

Progress in modelling undertaken by CIAM for the GP Revision

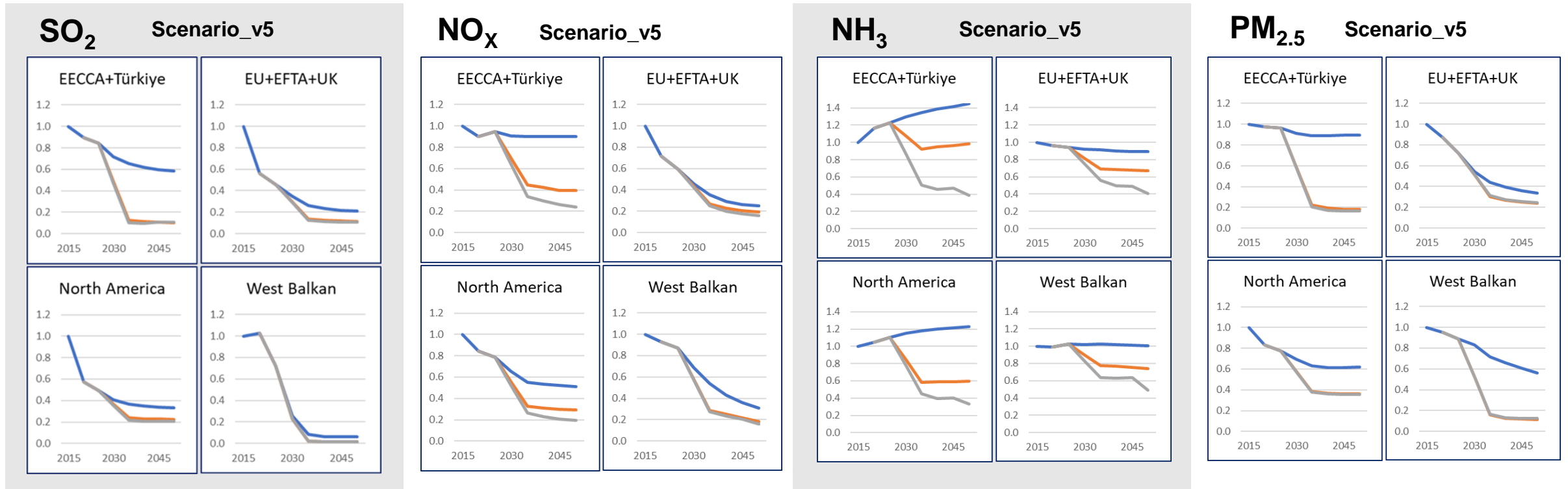
Z. Klimont, G. Kieseewetter, F. Wagner, C. Heyes, M. Posch, R. Sander, et.al.
CIAM/IIASA

54th session of the Task Force on Integrated Assessment Modelling, 3 – 4 April 2025, Laxenburg

Emission scenarios for GP Revision: v5a

- Baseline v5a:
 - Inclusion of outcomes from the bilateral consultations with EU Member States for Clean Air Outlook 4 ([EC Report](#) and [support report led by IIASA](#) released Mar 2025)
 - Inclusion of results from the EU4Green Project for West Balkan
- MTFR v5a
- LOW (not yet synchronized with latest updates)
- Cost-optimal scenarios (work in progress)
 - achieving -50% targets for mortality with different target setting options
 - Recent work: joint optimization for health and biodiversity risks (CLempN)
- Emission scenarios are documented in the Policy Brief on CIAM website (currently v5 but sub-grid increment not yet for the full domain)
- Emissions (Baseline, MTFR, Health OPT) are published on the [CIAM website](#) and on [Zenodo](#) (gridded emissions).

Emission trends across the UNECE region (scenario version 5)



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

Emissions have been made available on the [CIAM website](#), gridded sets available from [Zenodo](#) and provided to MSC-W for running the EMEP model



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*



GAINS Data Explorer

Greenhouse Gas - Air Pollution Interactions and Synergies

Model Release 4.0.3

Sign in [or create an account](#)

Username

Password

Restore last work session

Accept disclaimer

Login

Release notes

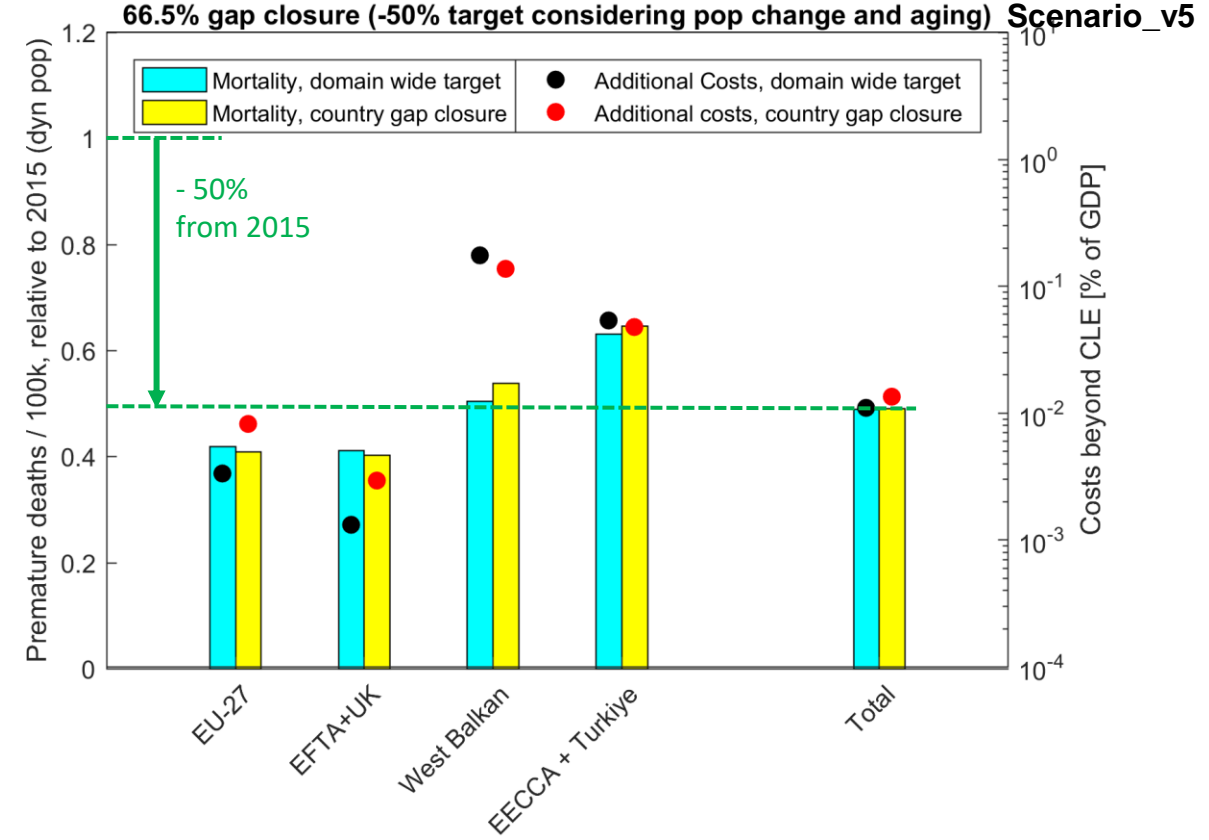
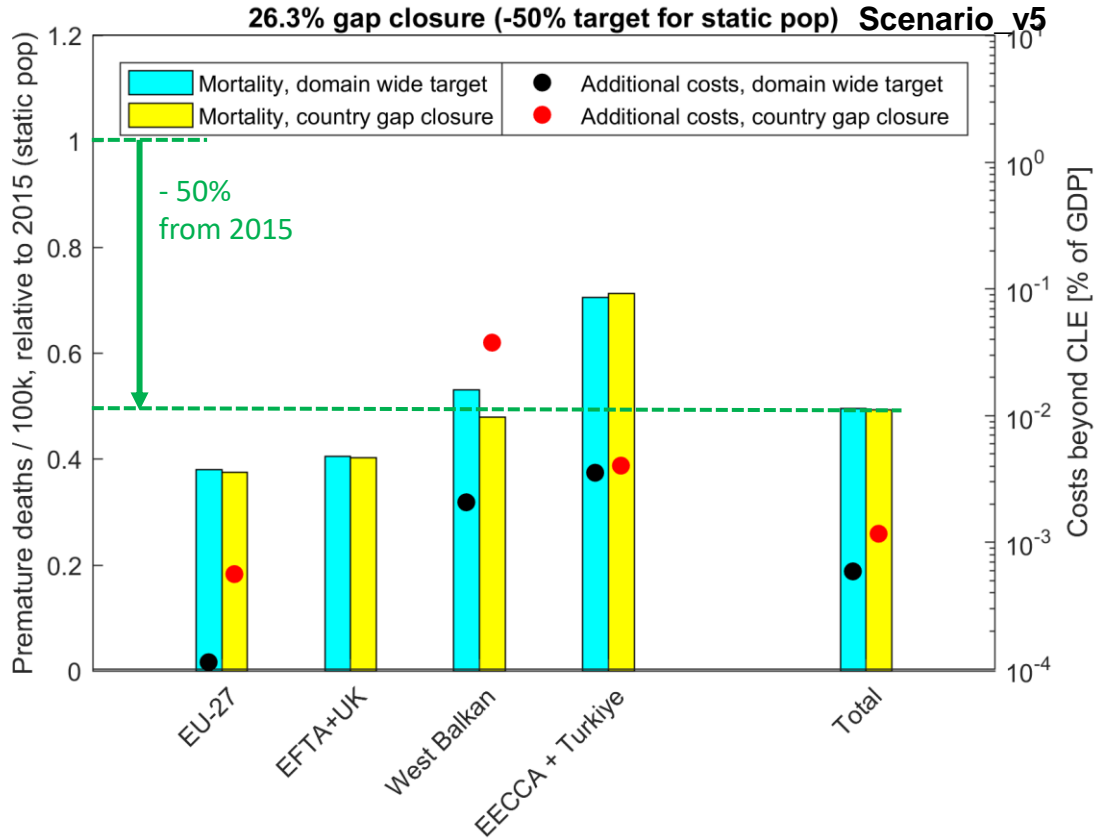
Resources

Previous Version

Modelling choices made after exchange with Parties and experts

- Assess least-cost solutions (=optimize) for 2040 relative to 2015
 - (2005 would be without ambition for some countries, and EECCA region lacks data for 2005; 2050 too far away; results will be presented in 5-year steps between 2015 and 2050)
- Optimize reaching targets cost-effectively across the UNECE and through equal relative improvement in each country
 - (Meeting a target is easier for a larger region; considering equal relative improvement by country brings in an egalitarian element)
- Optimisation based on risk-based indicator “deaths per 100,000 inhabitants” and dynamic population
 - Note: WHO seems in favour of excluding demographic change from assessments
- Focus on anthropogenic (the avoidable) PM_{2.5}

Least-cost reduction of PM health impacts (premature mortality) in UNECE (excl. North America) by 2040



Results from Dec 2024; update considering downscaling in EECCA region will be included for WGSR

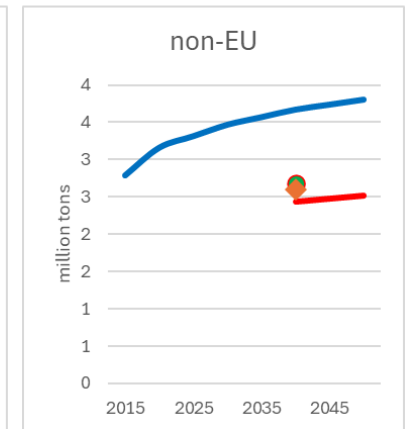
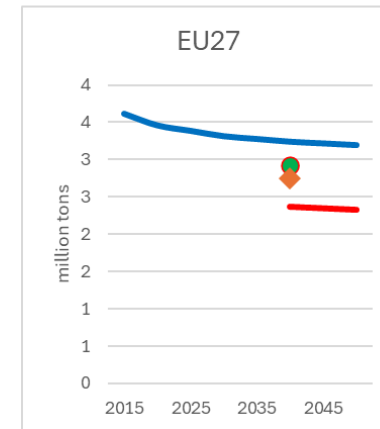
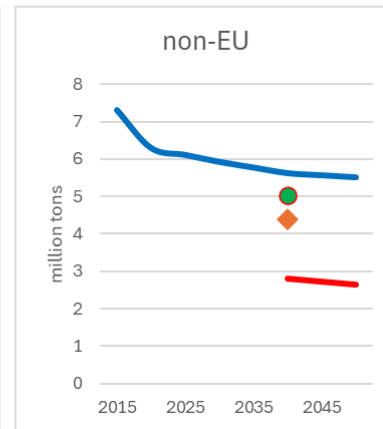
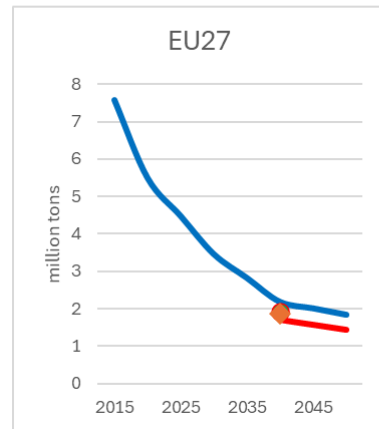
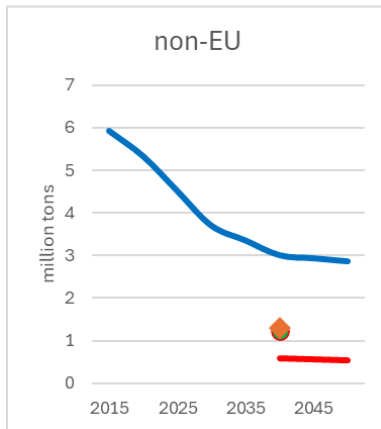
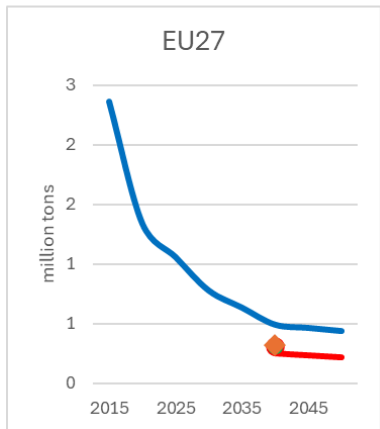
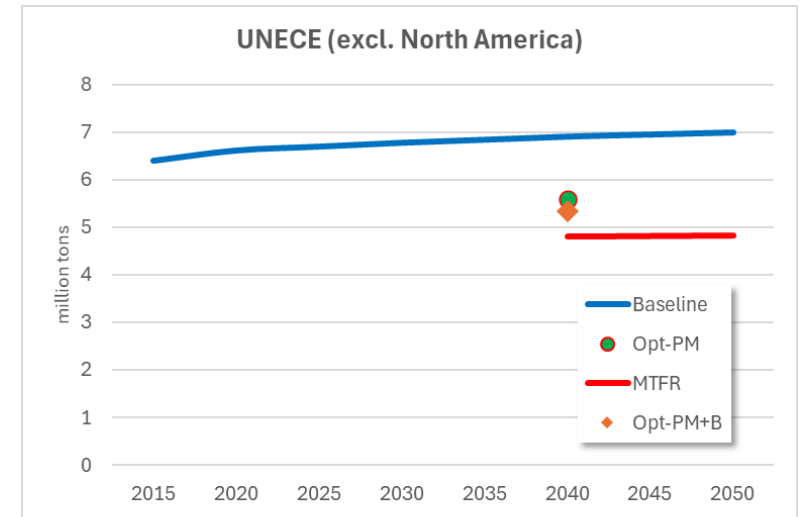
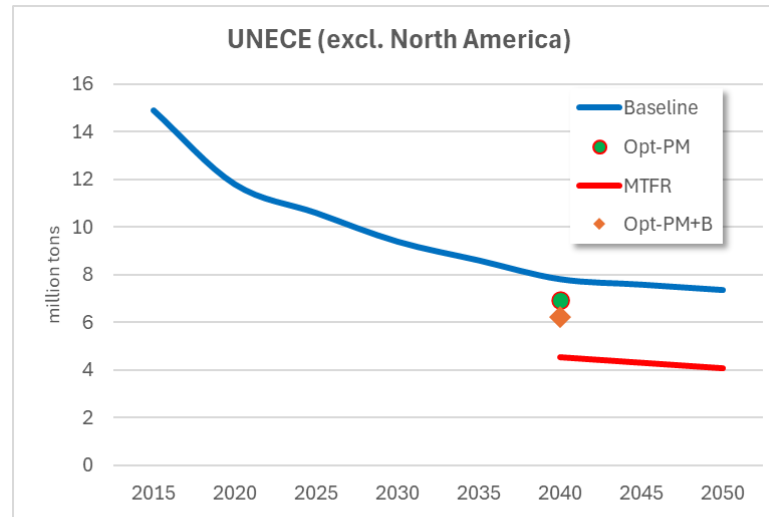
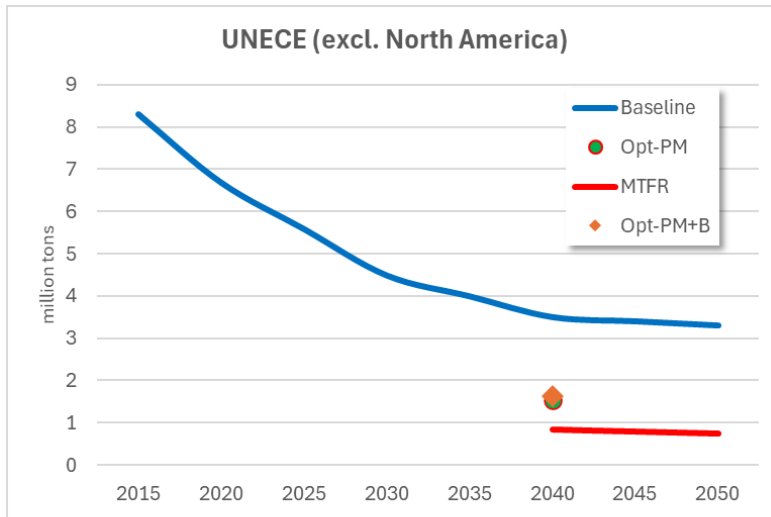
Sulfur and nitrogen emissions in the current scenarios (V5a)

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

Sulfur Dioxide (SO₂)

Nitrogen Oxides (NO_x)

Ammonia (NH₃)

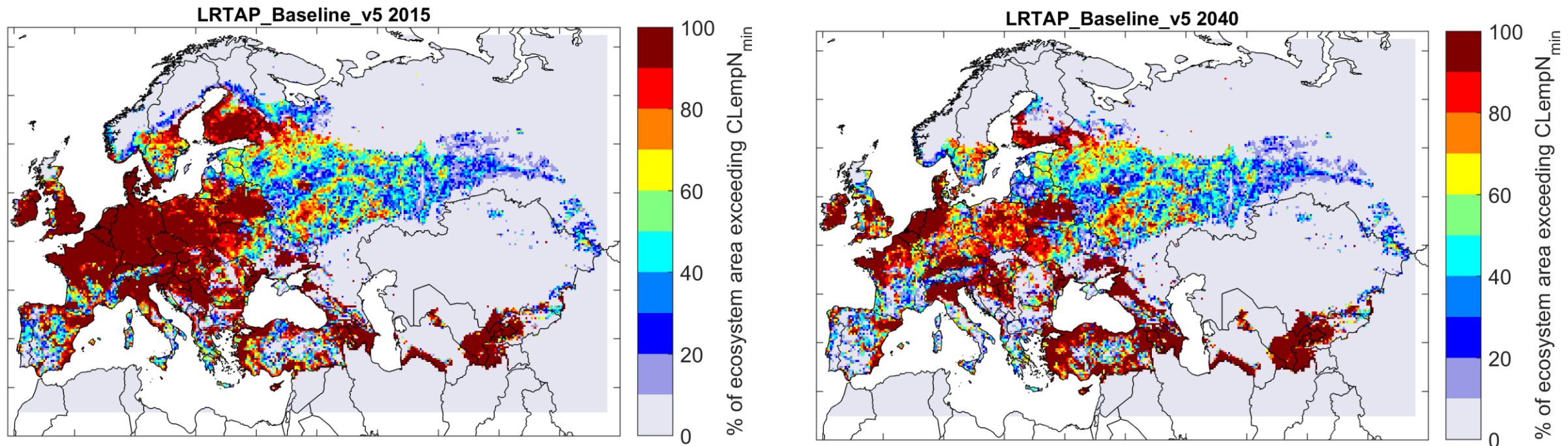


Empirical critical loads for nitrogen deposition

- CIAM received from CCE in April 2024:
 - Empirical critical loads for 48 ecosystem classes
 - Giving min and max CL [kgN/ha/yr]
 - And ecosystem maps for the whole domain (area of each class per grid cell)
- CIAM has processed and implemented them in GAINS for CLE and MTFR projections and least cost scenarios
- Calculated indicators equivalent to the acidification/eutrophication calculations: area exceeding CL, average accumulated exceedance (AAE)
- Only land and freshwater ecosystems are considered, not marine
- *CCE provided in March 2025 updated CLs based on contribution from National Focal Centers not included yet – discussion with CCE ongoing for assessment before WGSR.*

Ecosystem area exceeding CLs: 2015 and 2040

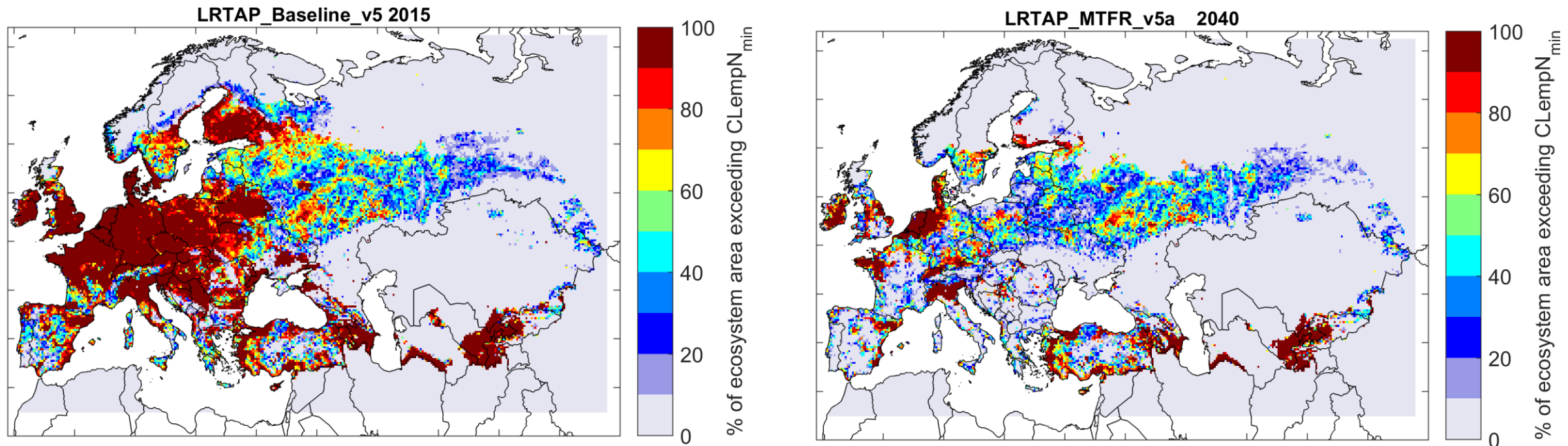
Lower range of CLs (CLempN_{min})



The message differs depending on ecosystem type and the level of CL used!

Ecosystem area exceeding CLs: 2015 and 2040 MTR

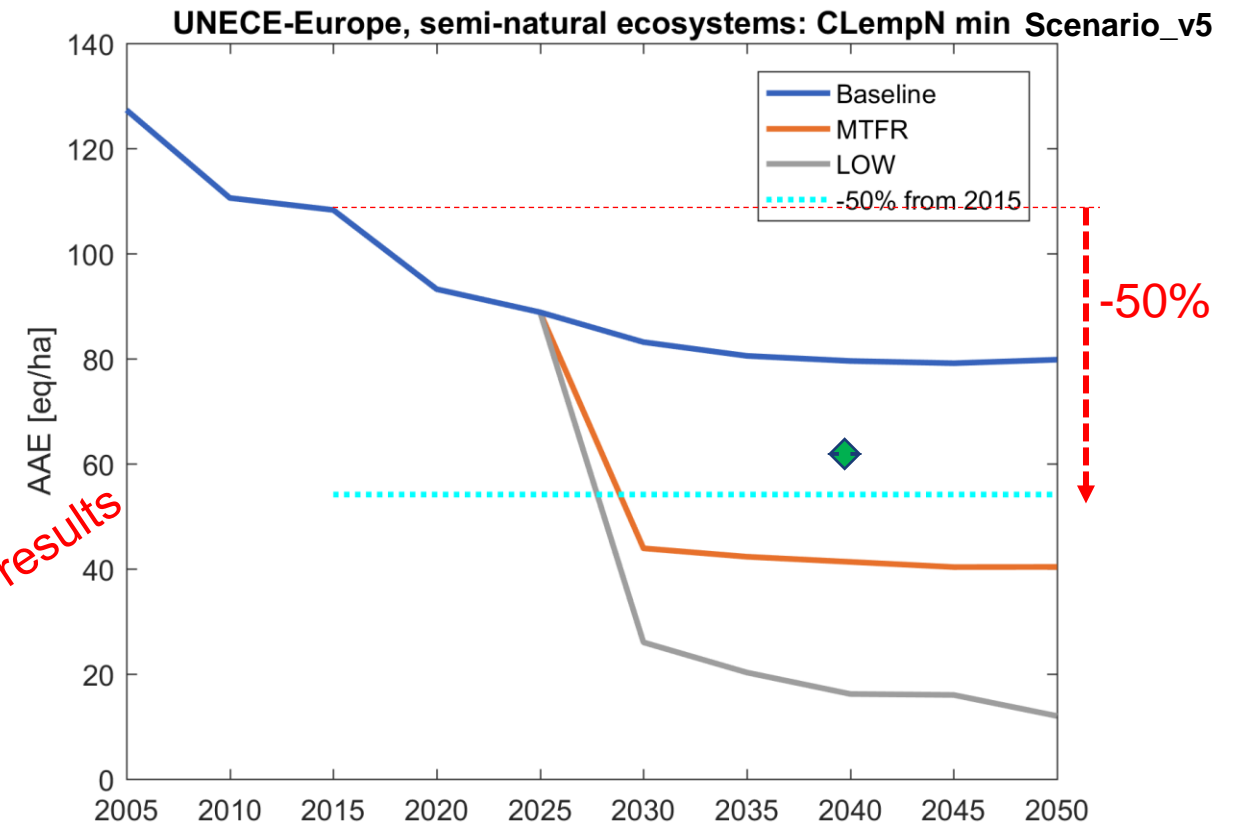
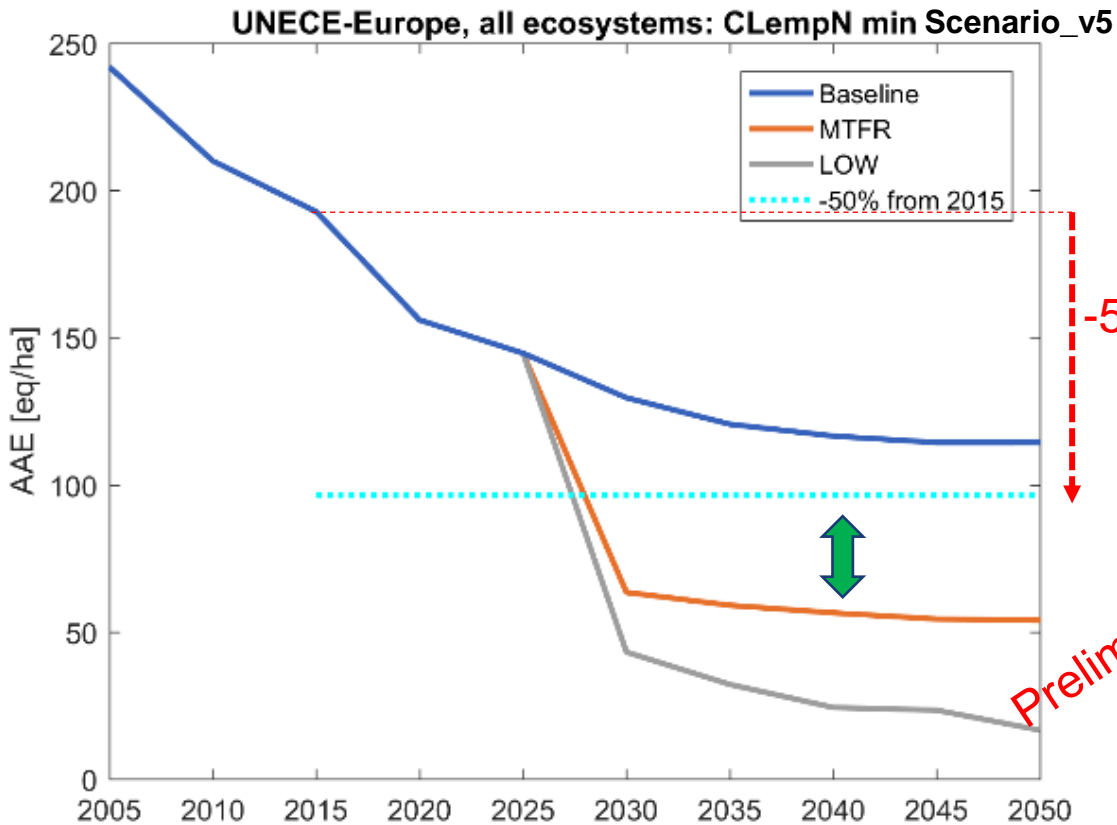
Lower range of CLs (CLempN_{min})



The message differs depending on ecosystem type and the level of CL used!

Scope for further mitigation in the UNECE region

Exploring attainability of 50% ecosystem (biodiversity) protection goal: AAE for all ecosystems

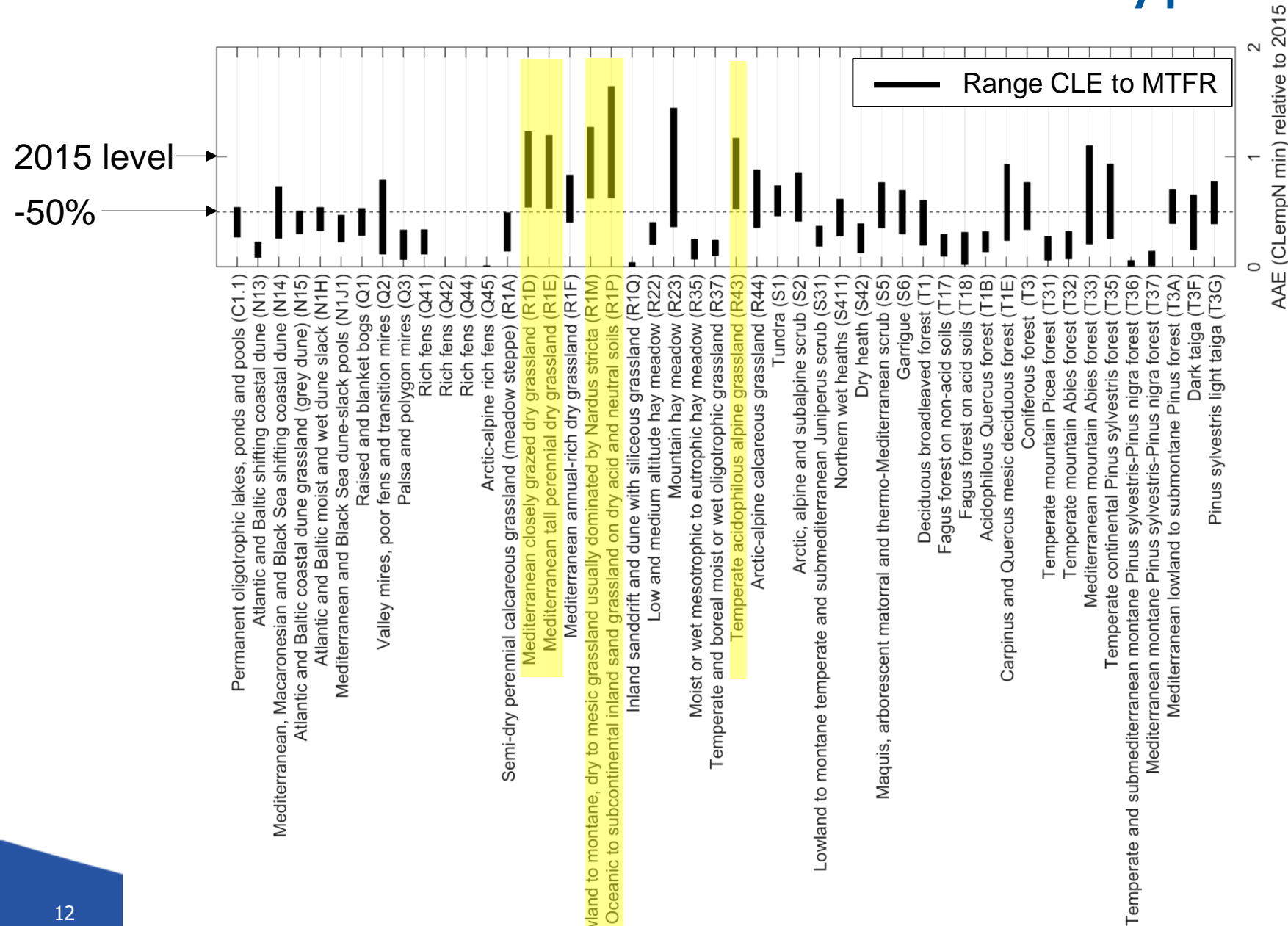


Preliminary results



Biodiversity risk when the health target of reducing premature mortality by 50% is achieved (dynamic population); the range reflects different distribution of reductions in the *domain wide* and *country gap closure* cases

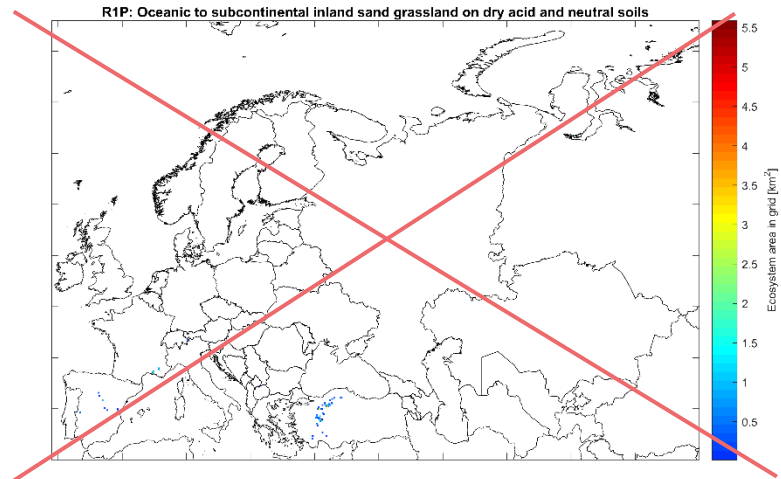
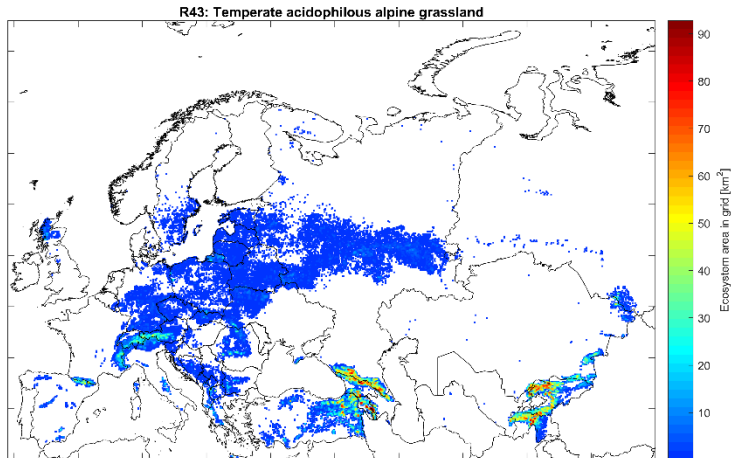
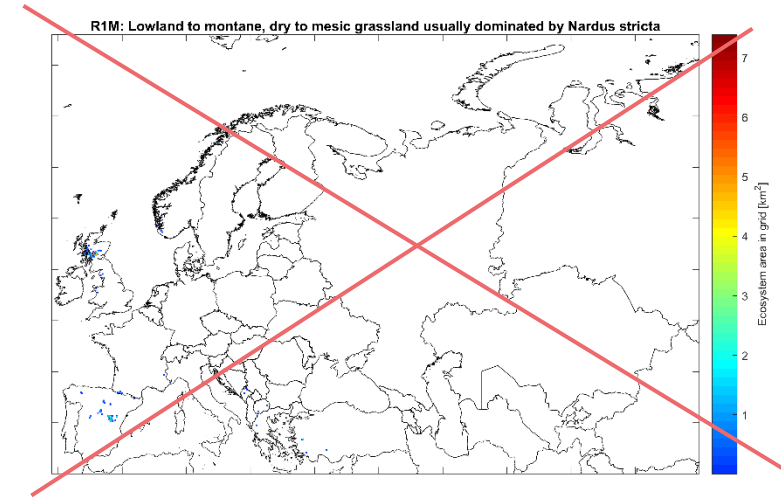
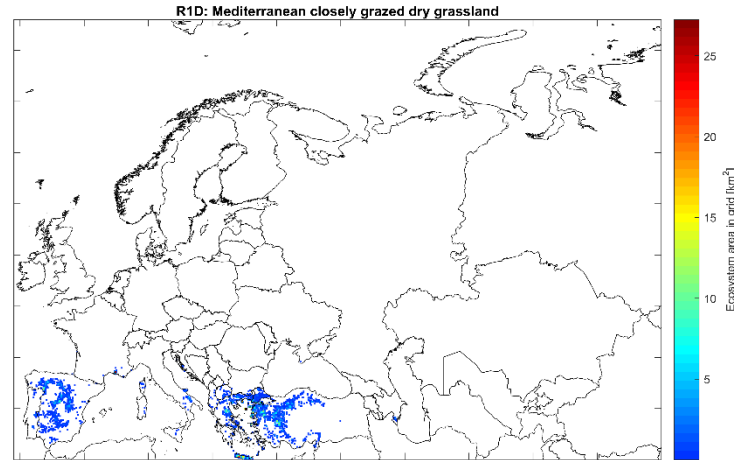
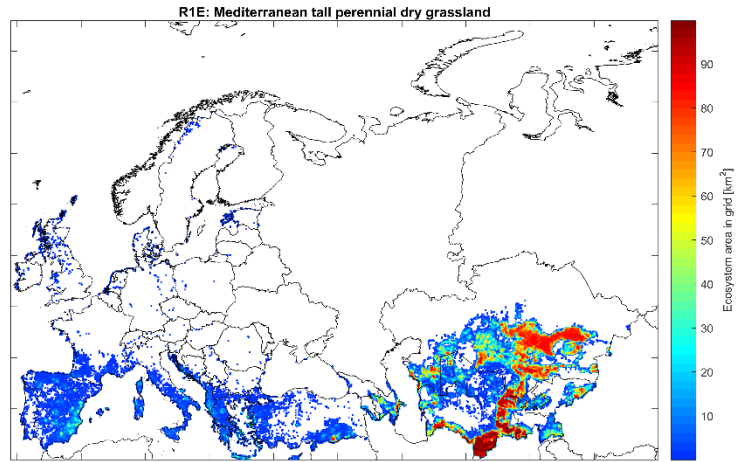
AAE for individual EUNIS habitat types (2040)



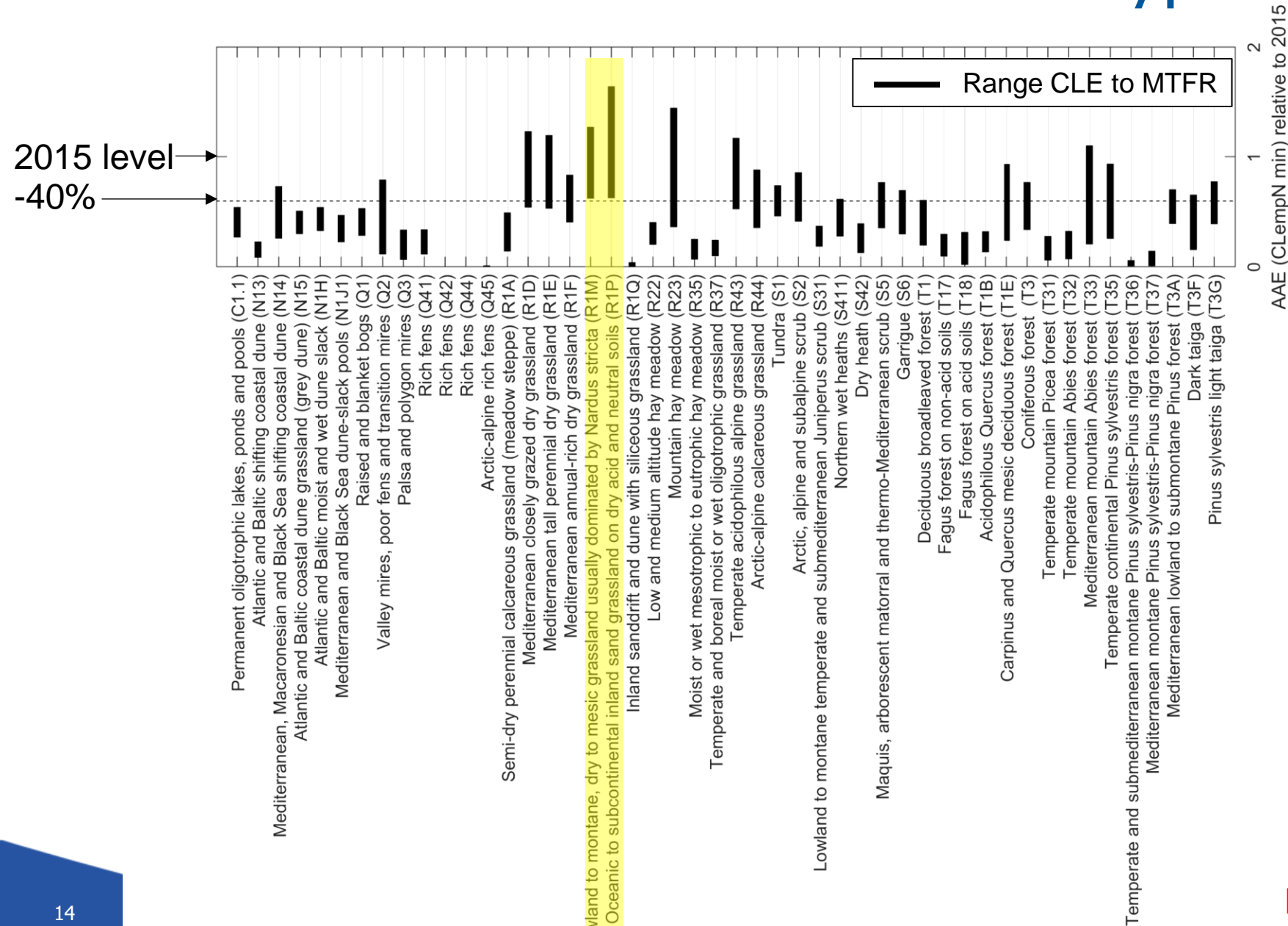
Reduction of AAE by 50% vs 2015 is not feasible for several grassland habitat types.

Preliminary results

Habitat types unable to reach -50% AAE (CL_{min})



AAE for individual EUNIS habitat types (2040)



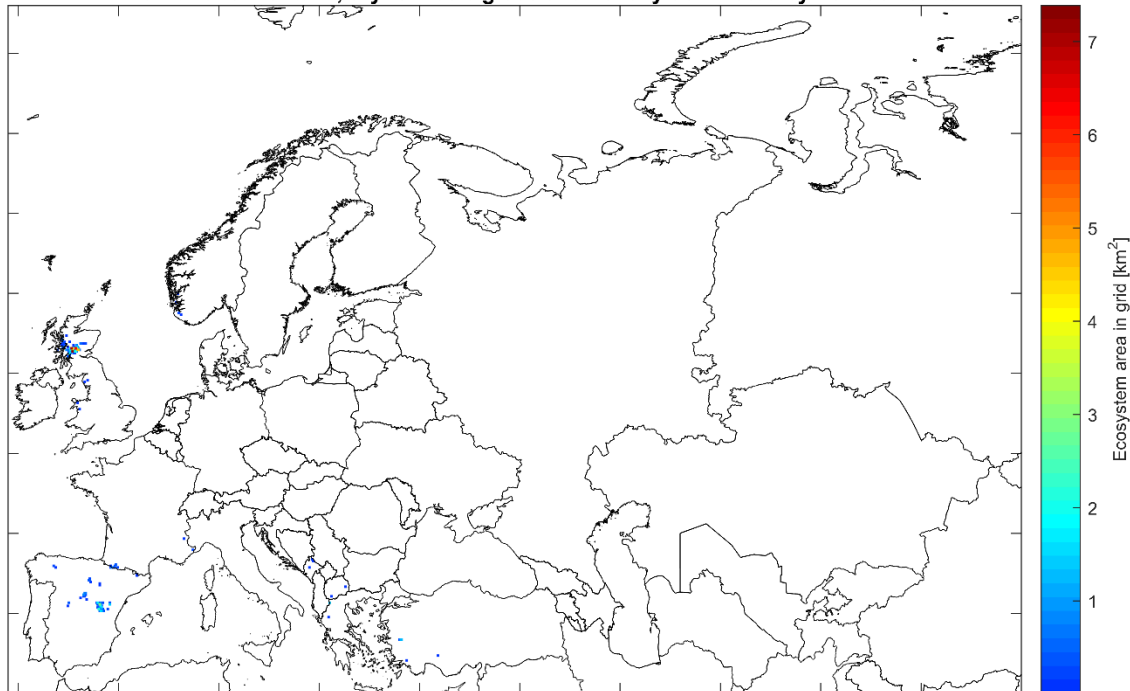
Target: -40% AAE (CLmin) is feasible for all except 2 habitat types.

As a first pragmatic solution, a -40% target was used, and 2 habitats were excluded from the optimization.

Other options for target setting could be explored.

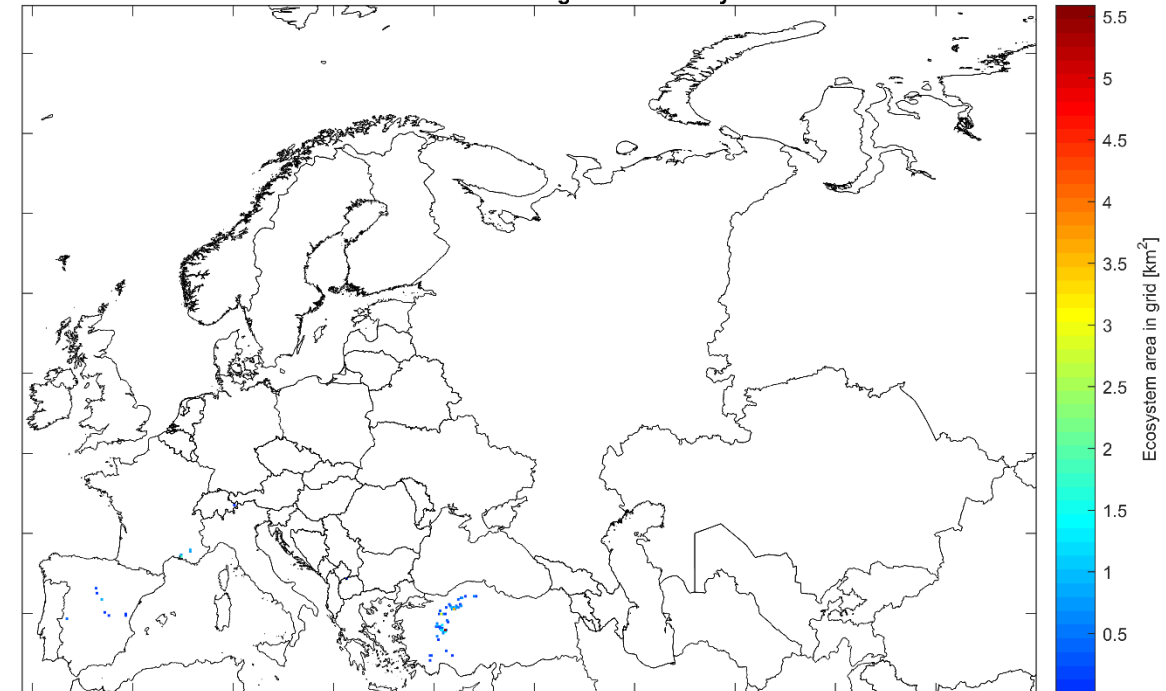
Habitat types excluded from the optimization

R1M: Lowland to montane, dry to mesic grassland usually dominated by *Nardus stricta*



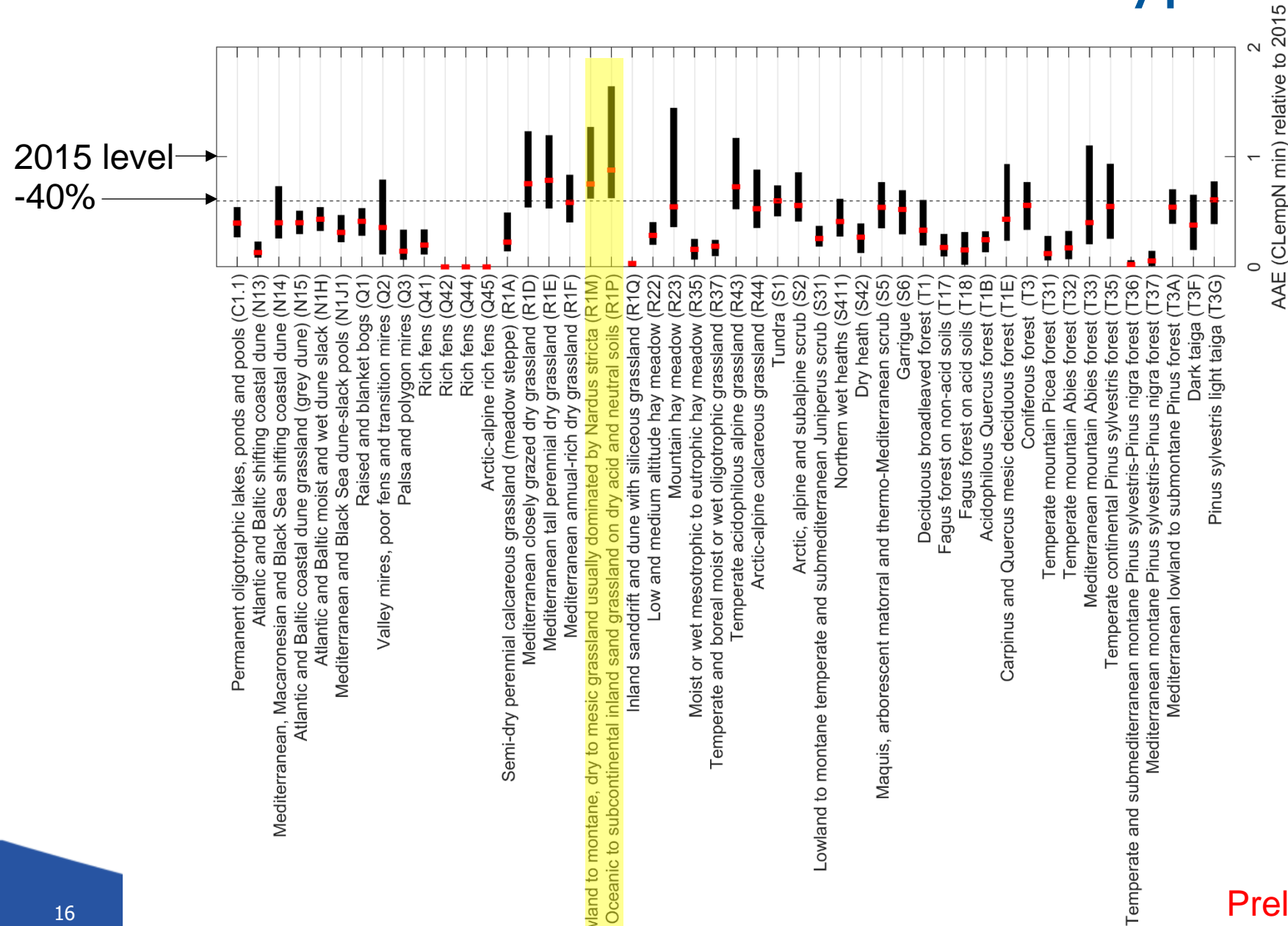
Total ecosystem area: 200km²
Exceeded in 2040 CLE: 4km²

R1P: Oceanic to subcontinental inland sand grassland on dry acid and neutral soils



Total ecosystem area: 40km²
Exceeded in 2040 CLE: 28km²

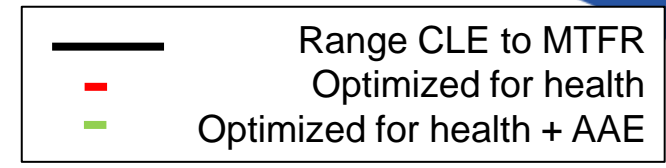
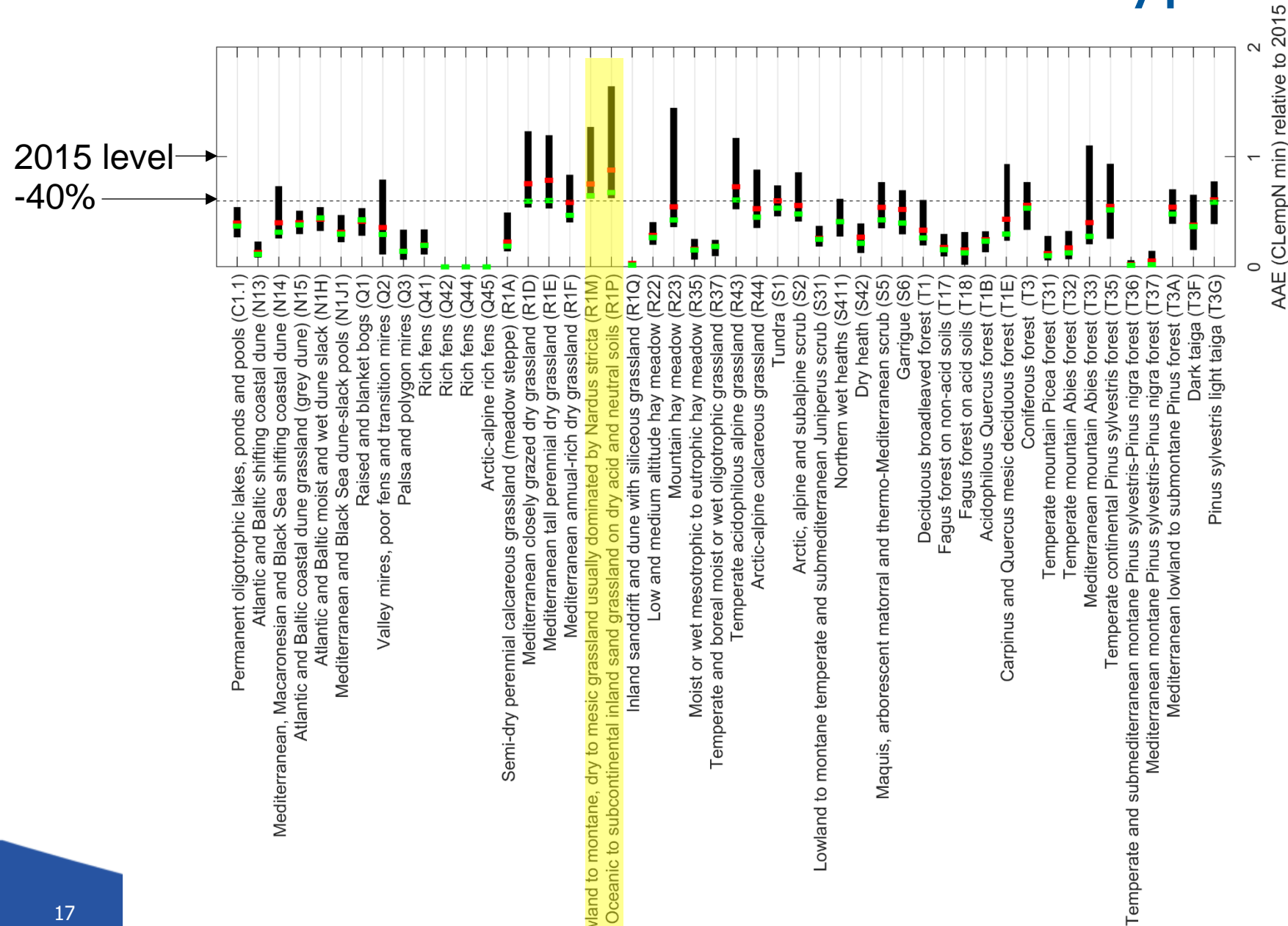
AAE for individual EUNIS habitat types (2040)



Already the PM-health target alone brings considerable reductions in AAE and for many habitat class delivers 40% reduction of risk.

Preliminary results

AAE for individual EUNIS habitat types (2040)



Already the PM-health target alone brings considerable reductions in AAE and for many habitat class delivers 40% reduction of risk.

Additional reductions in the health+AAE optimized case through further NO_x and NH₃ reductions.

Preliminary results

Initial conclusions – Biodiversity targets by 2040

First version of CLempN (Mar 2024)

Feasibility: Achieving 50% reduction of 2015 AAE for CLempN by 2040 appears feasible at the UNECE-Europe level and within all sub-domains for total ecosystems, but not for each habitat type individually.

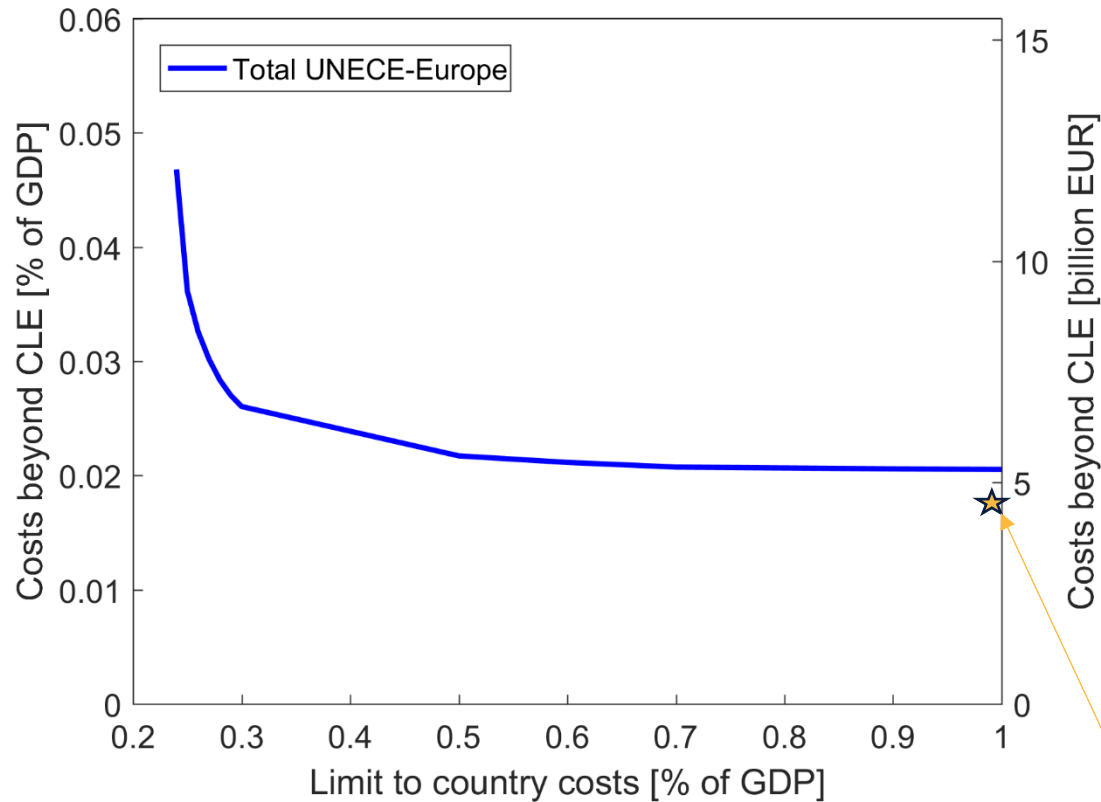
Importance of CLE enforcement: Full enforcement of Baseline policies (CLE) achieves by 2040 about 42% to 60% reduction in AAE in UNECE-Europe compared to 2015, for CLempN-MIN and CLempN-AVG, respectively.

Achieving 50% health (PM mortality) target brings large benefits: Over 55% and nearly 70% of biodiversity risk (CLempN-min, CLempN-avg) could be reduced when PM health target of 50% reducing premature mortality is met by 2040

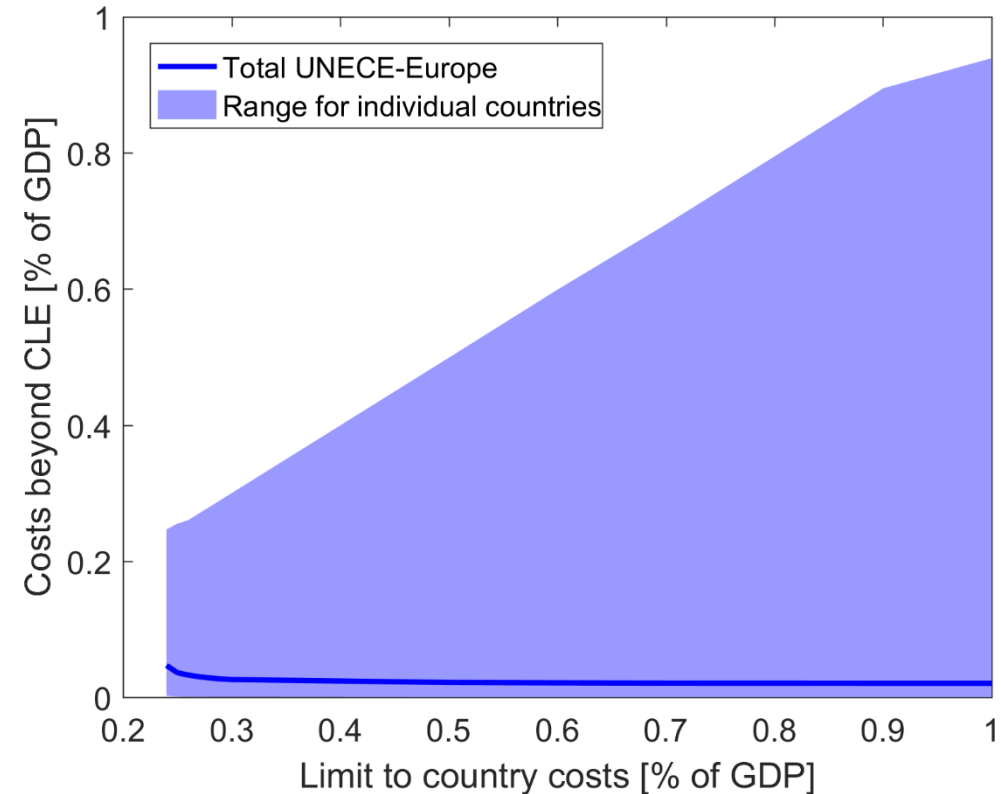
Cost optimization: first results available. Reduction targets for different ecosystem types rather than for different countries. Example target: -40% AAE for each ecosystem except 2 habitats.

Exploring “fairness”: Cost/GDP limits

On top of the -50% mortality and -40% AAE (CImin): What would it cost for the domain to constrain the costs (relative to GDP) for each country?



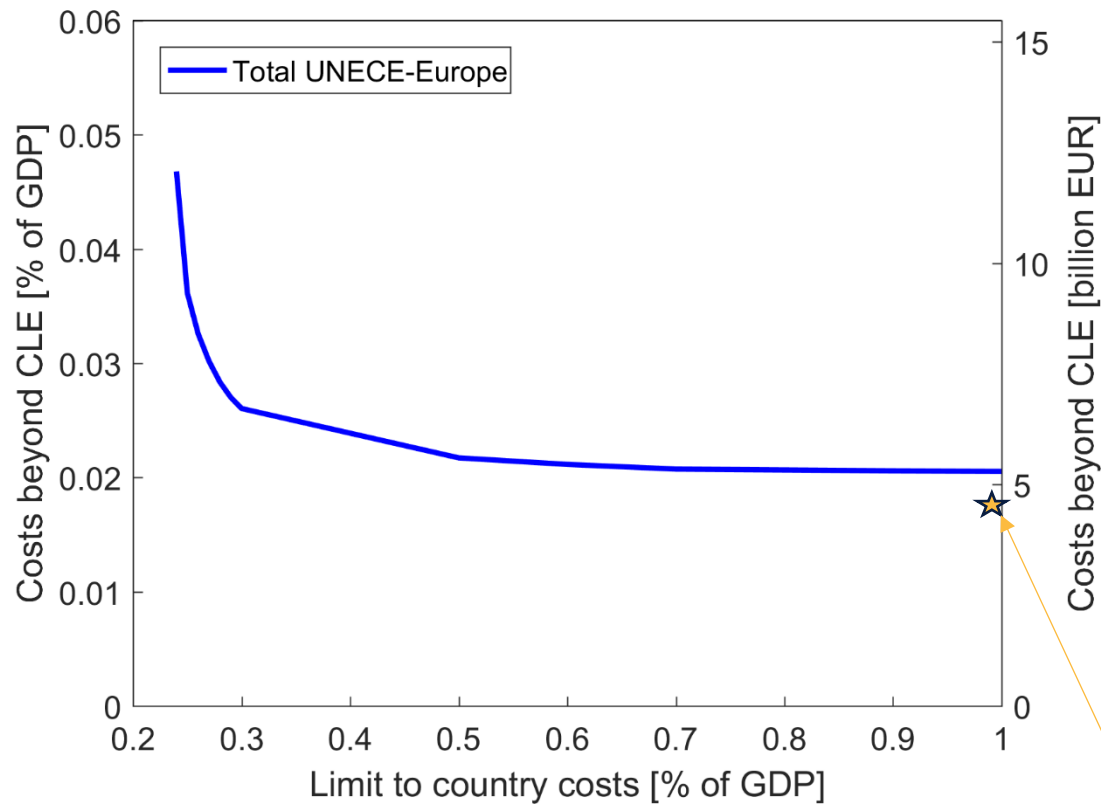
Health-only target



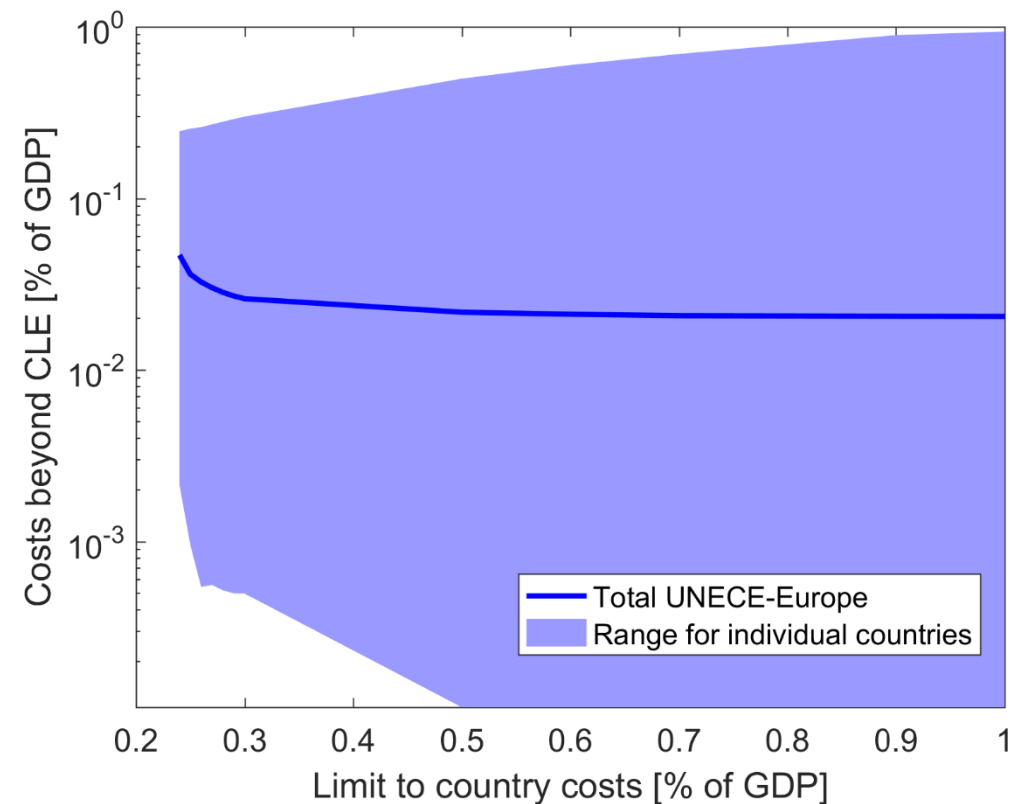
Preliminary results

Exploring “fairness”: Cost/GDP limits

On top of the -50% mortality and -40% AAE (C_{lmin}): What would it cost for the domain to constrain the costs (relative to GDP) for each country?

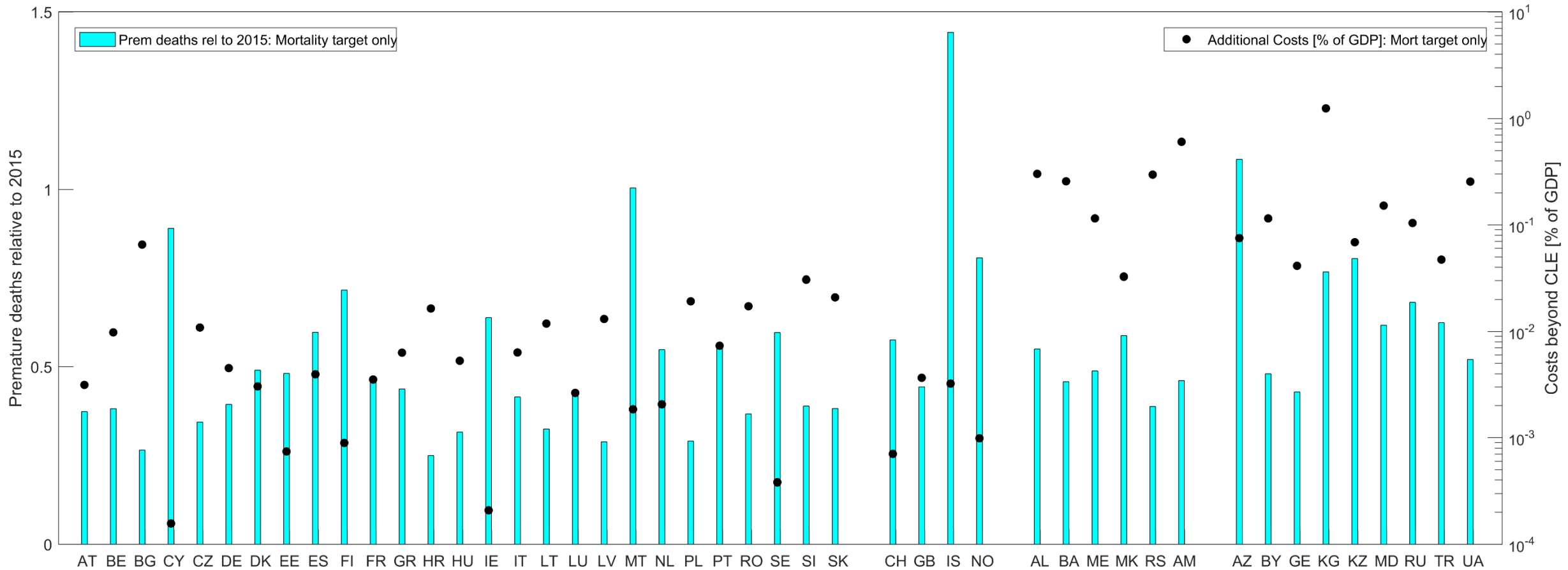


Health-only target

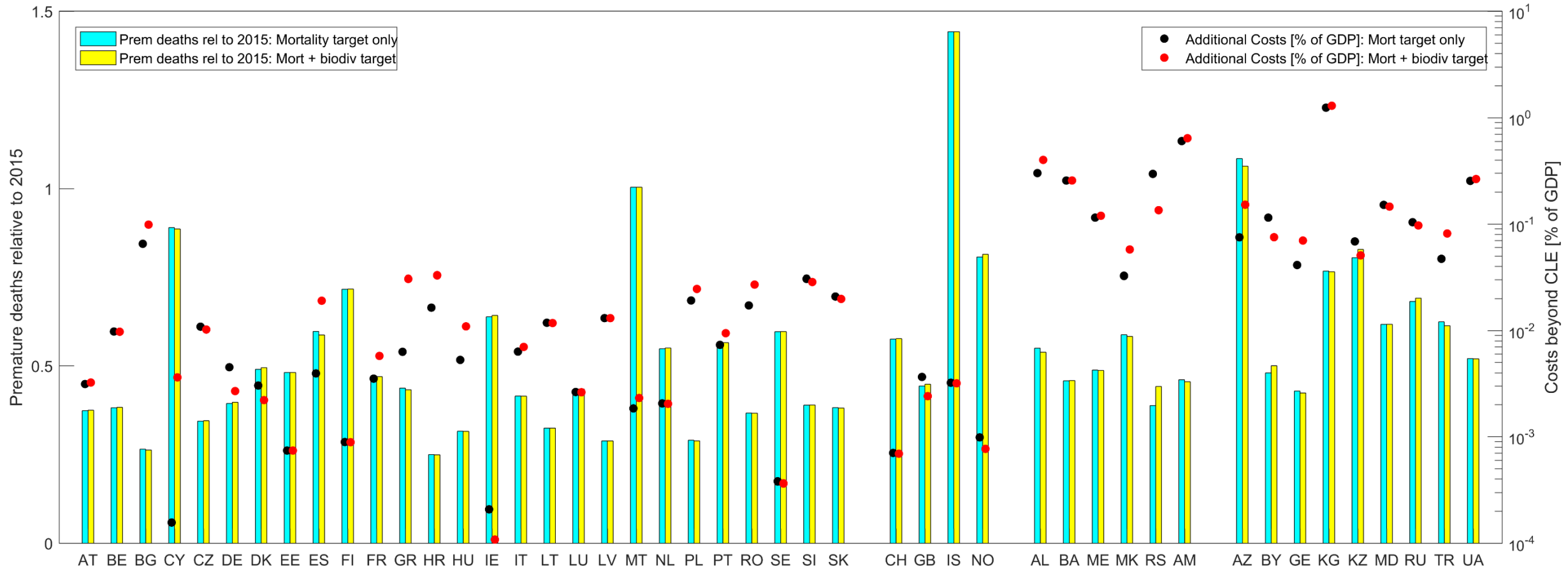


Preliminary results

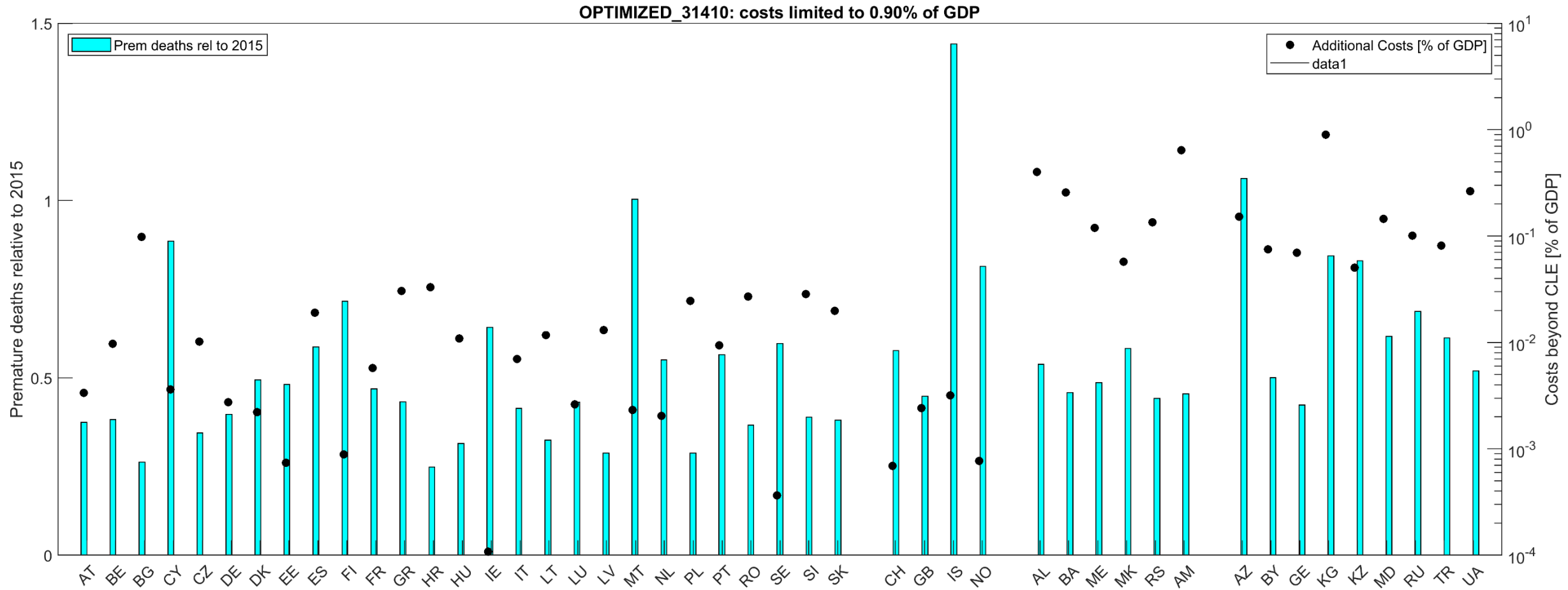
Costs distribution: Health-only solution



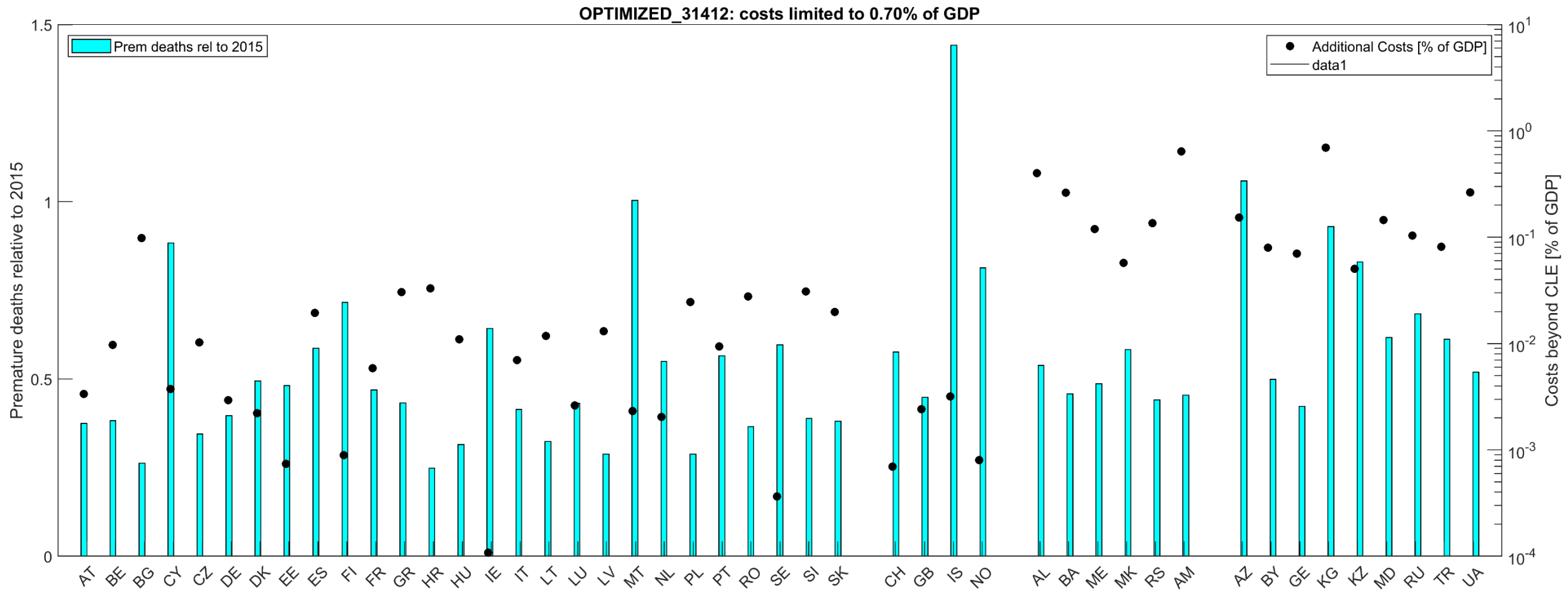
Costs distribution: Health-only vs combined solution



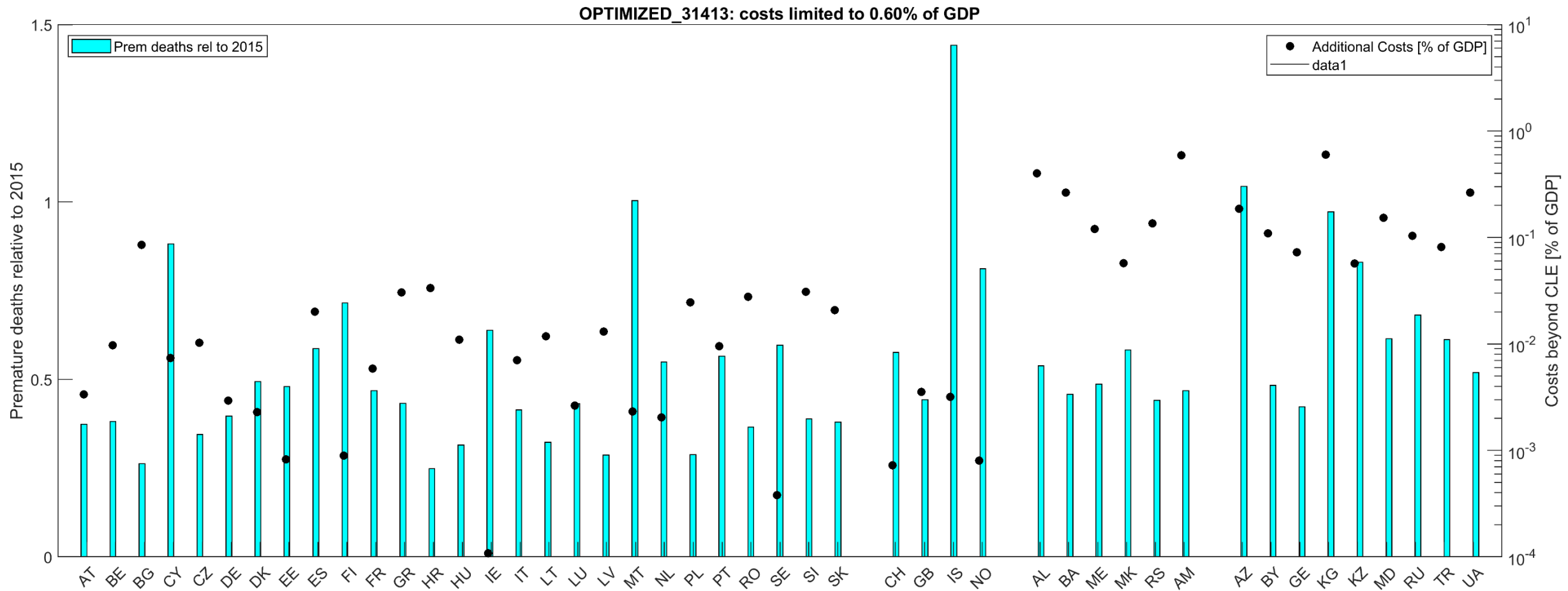
Costs distribution: combined solution with cost cap



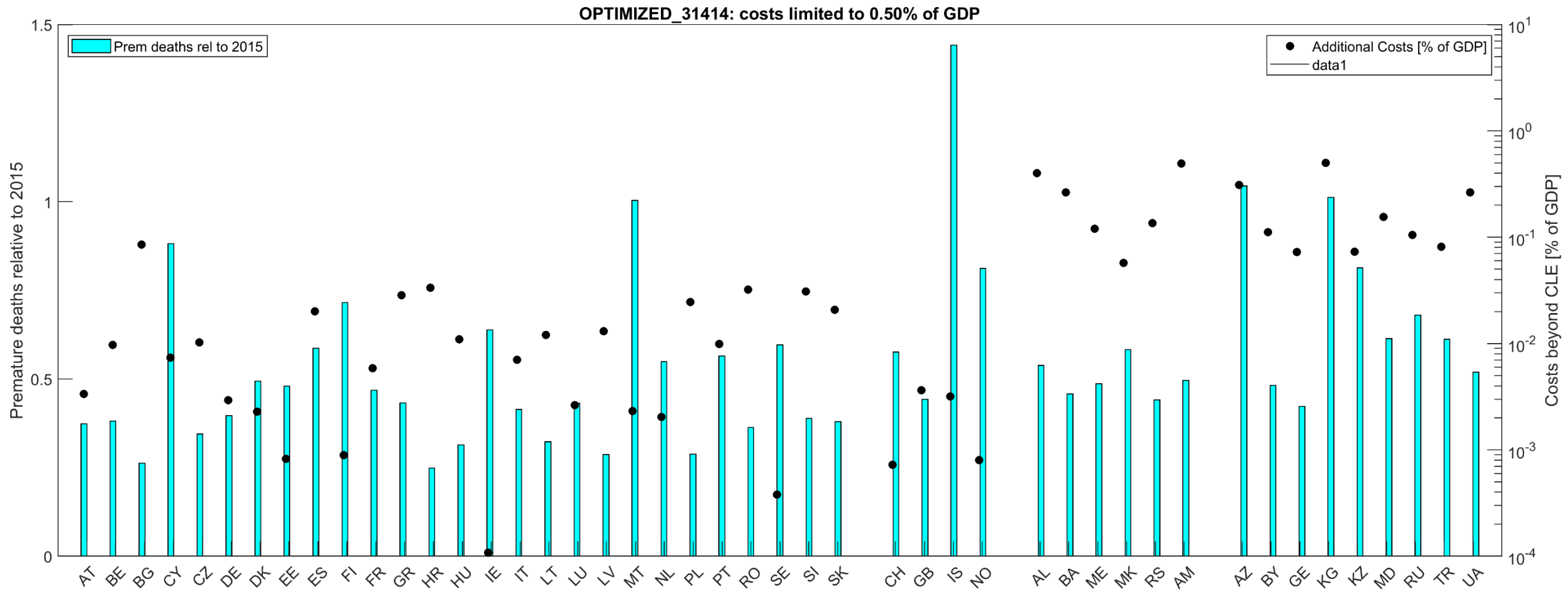
Costs distribution: combined solution with cost cap



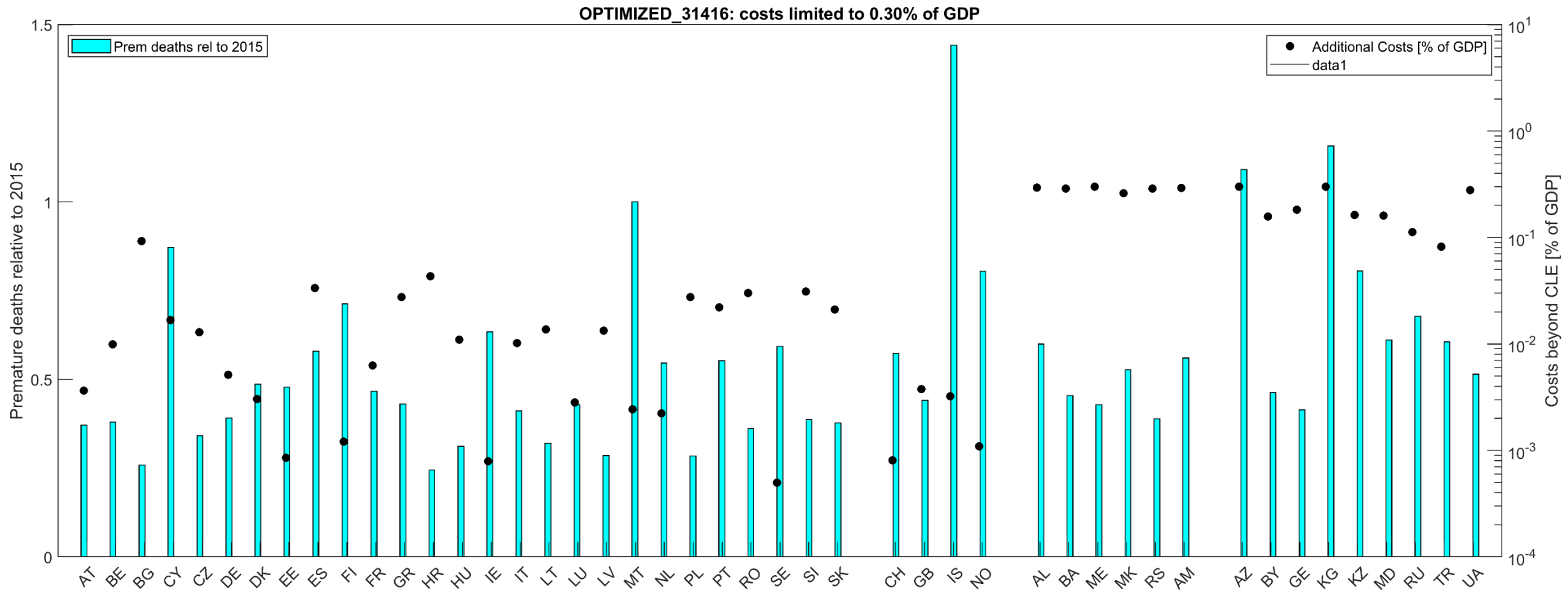
Costs distribution: combined solution with cost cap



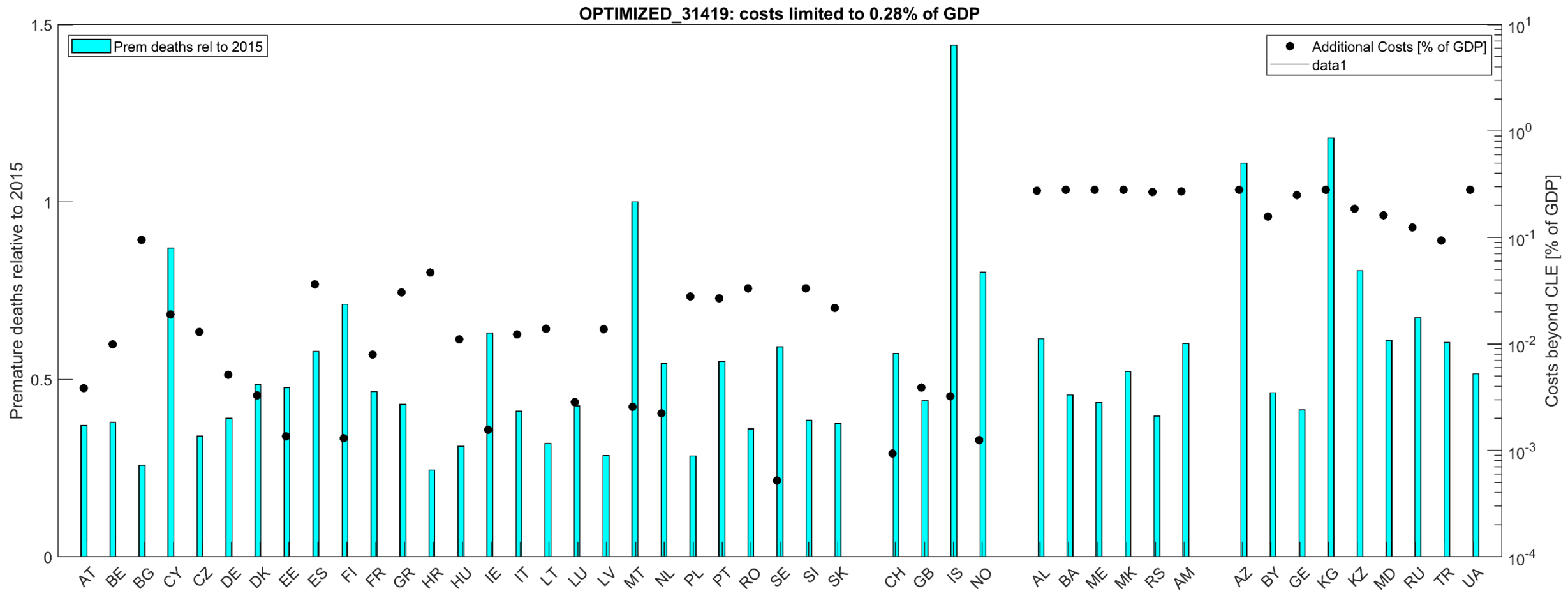
Costs distribution: combined solution with cost cap



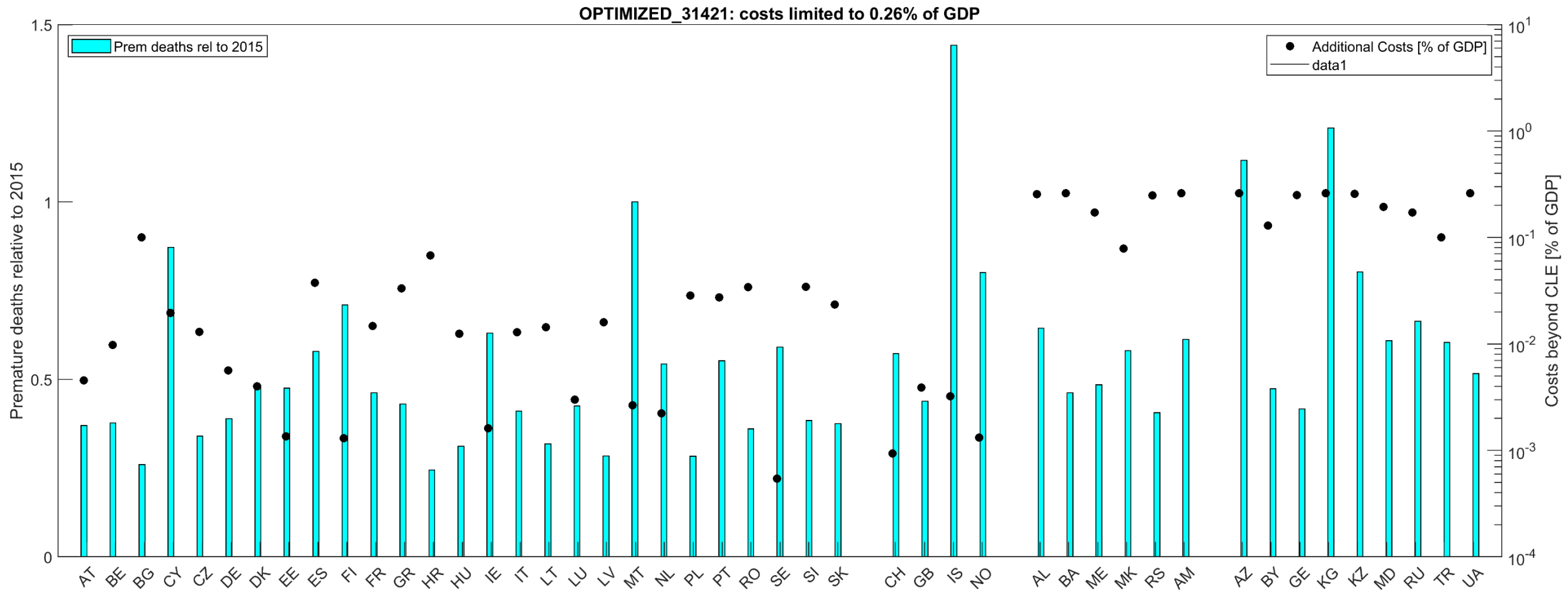
Costs distribution: combined solution with cost cap



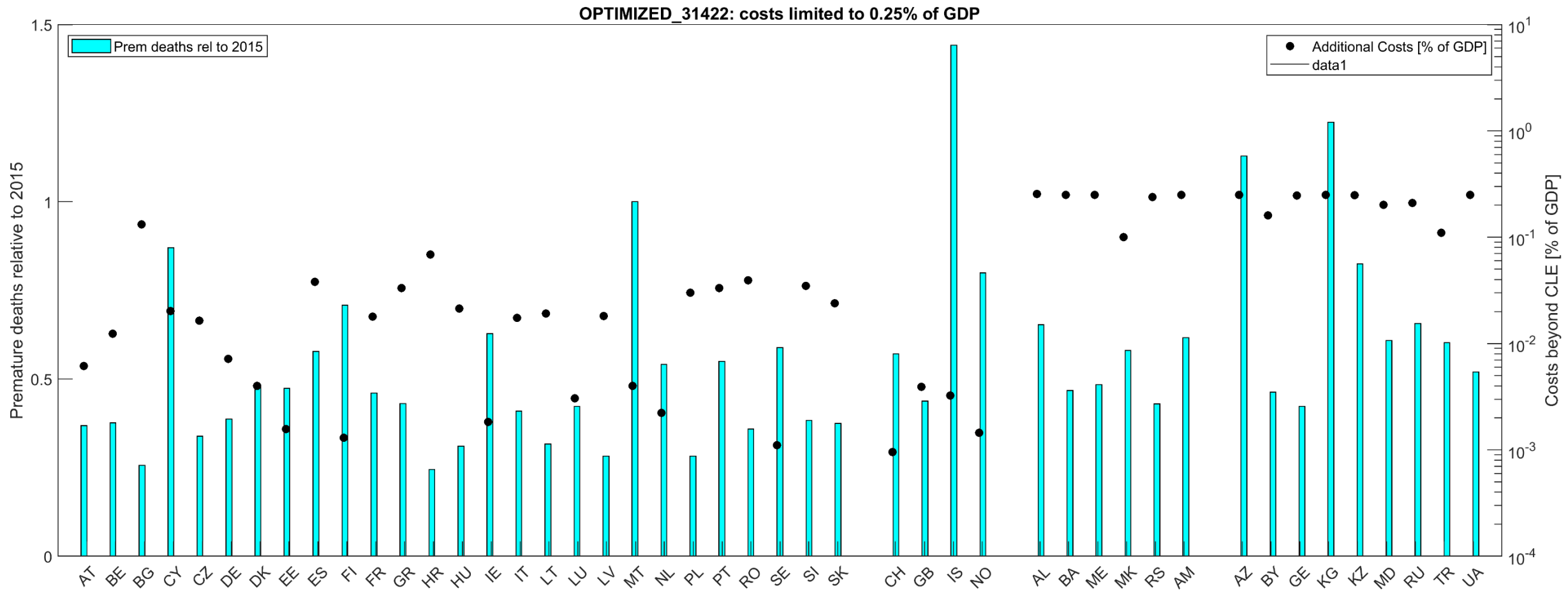
Costs distribution: combined solution with cost cap



Costs distribution: combined solution with cost cap



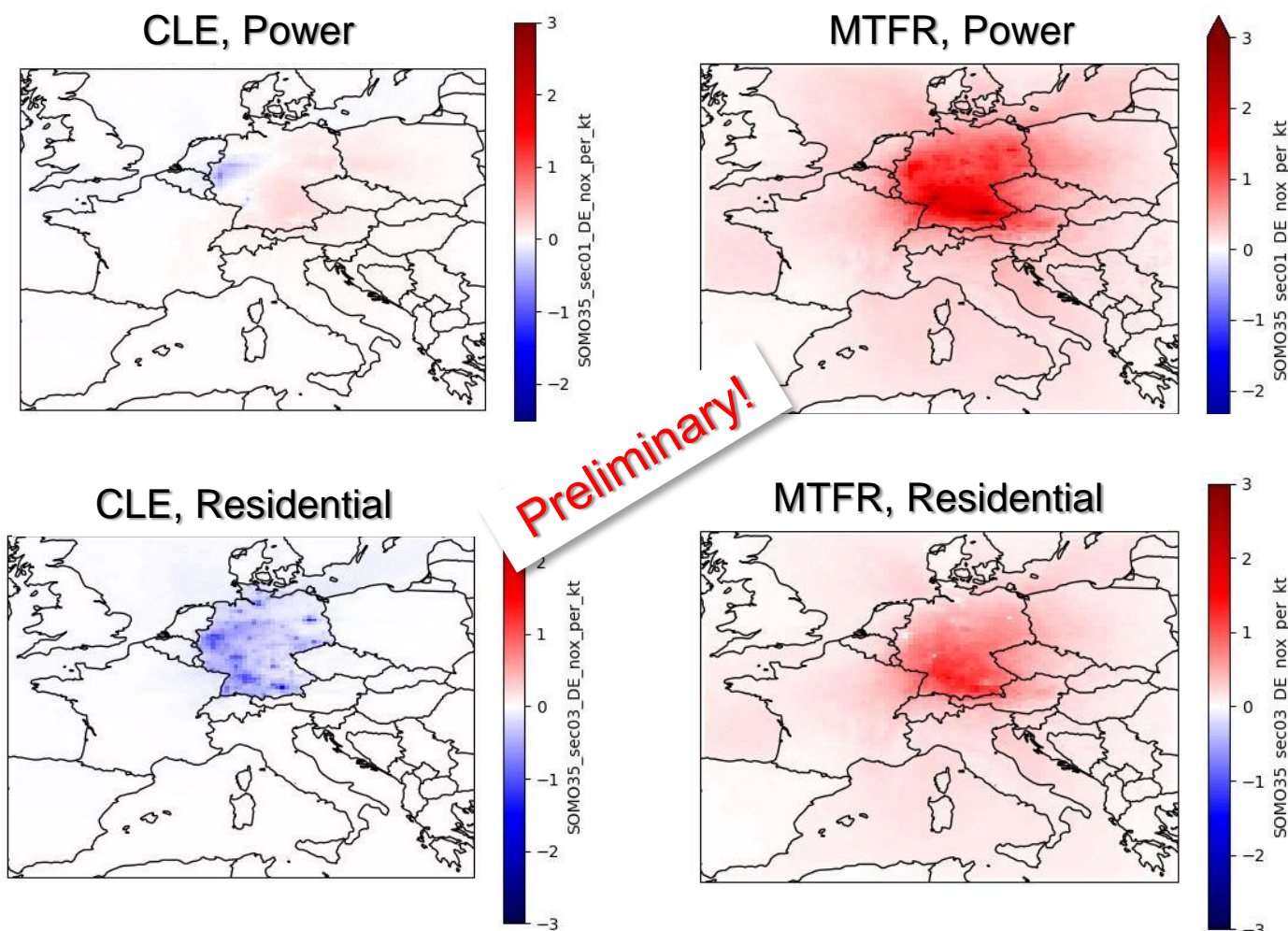
Costs distribution: combined solution with cost cap



O₃ transfer coefficients for GAINS

In planning, based on local fraction tracking in EMEP model.

Example: Effect of 1kt NO_x sectoral emission increase from Germany on SOMO35:

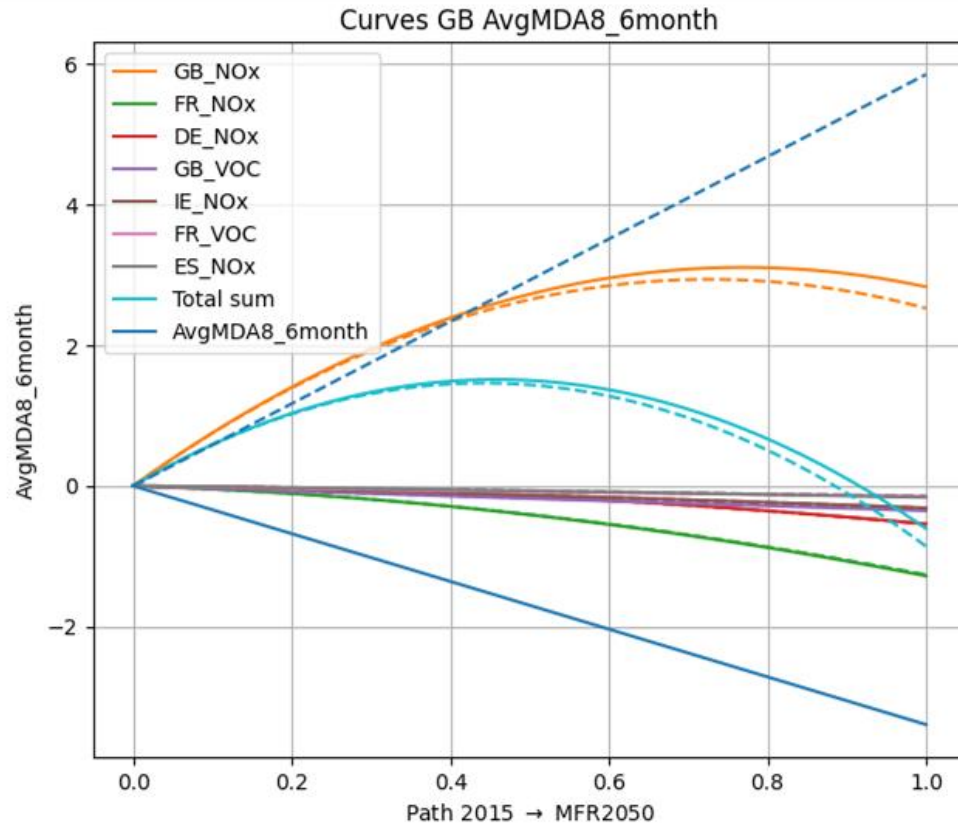


The EMEP model can now track source contributions to ambient pollution also with chemistry (see EMEP Status Report 1/2024).

We are planning to use this method to re-introduce O₃ impact calculations in GAINS. Details being currently finalized, model runs at MSC-W to start soon.

Do sensitivities depend on boundary conds?

Example: How does peak-season MDA8 in NL change when different countries change emissions along the path 2015 → 2050 MTR?



Although the absolute value depends on the boundary conditions, the sensitivities (transfer coefficients) do not!

Conclusions from test simulations

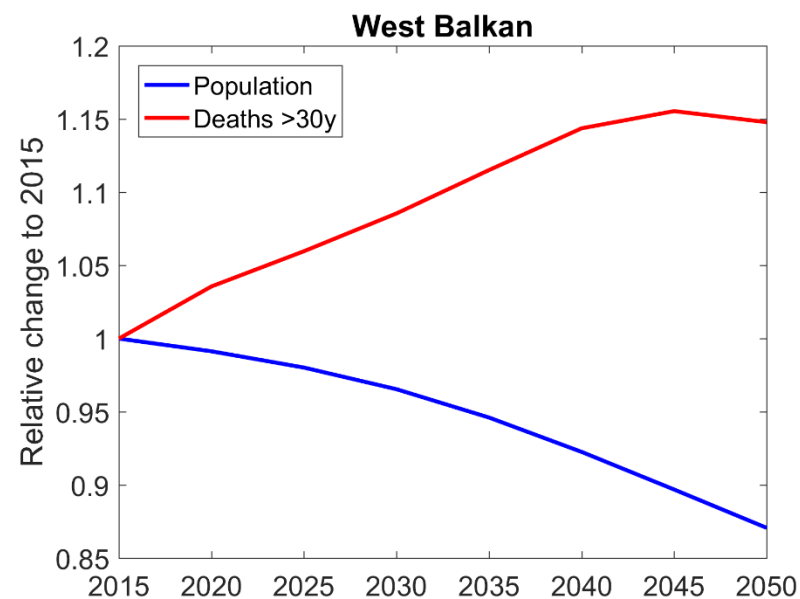
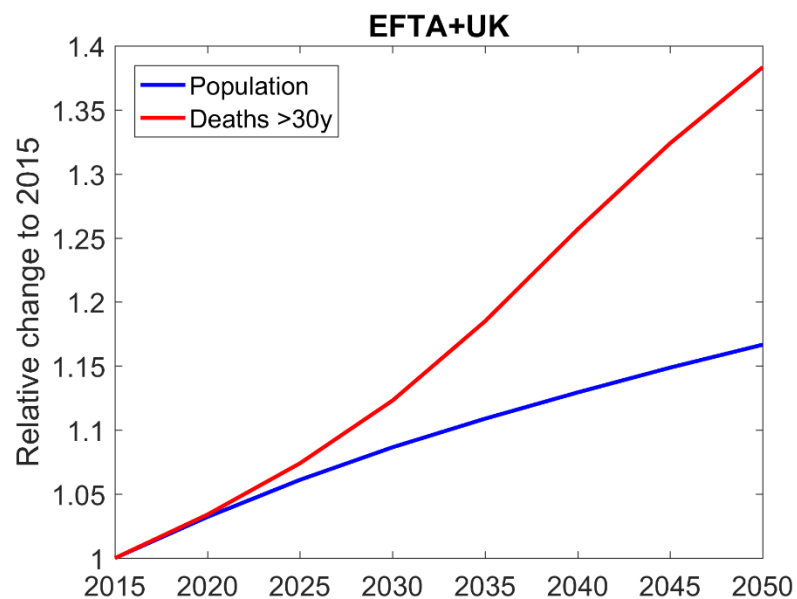
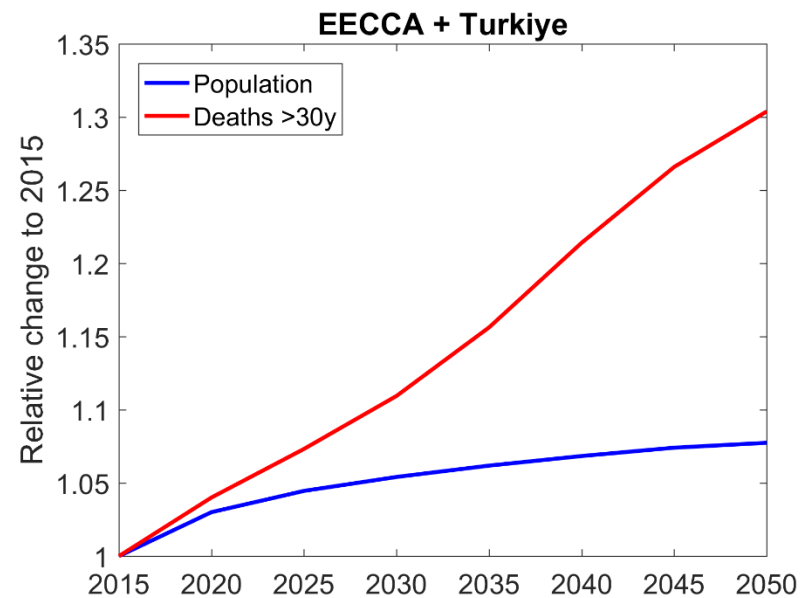
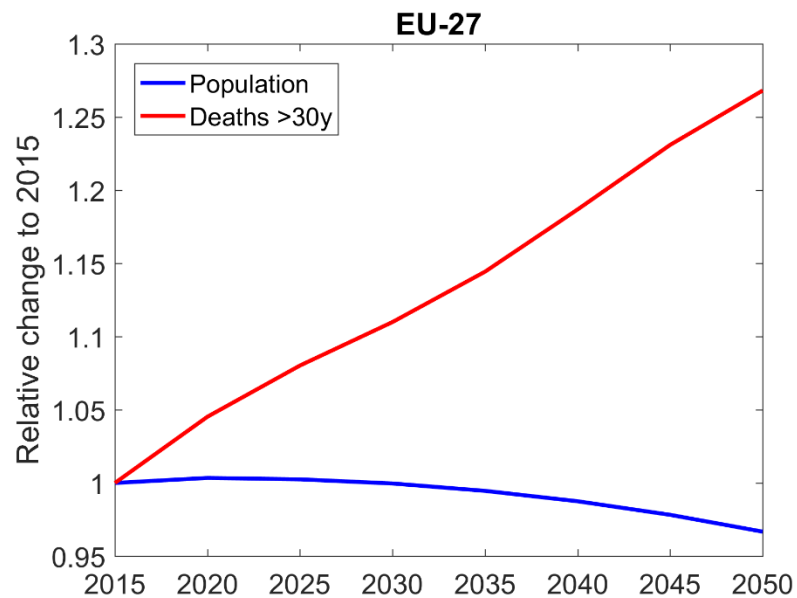
MSC-W have conducted extensive tests regarding the setup:

- Boundary Conditions:
 - The absolute value of the indicator depends on boundary conditions, but the derivatives/sensitivities are largely unaffected.
- SoilNOx scheme:
 - smaller impact on indicator but larger impact on derivative compared to changing boundary conditions
- Resolution:
 - Higher resolution does seem to induce a small bias in the total indicator, but as there is no bias in the difference of indicators, this is approximately evenly distributed between CLE and MFR
 - No clear systematic pattern in derivatives
- High versus low-level sources:
 - Important – therefore would be good to have sectoral split included
- CO:
 - Smallest impact of all of the tested ones

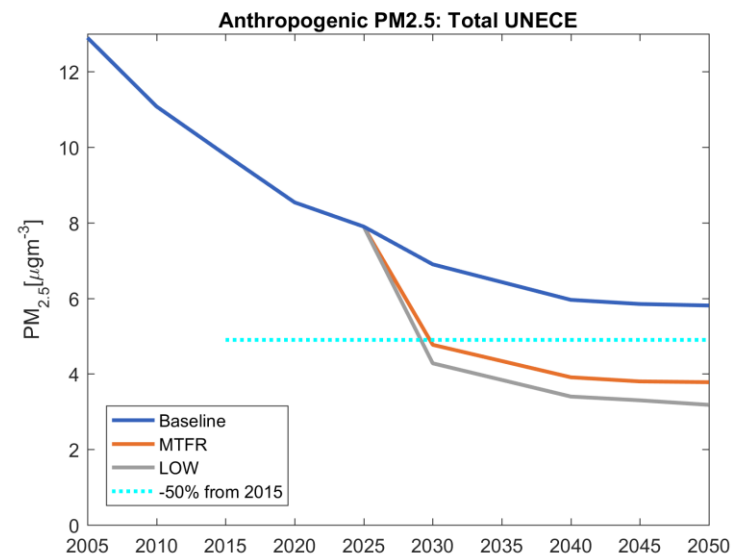
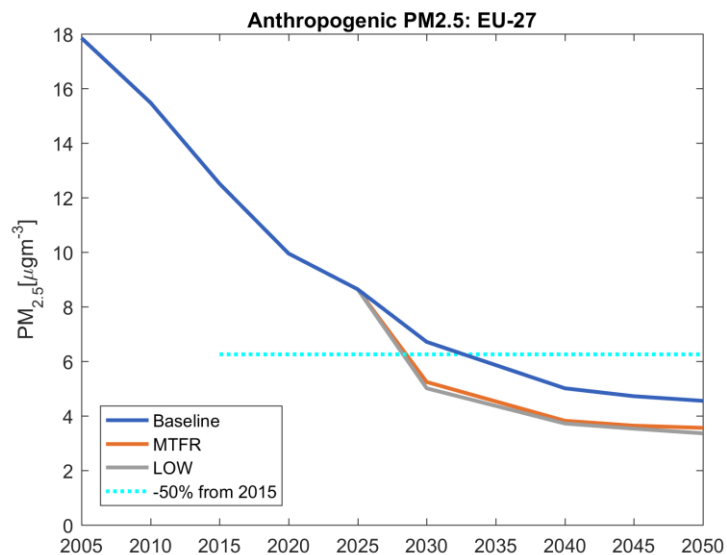
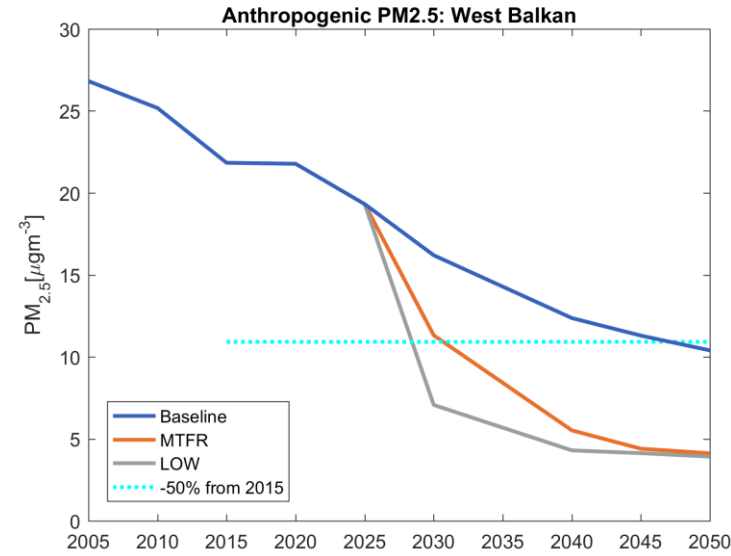
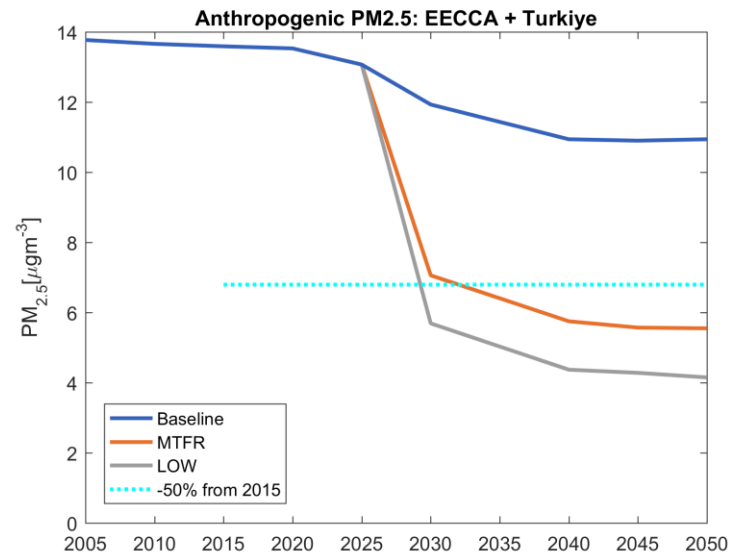
All tests finalized - final model runs about to start and will be parametrized and implemented in GAINS

Considering aging in health target setting - discussion

Mortality indicators and the impact of aging trends

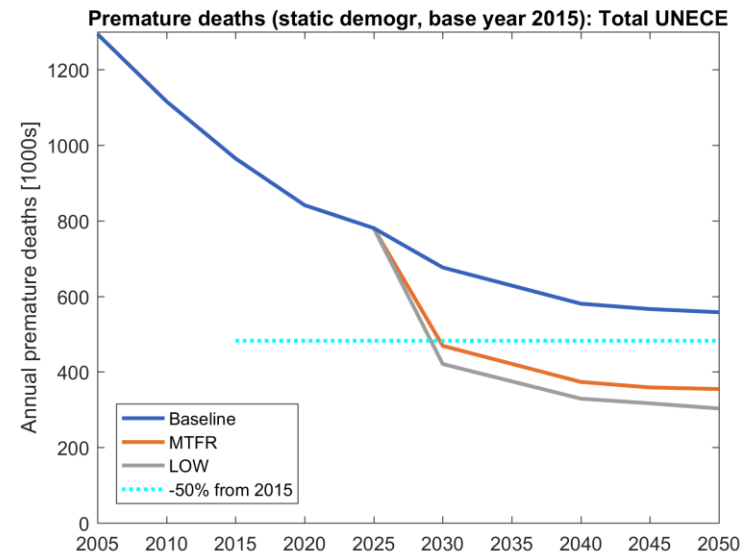
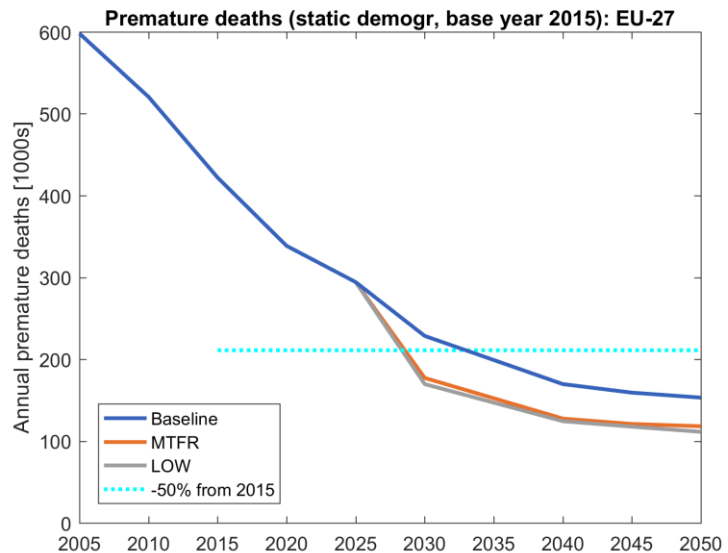
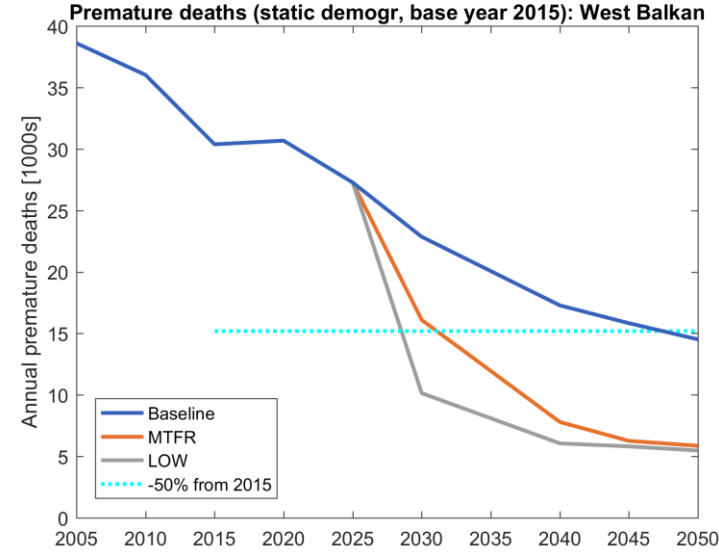
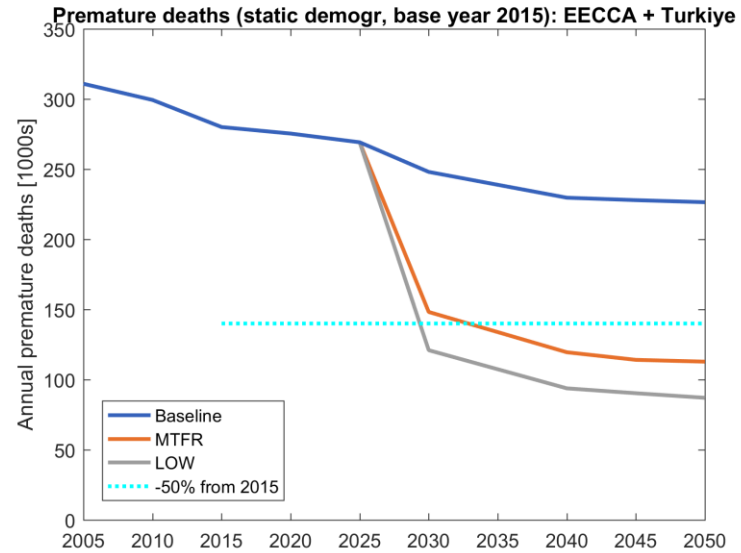


Anthropogenic PM_{2.5}



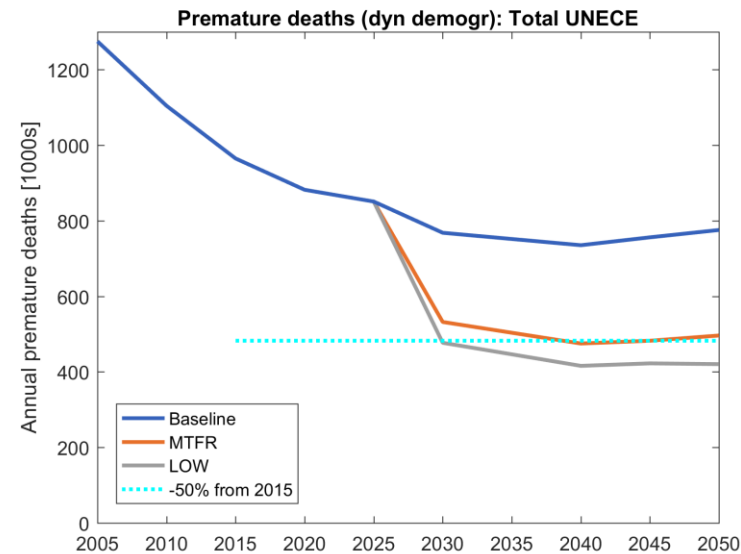
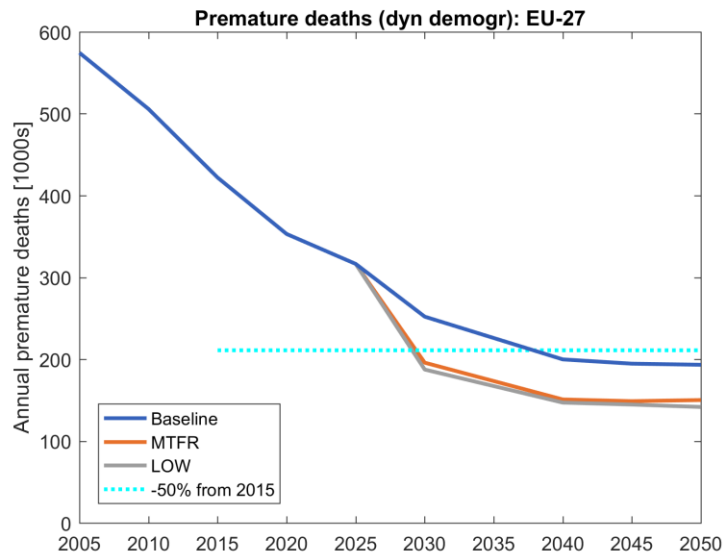
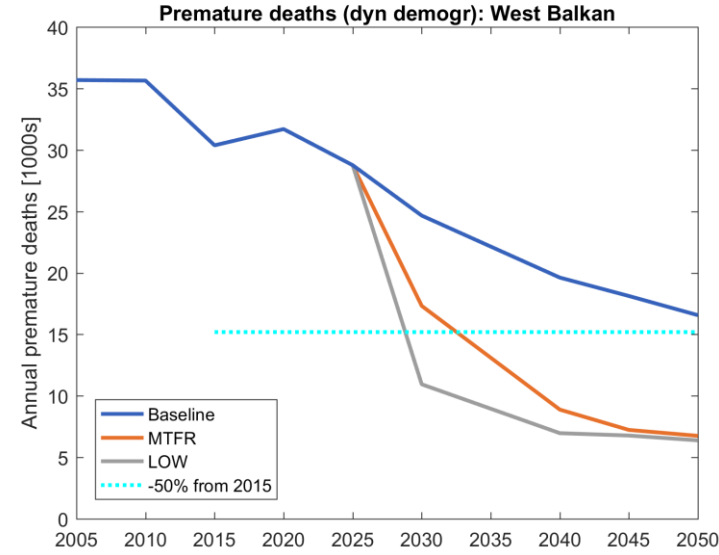
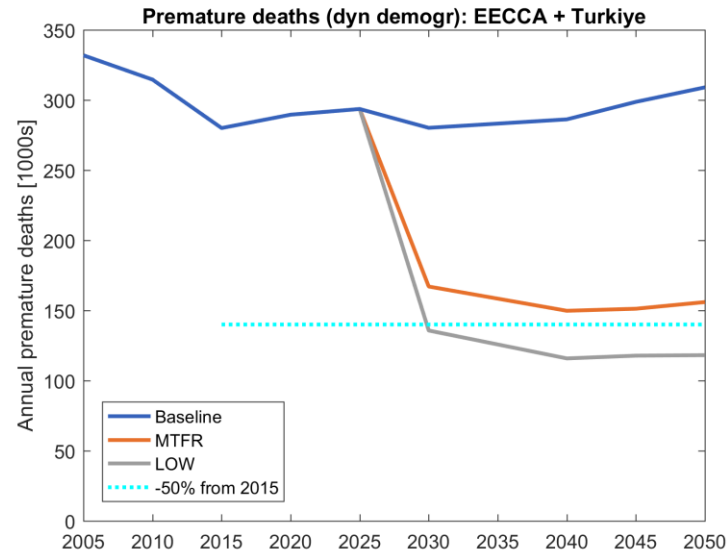
Existing legislation and plans are expected to decrease anthropogenic PM_{2.5} but to different extents in different regions. Further potential for mitigation exists, -50% from 2015 is achievable.

Premature deaths: 2015 demography



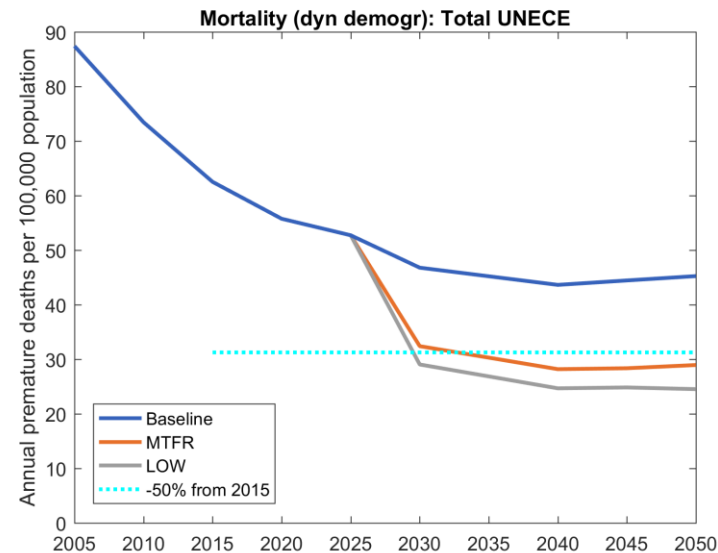
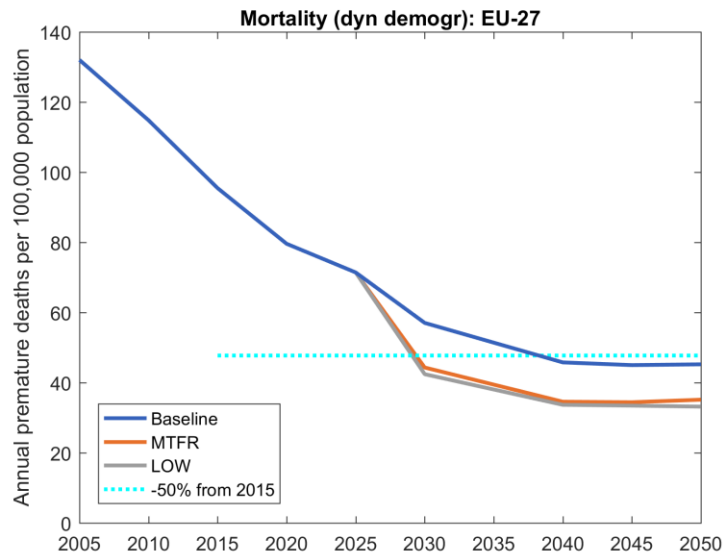
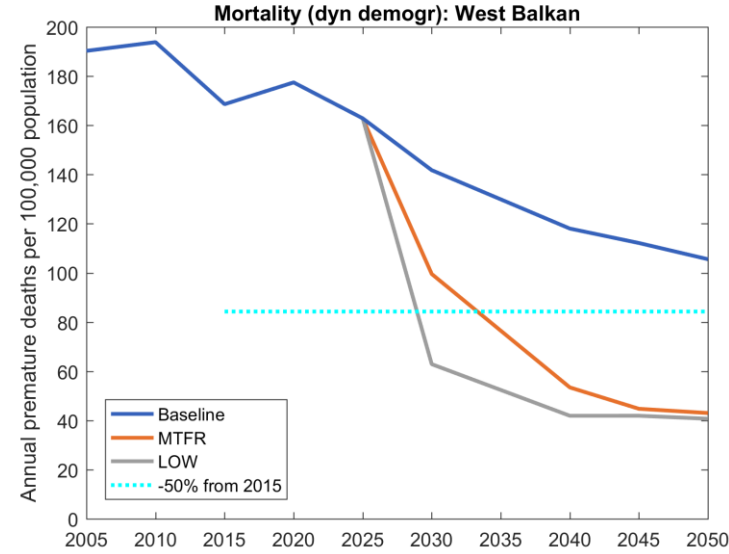
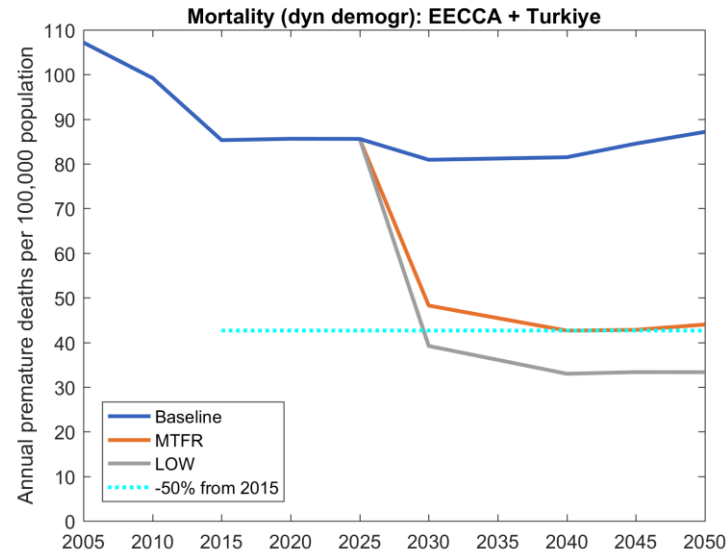
Trends for premature deaths with static demography are proportional to anthropogenic PM_{2.5}.

Premature deaths: with pop dynamics



Population aging shifts trends in expected premature deaths upwards.

Premature deaths per 100,000



Premature mortality (deaths per 100,000 people) is a better indicator for the risk to individuals.

Next steps – for discussion

- Analysis for the next WGSR
 - Varying ambition level for health goals
 - Agree on health impact assessment...discuss with TFH
 - What shall be the target for biodiversity?
 - Inclusion of NFC CLs for biodiversity ...or at least ex-post analysis for current opt solution
- Do we need CBA?
- Implementation of ozone in GAINS
 - How to define targets for joint PM+ozone health impacts?
- Towards new scenarios -> updates before WGE?
 - Capitalizing on the TAIEX meeting
 - West Balkan 2
- Work on phased approach -> need guidance
- Potentially, searching for more equitable solutions

Timeline (2024-25)

