

Integrated assessment modelling contribution to Air Convention protocols

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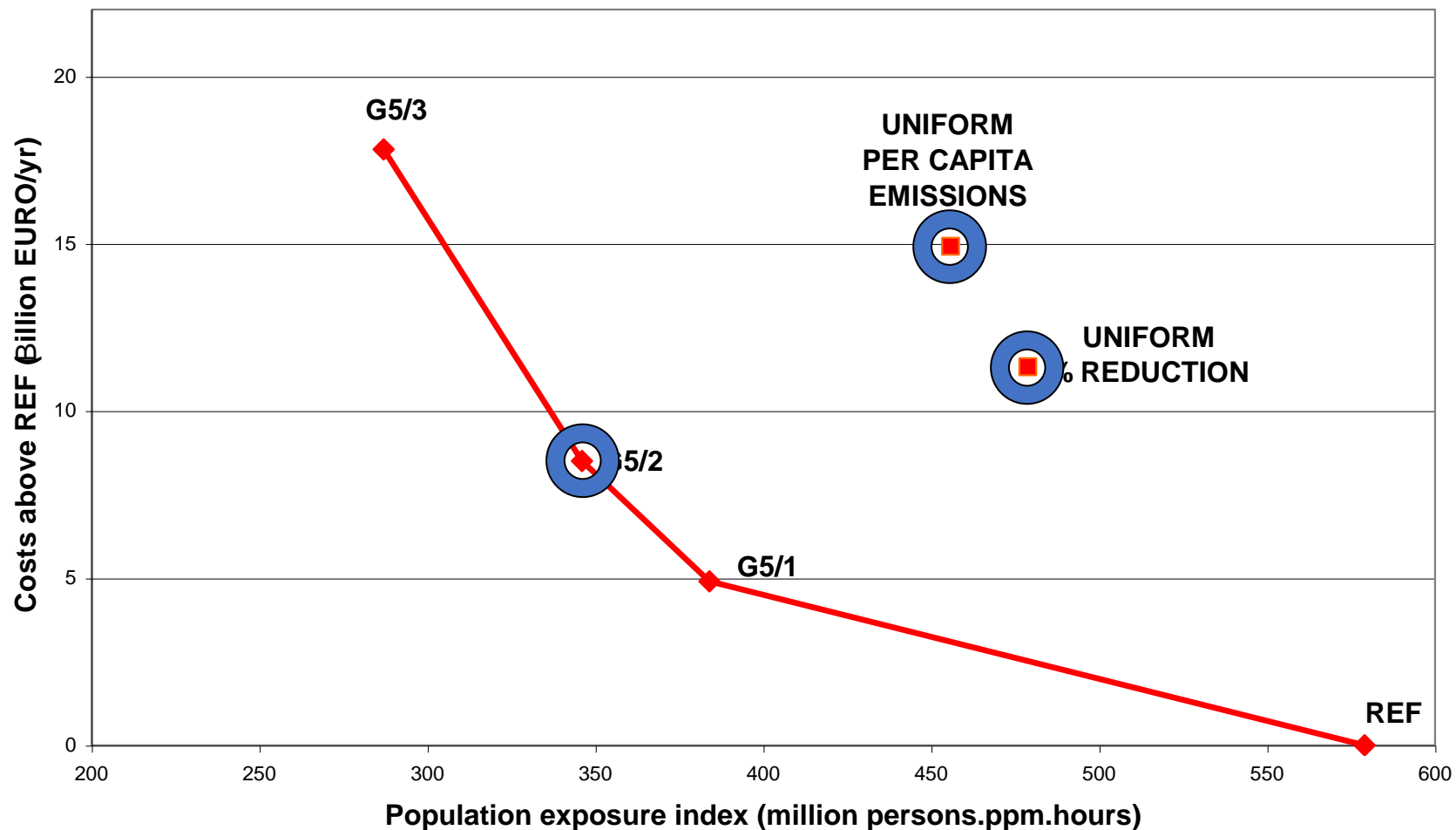
Centre for Integrated Assessment Modelling (CIAM)

International Institute for Applied Systems Analysis (IIASA)

EANET Workshop on the Relationship between the Atmospheric Environment, Human Health and Ecosystems
31 October 2022

Uniform or effect-based scenarios?

Example from discussion leading to Gothenburg Protocol (1999)



The cost-effectiveness approach

Models help to separate policy and technical issues:

Decision makers

Decide about

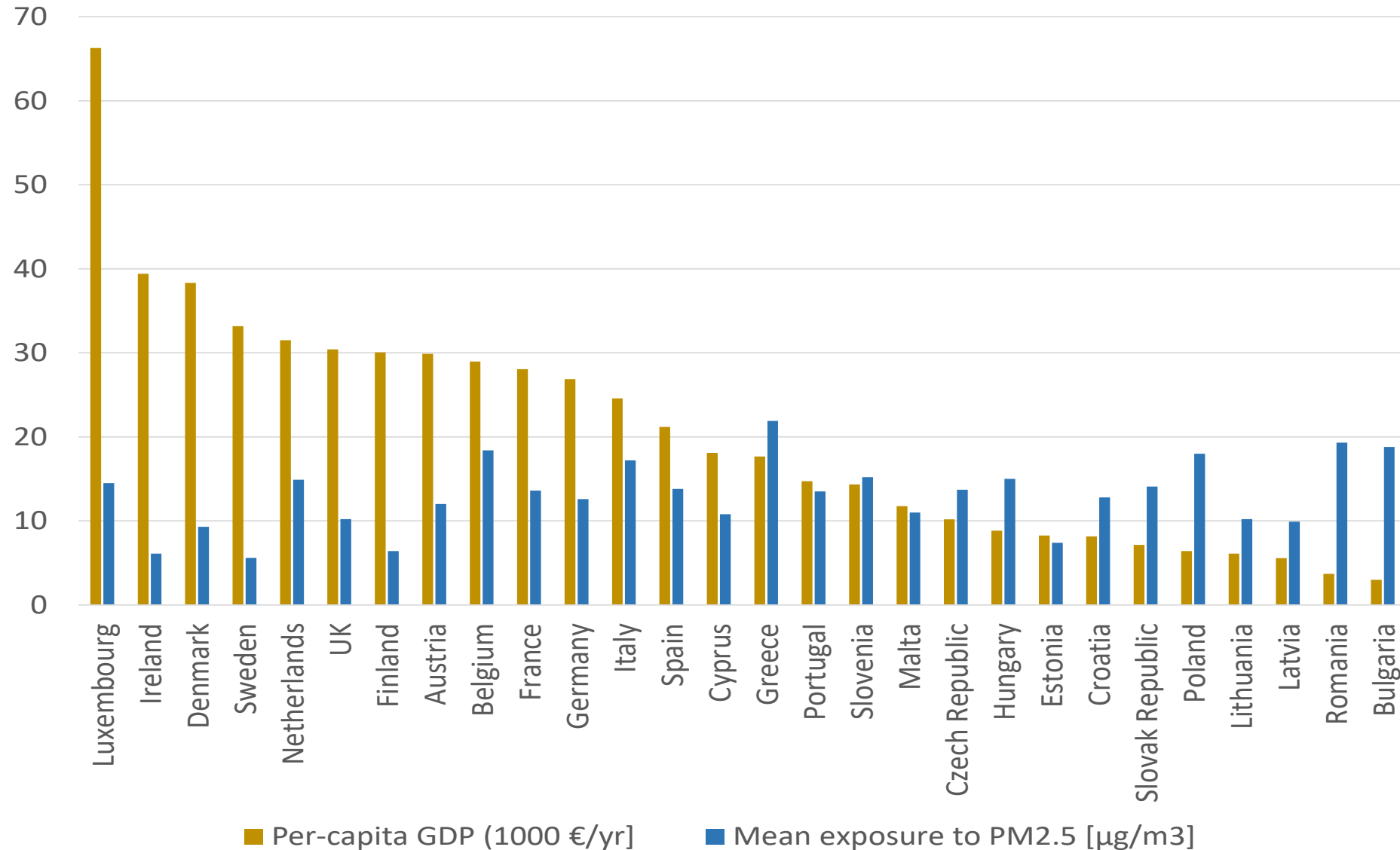
- Ambition level
(environmental targets)
- Level of acceptable risk
- Willingness to pay

Models

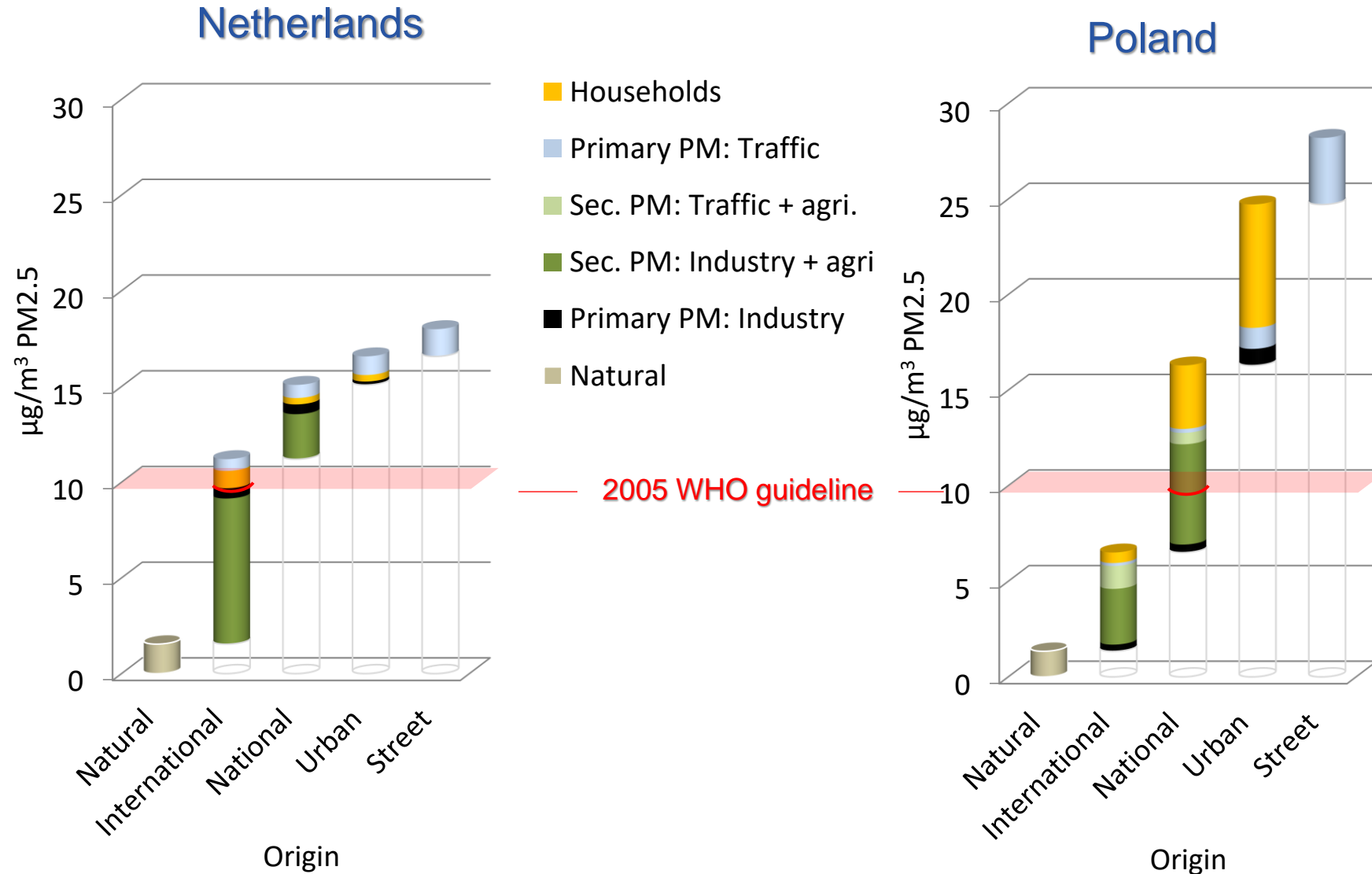
Identify cost-effective and robust measures:

- Balance controls over different countries, sectors and pollutants
- Regional differences in Europe
- Side-effects of present policies
- Maximize synergies with other air quality problems
- Search for robust strategies

There are large differences among countries in economic wealth and pollution (example for the EU)



There are large differences in the contributions of different sources to ambient PM_{2.5}



Importance of an integrated approach

Air pollution policy cannot be viewed in isolation as it is closely linked to climate and energy policies, to transport and trade policies, and to agricultural and biodiversity policies. An integrated approach takes into account the co-benefits of linking climate and air policies, and the potential impacts of action in one area on another.

Exploring synergies between air pollution policy at local, regional and hemispheric scales,....could help to identify additional cost-effective measures.

Towards Cleaner Air, Scientific Assessment Report 2016 (UNECE)

<https://unece.org/environment-policy/publications/towards-cleaner-air-scientific-assessment-report-2016>



Air pollution policy processes in Europe

1979: UN/ECE Convention on Long-range Transboundary Air Pollution (CLRTAP)

1981: European Monitoring and Evaluation Programme (EMEP) established

1985-2001:

A number of Protocols signed under the CLRTAP;
SO₂ (1985, 1994), NO_x (1987), NMVOC (1991), HM (2001)

1997: EU Acidification strategy

1999: Gothenburg Protocol [multipollutant] (1999),

2001: EU National Emission Ceilings (NEC) Directive

2005: EU Clean Air For Europe (CAFE) strategy proposed (*incl. for the first time targets for PM*)

2007-14: Review of the EU NEC Directive

2008-12: Review of the Gothenburg Protocol

2016-17: New EU NEC Directive ceilings signed and first progress report (1st Clean Air Outlook)

2019: 2nd Clean Air Outlook

2020-21: European Green Deal and *Fit for 55* legislation package

2021-22: Review of the Gothenburg Protocol

2021-22: Impact assessment of the revision of the EU Air Quality Directives

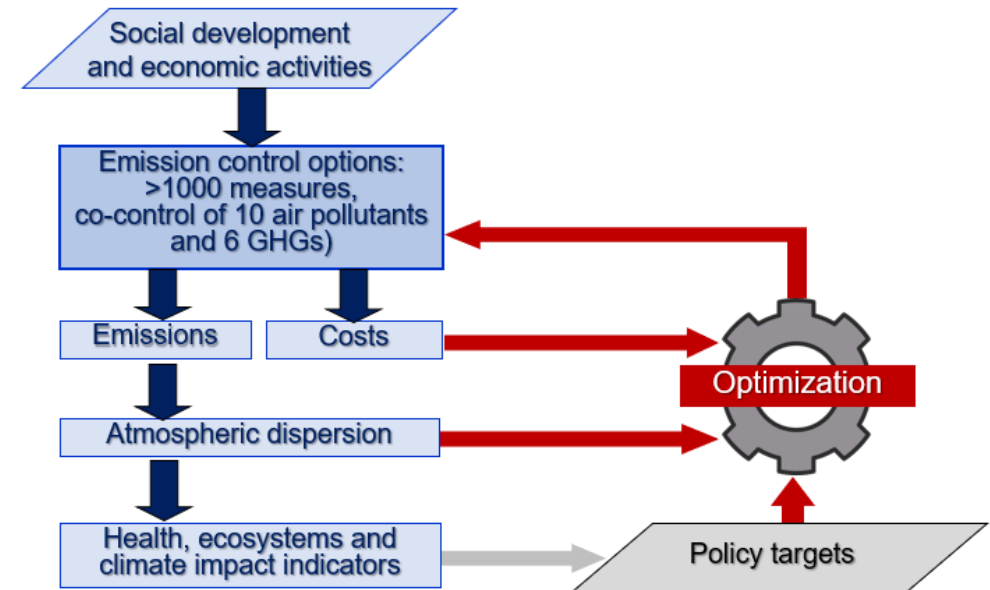
2022: 3rd Clean Air Outlook

Purpose of IAMs in UNECE LRTAP and Revision of the EU air quality policy

- Assess future situations based on current trends and policy interventions
- Identify cost-effective and win-win packages of policy interventions
- Reveal multiple benefits of policy interventions for diverse stakeholders

GAINS: A tool for a systematic assessment of the cost-effectiveness of emission control strategies

- GAINS quantifies sectoral emission control potentials and costs,
 - for exogenous (governmental, international agencies) activity projections,
 - considering physical and economic interactions between pollutants.
- Search for least-cost mix of mitigation measures to meet air quality and/or GHG targets
- GAINS is implemented for Europe, Asia, several single countries, and globally.



Towards revision of the Gothenburg Protocol in 2012

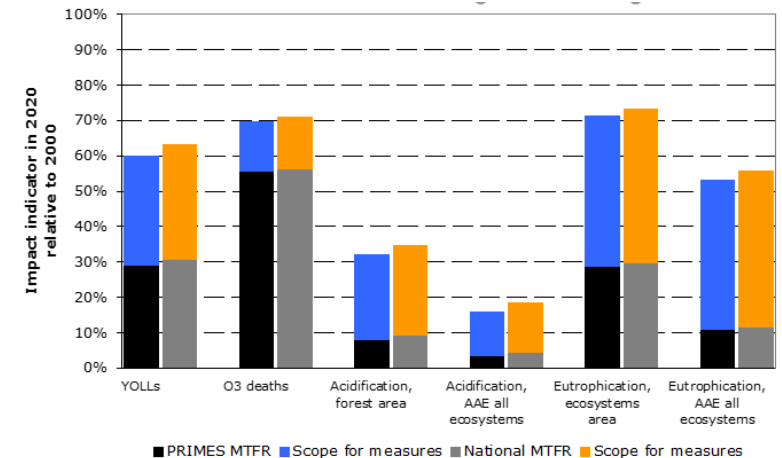
*The cost-effective distribution of efforts depends on the distribution of environmental targets:
Four options for target setting (TFIAM/CIAM analysis supported by Working Group on Strategies)*

Environmental targets for a cost-effectiveness optimization

- must be achievable in all countries,
- should result in internationally balanced costs and benefits.

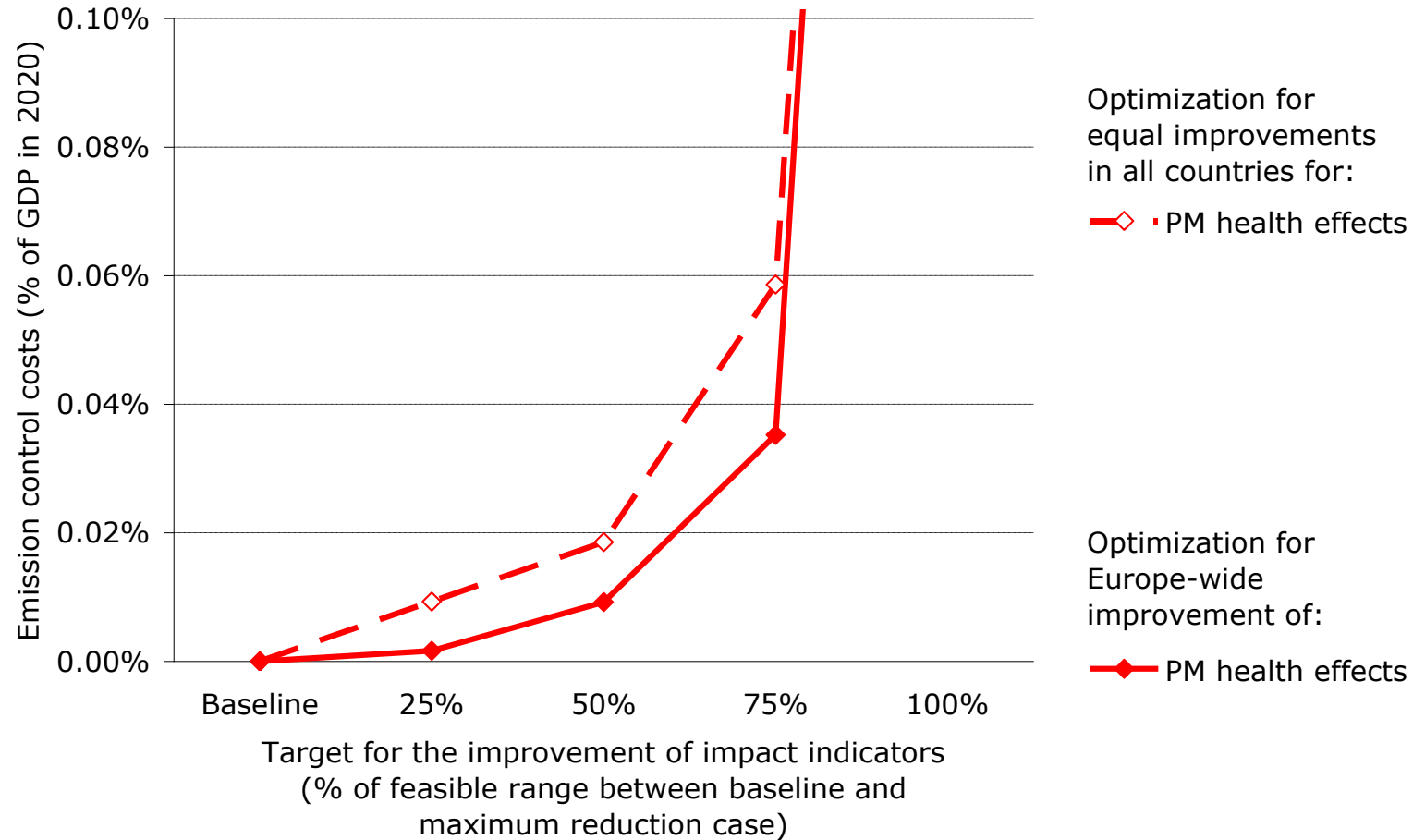
Four options analyzed with GAINS:

1. Uniform absolute targets ('caps') on environmental quality (in terms of impact indicators)
2. Equal relative change ('gap closure') in impact indicators compared to a base year
3. Equal portions of the possible improvements in each country (equal 'gap closure' between Baseline and MTFR)
4. Europe-wide improvements at least cost



Option 4: Achieve improvements Europe-wide at least costs

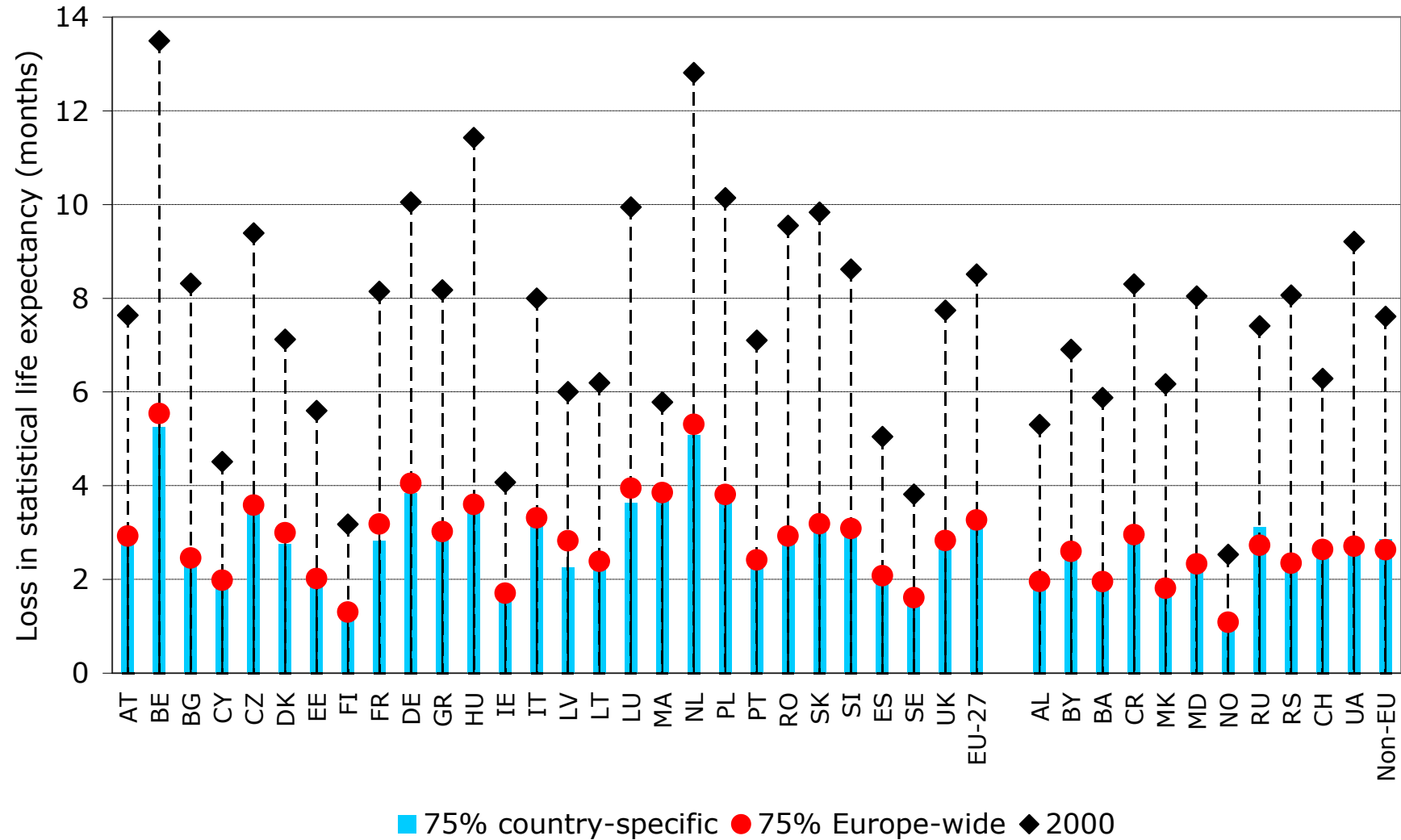
Costs for YOLL target



Illustrative results!

Loss in statistical life expectancy

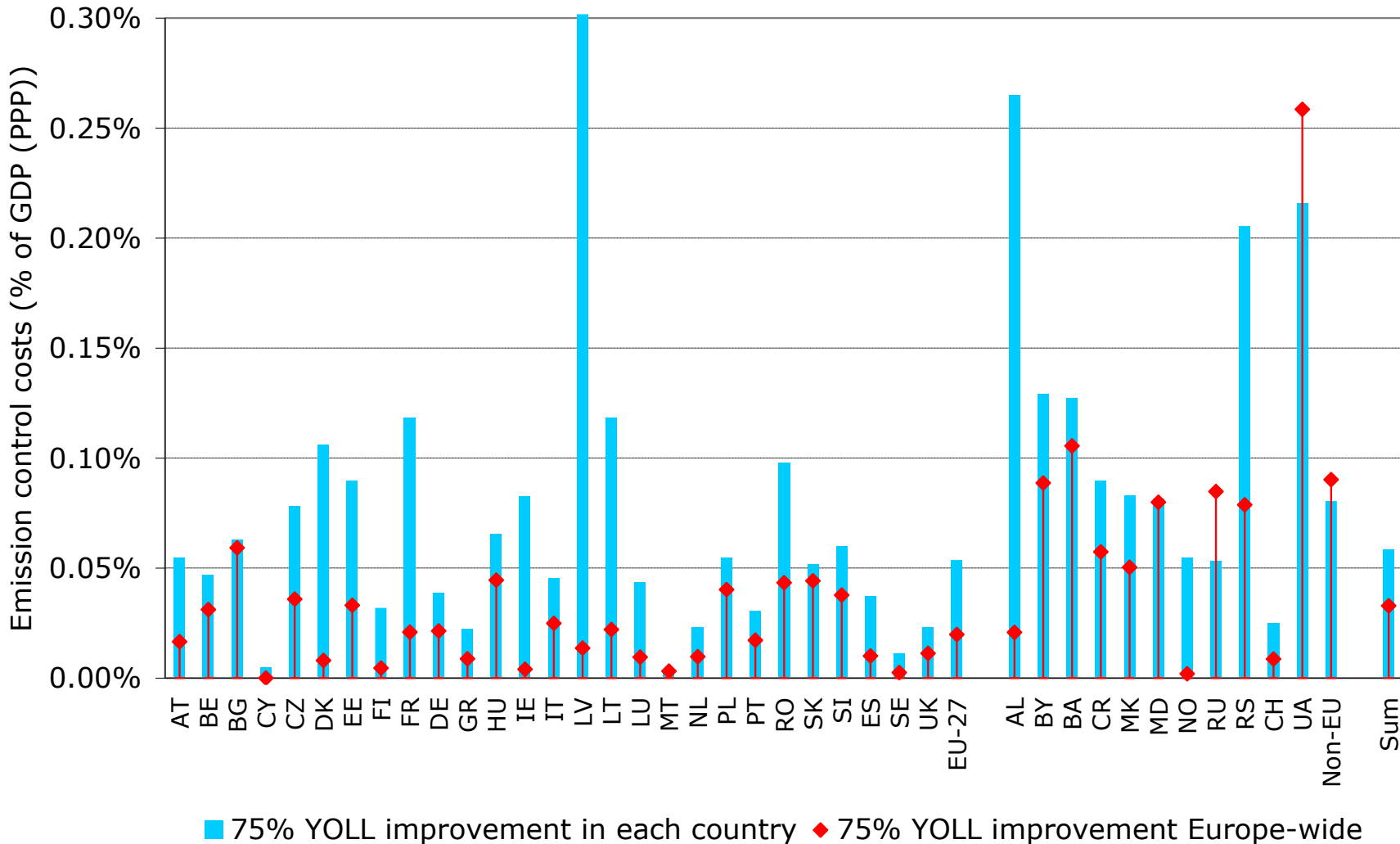
75% improvement, country-specific vs. Europe-wide



Illustrative results!

Emission control costs (on top of CLE, per GDP)

75% improvement in YOLL, country-specific vs. Europe-wide



Conclusions:

1. Additional measures imply higher burdens in non-EU than in EU countries
2. Costs are strongly influenced by countries driven to extreme targets
3. EU-wide target smoothes out distribution of burdens

Illustrative results!

Conclusions from the analysis of the 4 options

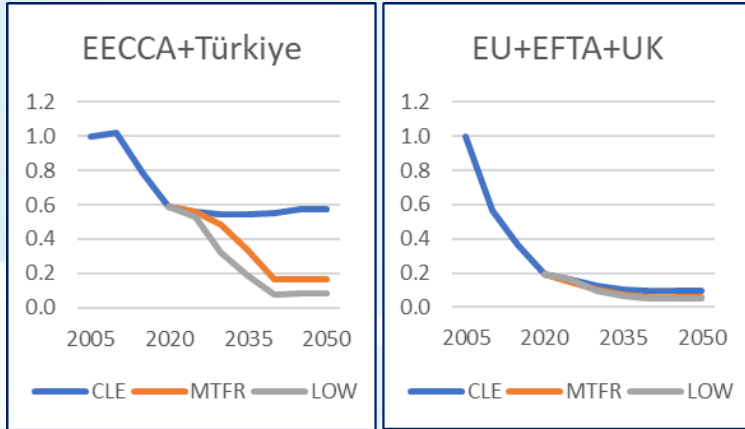
The target setting approach will determine the ambition level and distribution of costs:

1. Uniform absolute caps on environmental quality indicators will not produce equitable distributions of reduction costs.
2. Equal relative improvements compared to a base year (e.g., 2000) are constrained by countries with untypical situations.
3. 'Equal portions of the possible improvements' targets lead to more equitable distributions of costs, but are sensitive to weakly defined baselines and MTRs.
4. Larger spatial flexibility will reduce total costs, but result in uneven environmental benefits (might be acceptable for YOLLs, but questionable for ecosystems.)

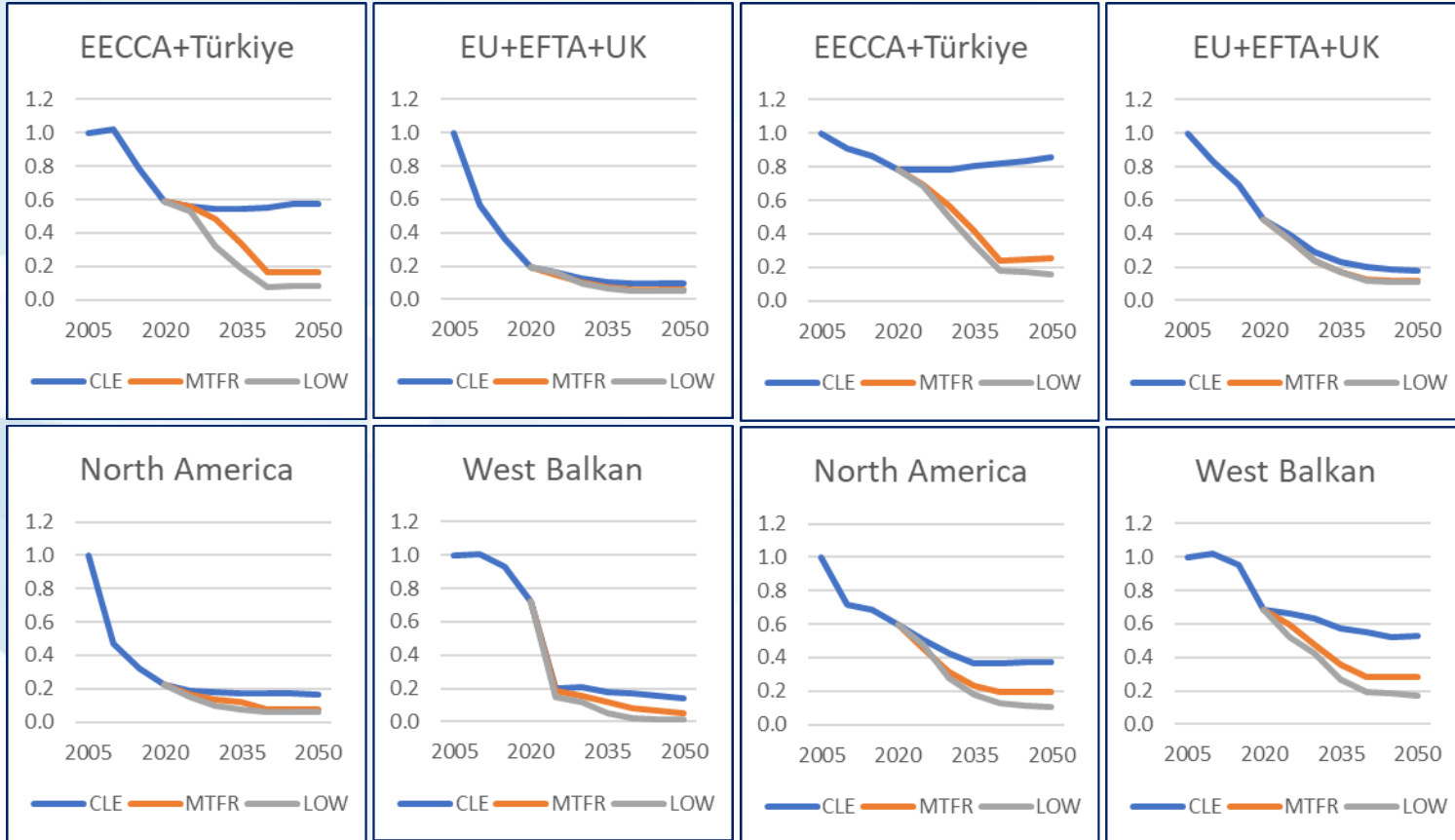
Review of the Gothenburg Protocol – 2021-22

Emission trends and mitigation potential in the UNECE region (1)

Sulfur dioxide (SO₂)



Nitrogen oxides (NO_x)

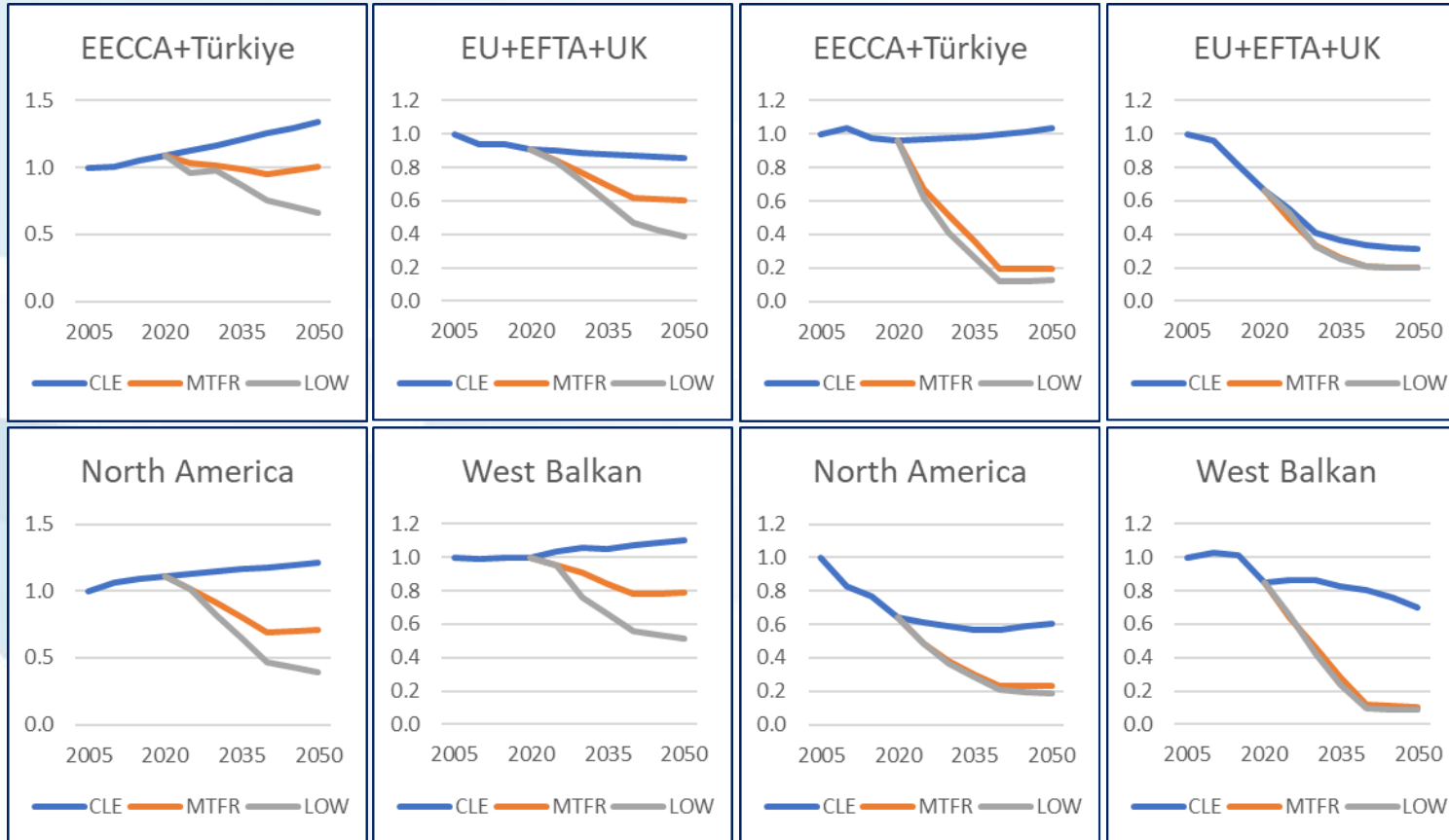


- For SO₂ – apart from EECCA, most of the further mitigation potential committed in current legislation – assuring enforcement essential!
- For NO_x – similar picture to SO₂, although larger mitigation potential available;
Remote sensing data (and N deposition measurements) indicate that emission inventories overestimate decline in emissions in the last decade

Source: GAINS model

Emission trends and mitigation potential in the UNECE region (2)

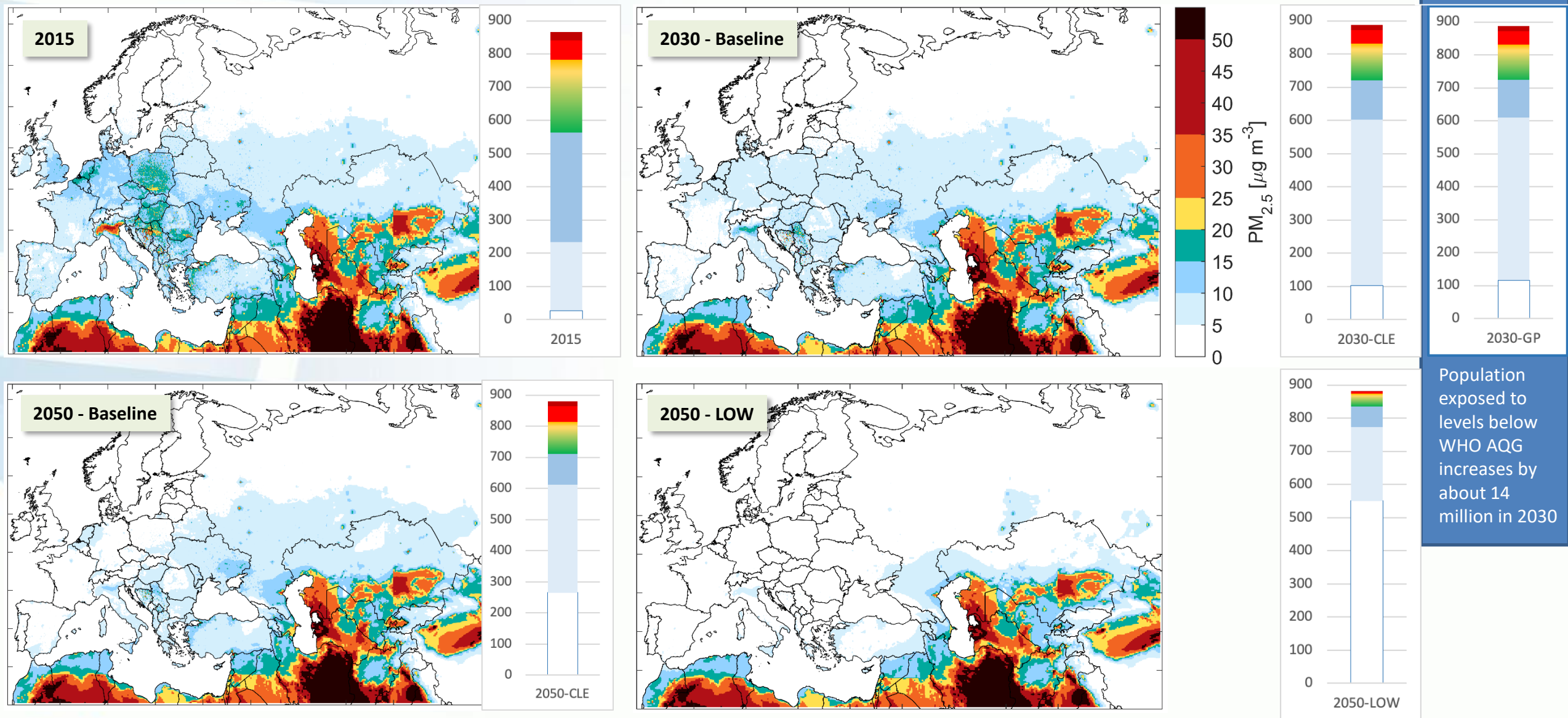
Ammonia (NH₃)



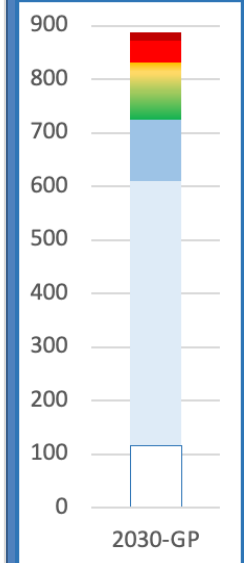
Source: GAINS model

- For NH₃ – current policies include little mitigation, similar further potential exists across all regions; Overall mitigation potential much smaller than for other air pollutants - need for structural and behavioral changes
- primary PM_{2.5} – large potential exists in some regions, especially in EECCA and West Balkan (industry and residential sector coal and wood)
- The newly developed ‘LOW’ scenario offers significant further mitigation for NH₃ only, and co-benefits for methane (not shown); for SO₂, NO_x, PM_{2.5}, additional mitigation not large but in relative terms might halve emissions in 2050

PM_{2.5} concentrations and population exposure (mln)

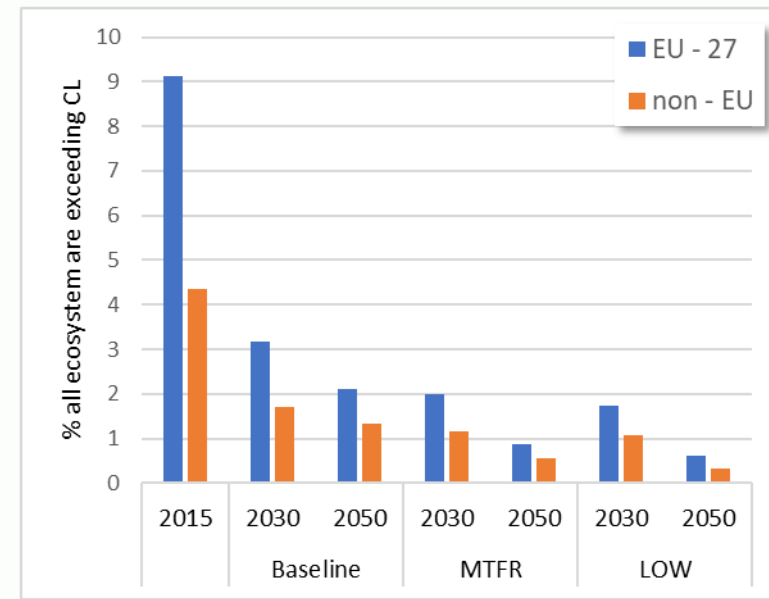
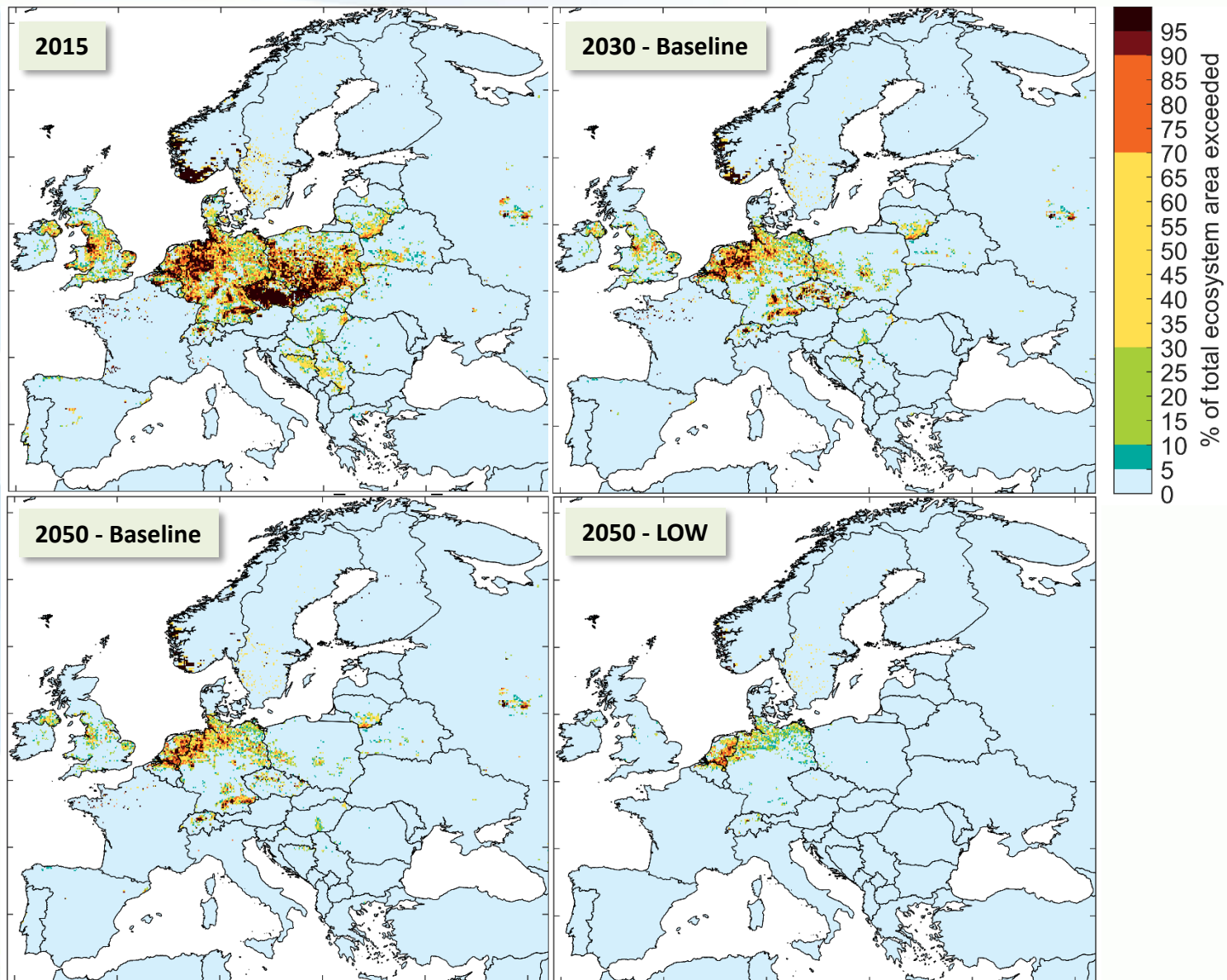


GP compliance



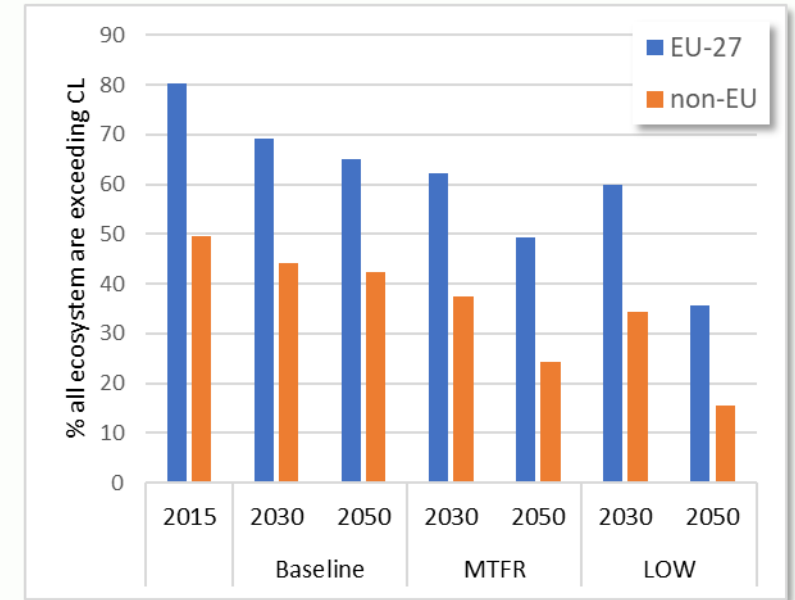
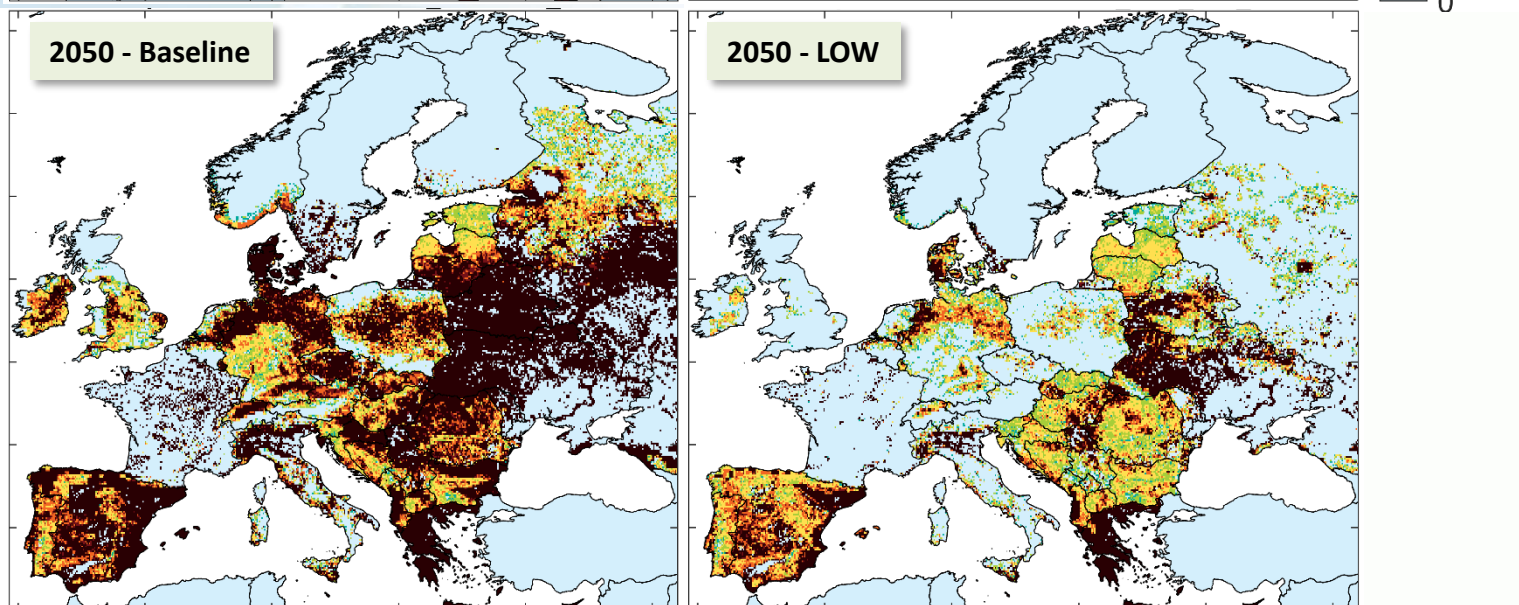
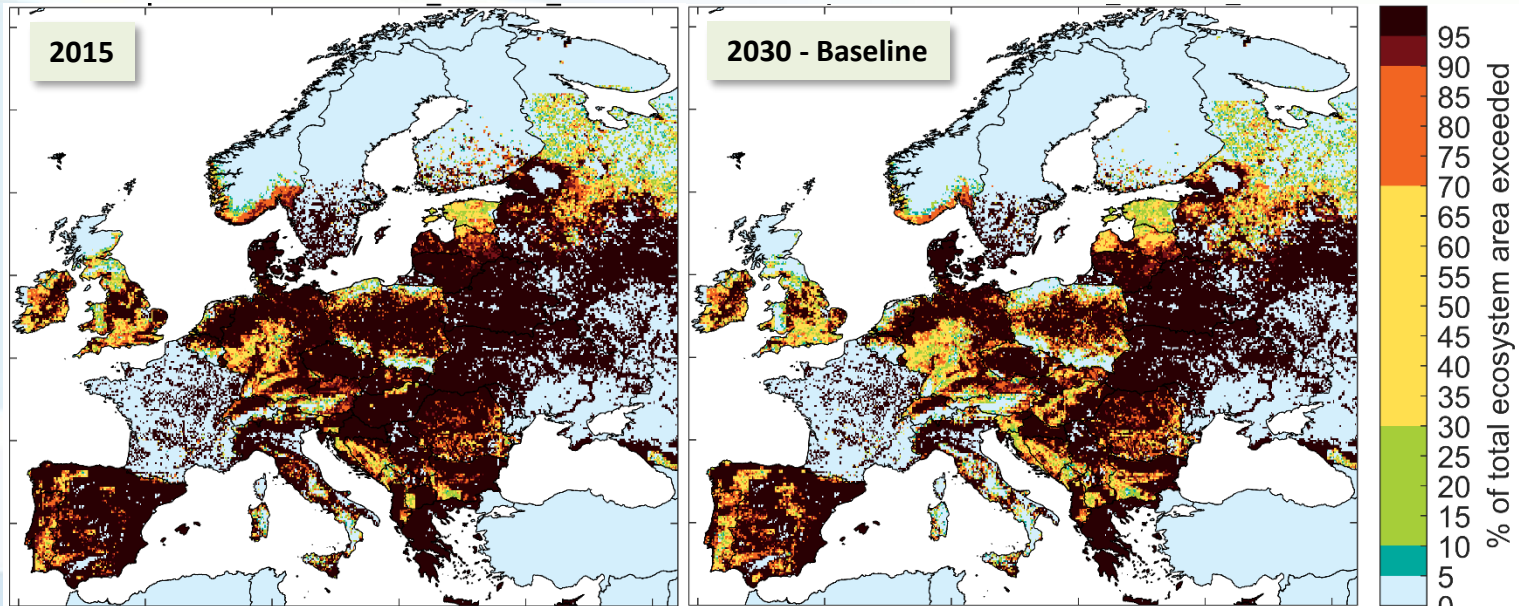
Population exposed to levels below WHO AQG increases by about 14 million in 2030

Acidification



Compared to the *Baseline*, achieving GP ceilings in 2030, could reduce ecosystem area where CLs are exceeded by about 6%, i.e., ~4,700 km² [not shown in the charts above]

Eutrophication



Compared to the *Baseline*, achieving GP ceilings in 2030, could reduce ecosystem area where CLs are exceeded by about 1%, i.e., ~17,000 km² [not shown in the charts above]

Air pollution policy processes in Europe

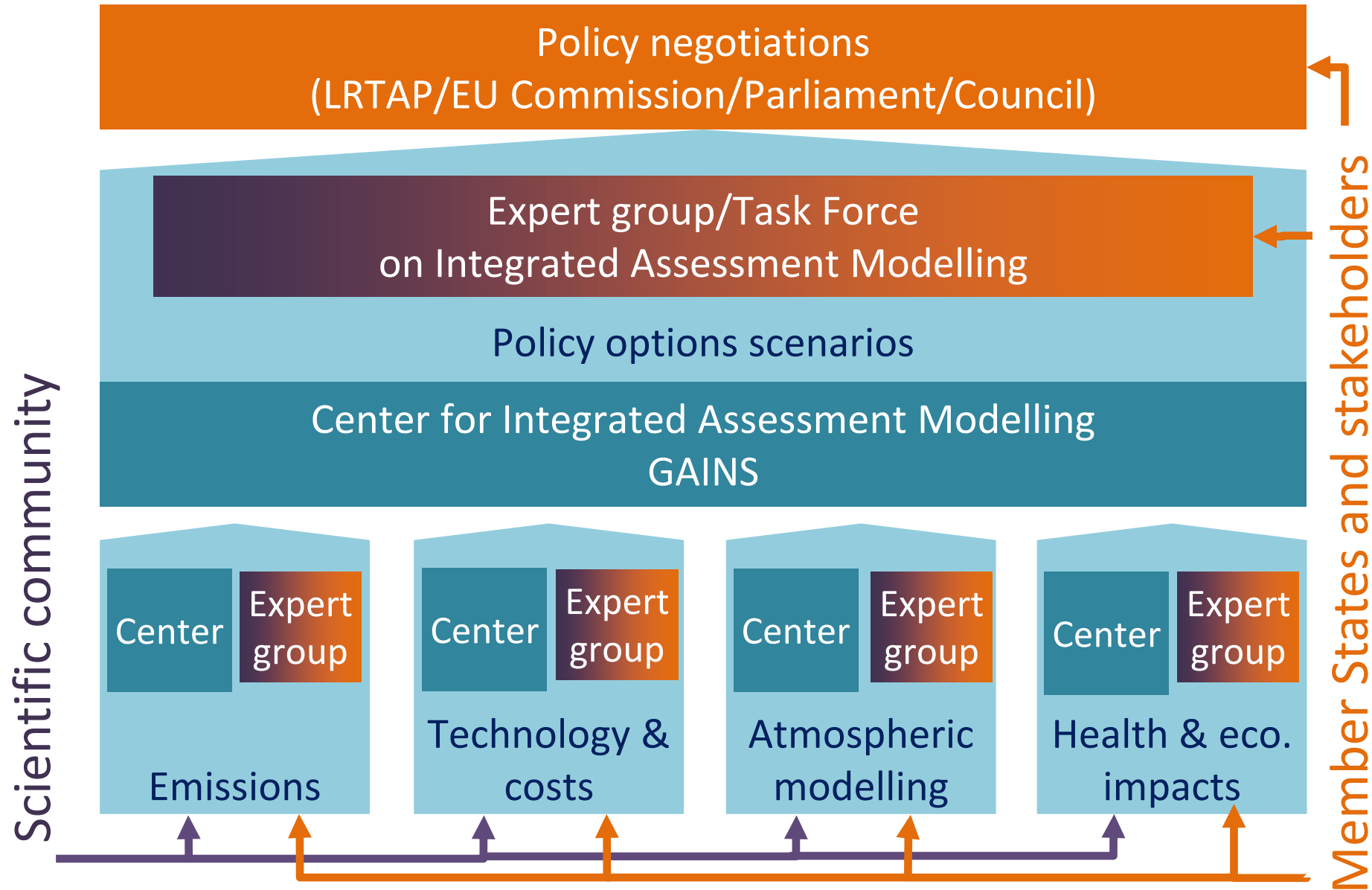
- Regional air quality policy process initiated by signature of the LRTAP Convention (1979)
- Change in approach: LRTAP SO₂ protocol (1994) - models were used for the first time
- Multi-pollutant/multi-effect approach introduced in Gothenburg Protocol (1999) and EU acidification strategy (1997-2001) and applied in revised GP (2012), EU NECD (2013, 2016)
- Lessons learned so far (policy-science perspective)
 - Science has a role helping to separate policy and technical issues
 - Building trust in science results takes time
 - Robustness of results often more important than presentation of uncertainties
 - Cost-effectiveness approach has been accepted but will be always confronted with equality/fairness of burdens
 - Involving stakeholders from industry, NGOs essential

Scientific tools like GAINS can reveal win-win solutions that facilitate support from different interest groups

Four essential ingredients:

- **Credibility:**
 - Robust science, appropriate methods, peer review
- **Salience:**
 - Illustrating consequences of alternative policy decisions
- **Transparency:**
 - ‘Black box’ models are not helpful
- **Legitimacy:**
 - Participatory process, not one-time publication
 - Institutions (IIASA serves as an impartial broker)

Policy analysis: Institutional arrangements in Europe



Utilizing IAM results to support science-based, policy-oriented cooperation

CIAM (Center for Integrated Assessment Modelling): ingredients for success

- Open access to model and data
- Regular scientific peer review
- Data input: Structured data input from WGs/centers – approved by consensus
- Regular reviews of key outcomes by TFIAM
- Regular participation of CIAM in other working groups/scientific networks
- Regular consultations with national experts and other stakeholders

Center or Ensemble approach?

- Originally three IAMs in Europe - Now links to national analyses/models