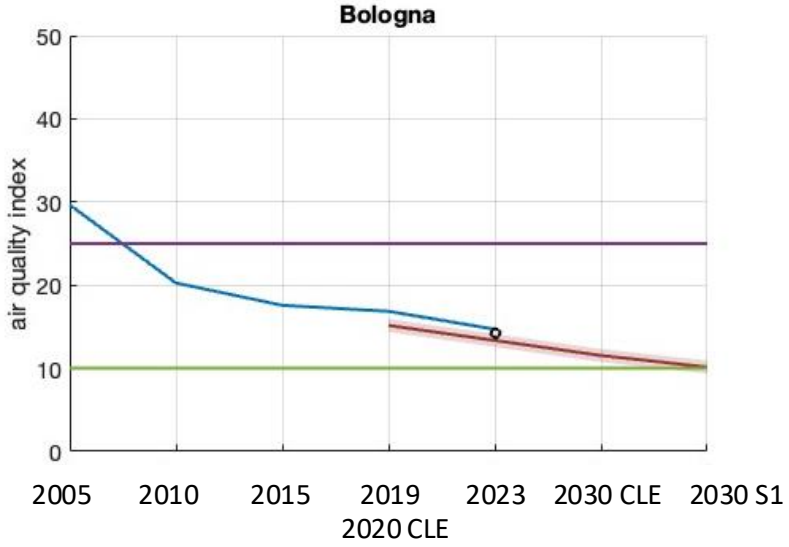
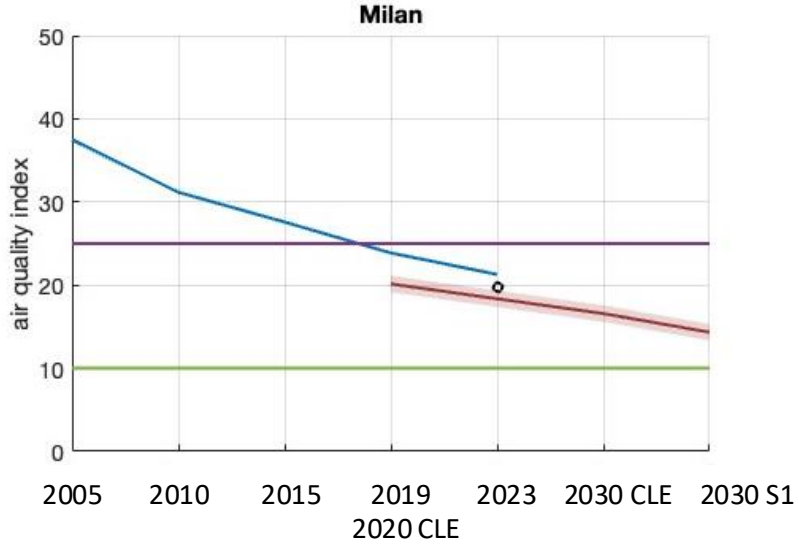
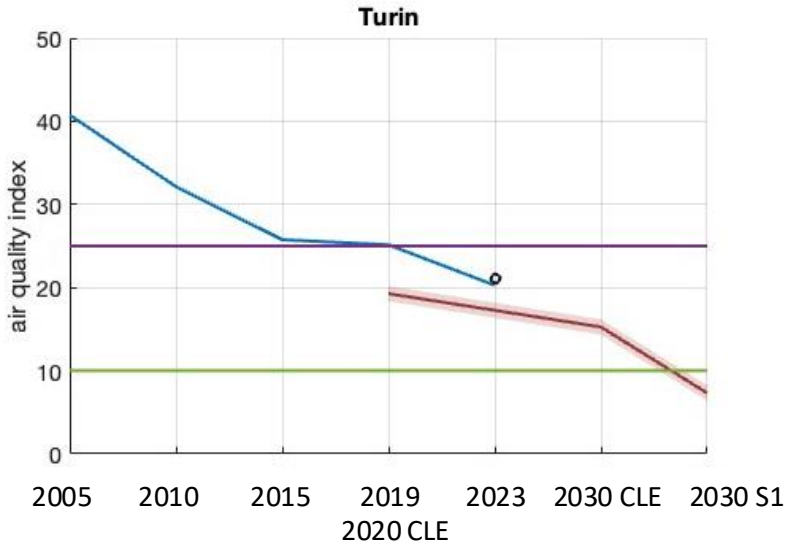
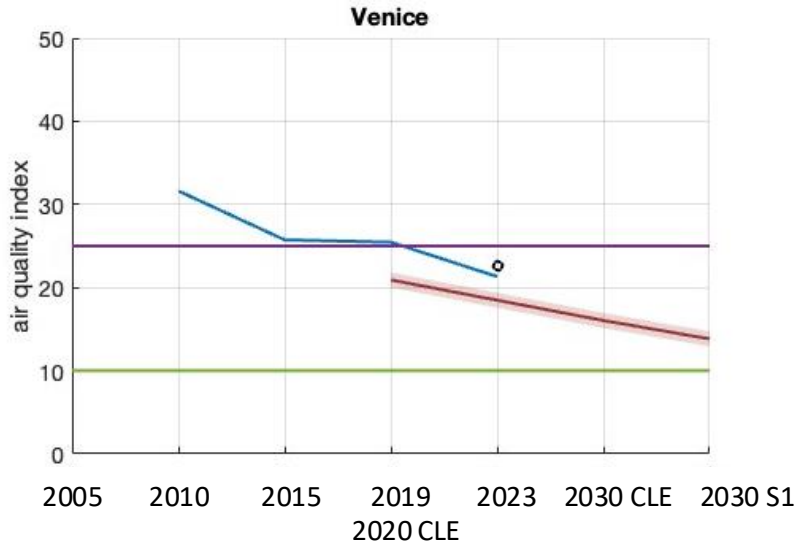
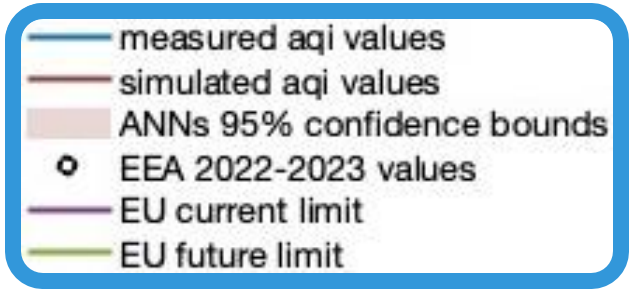




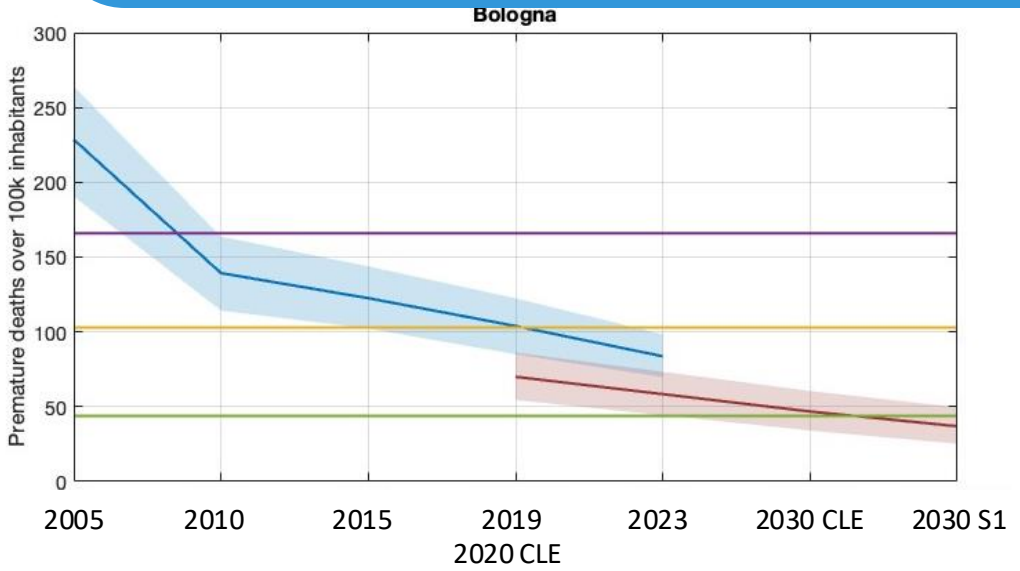


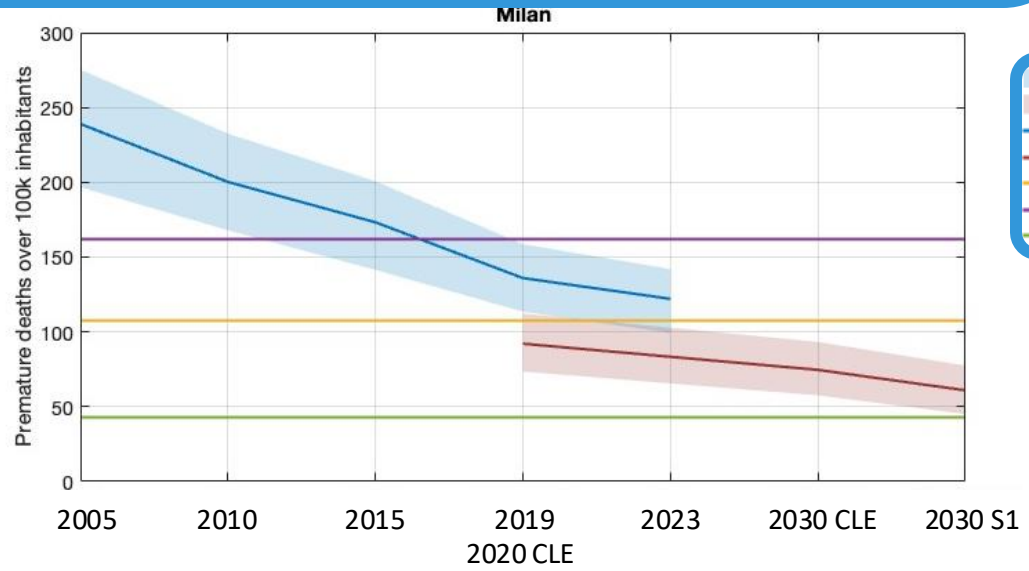


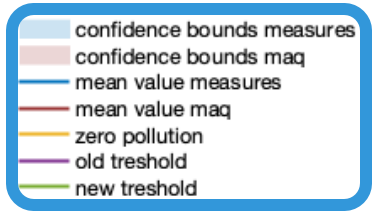


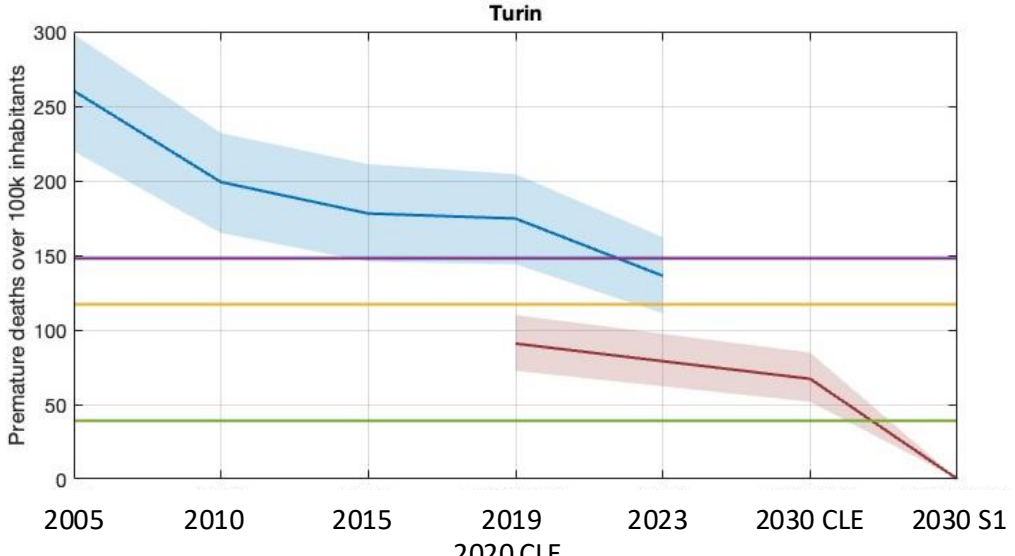
https://www.eea.europa.eu/en/topics/in-depth/air-pollution/european-city-air-quality-viewer

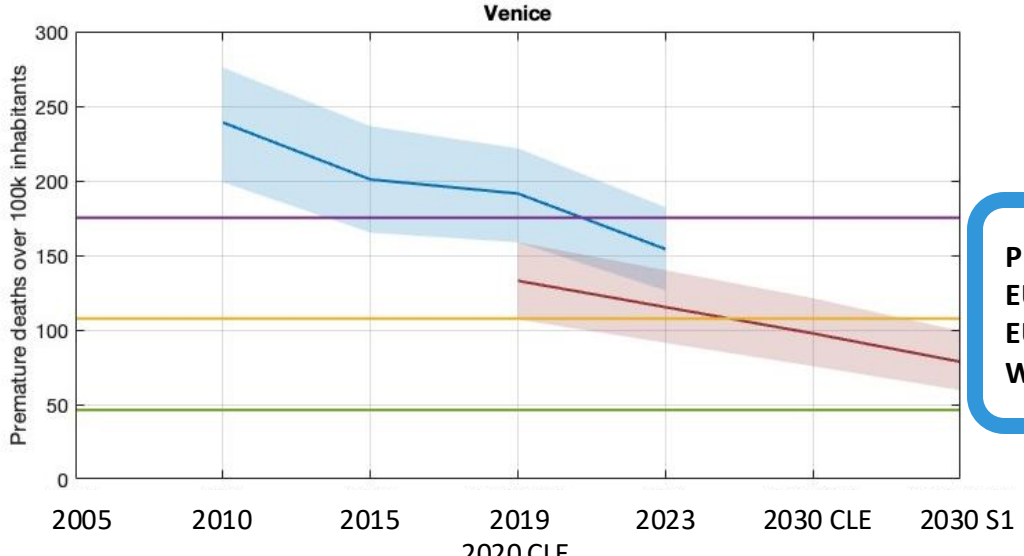
Premature deaths due to PM2.5 exposure in the main Po Valley cities











PM2.5 exposure treshold
EU - Current: 25 µg/m^3
EU - Future: 10 µg/m^3
WHO guideline: 5 µg/m^3

Conclusions

- **AIM:** will Northern Italy cities achieve **zero pollution** target?
- **METHODOLOGY:**
  - integration of measured and simulated data
  - model uncertainty
- **RESULTS:**
  - **zero pollution** target achieved 
  - future EU targets not achievable

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