Progress and policies to achieve the Zero Pollution Action Plan and EU 2024/2881 PM2.5 targets in Northern Italy

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6th EPCAC workshop – 18-19 November 2025

PM2.5 objectives

The ZPAP Target

Improving air quality to **reduce the number of premature deaths caused by air pollution by 55%, relative to 2005.**

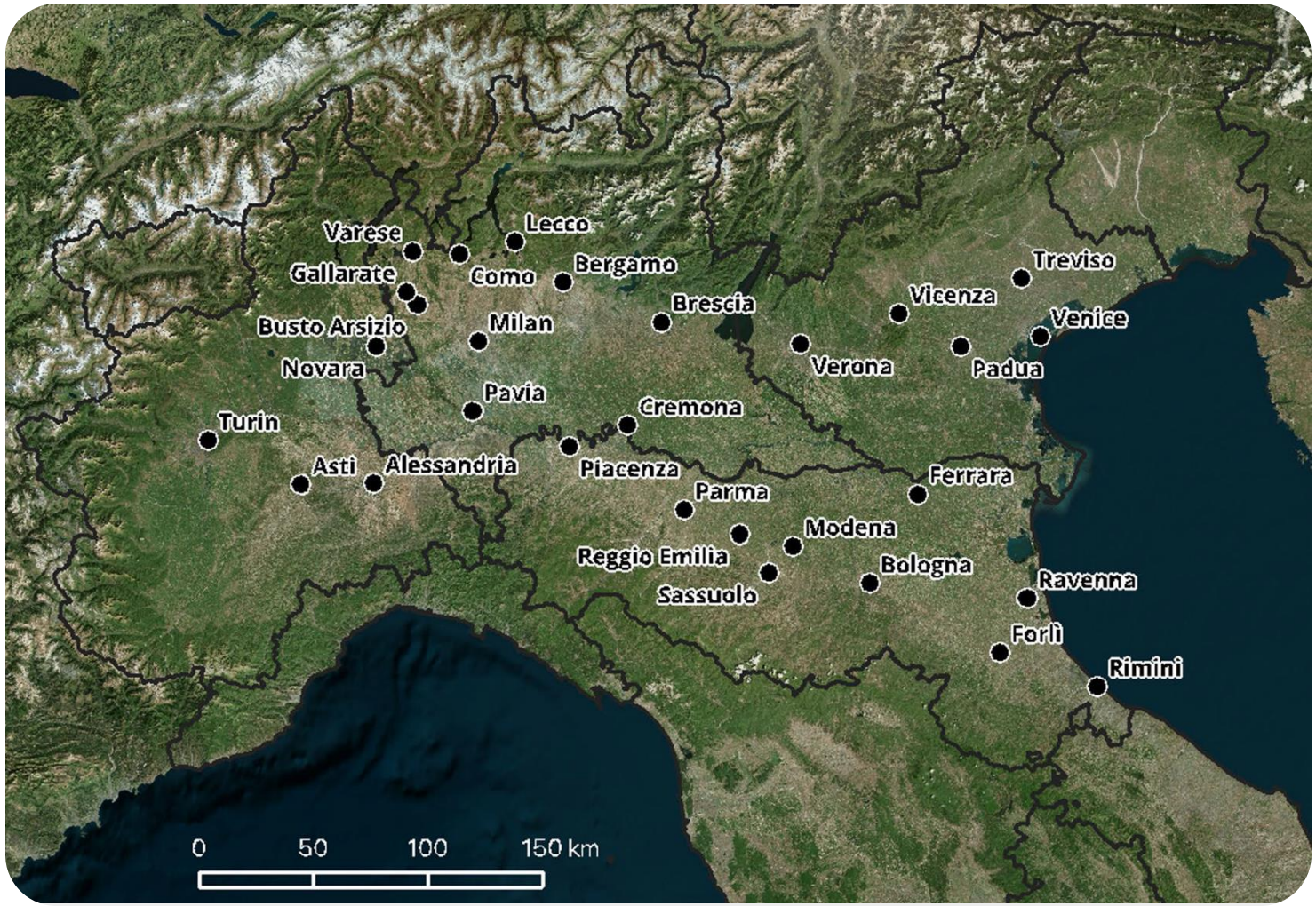
EU 2024/2881 Directive

AQ standard	EU 2008/50	EU 2024/2881
Annual limit value	25 µg/m^3	10 µg/m^3

https://environment.ec.europa.eu/strategy/zero-pollution-action-plan_en
https://eur-lex.europa.eu/eli/dir/2024/2881/oj/eng

Domain: Northern Italy

29 Cities with a population of 5.814.755



Research questions

The ZPAP Target

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EU 2024/2881 Directive

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1) Have the targets already been reached?

2) Will current policy meet the targets?

3) Are additional measures needed ?

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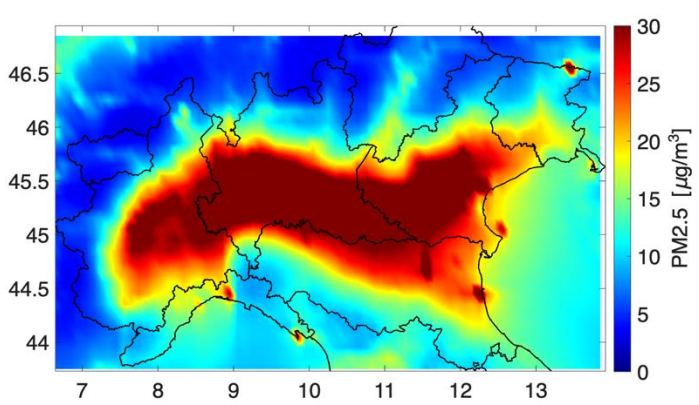
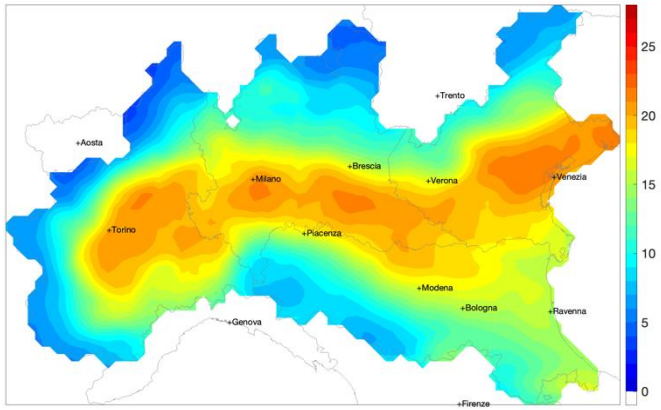




2005

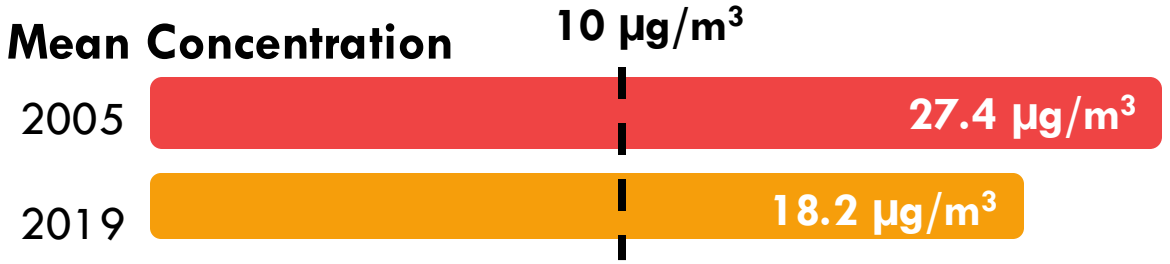
2019

EEA PM2.5 concentrations in the main cities of the study domain

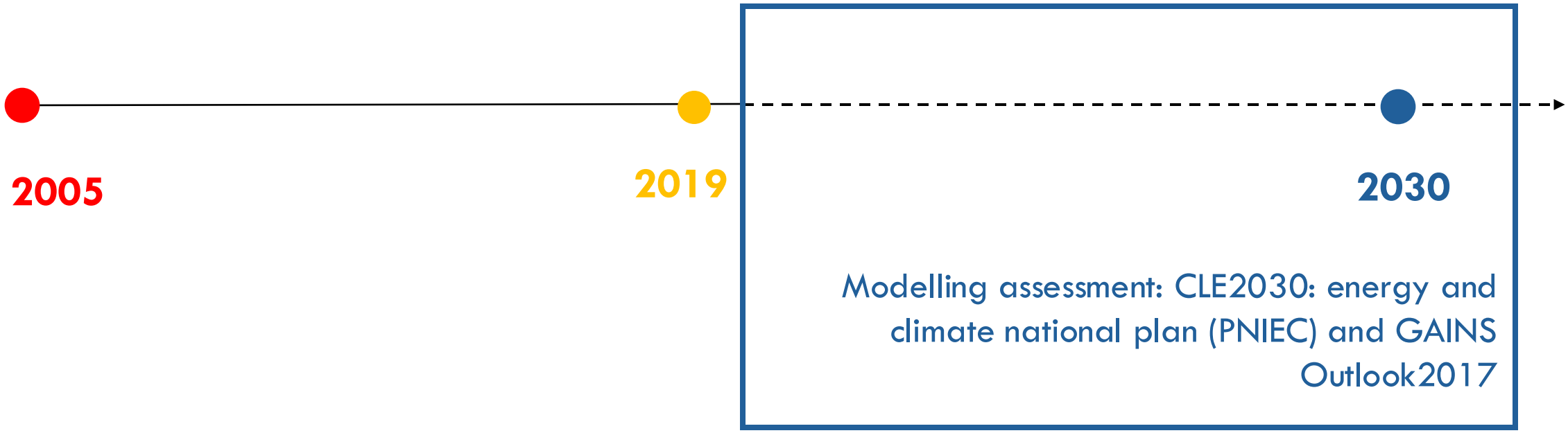
1) Have the targets already been reached?

ZPAP

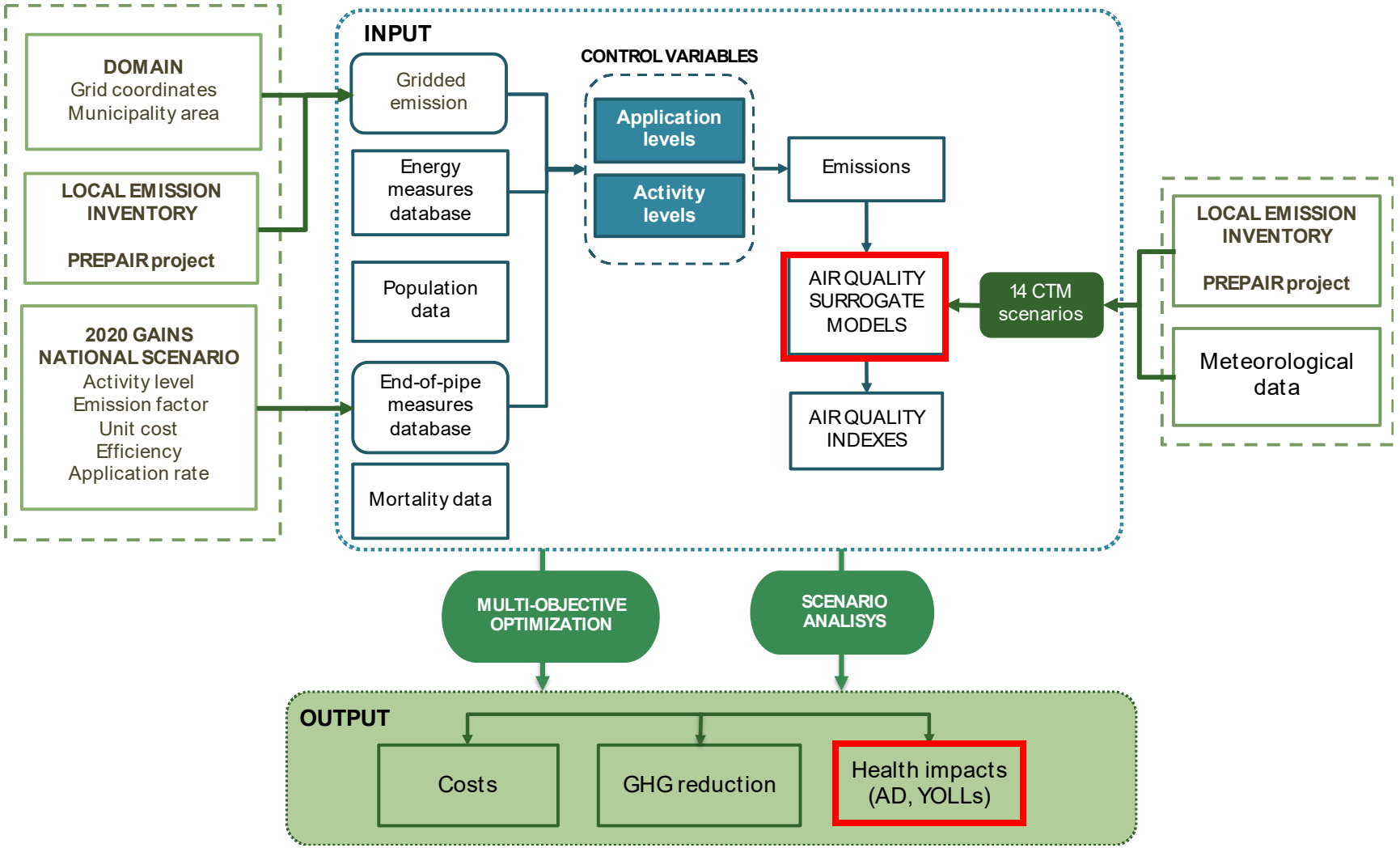
2024 AAQD



2) Will current policy meet the 2030 targets?

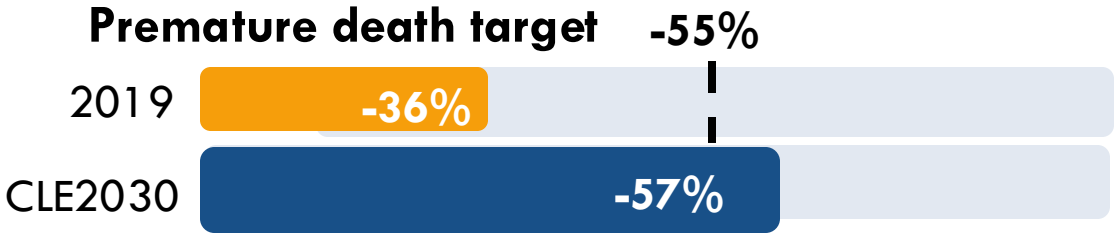


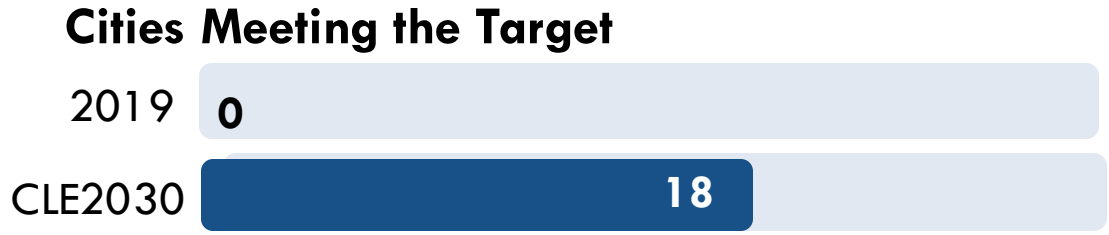
Integrated Assessment Model - MAQ



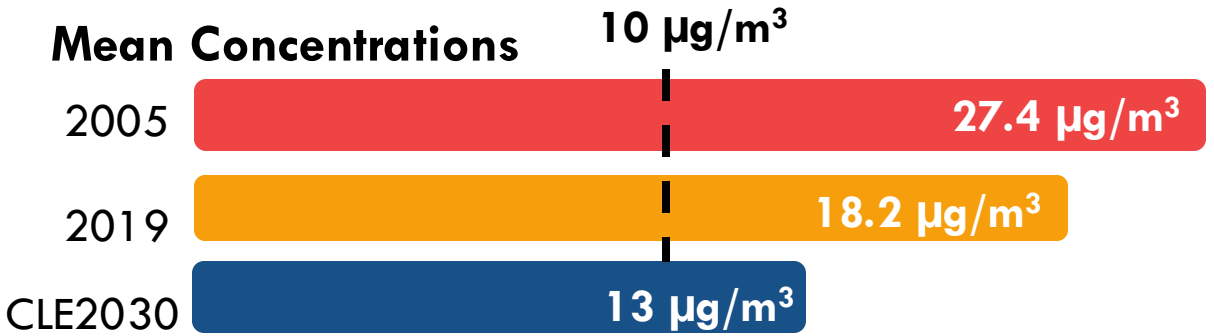
2) Will current policy meet the targets?

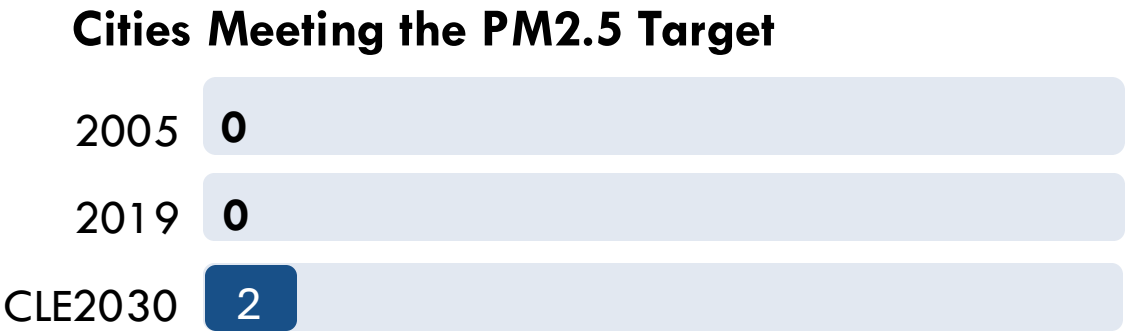
ZPAP



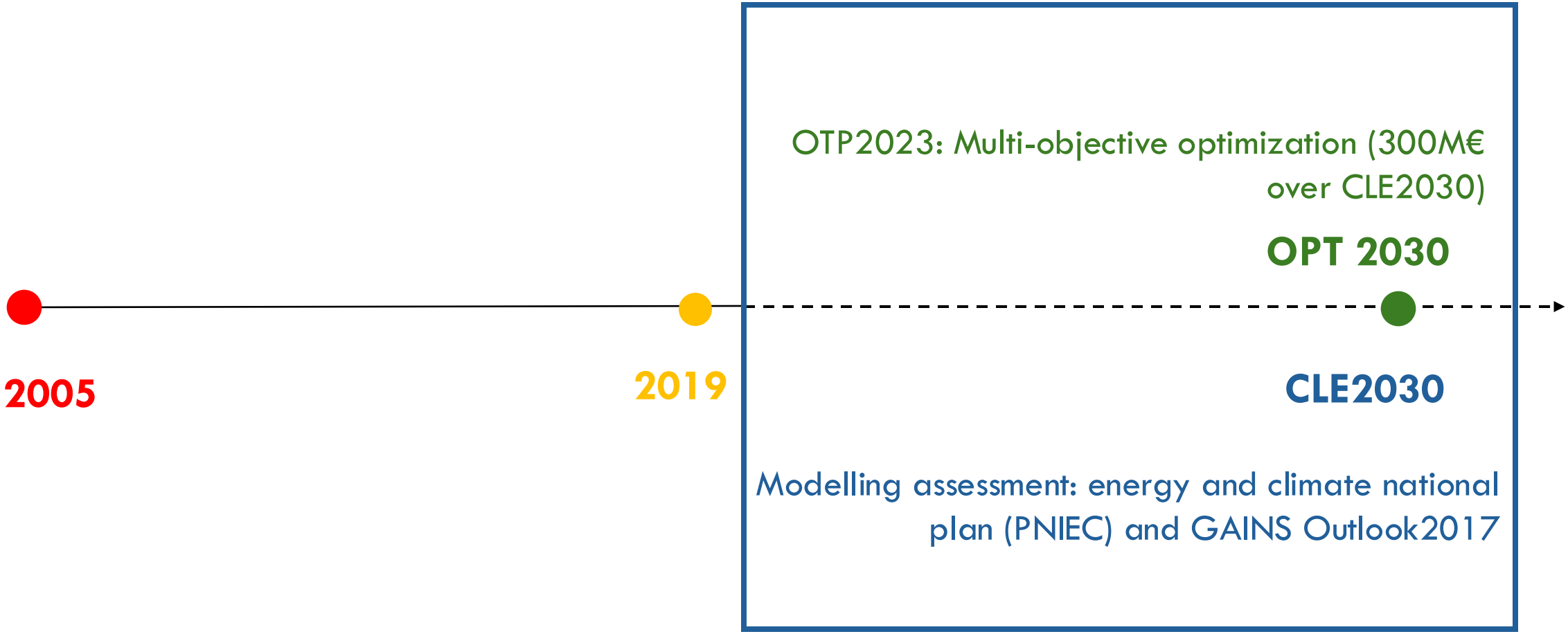


2024 AAQD





3) Are additional measures needed ?



Decision Problem

$$\min_{\theta} J(\theta) = \min_{\theta} [AQI(x), C(x)]$$

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

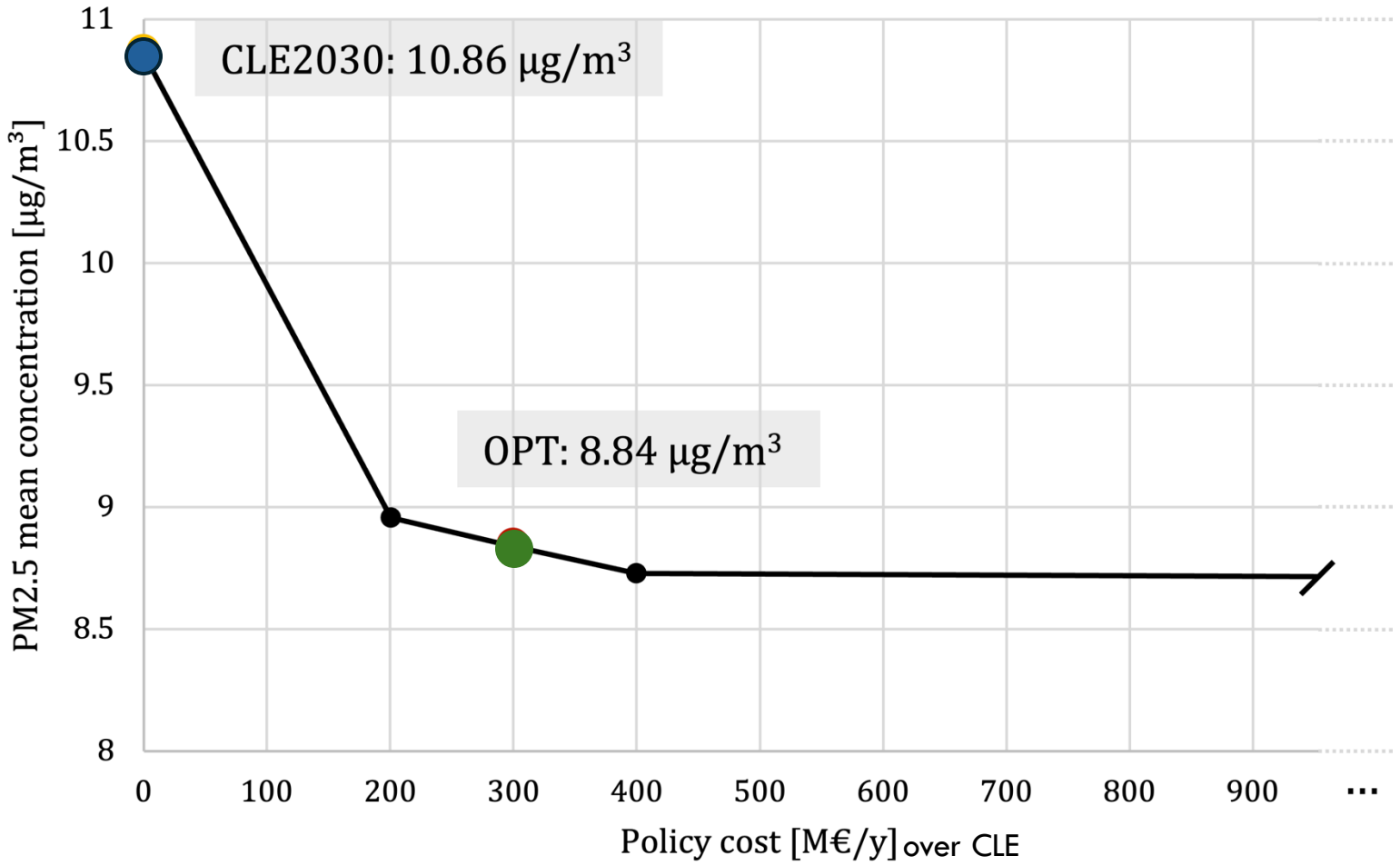
AQ SURROGATE MODEL:
Artificial Neural Network

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

$$E^{d,p}(\Theta) = \sum_{k} \left[A_k^d \cdot ef_k^p \cdot \left(1 - \left(\sum_{s \in S_k} \phi_s + \sum_{f \in F_k} \psi_f \right) \right) \cdot \left(1 - \sum_{m \in M_k} eff_m^p \cdot \gamma_m \right) \right]$$

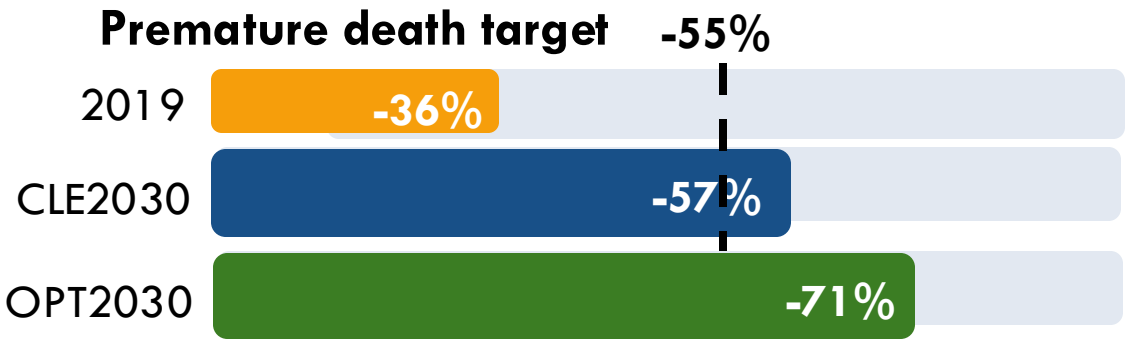
E. Turrini, C. Carnevale, G. Finzi, M. Volta. A non-linear optimization programming model for air quality planning including co-benefits for GHG emissions, Sci. Total Environ., 621 (2018), pp. 980-989

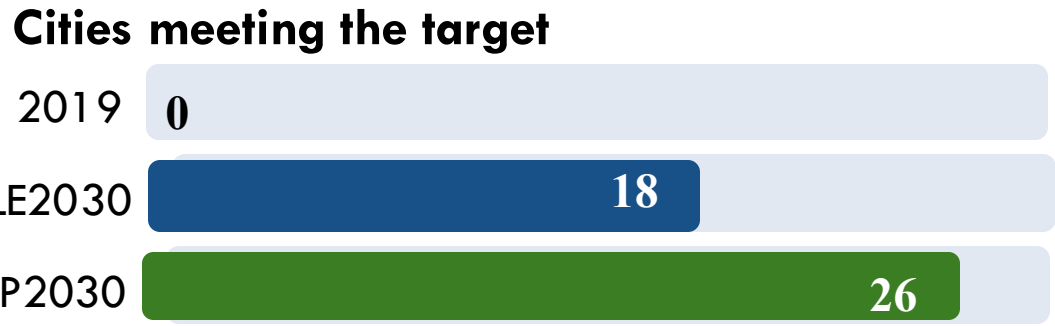
Pareto Front:
decision problem efficient solutions



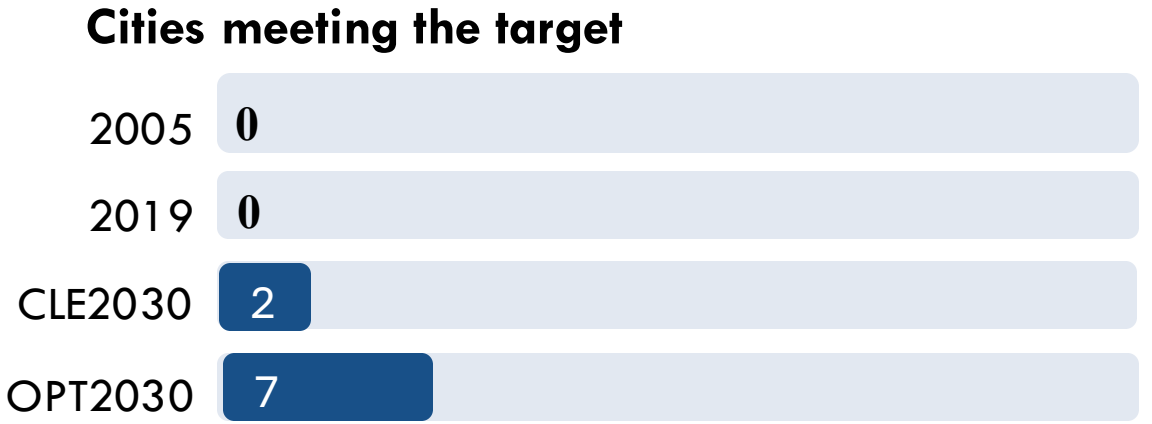
Additional measures: efficient policy OPT2030

ZPAP

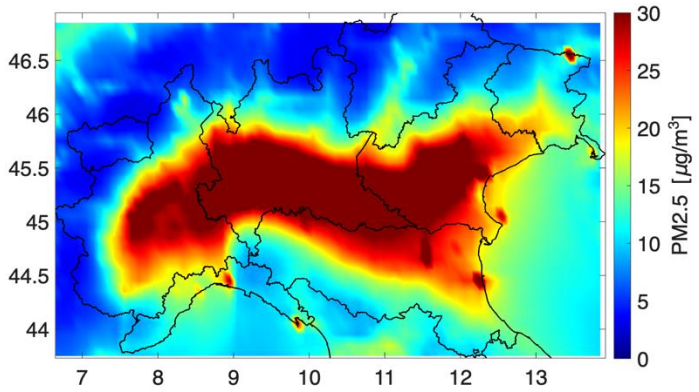


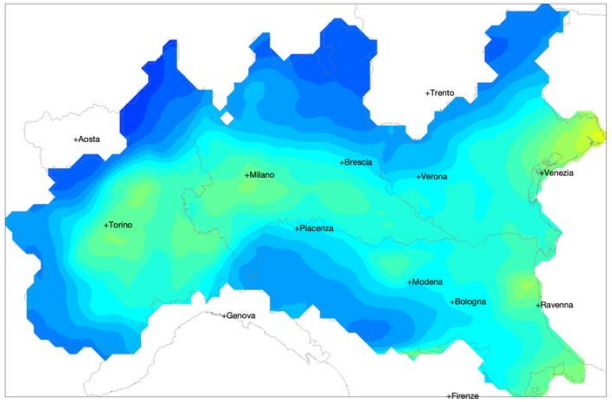


2024 AAQD



PM2.5 annual mean concentrations



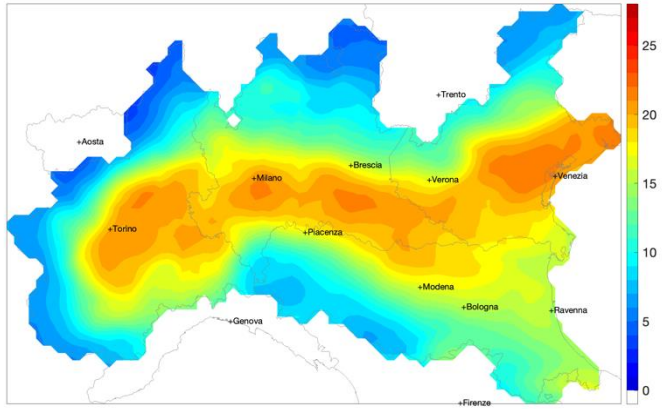


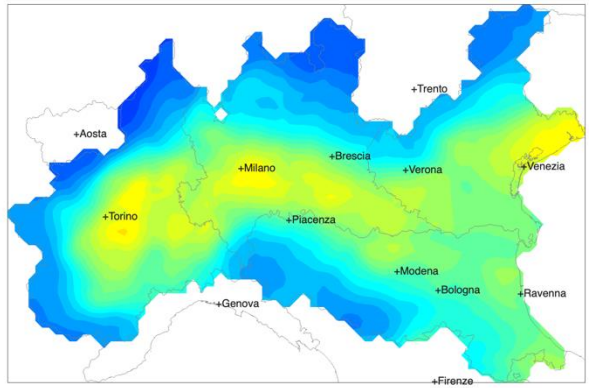
OPT 2030

2005

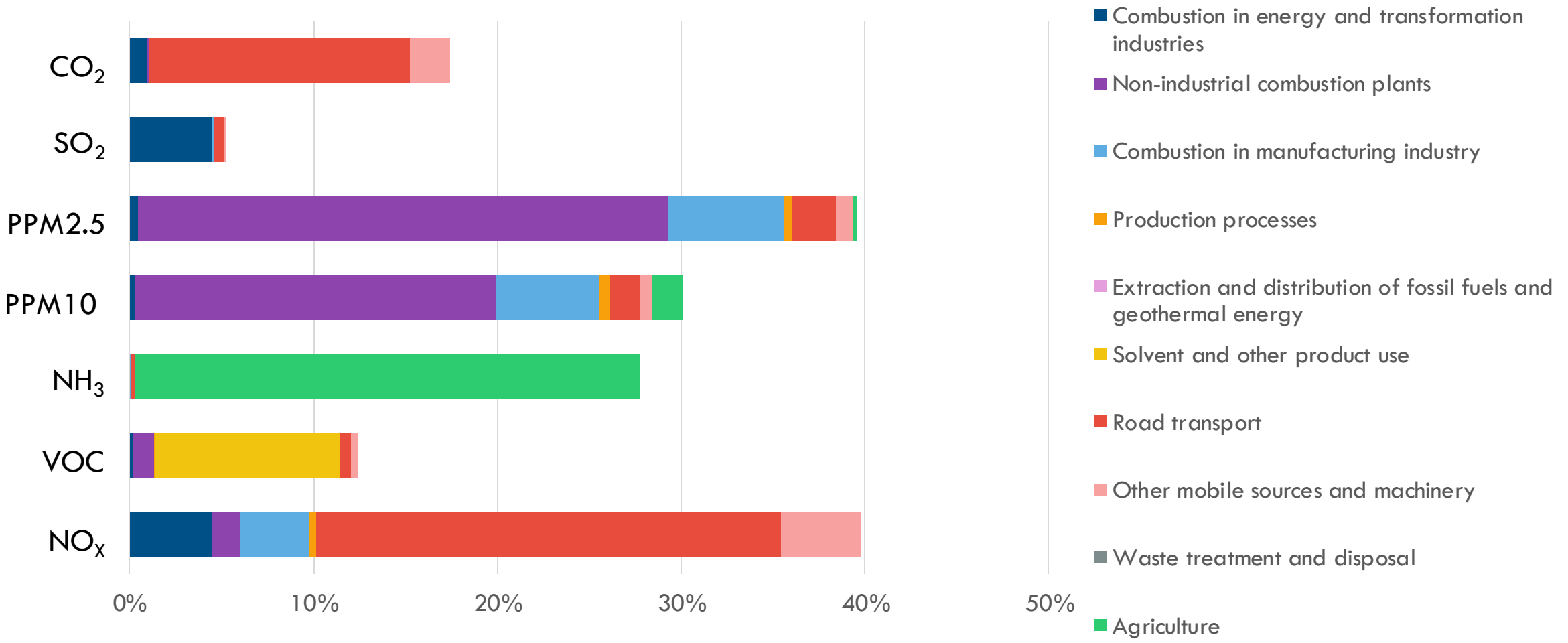
2019

CLE2030

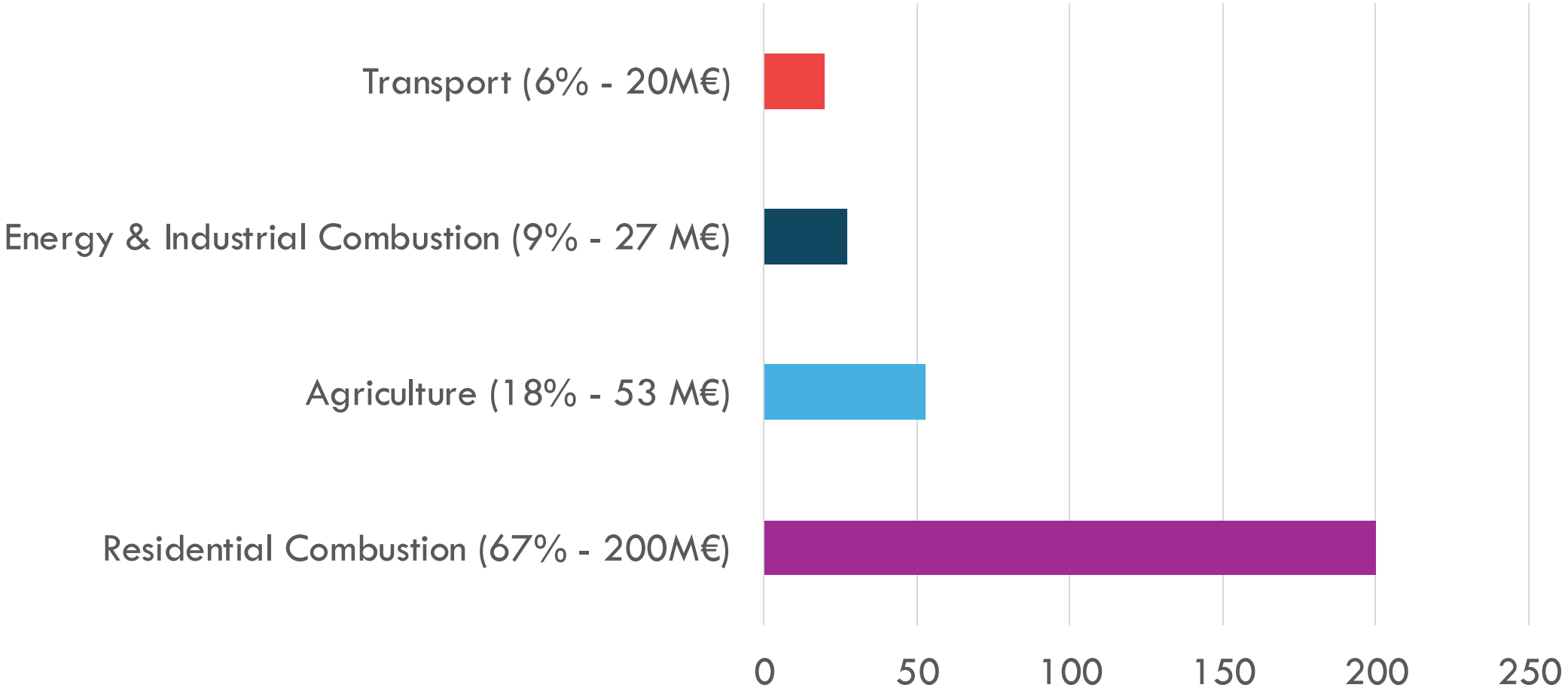




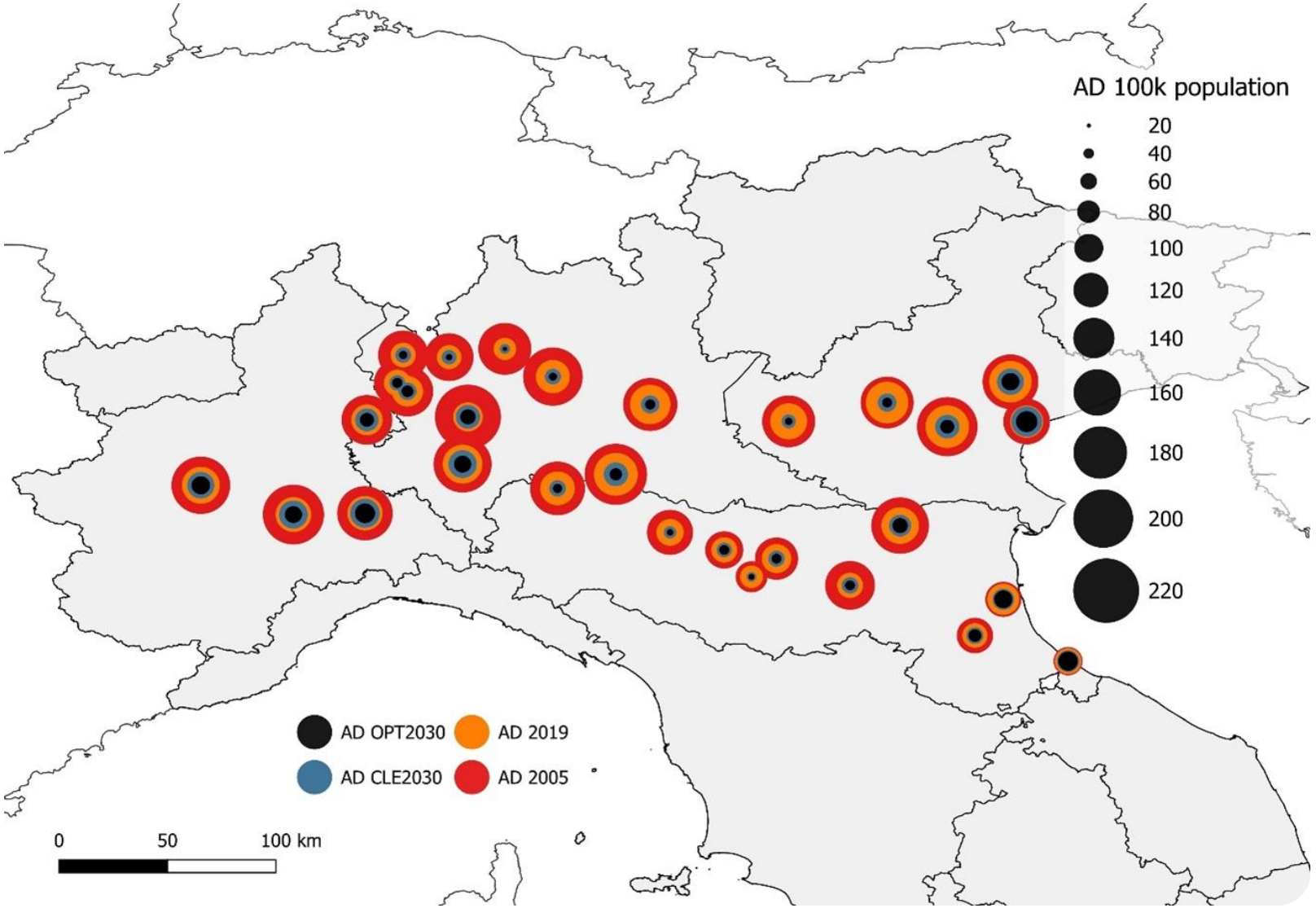
Emission reductions OPT2030 vs CLE2030



OPT2030 Budget



Attributable Deaths



Discussion

ZPAP Target is Achievable

- The 55% mortality reduction (ZPAP) is a more achievable policy benchmark for the Po Valley than the 2024 AAQD concentration limit.
- Current policies (CLE) get 18 of 29 cities there.
- Optimized policies (OPT) get 26 of 29 cities there.

2024 AAQD Target is Not

- The 10 μg/m3 (AAQD) target remains "infeasible in the medium term" for the region.
- Even with an extra 300 M€/year, less than half of the cities (13 of 29) are projected to comply.

Conclusions

- **METHODOLOGY:**
  - integration of measured and modeling data
  - multi-scale policy assessment
  - multi-objective, cost-effectiveness analysis
  - model uncertainty (Monte Carlo)
- **RESULTS:**
  - **Progress (2005-2019):** A 36% reduction in premature deaths is significant, but the ZPAP target was not met.
  - **Current Policy (CLE2030):** Is not sufficient. It leaves 11 of 29 cities non-compliant with the ZPAP target.
  - **Optimal Policy (OPT2030):** Is necessary. It achieves a 71% average reduction and brings 26 of 29 cities into compliance.
  - **Targeted action** is key: This optimal policy must focus on two key sectors: residential wood burning (for Primary PM2.5) and agriculture (for Ammonia).

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www.nature.com/scientificreports

scientific reports

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Thank you for your attention!

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