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Scenarios for the revision of the Gothenburg Protocol

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EMEP Centre for Integrated Assessment Modelling (CIAM)

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Revision of the Gothenburg Protocol

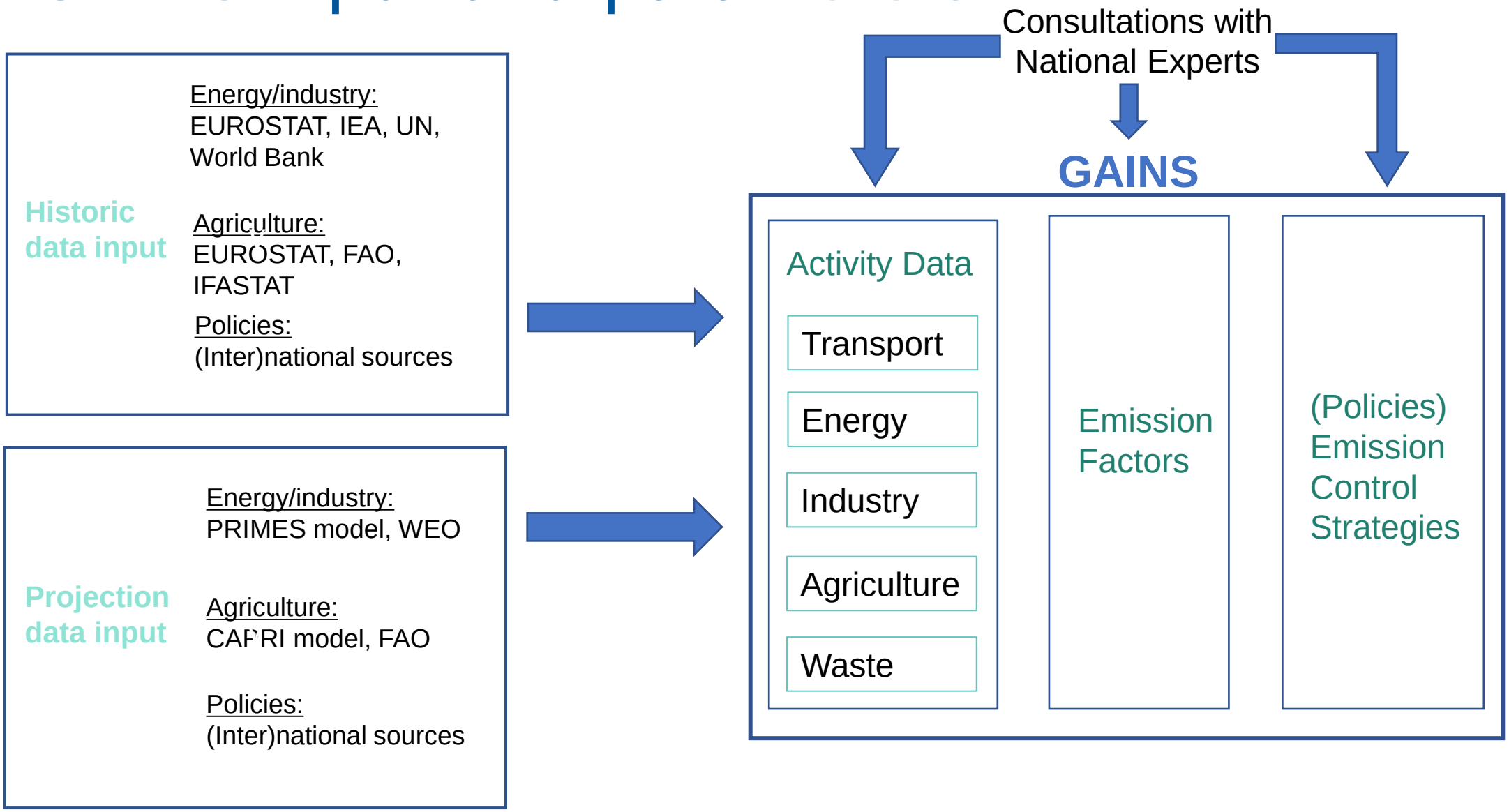
- National emission ceilings for NO_X, SO_2, NH_3, VOCs and $PM_{2.5}$ limiting health and ecosystem impacts
- Revision decided in 2023: process scheduled for 2024-2026
- Currently analysed targets focus on reducing impacts by 50% by 2040, compared to 2015
- Feasibility of achieving such targets across the region for premature mortality (including PM and ozone) and risk of biodiversity being analysed
- *Eventual targets will be defined/decided by policymakers during the revision process*

IIASA's role

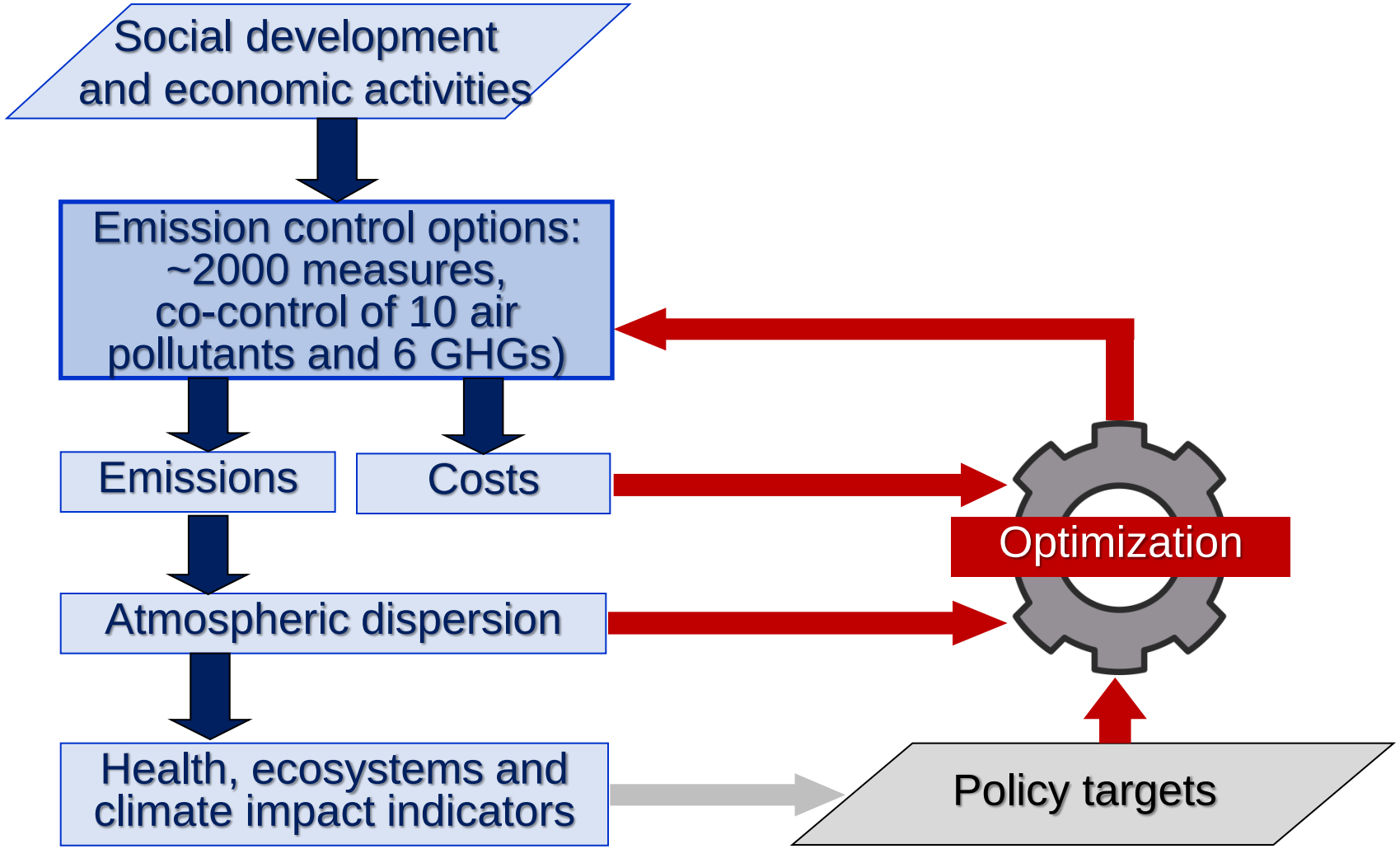
- Center for Integrated Assessment Modelling (CIAM)
  - Providing technical background material for the annual meetings of the Task Force on Integrated Assessment Modelling (TFIAM) on cost-effective emission control strategies

- Using the GAINS model to develop and assess different scenarios to support the revision of the Gothenburg Protocol

GAINS input and parameters



GAINS Optimization



Key scenarios for UNECE GP revision [a)]

- *Baseline* 'CLE'
  - Implementation of current policies
  - Energy and agriculture for the **EU27** – Green Deal, including Fit for 55 package, RePowerEU initiatives, revision of the IED, results of the MS consultations during fourth Clean Air Outlook [b)]
  - **West Balkan** – PRIMES and CAPRI model activity scenarios, results of consultations during EU4Green project
  - **Rep of Moldova, Georgia, and Ukraine** - PRIMES and CAPRI model activity scenarios, consultations with Moldova and Georgia
  - **Turkey, remaining EECCA, US, Canada, and rest of the world** - activity projections derived from IEA World Energy Outlook (IEA, 2023) and FAO agricultural outlook (FAO, 2018)

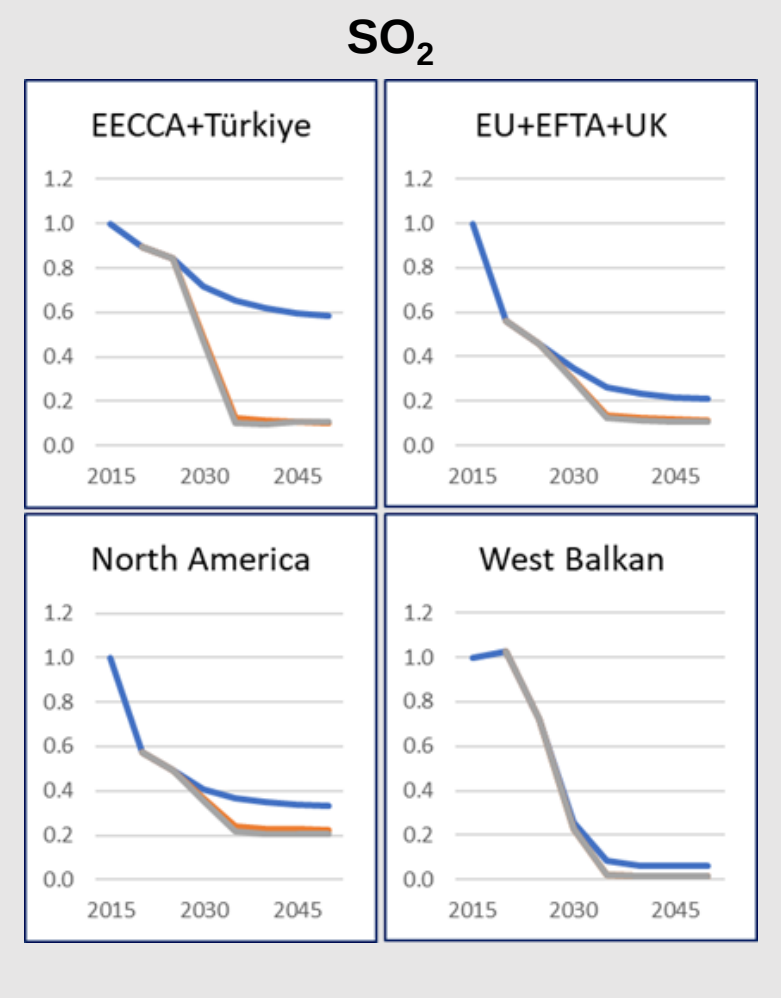
[a)] – Further details available in the *Policy Brief*
[b)] – https://environment.ec.europa.eu/topics/air/clean-air-outlook_en

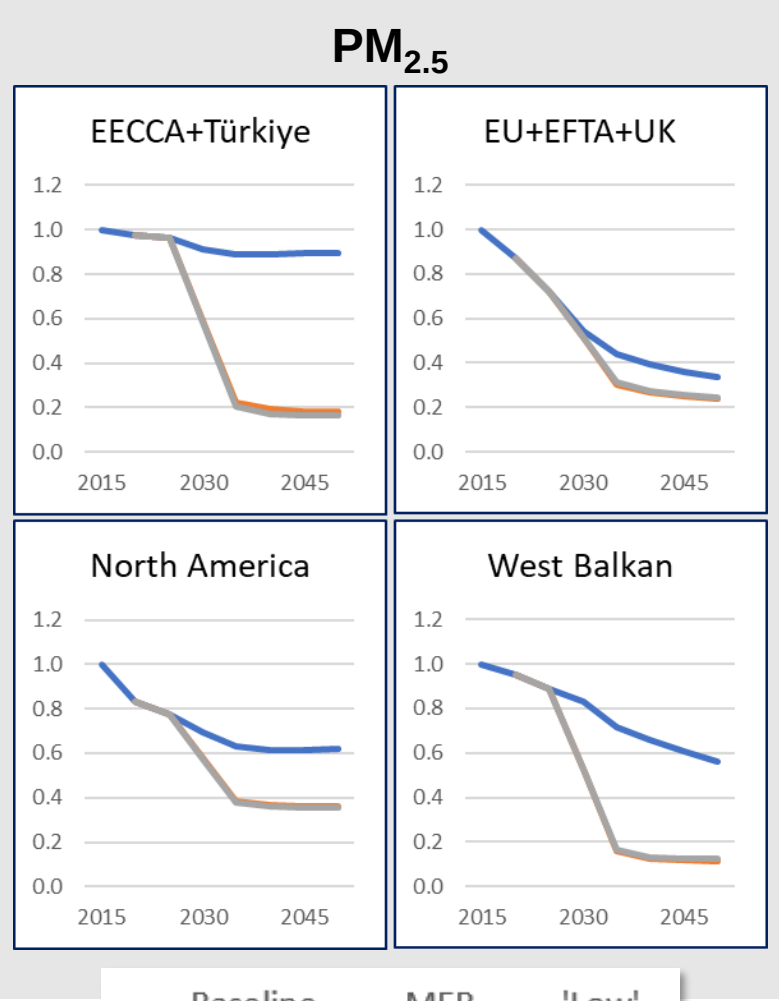
Key scenarios for UNECE GP revision [a)]

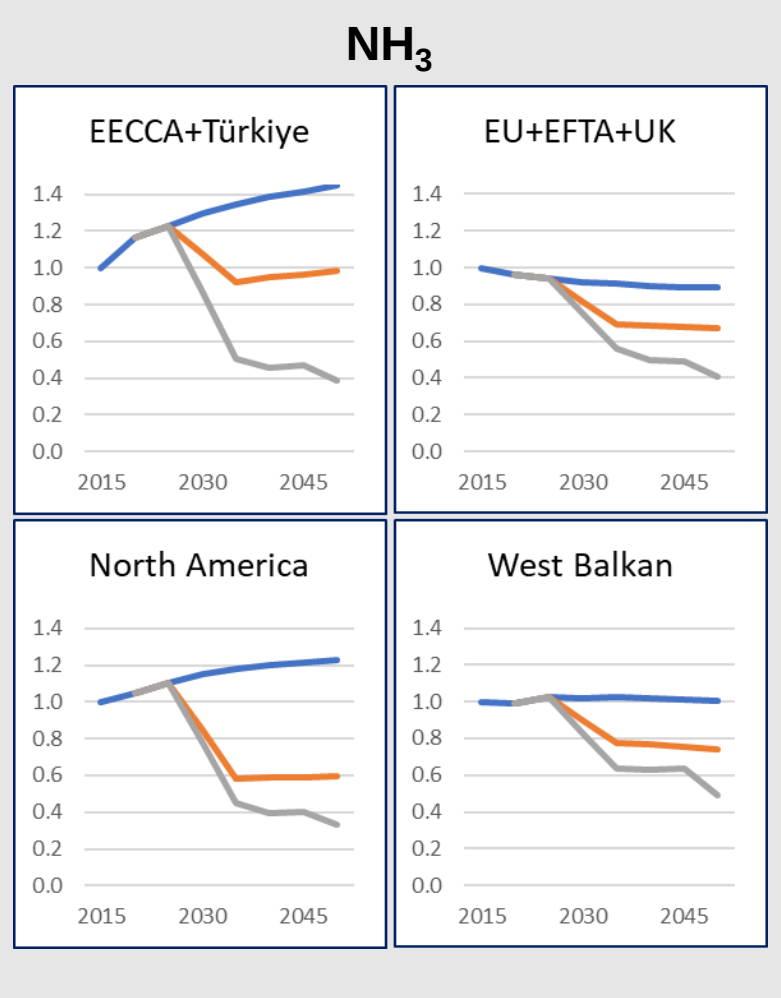
- Maximum Technically Feasible Reduction '*MTFR*'
- Cost-optimal scenarios (work in progress)
  - achieving -50% targets for mortality with different target setting options
    - Domain wide target vs gap closure
    - dynamic vs static population
  - Recent work: joint optimization for health and biodiversity risks (CLempN)
- Alternative '*LOW*' scenario – to be adjusted
  - Climate policies compatible with Paris goals;
  - *MTFR* for air pollutants and methane, including shipping sources
  - Behavioural change - dietary changes (lower meat protein consumption)

[a)] – Further details available in the *Policy Brief*

Key PM precursor emission trends across the UNECE region



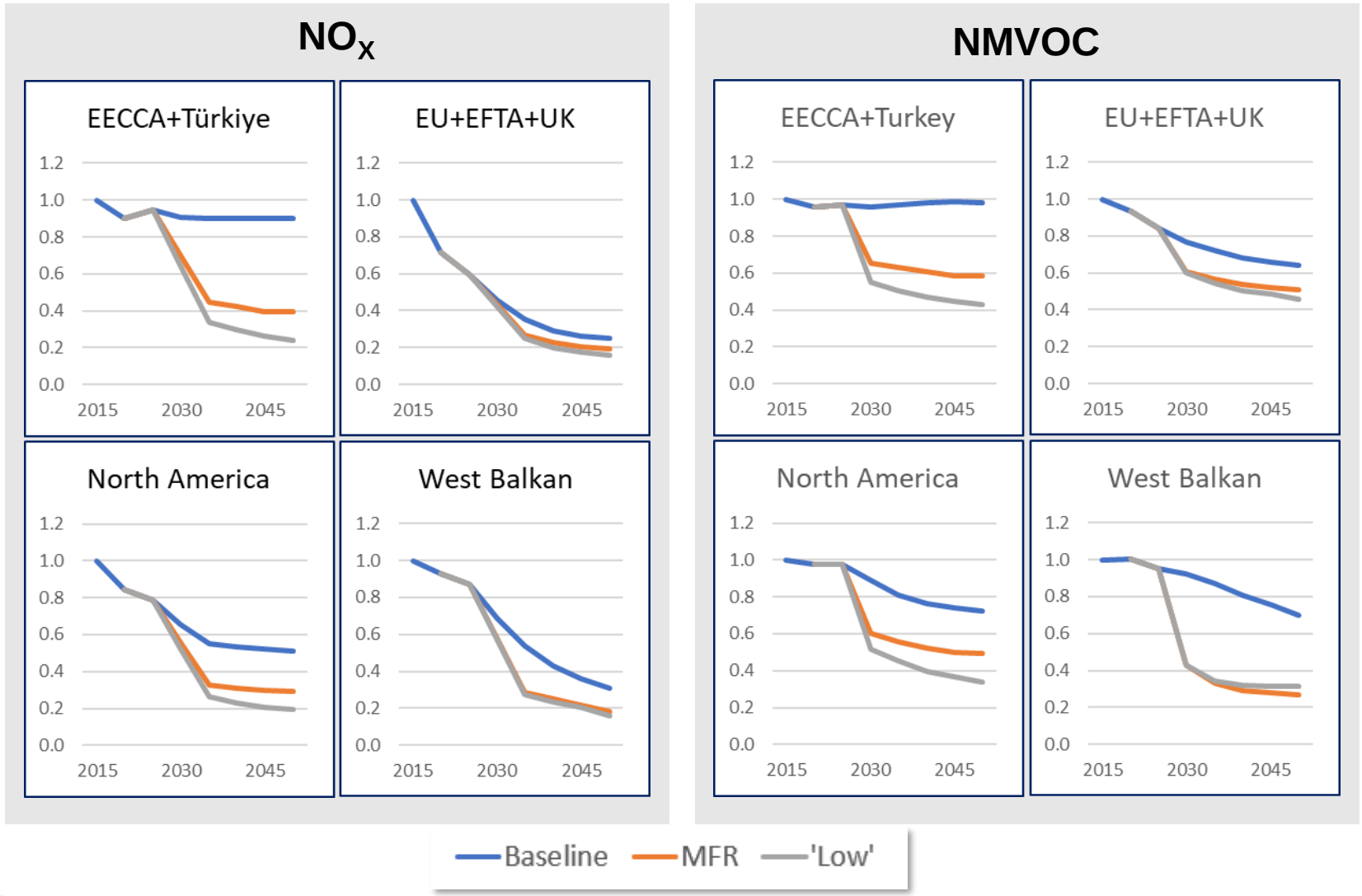




LOW scenario is not entirely consistent for energy sources; work in progress

Source: IIASA-GAINS model

Non-methane ozone precursor emission trends across the UNECE region



LOW scenario is not entirely consistent for energy sources; work in progress

Source: IIASA-GAINS model

Testing targets for reduced mortality and ecosystems protection

Target setting

Health:

Tested target: Domain wide -50% of premature deaths by 2040 compared to 2015

- Premature deaths per 100 000 inhabitants
- Including dynamic population development and aging

Ecosystems protection:

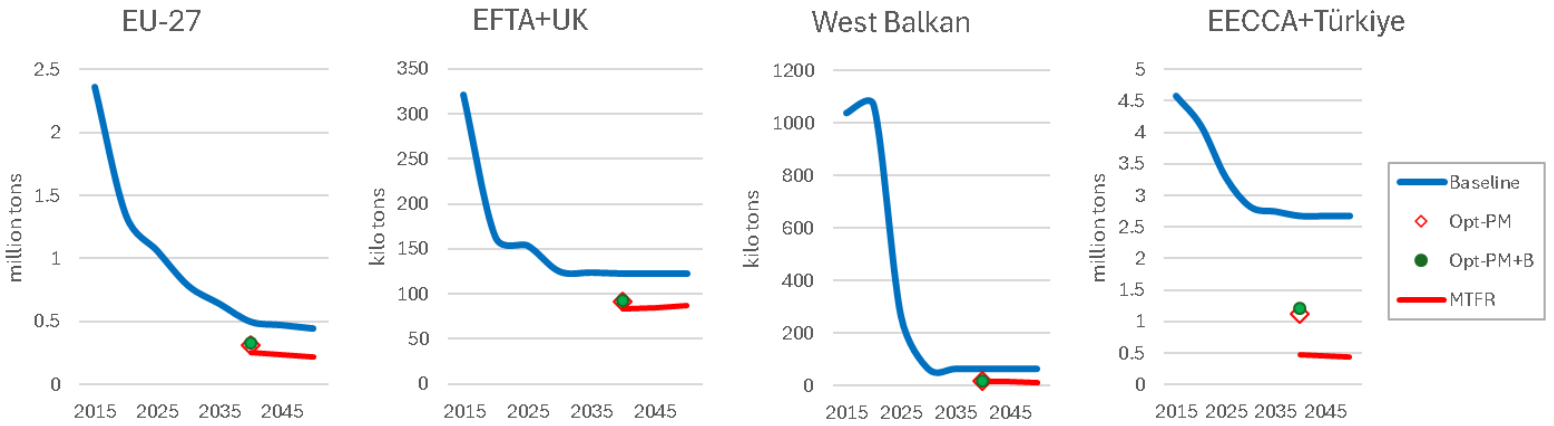
Tested target: Domain wide -40% of average accumulated exceedance per ecosystem type by 2040 compared to 2015

- Empirical critical loads for 48 ecosystem classes in **Europe** from background database and country focal points
- Calculated indicators: area exceeding CL - average accumulated exceedance (AAE)
- Only land-based ecosystems are considered, not marine

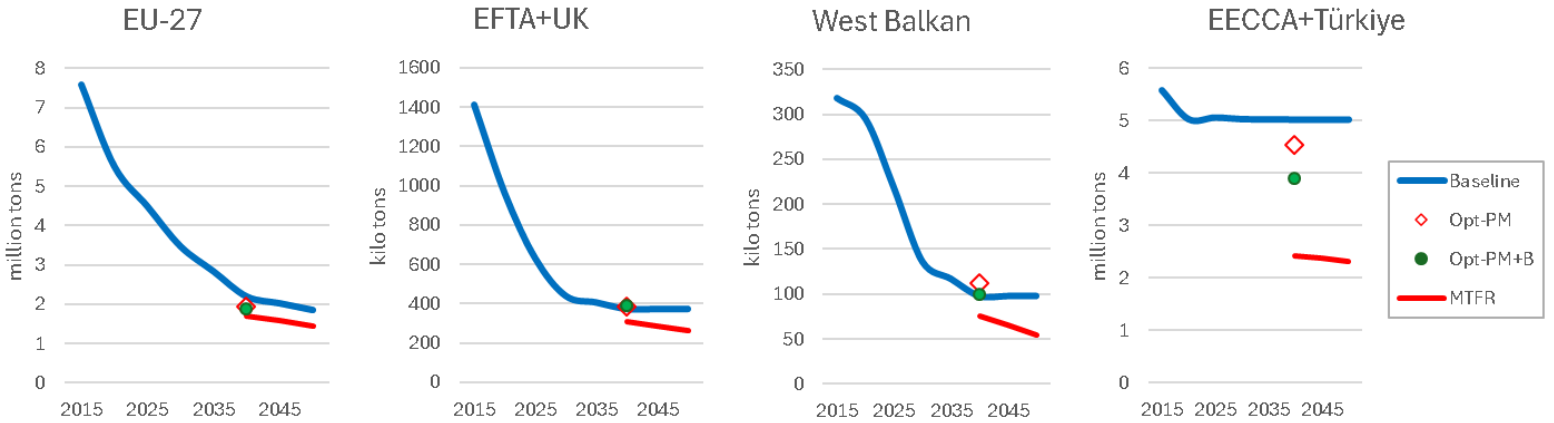
Emission trends and targets per region and pollutant

Opt-PM - 50% reduction of premature mortality (PM) for UNECE, dynamic population,
Opt-PM+B refers to PM and biodiversity (B) targets,

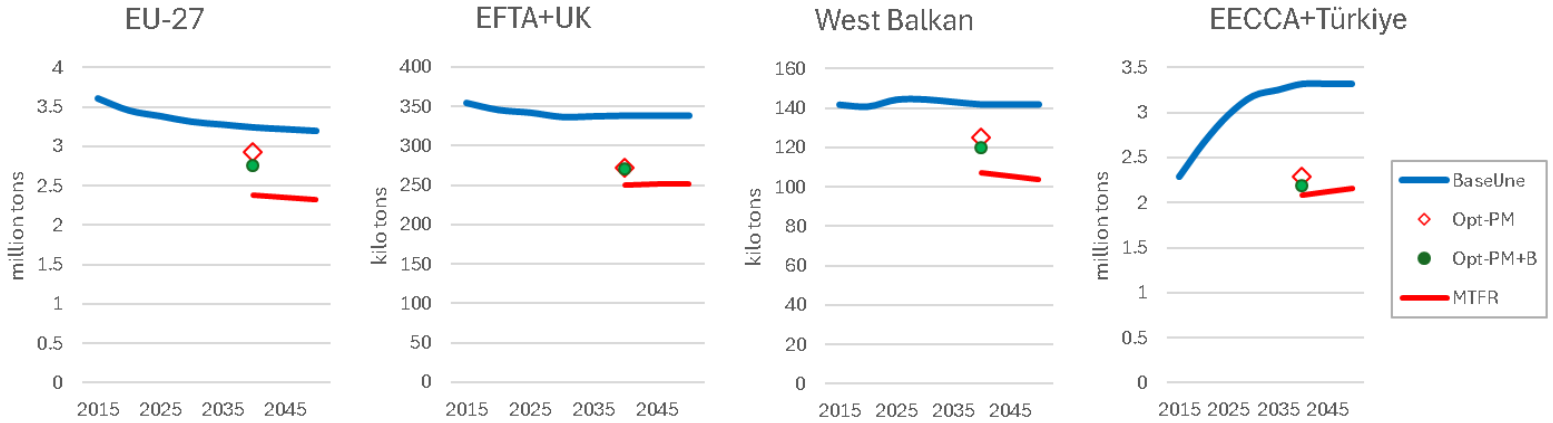
SO_2


EU-27
million tons
2.5
2
1.5
1
0.5
0
2015 2025 2035 2045
EFTA+UK
kilo tons
350
300
250
200
150
100
50
0
2015 2025 2035 2045
West Balkan
kilo tons
1200
1000
800
600
400
200
0
2015 2025 2035 2045
EECCA+Türkiye
million tons
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2015 2025 2035 2045
Baseline
Opt-PM
Opt-PM+B
MTFR

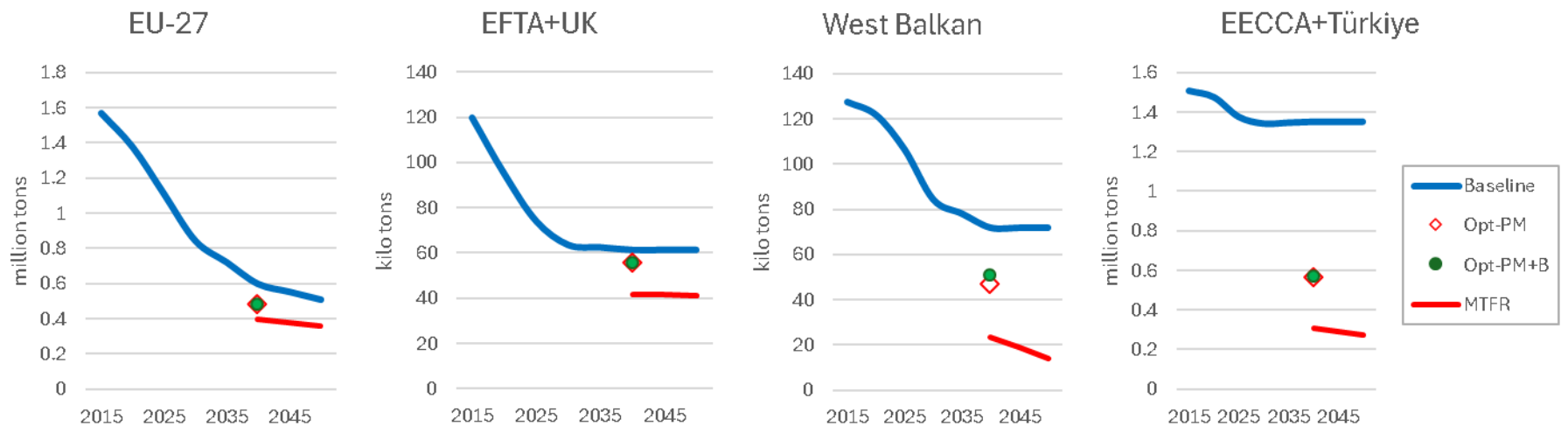
NO_X


EU-27
million tons
8
7
6
5
4
3
2
1
0
2015 2025 2035 2045
EFTA+UK
kilo tons
1600
1400
1200
1000
800
600
400
200
0
2015 2025 2035 2045
West Balkan
kilo tons
350
300
250
200
150
100
50
0
2015 2025 2035 2045
EECCA+Türkiye
million tons
6
5
4
3
2
1
0
2015 2025 2035 2045
Baseline
Opt-PM
Opt-PM+B
MTFR

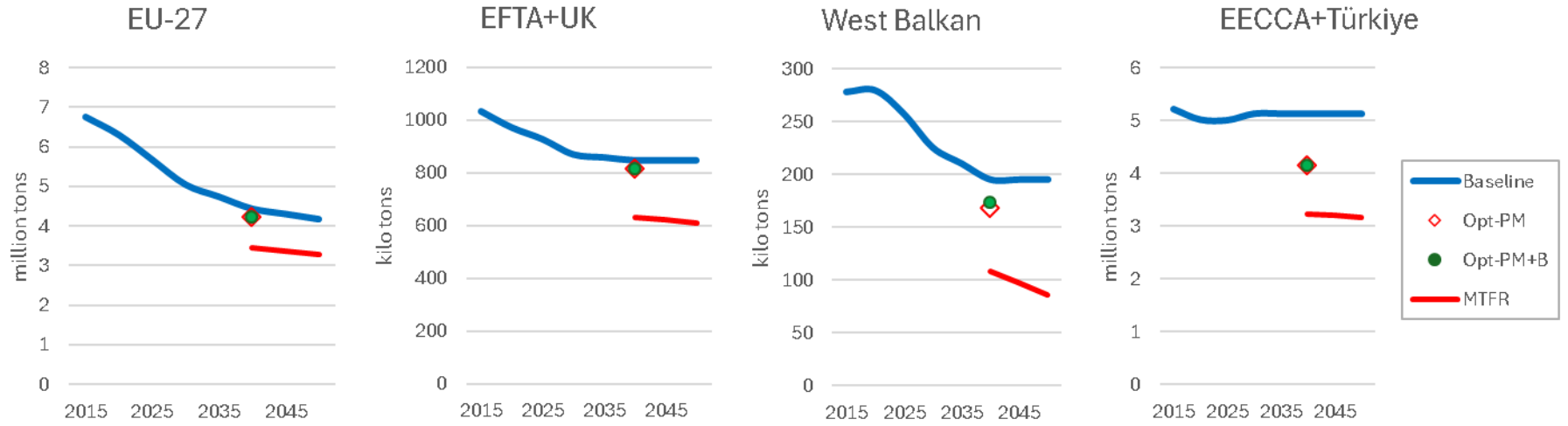
NH_3


EU-27
million tons
4
3.5
3
2.5
2
1.5
1
0.5
0
2015 2025 2035 2045
EFTA+UK
kilo tons
400
350
300
250
200
150
100
50
0
2015 2025 2035 2045
West Balkan
kilo tons
160
140
120
100
80
60
40
20
0
2015 2025 2035 2045
EECCA+Türkiye
million tons
3.5
3
2.5
2
1.5
1
0.5
0
2015 2025 2035 2045
BaseUne
Opt-PM
Opt-PM+B
MTFR

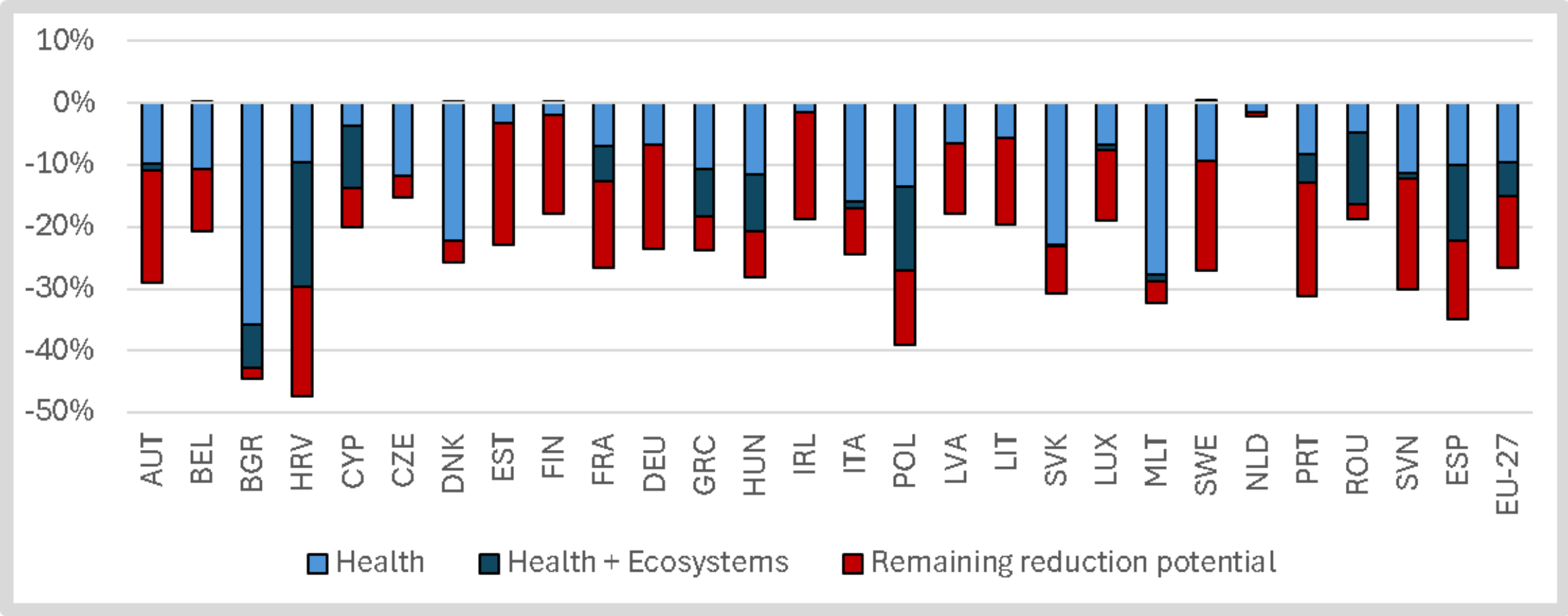
$PM_{2.5}$


EU-27
million tons
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2015 2025 2035 2045
EFTA+UK
kilo tons
140
120
100
80
60
40
20
0
2015 2025 2035 2045
West Balkan
kilo tons
140
120
100
80
60
40
20
0
2015 2025 2035 2045
EECCA+Türkiye
million tons
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2015 2025 2035 2045
Baseline
Opt-PM
Opt-PM+B
MTFR

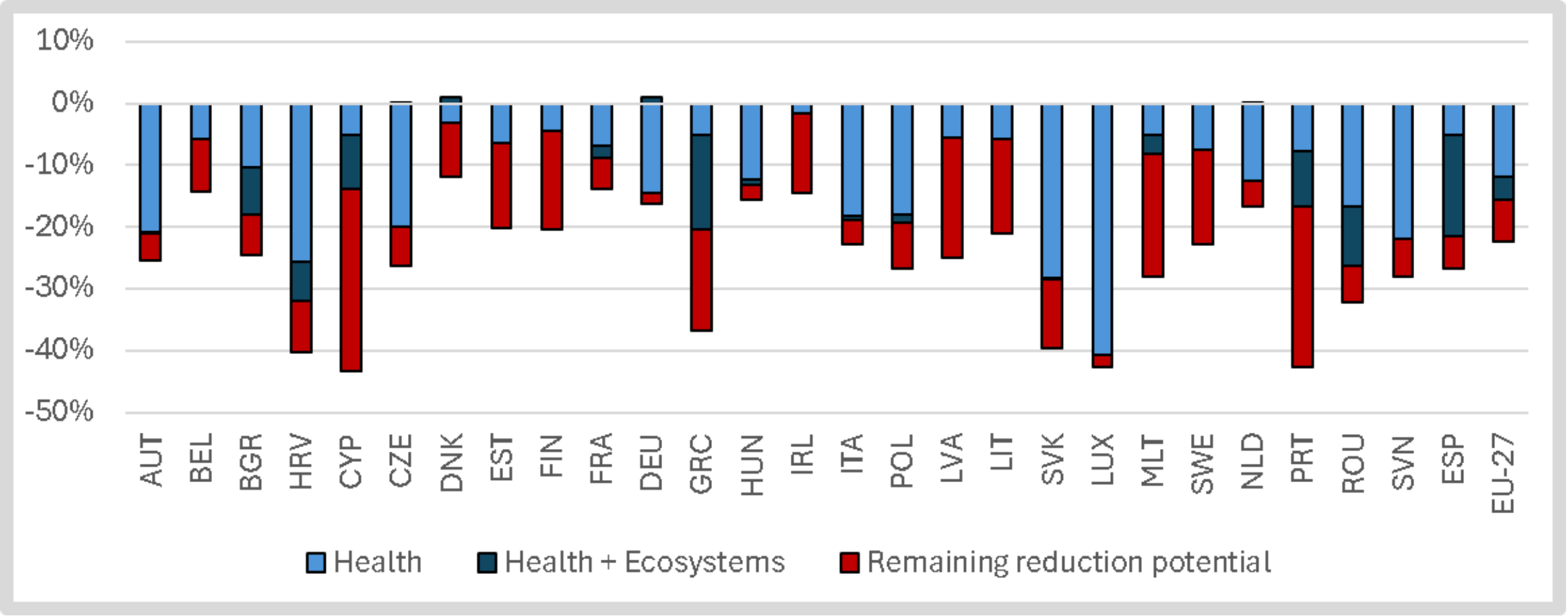
NMVOC


EU-27
million tons
8
7
6
5
4
3
2
1
0
2015 2025 2035 2045
EFTA+UK
kilo tons
1200
1000
800
600
400
200
0
2015 2025 2035 2045
West Balkan
kilo tons
300
250
200
150
100
50
0
2015 2025 2035 2045
EECCA+Türkiye
million tons
6
5
4
3
2
1
0
2015 2025 2035 2045
Baseline
Opt-PM
Opt-PM+B
MTFR

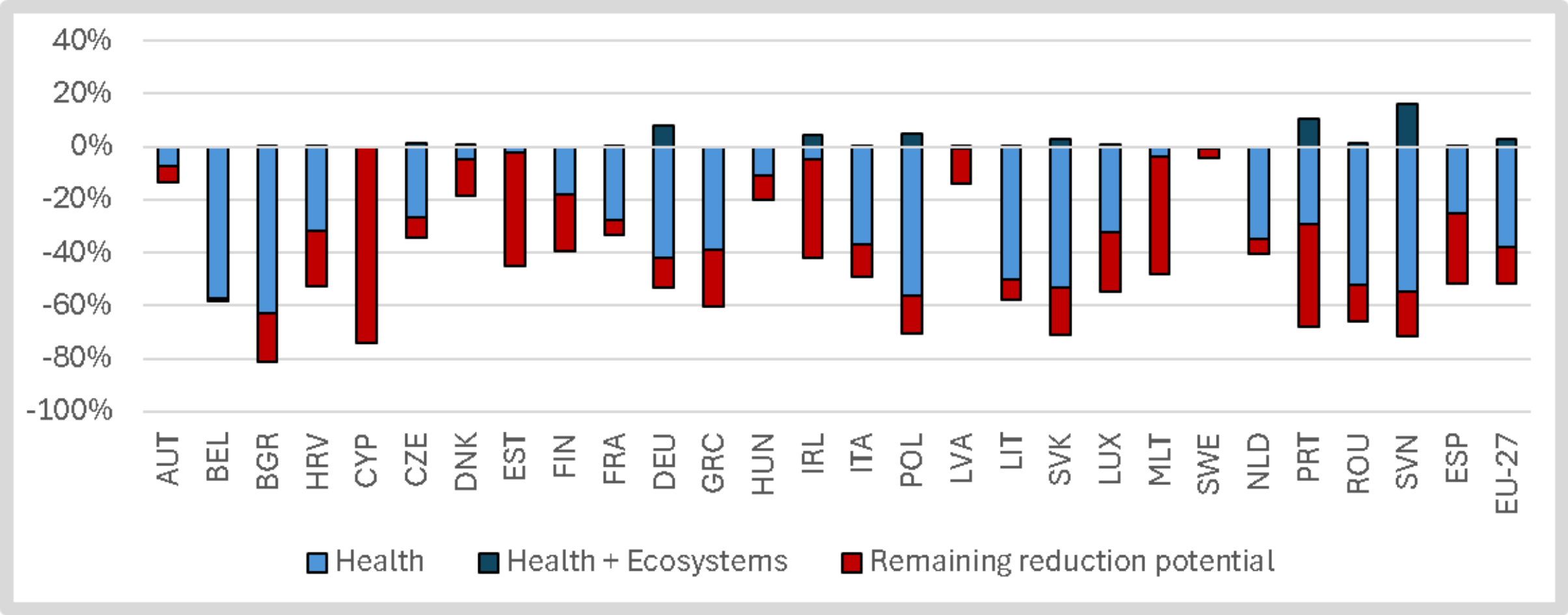
NH_3 reductions (beyond *Baseline*) per EU-27 country and scenario



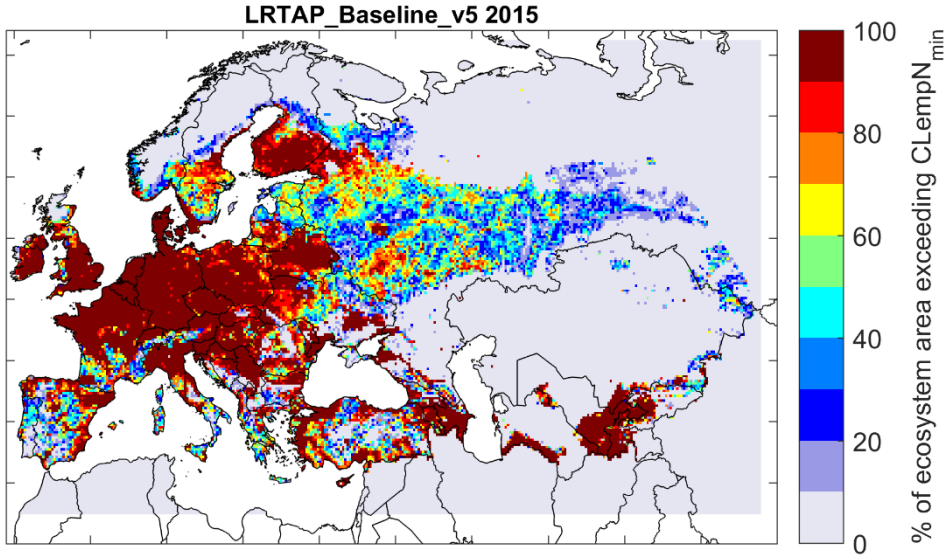
NO_X reductions (beyond *Baseline*) per EU-27 country and scenario

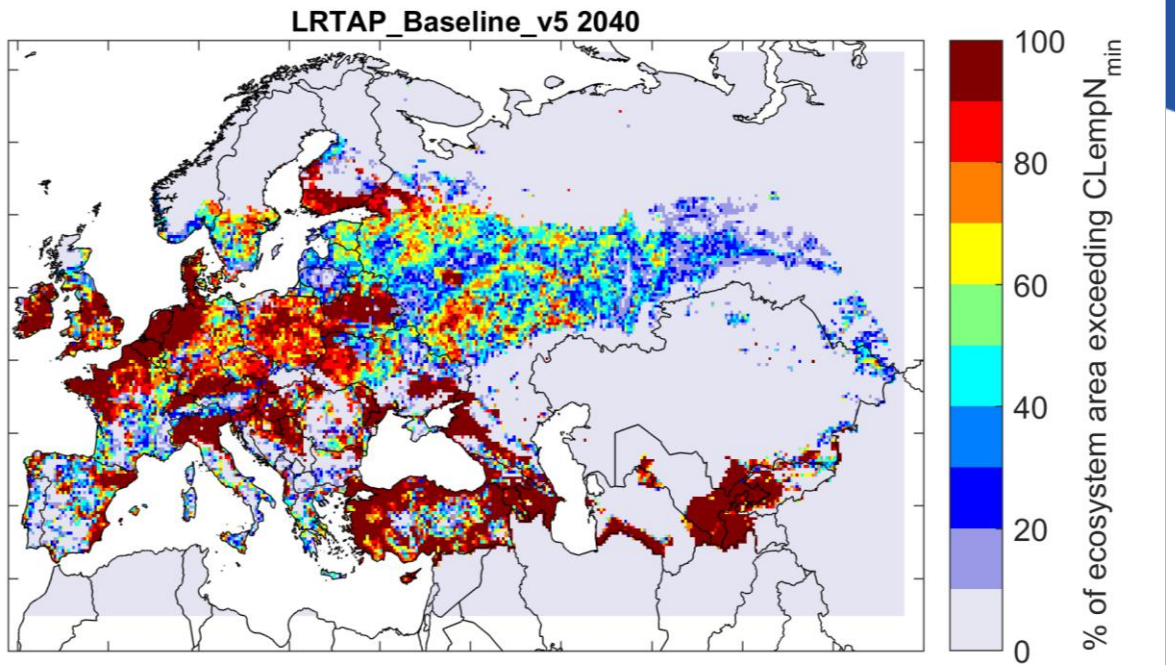


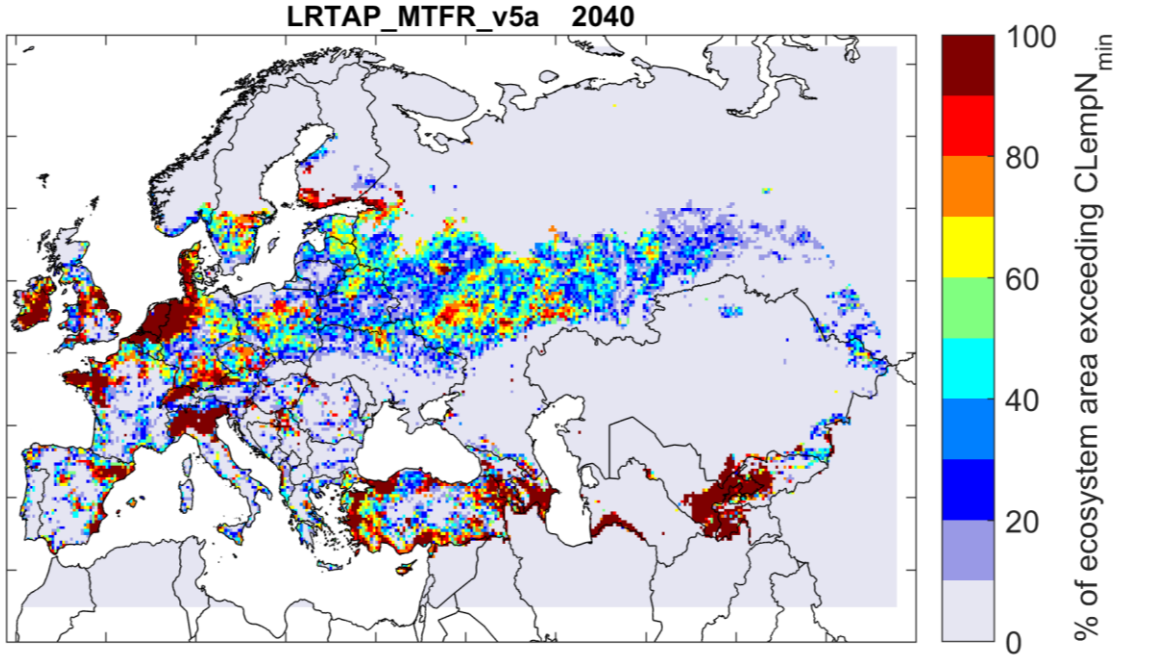
SO_2 reductions (beyond *Baseline*) per EU-27 country and scenario



Ecosystem area exceeding CLs: 2015, 2040 and 2040 MTFR







Source: critical Loads (CCE), GAINS model (CIAM/IIASA)

Initial conclusions and outlook

- CLE already shows strong reductions of air pollutants from 2015 to 2040
- -50% targets for both, health and ecosystems protection, are not feasible in the current baseline
    - Target for domain wide -50% of premature deaths by 2040 is feasible
    - Target for domain wide -40% of average accumulated exceedance per ecosystem type by 2040 compared to 2015 feasible
    - Large differences in costs - exploring options for solutions with more even distribution of additional costs, e.g., caping maximum expenditure
- Ozone will be included in the health target
- Further work on the LOW scenario and Methane
- Further consultations on Baseline (EU4Green, EECCA)

New GAINS Explorer *(draft version)*

https://gains.iiasa.ac.at/gains/GPV/index.login

Online application to view for discussed policy scenarios:

- *Emissions,*
- *Concentrations,*
- *Exposure,*
- *Impacts,*
- *…and more coming*