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Institut Ochrony Środowiska  
Państwowy Instytut Badawczy

# Effects of the national BAU and MRF emission scenarios on air quality and health in major cities in Poland

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# Motivation

- WHO Guidelines (October 2021)
- Review of the Air Quality Directive (since 2022)

Summary of recommended AQG levels and interim targets

Pollutant	Averaging time	IT1	IT2	IT3	IT4	AQG level
PM <sub>2.5</sub> , µg/m <sup>3</sup>	Annual	35	25	15	10	5
PM <sub>2.5</sub> , µg/m <sup>3</sup>	24-hour <sup>a</sup>	75	50	37.5	25	15
PM <sub>10</sub> , µg/m <sup>3</sup>	Annual	70	50	30	20	15
PM <sub>10</sub> , µg/m <sup>3</sup>	24-hour <sup>a</sup>	150	100	75	50	45
O <sub>3</sub> , µg/m <sup>3</sup>	Peak season <sup>b</sup>	100	70	–	–	60
O <sub>3</sub> , µg/m <sup>3</sup>	8-hour <sup>a</sup>	160	120	–	–	100
NO <sub>2</sub> , µg/m <sup>3</sup>	Annual	40	30	20	–	10
NO <sub>2</sub> , µg/m <sup>3</sup>	24-hour <sup>a</sup>	120	50	–	–	25
SO <sub>2</sub> , µg/m <sup>3</sup>	24-hour <sup>a</sup>	125	50	–	–	40
CO, mg/m <sup>3</sup>	24-hour <sup>a</sup>	7	–	–	–	4

## Ministry of Climate and Environment:

“Analysis of the feasibility of meeting the air-quality standards recommended by WHO, not only in terms of technical–technological, financial and social capabilities [...] assessment of health costs [and] analysis and indication of pollutant levels that would be achievable under national conditions.”



# ReduCost: aim and scope

## Main objective:

Analysis of the potential for reducing emissions of atmospheric pollutants and the costs of reduction measures, taking into account technical–technological, financial, and social aspects.

## Scope:

- Pollutants: NO<sub>2</sub>, NO<sub>x</sub>, SO<sub>2</sub>, PM10 and PM2.5, B(a)P
- Emission sectors: residential/municipal [1], transport [2], agriculture, power generation (based on [1] and [2])
- Selection of key sectors agreed with the Ministry of Climate and Environment, considering emission shares and potential for change
- Base year 2022



# ReduCost: scenarios

Expert assessment on the possibilities for reducing pollutant emissions in the including a proposal of actions in individual sectors, taking into account the current situation as well as technical and non-technical options for reduction

- **BAU Scenario – Business as Usual**
- **MFR Scenario – Maximum Feasible Reduction**

The proposed BAU and MFR scenarios represent illustrative sets of potential reduction measures based on the scientific expertise of the specialists invited to participate in the project.



# Central Emission Database

- **Central Emission Database (CED)** was used to calculate scenarios
- The CBE has been developed at KOBiZE (IOŚ-PIB) **since 2018** for the purpose of centralized air-quality modelling at the national scale
- The main advantages of the CBE are **methodological and computational consistency** across the entire country, as well as **high spatial resolution**
- The CBE is used, among other things, for the Annual AQ, the National Air Pollution Control Programme and broadly support for the Ministry of Climate and Environment.

Residential

Agriculture

Road transport

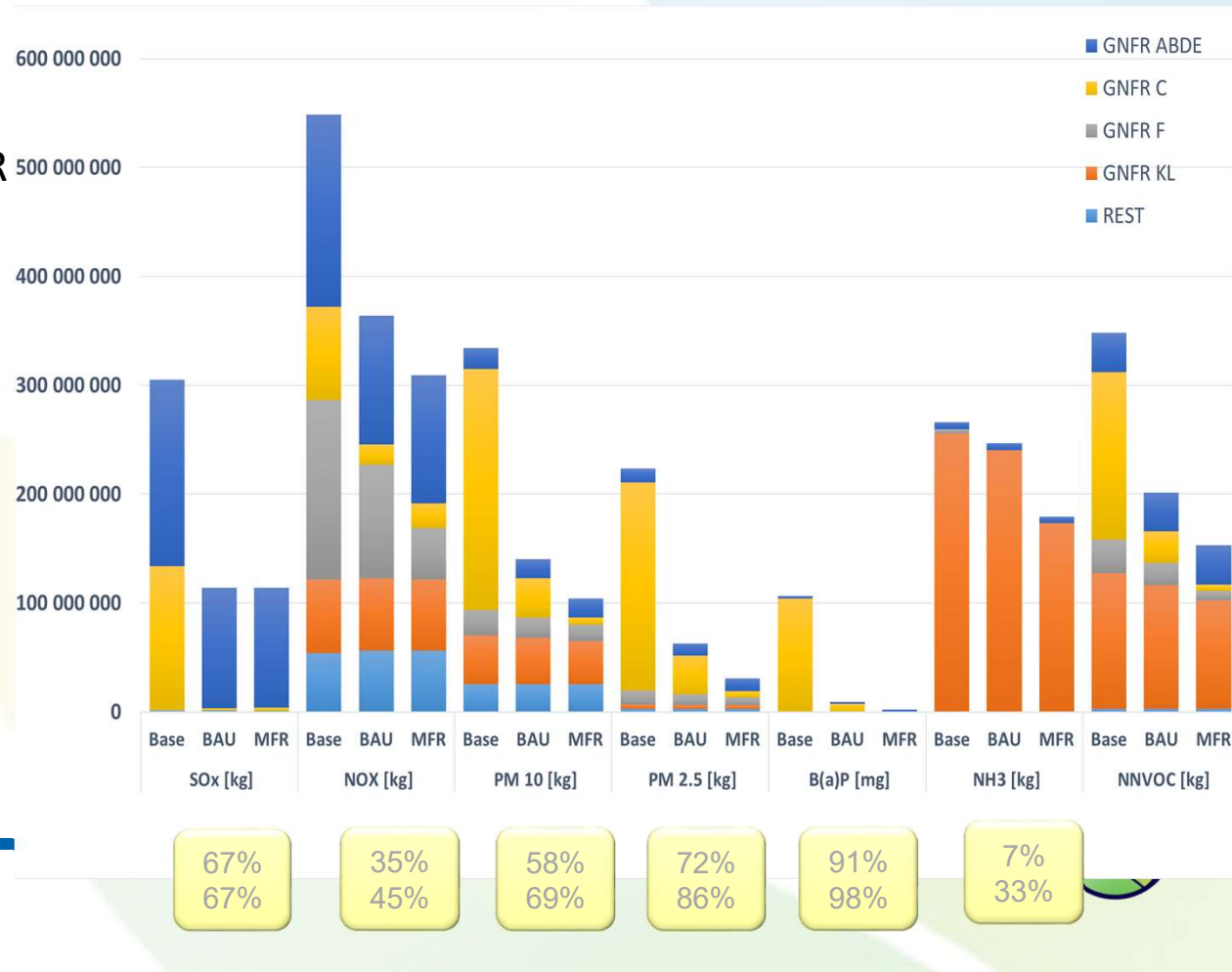
# Development

- Implementation of data from the Central Register of Building Emissions (CEEB) into the CBE – identification of uniform heat sources for over **3 million buildings**.
- An **IT tool** for aggregating household-level indicators
- New spatial distributions for **crops**
- Development of the **emission-estimation methodology** to include individual indicators for livestock production.
- Calculating scenarios involving the development or **modification of infrastructure** (new roads, airports).



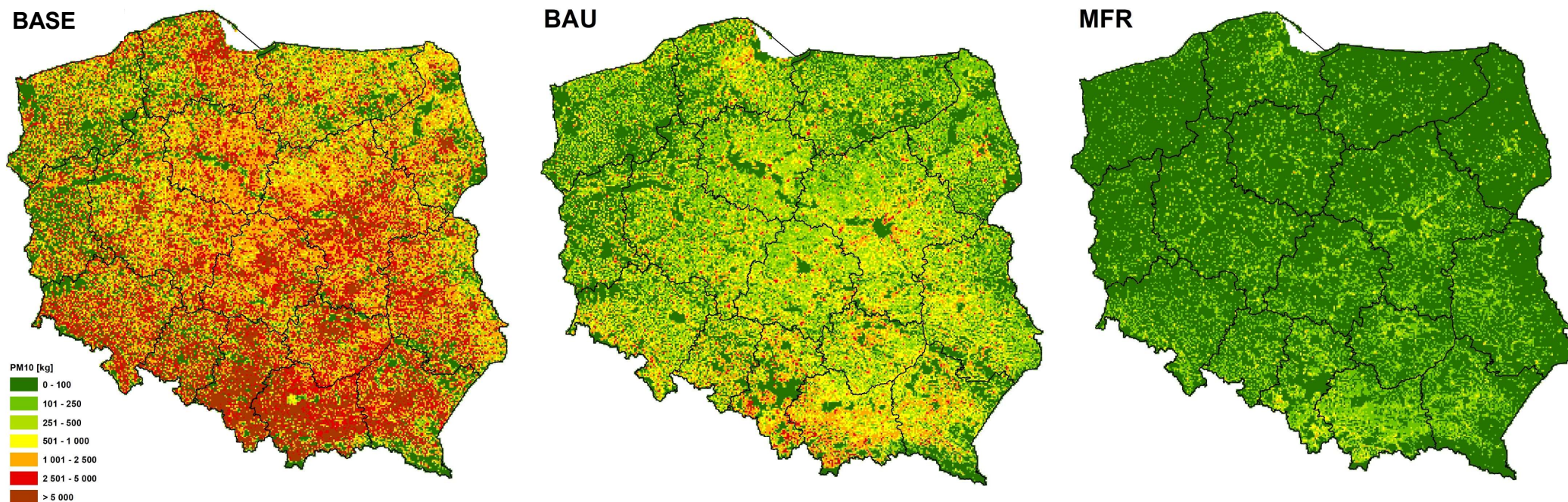
# Emission Scenario Results

- Significant reduction of PM10 and PM2.5 emissions in the BAU and MFR scenarios, particularly in the residential sector.
- B(a)P emissions reduced almost to zero in the residential sector.
- A clear decrease in NOx emissions from road transport.
- SOx emissions significantly reduced in the residential sector and moderately in the energy sector.
- Reduction of NH<sub>3</sub> emissions in agriculture in the MFR scenario.



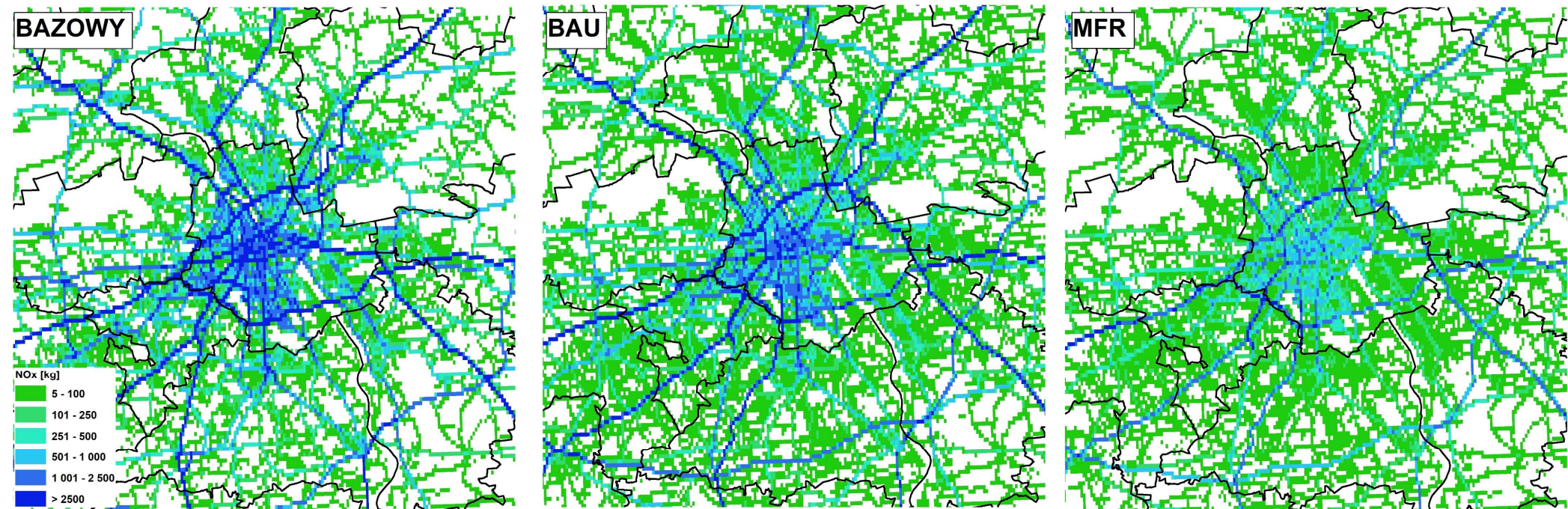
# Emission Scenario Results – residential sector

- High reduction of particulate emissions in cities already under BAU
- Elimination of particulate emissions across the whole of Poland under MFR



# Emission Scenario Results – road transport

- Inclusion of the road network for 2040 (CUPT data), vehicle fleet projections for 2040
- Significant reduction of NO<sub>x</sub> emissions in cities and main roads under BAU



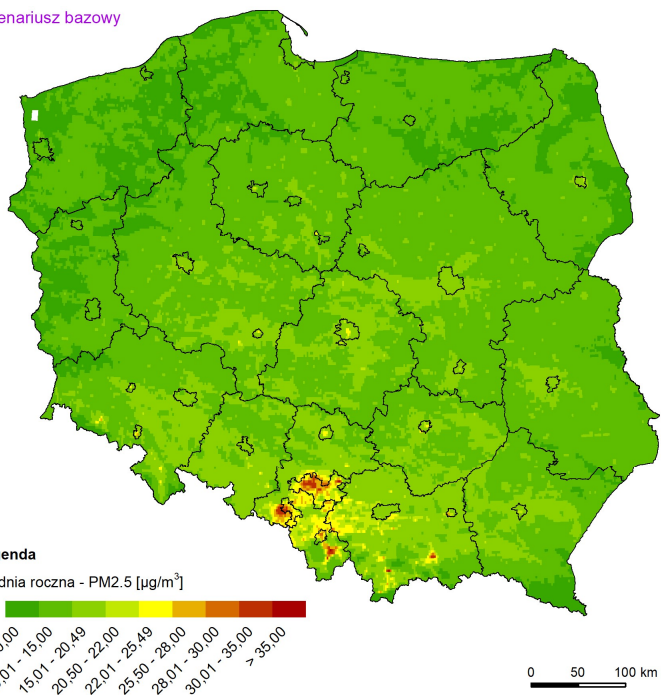
# ReduCost: results

- Analysis of the feasibility of achieving the thresholds proposed by the AAQD as a result of reducing emissions of the pollutants
- Analysis of the health, social, and economic impacts of reducing the pollutants under consideration
- Economic analysis:
  - costs of implementing reduction measures in individual sectors
  - external costs, including health-related costs, resulting from undertaking reduction measures

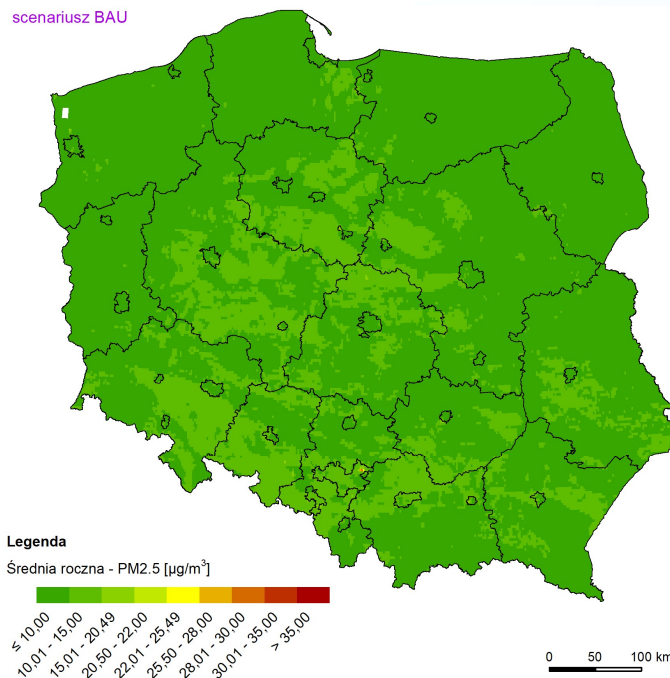


# PM2.5

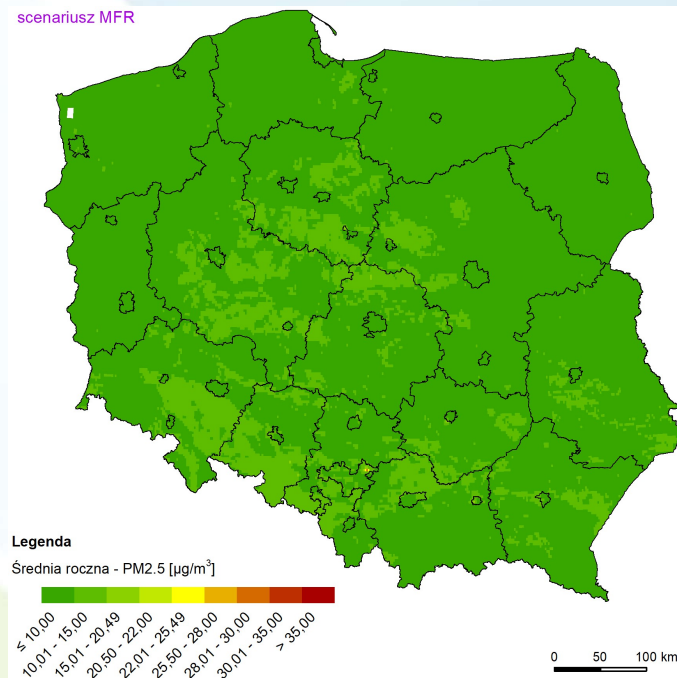
scenariusz bazowy



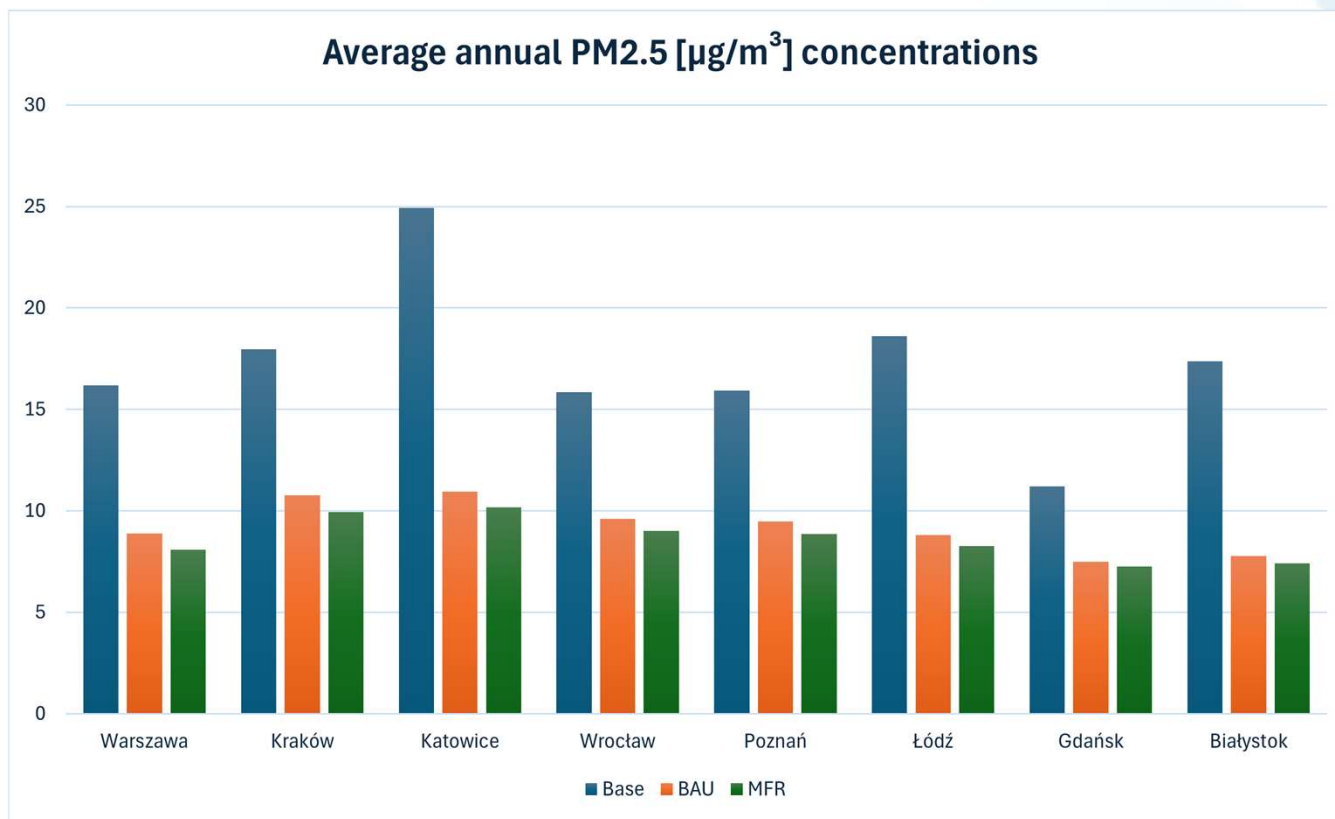
scenariusz BAU



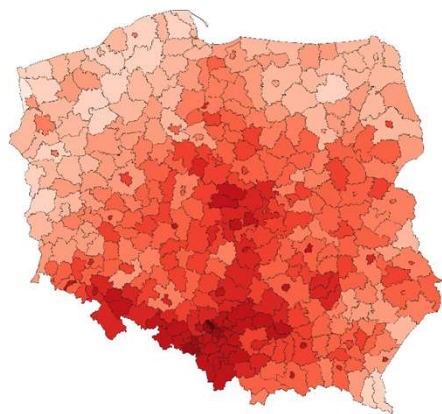
scenariusz MFR



# PM2.5 concentrations reduction in cities

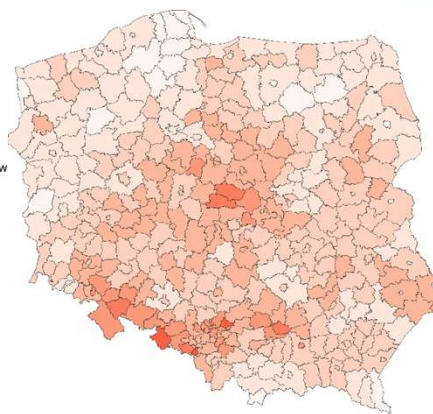


# PM2.5 health exposure



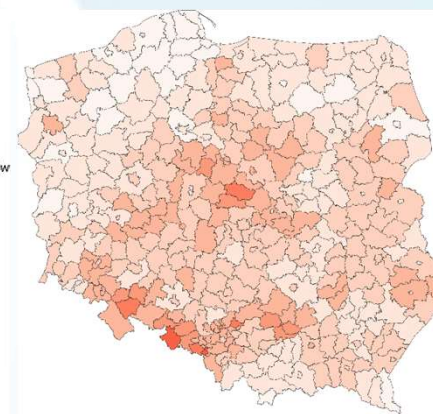
Pył PM2.5  
Liczba przedwczesnych zgonów  
w przeliczeniu na 100tys. mieszkańców  
Scenariusz 2022

- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 100
- 100 - 120
- 120 - 140
- 140 - 160
- 160 - 180
- 180 - 200
- 200 - 300
- 300 - 400
- 400 - 470



Pył PM2.5  
Liczba przedwczesnych zgonów  
w przeliczeniu na 100tys. mieszkańców  
Scenariusz BAU

- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 100
- 100 - 120
- 120 - 140
- 140 - 160



Pył PM2.5  
Liczba przedwczesnych zgonów  
w przeliczeniu na 100tys. mieszkańców  
Scenariusz MFR

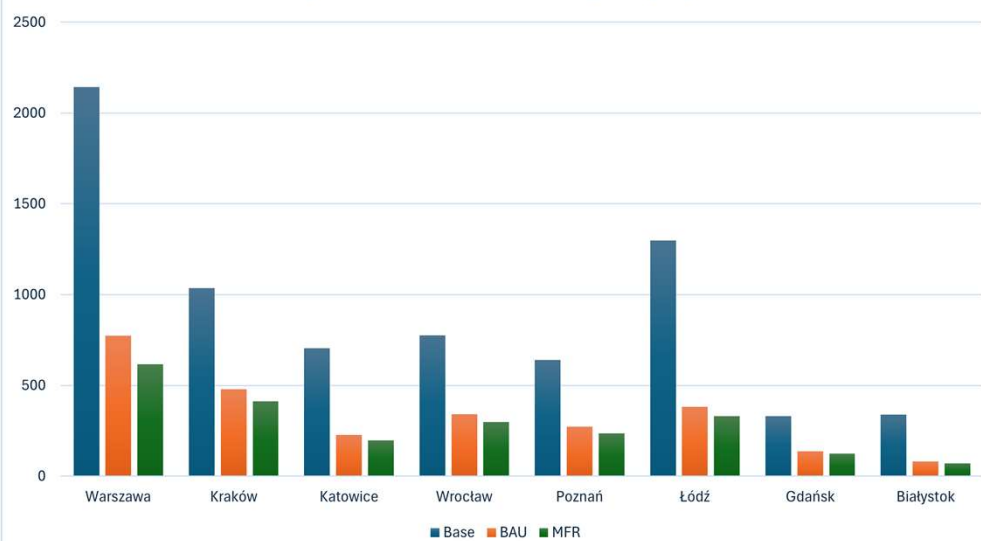
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 100
- 100 - 120
- 120 - 140
- 140 - 160

Scenario	Number of premature deaths (30+)	Percent of premature deaths (30+)	Number of premature deaths (30+) per 100 tys. inhabitants
Base (2022)	43 321	10,9	166
BAU	18 451	4,6	71
MFR	16 809	4,2	64

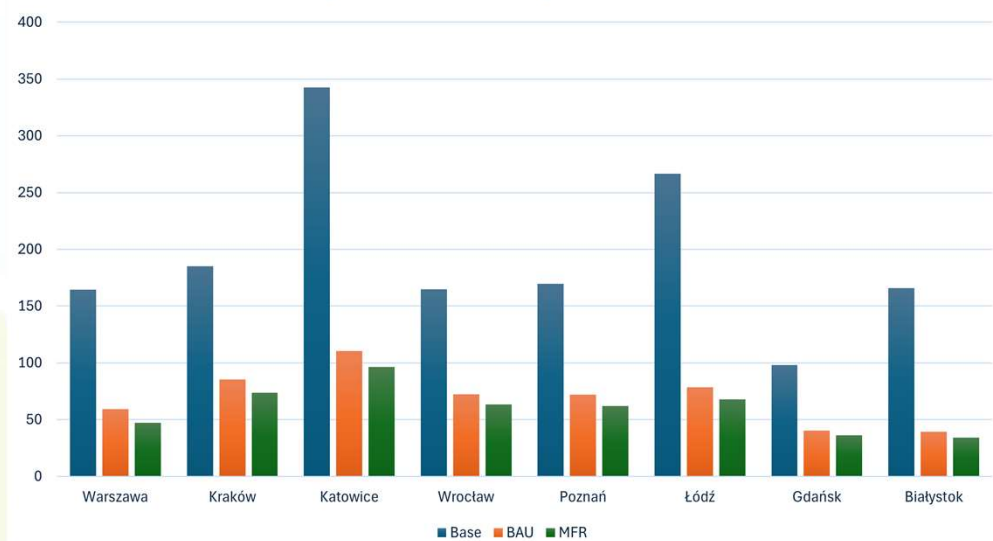


# PM2.5 premature deaths

Number of premature deaths among the population 30+

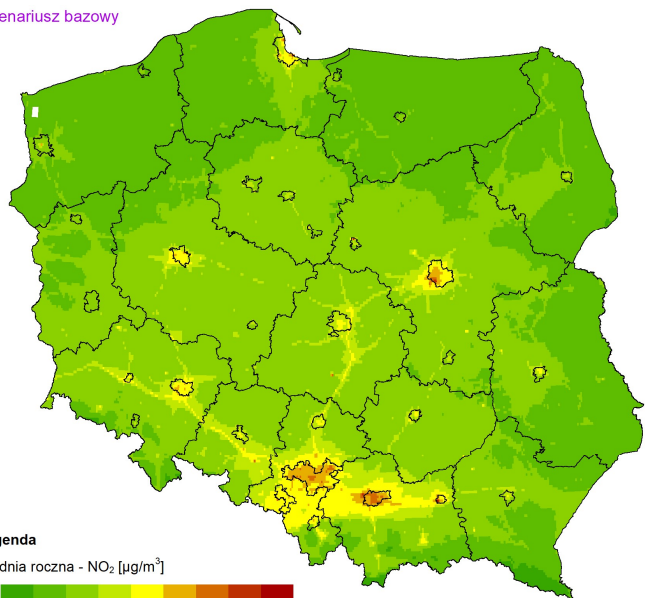


Number of premature deaths per 100,000 inhabitants



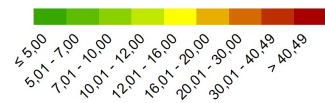
# NO<sub>2</sub>

scenariusz bazowy



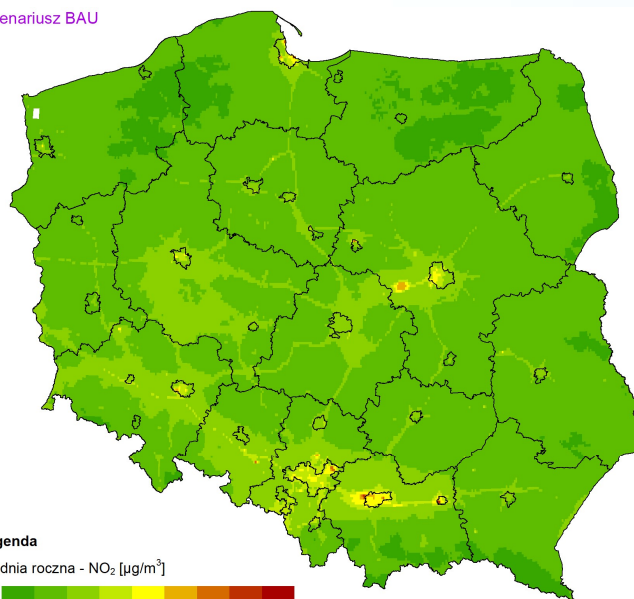
Legenda

Średnia roczna - NO<sub>2</sub> [µg/m<sup>3</sup>]



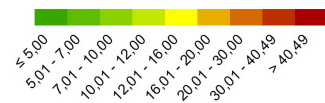
0 50 100 km

scenariusz BAU



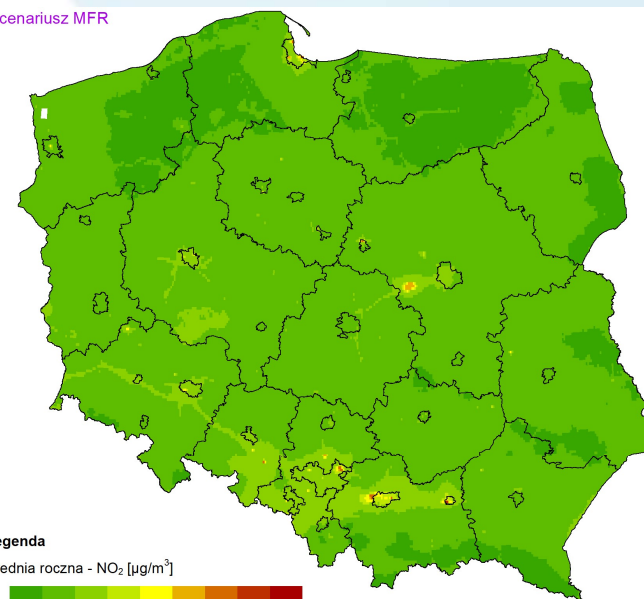
Legenda

Średnia roczna - NO<sub>2</sub> [µg/m<sup>3</sup>]



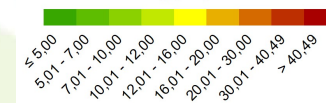
0 50 100 km

scenariusz MFR



Legenda

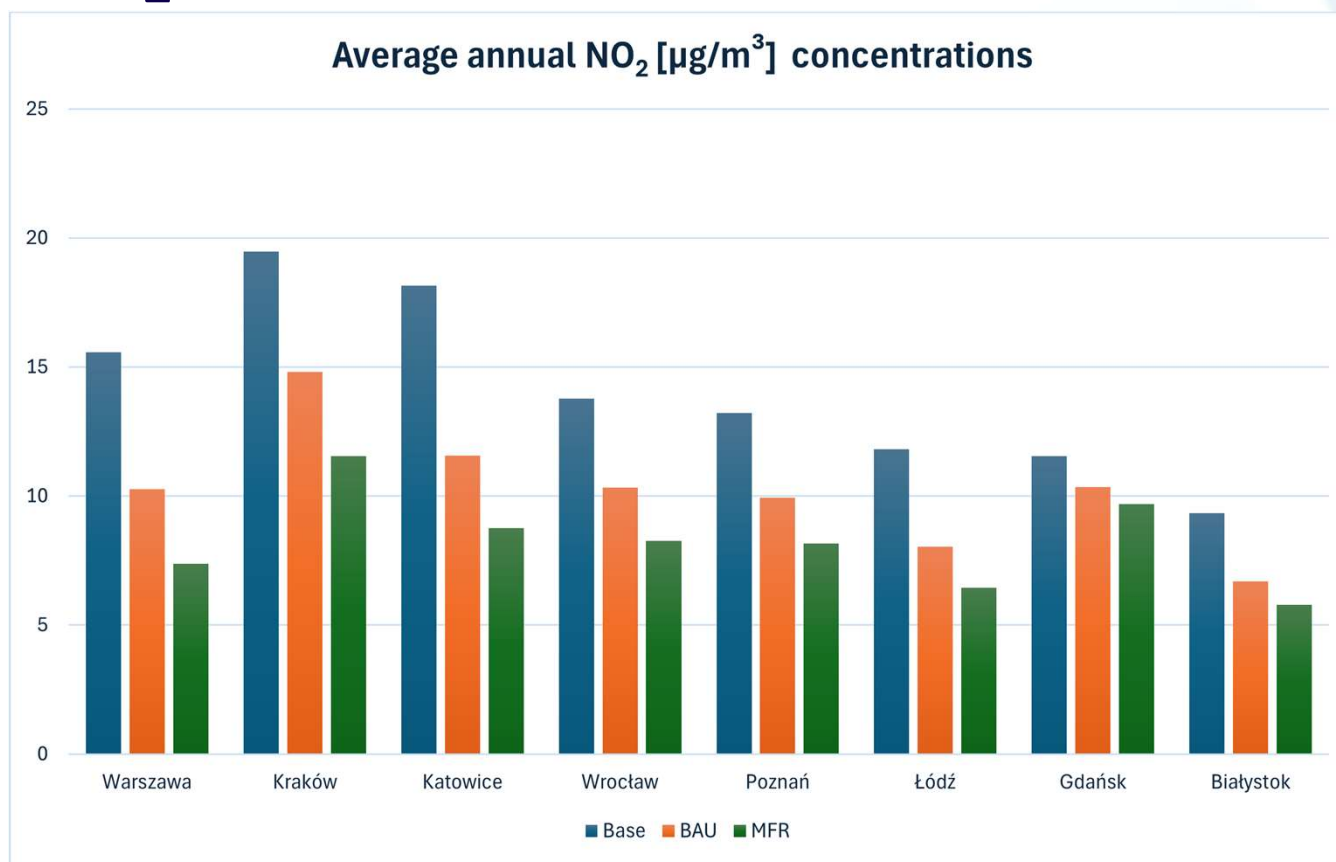
Średnia roczna - NO<sub>2</sub> [µg/m<sup>3</sup>]



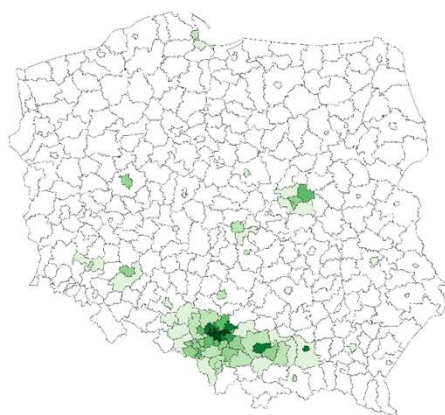
0 50 100 km



# NO<sub>2</sub> concentrations reduction in cities



# NO<sub>2</sub> health exposure



NO<sub>2</sub>  
Liczba przedwczesnych zgonów  
w przeliczeniu na 100tys. mieszkańców

Scenariusz 2022

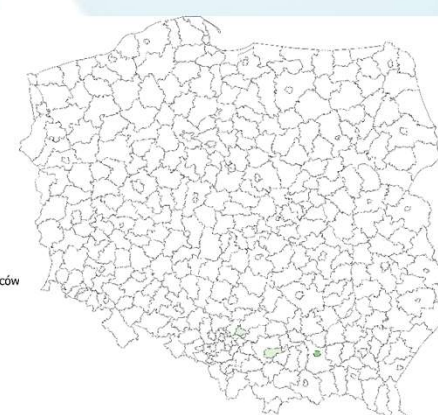
- 0
- 0,1 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 71,5



NO<sub>2</sub>  
Liczba przedwczesnych zgonów  
w przeliczeniu na 100tys. mieszkańców

Scenariusz BAU

- 0 - 0,1
- 0,1 - 10
- 10 - 20
- 20 - 30
- 30 - 40



NO<sub>2</sub>  
Liczba przedwczesnych zgonów  
w przeliczeniu na 100tys. mieszkańców

Scenariusz MFR

- 0
- 0,1 - 10
- 10 - 20
- 20 - 30
- 30 - 40

Scenario	Number of premature deaths (30+)	Percent of premature deaths (30+)	Number of premature deaths (30+) per 100 tys. inhabitants
Base (2022)	2326	0	8,9
BAU	353	0	1,4
MFR	82	0	0,3

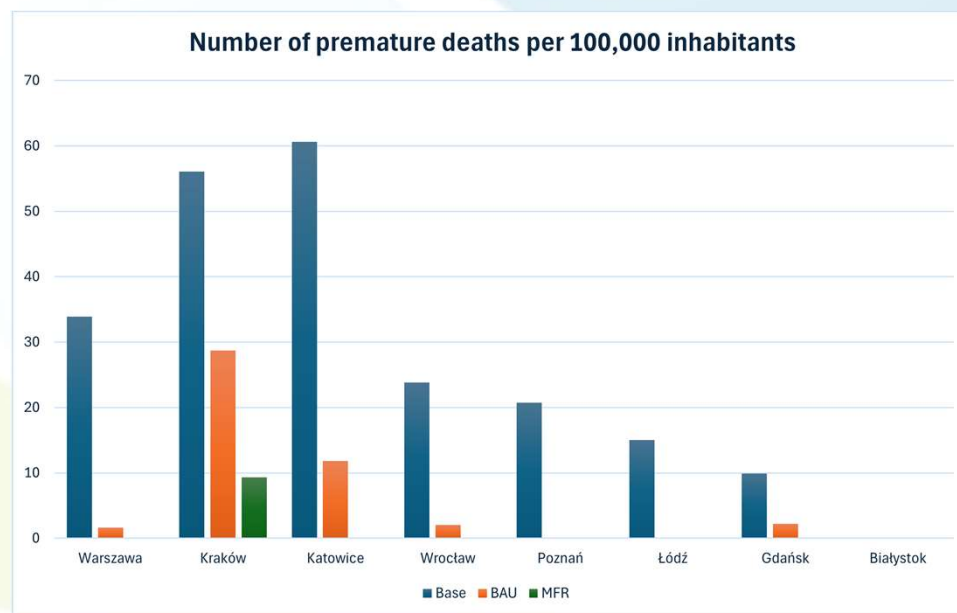
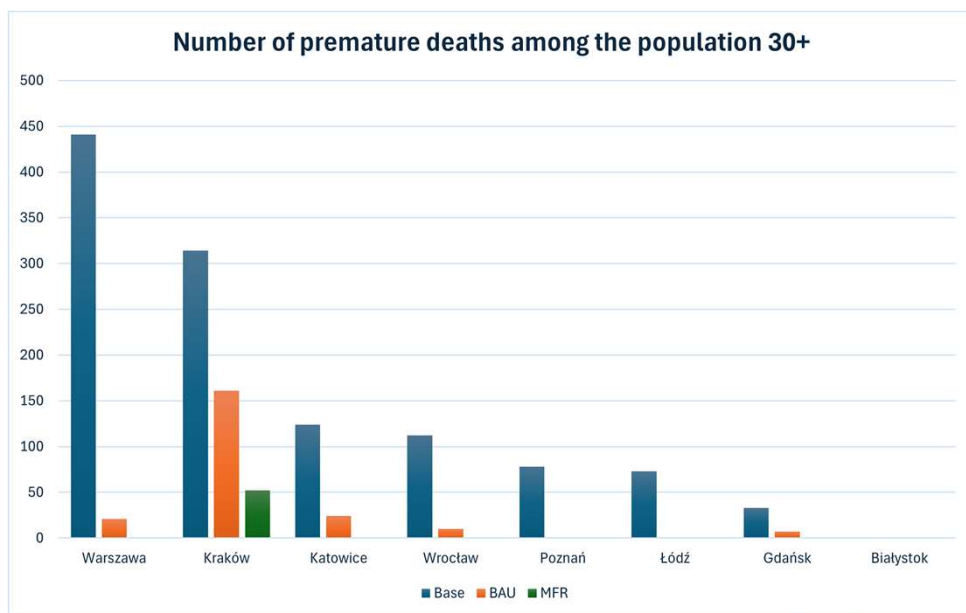
67 admin units

23 admin units

3 admin units

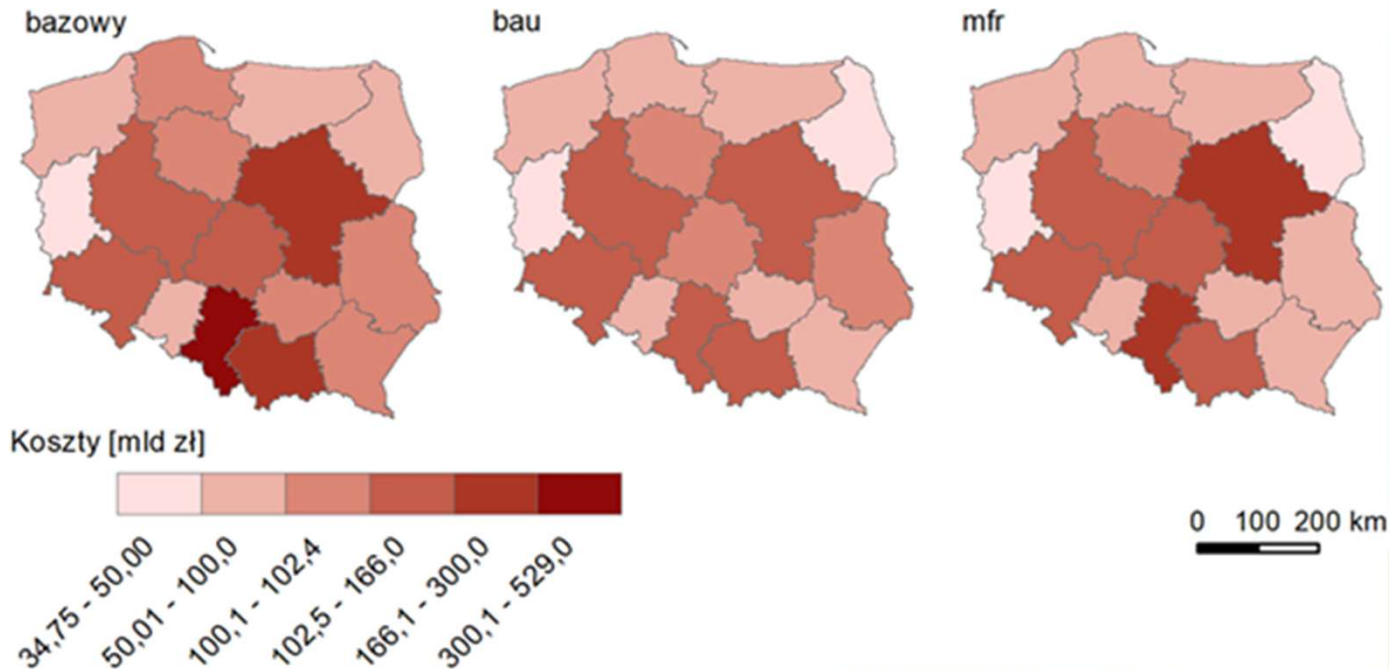


# NO2 premature deaths



# Cost analysis

## PM2.5 - koszty zewnętrzne



The health-related external costs show a similar pattern across provinces and in terms of the direction of change in these costs. This confirms the consistency of the analyses.

- PM2.5 particles generate significant external costs.
- A reduction in health-related external costs is observed in both scenarios compared with the baseline scenario, with greater savings in the MFR scenario.



# Summary

- BAU and MFR scenarios show technically feasible and significant pollution reduction potential in Poland
- The project delivered the first comprehensive national cost–benefit analysis of reduction measures
- Significant regional differences
- Possible significant decrease of the estimated number of avoidable premature deaths in cities is a result of the national-wide actions
- Results were communicated to Marshall Offices responsible for implementation of Road Maps and Air Quality Plans





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**Thank you for your attention**

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