International Institute for
Applied Systems Analysis
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science for global insight

Cost-effective ways to improve air quality

The GAINS model to support effective policy making

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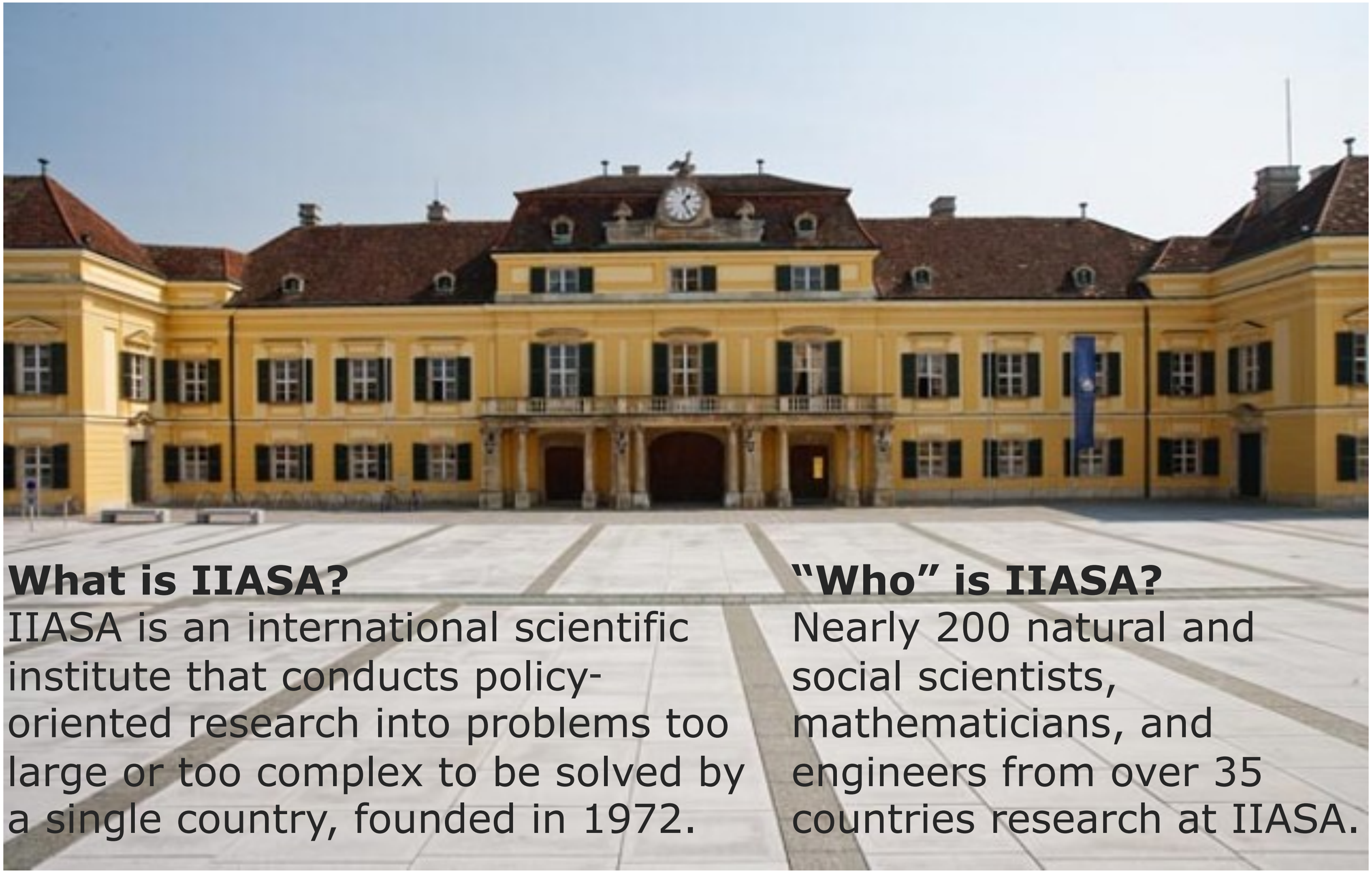


What is IIASA?
IIASA is an international scientific institute that conducts policy-oriented research into problems too large or too complex to be solved by a single country, founded in 1972.

"Who" is IIASA?
Nearly 200 natural and social scientists, mathematicians, and engineers from over 35 countries research at IIASA.

Consulting EU Commission on Air Quality Strategy since 90'ies

Complex interactions between economic activities, impacts and potential measures

Acid rain/forest loss

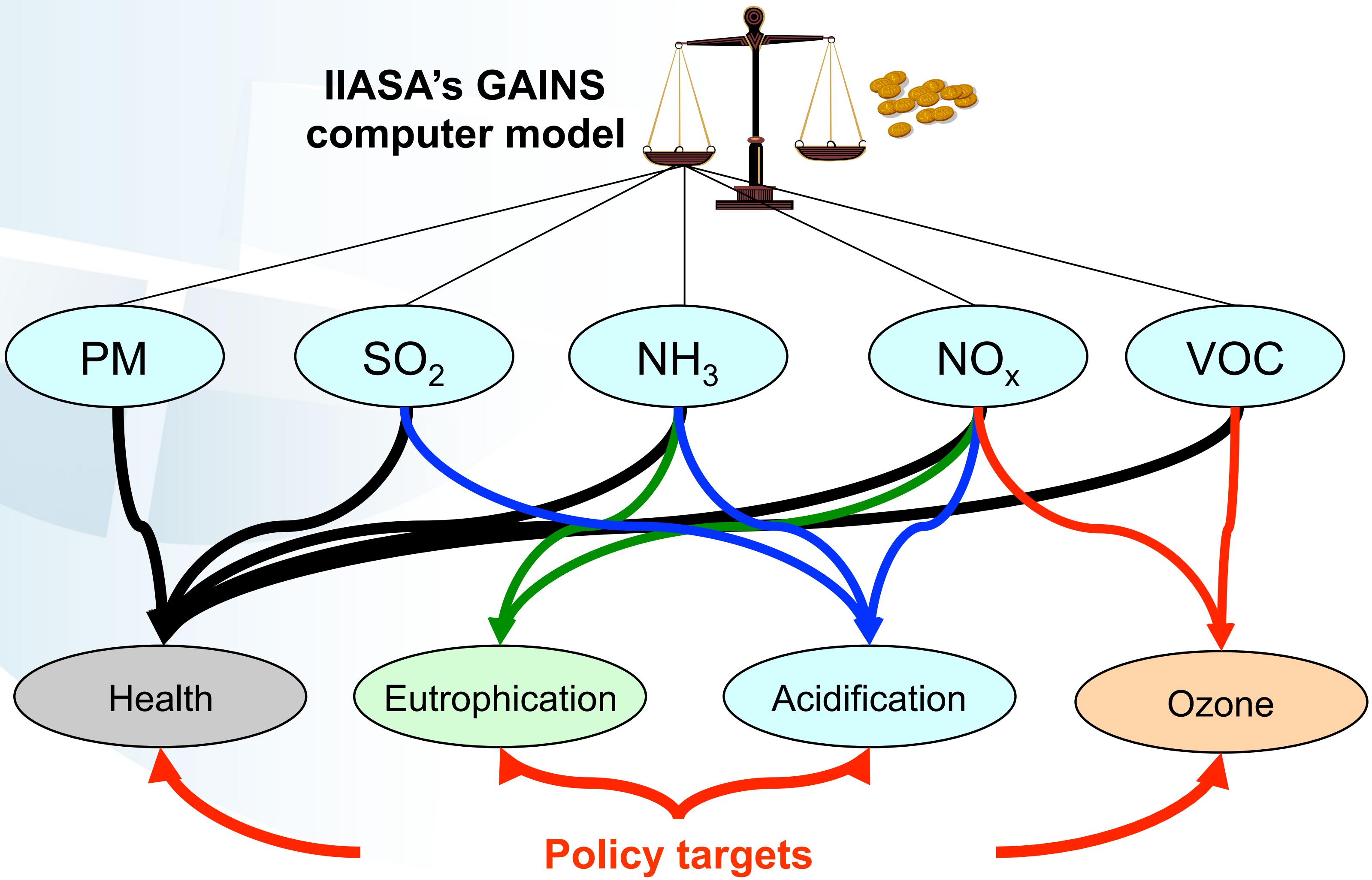
Economic driver / source of pollutant

Central questions for policy makers

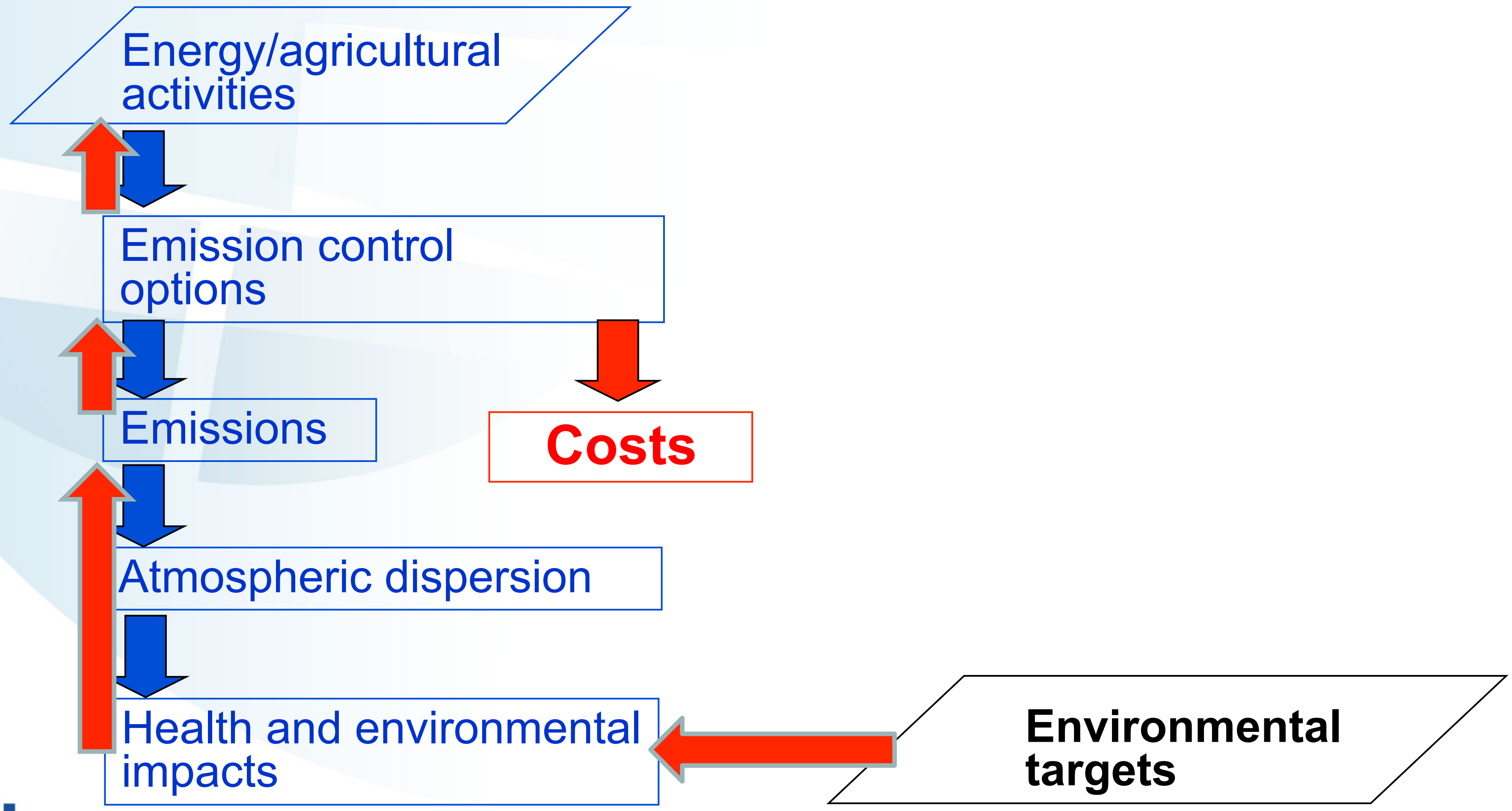
- What impacts in future from current policies?
- What reductions are technically feasible?
- How much do they cost? – optimal/non-optimal
- Who (which countries) pay(s)?
- How much are they willing to pay?
- Who benefits?
- Is it enough?
- Is it fair?

Concurrent impacts – multiple pollutants – complex interactions

policy needs analysis for cost-effective decisions



The GAINS model follows impact pathway - effective policy should start from targets



Central questions for policy makers

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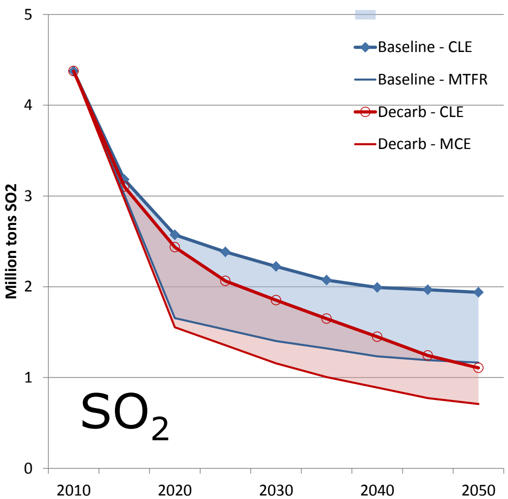
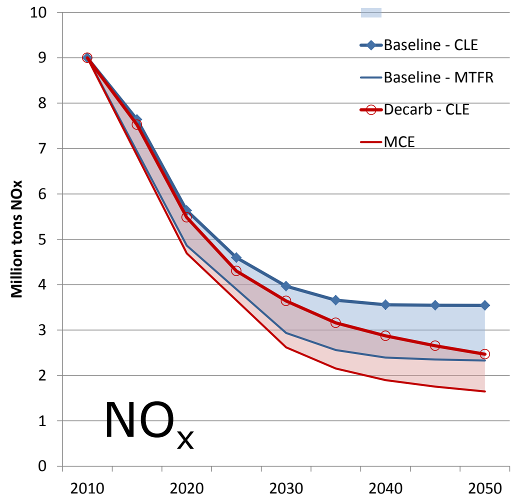
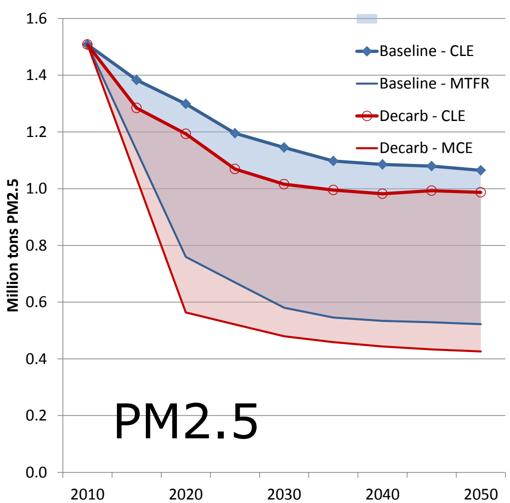
Emission scenarios for EU-28

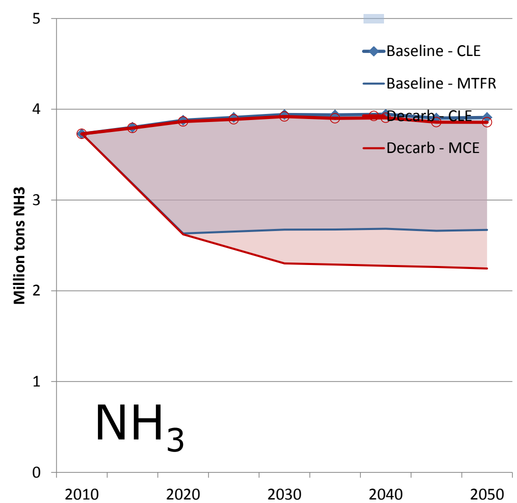
2010-2050

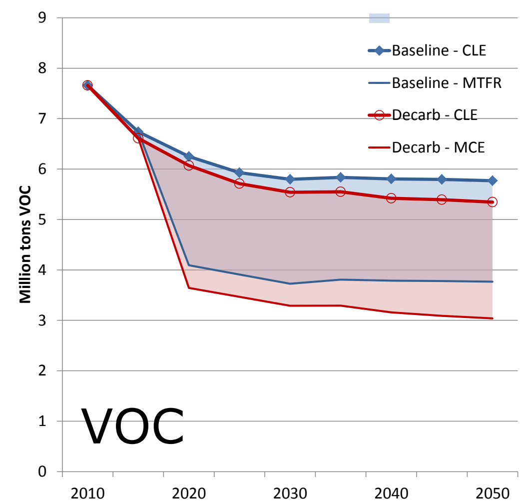




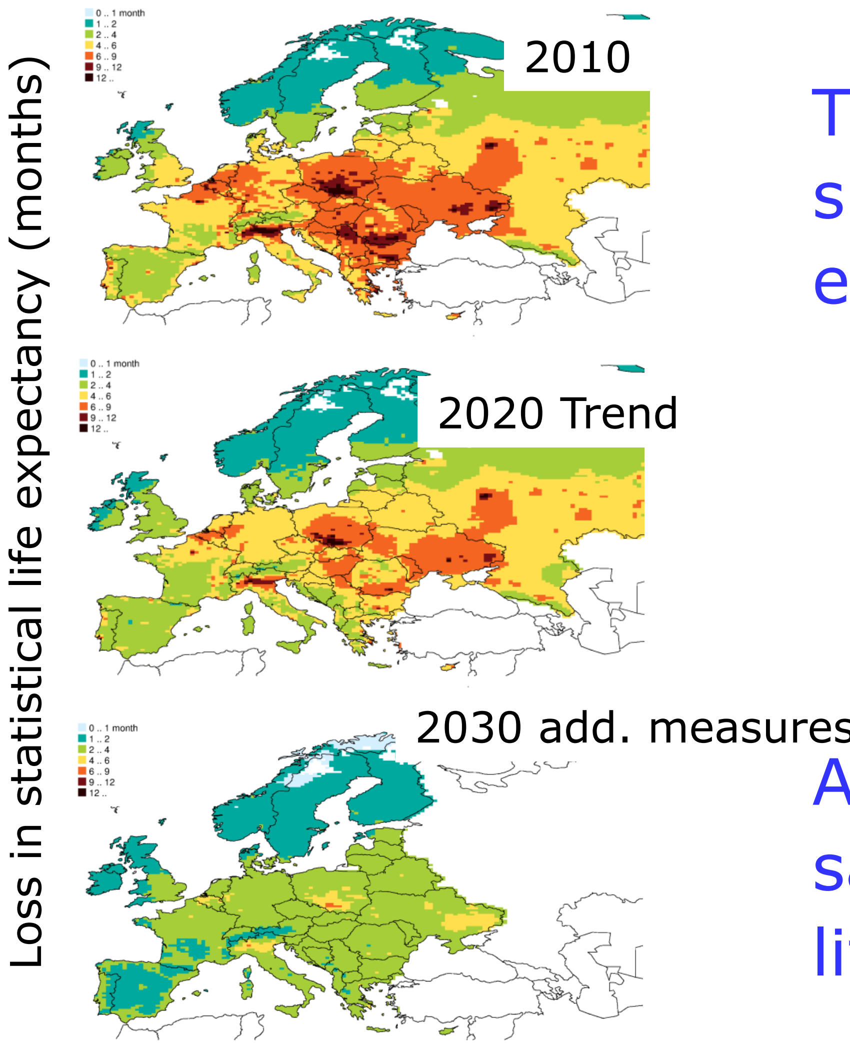
- Upper **blue** line: Trend scenario (PRIMES 2010)
- Red range: Emissions **with additional** measures







Health impacts:
Loss in statistical life through PM2.5

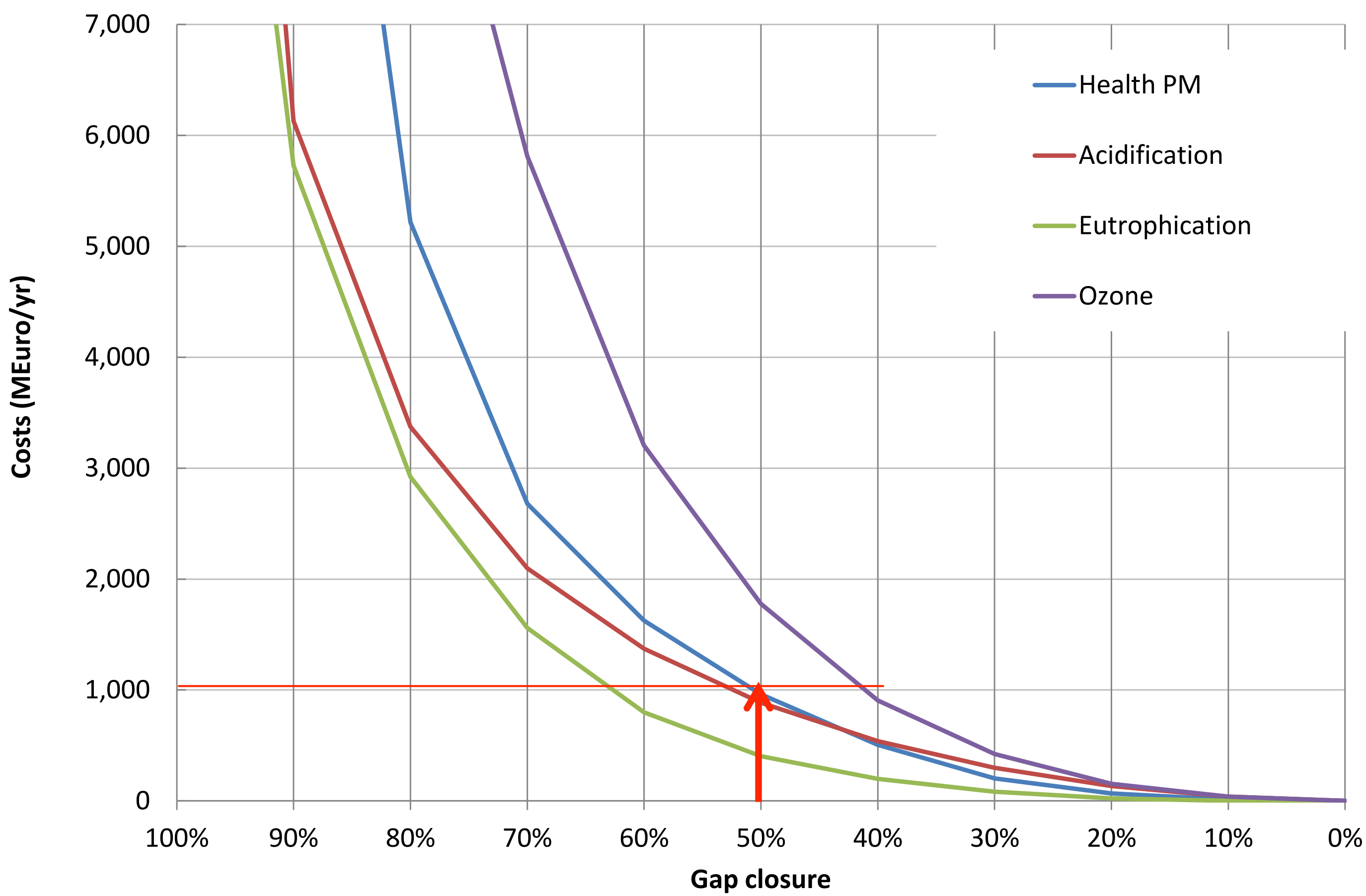


Trend: ~5 months shortening of statistical life expectancy after 2020

Additional measures could save ~55 million years of life of European population

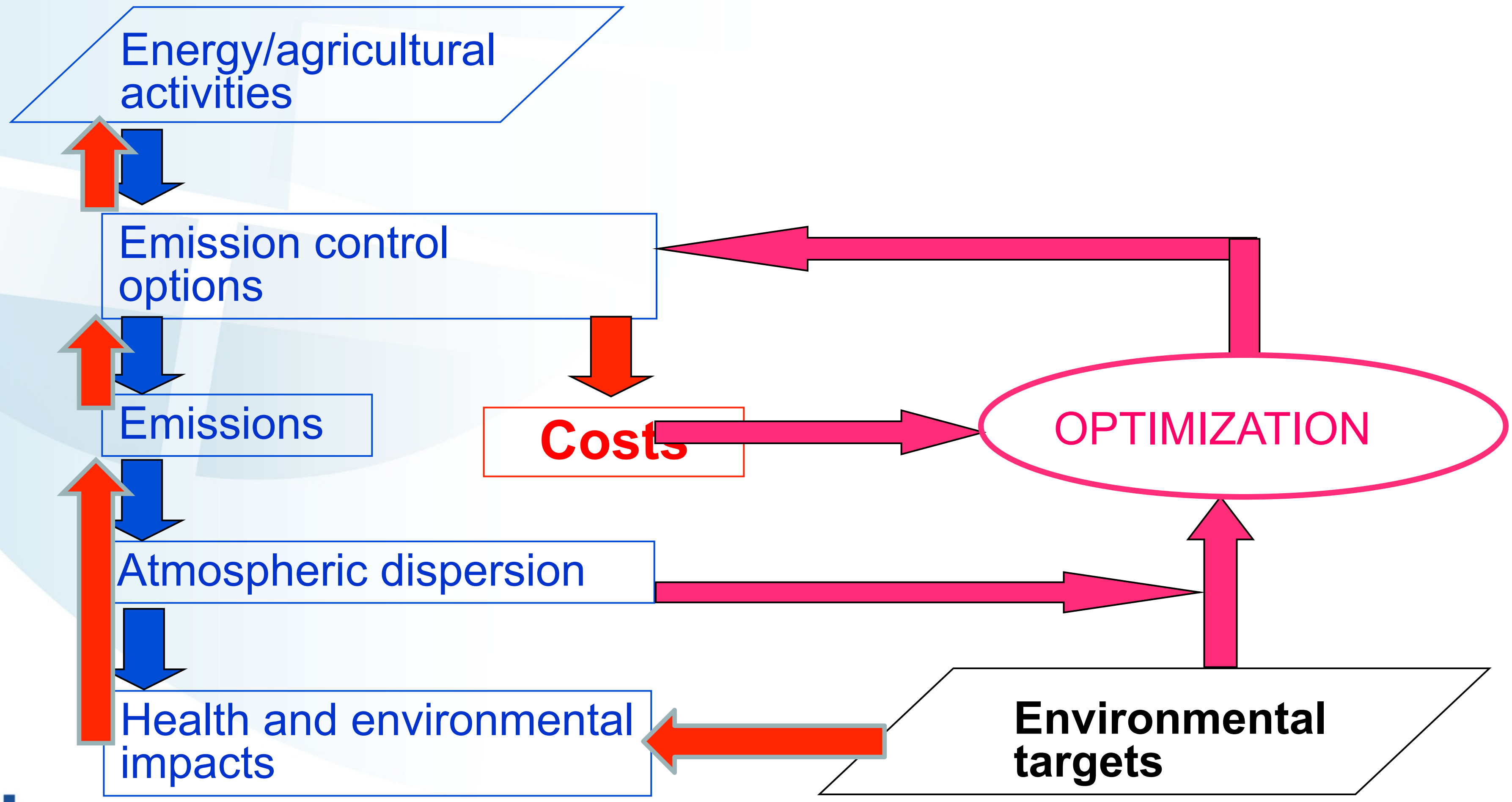
Choosing an ambition level

Costs for improving individual effects



100% means: impact is reduced from
Baseline to Maximum Technically Feasible Reduction

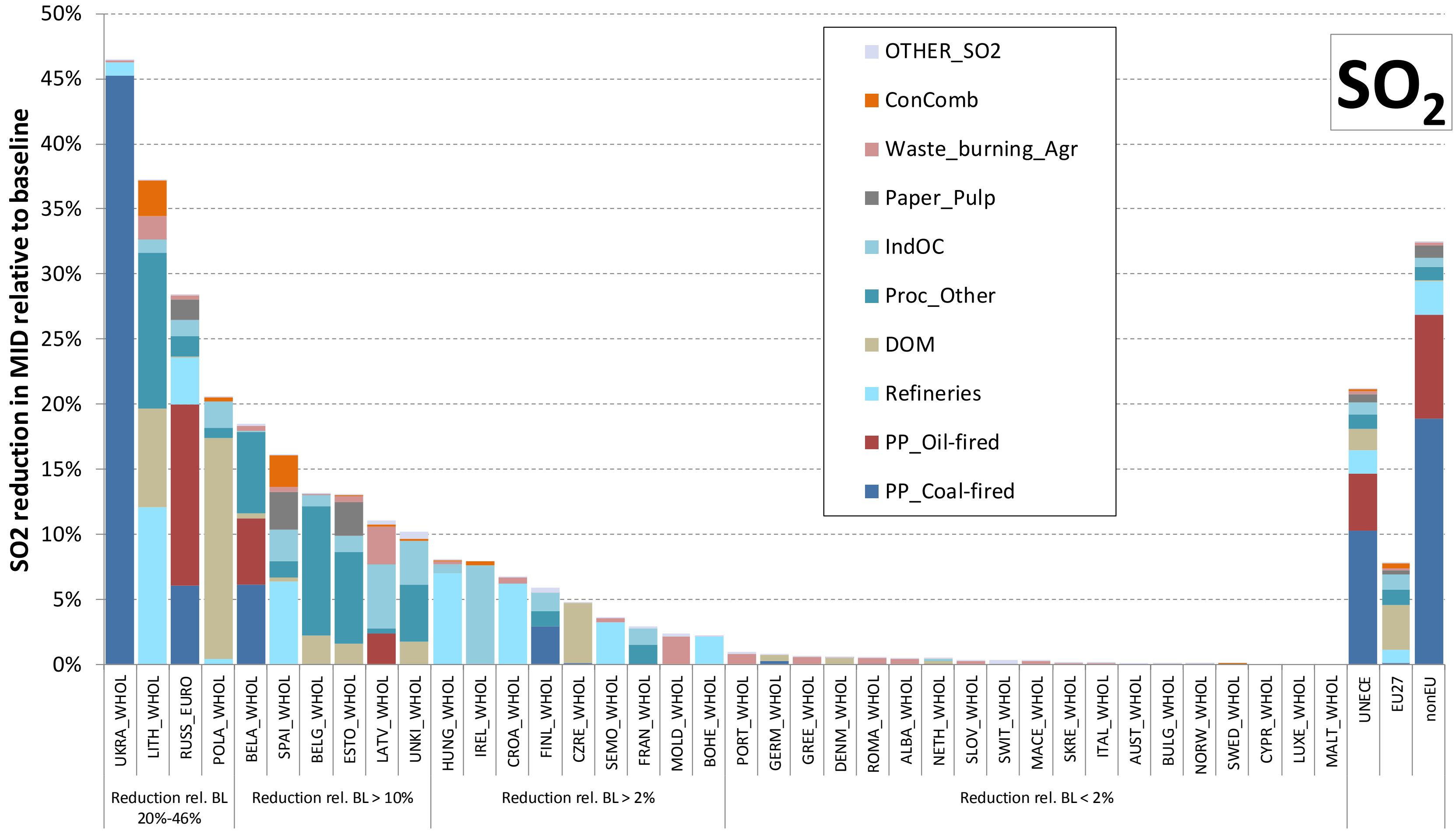
The GAINS model follows impact pathway - uneven effects offer scope for optimisation



Additional measures for SO_2

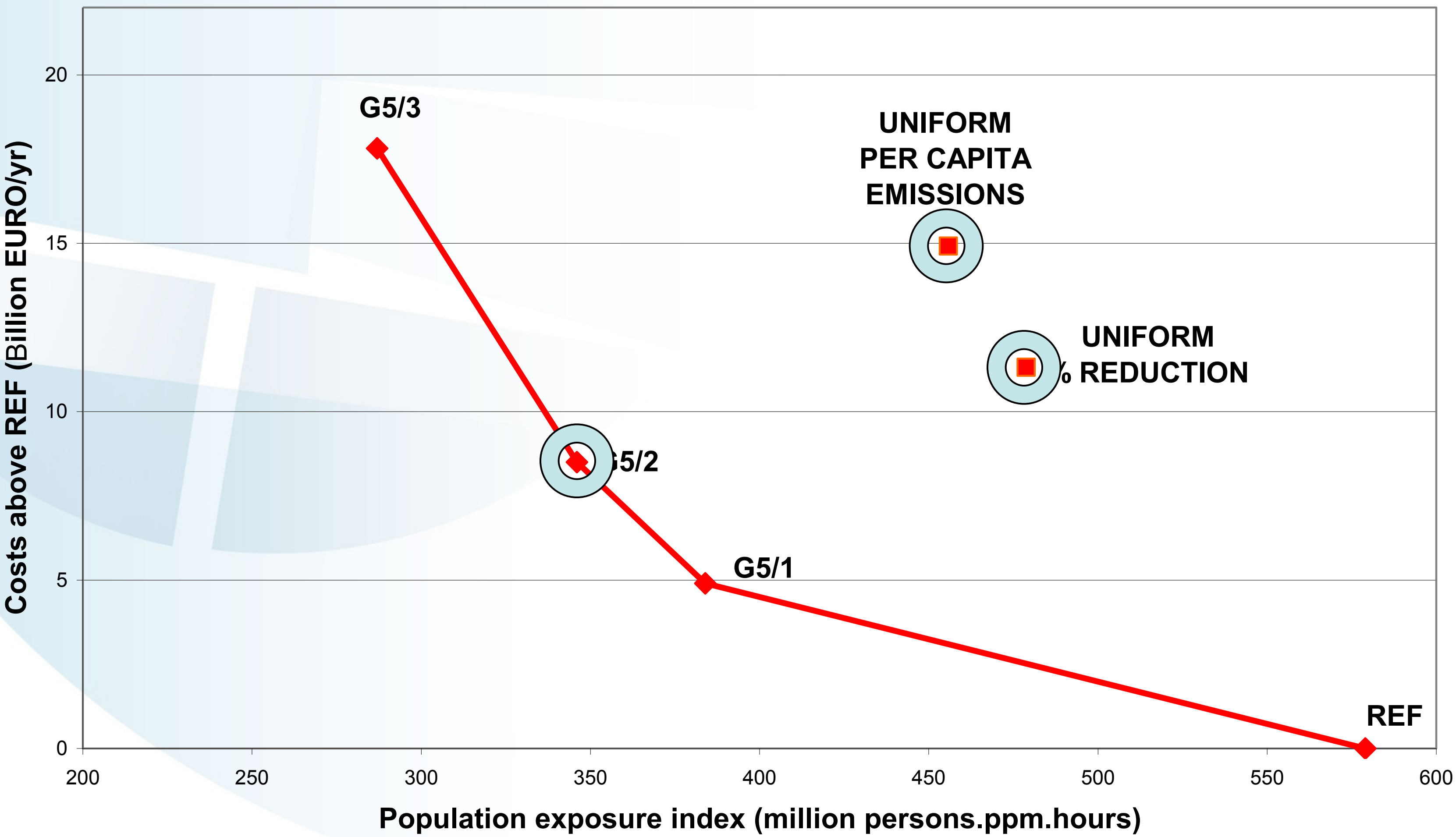
to achieve the MID case

Different countries tackle different pollutants with different technologies



Uniform or effect-based scenarios?

Example from discussion leading to Gothenburg Protocol (1999)



Four options for target setting

Where do we want to go by 2020?

Environmental targets for a cost-effectiveness optimization

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

Four options have been analysed 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 Maximum Technically Feasible Reduction)
4. Europe-wide improvements at least cost

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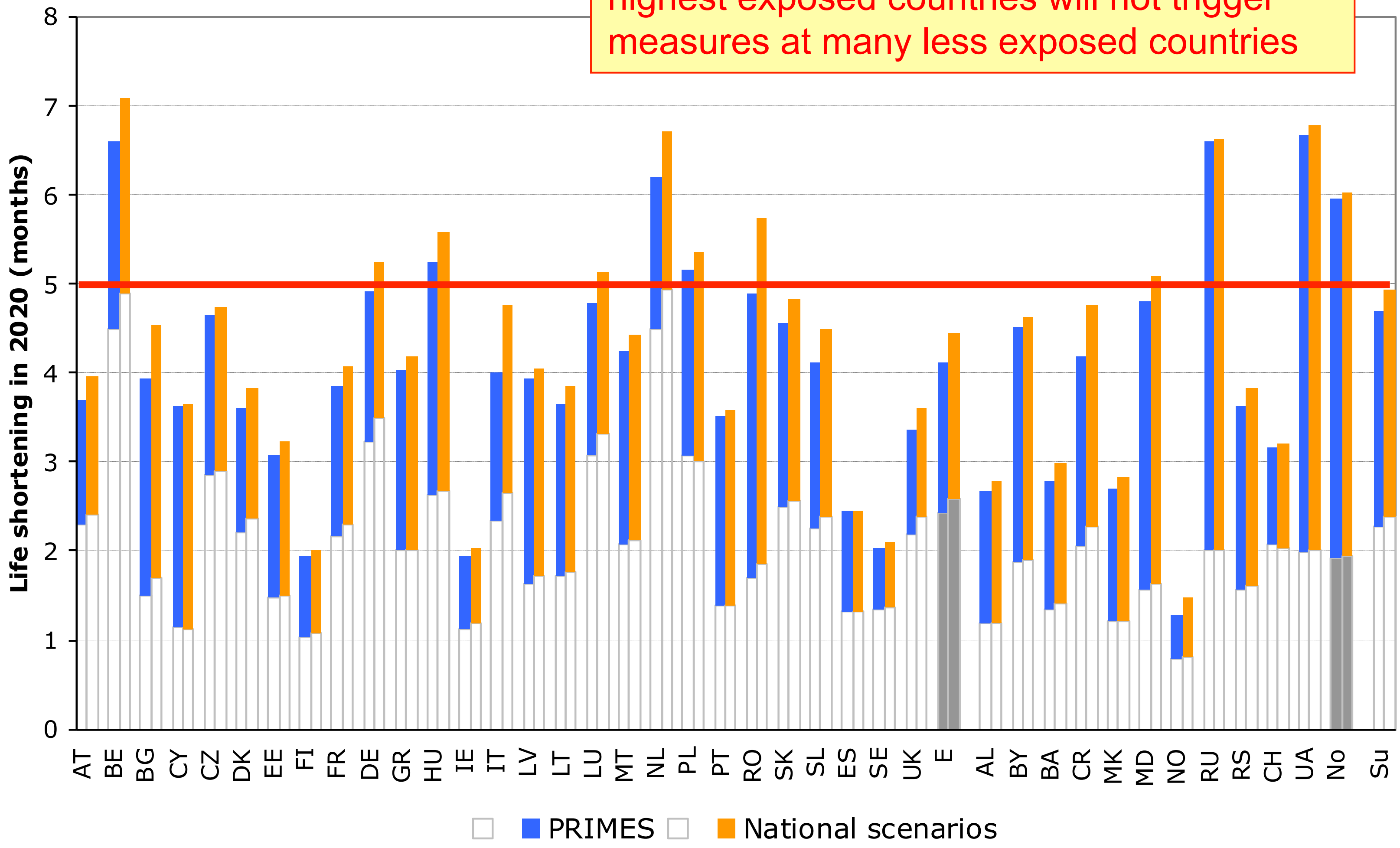
Option 1: Uniform cap of impact indicators

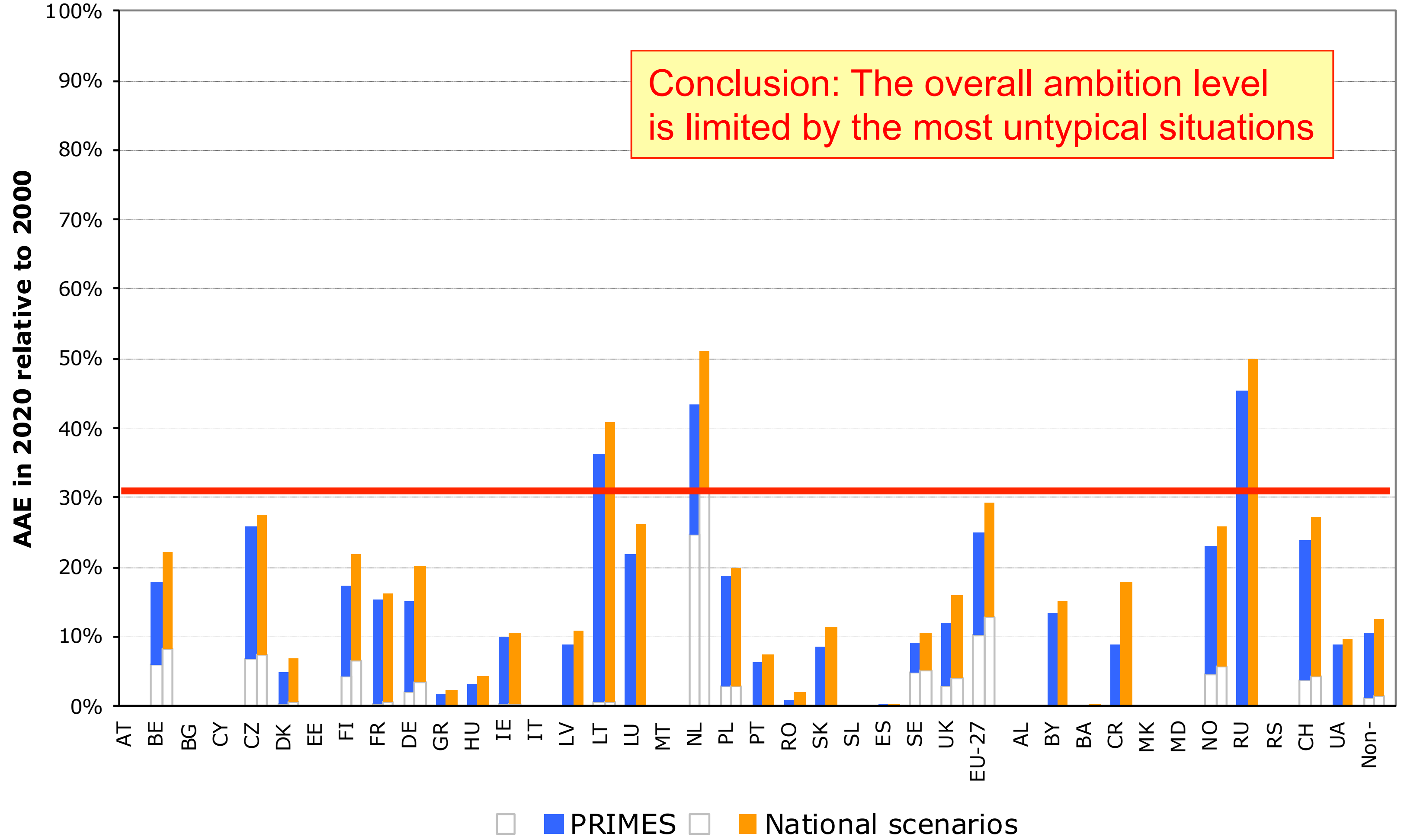
Loss in statistical life expectancy from PM2.5 (months)

Conclusion: Targets that are feasible for the highest exposed countries will not trigger measures at many less exposed countries



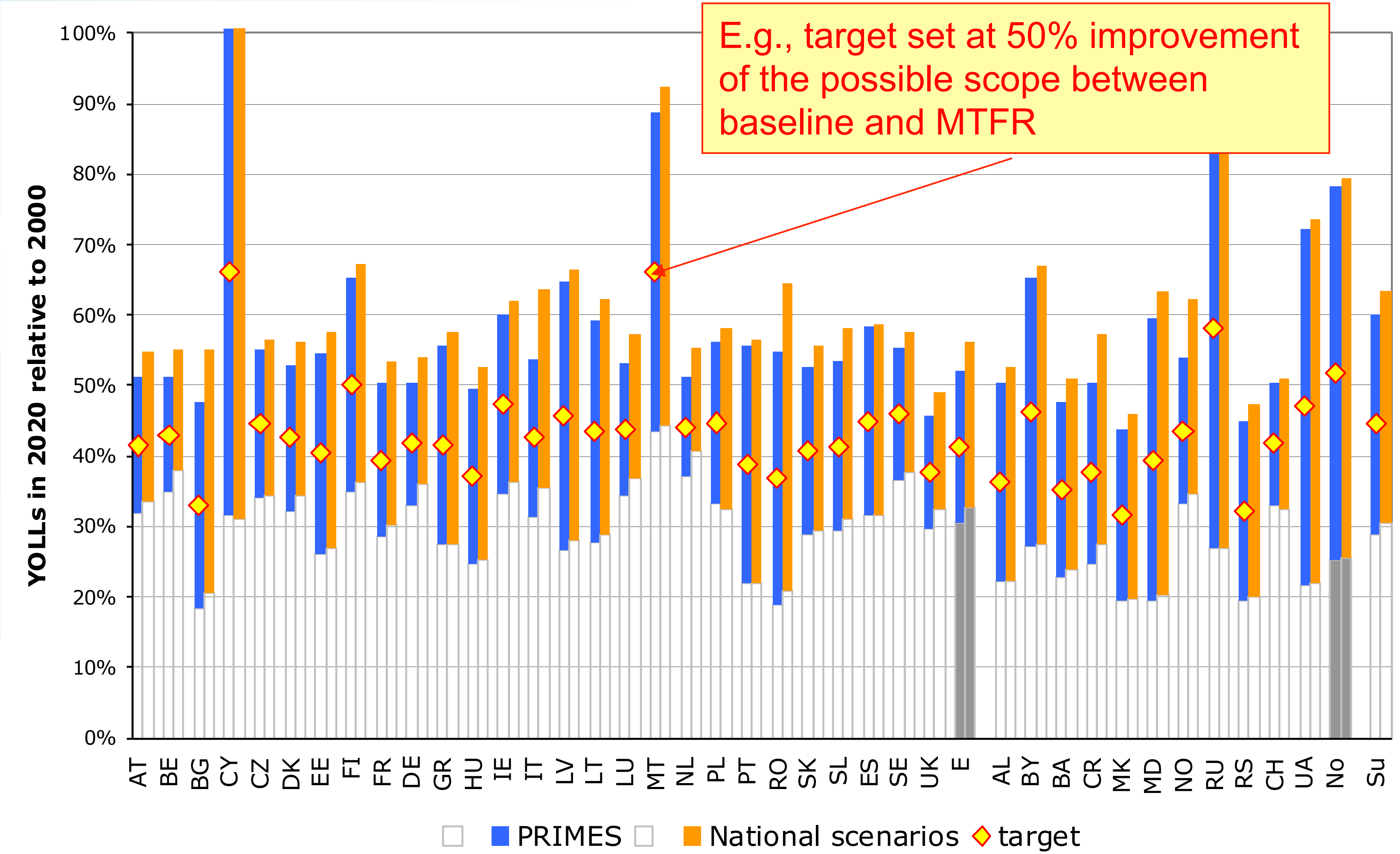
Option 2:
Equal relative improvements compared to 2000

Acidification, accumulated excess deposition



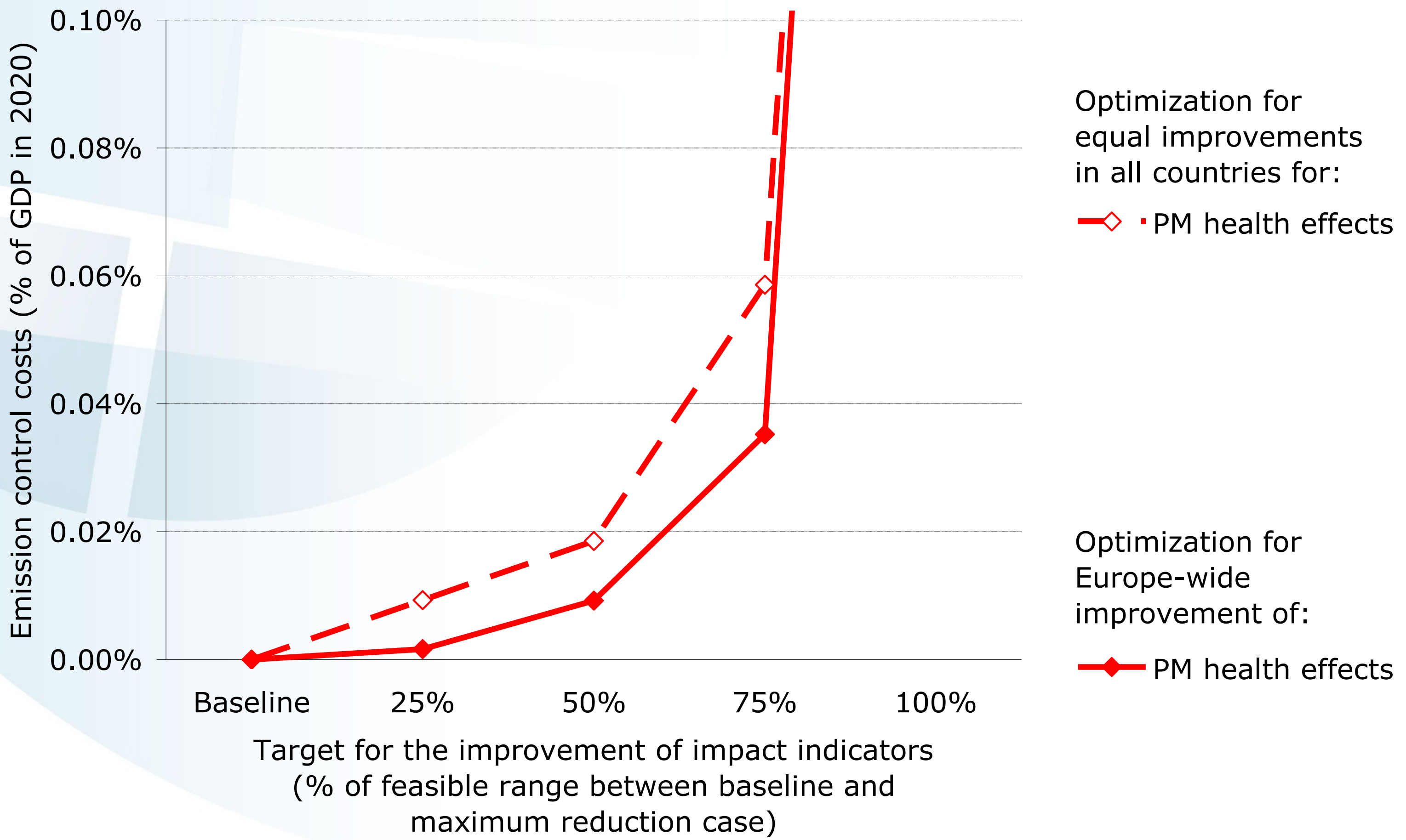
Option 3:
Equal progress of the feasible improvement

Mortality due to PM2.5 (YOLLs)



Provisional results!

Option 4:
Achieve improvements Europe-wide at least costs
Costs for YOLL target



Provisional results!

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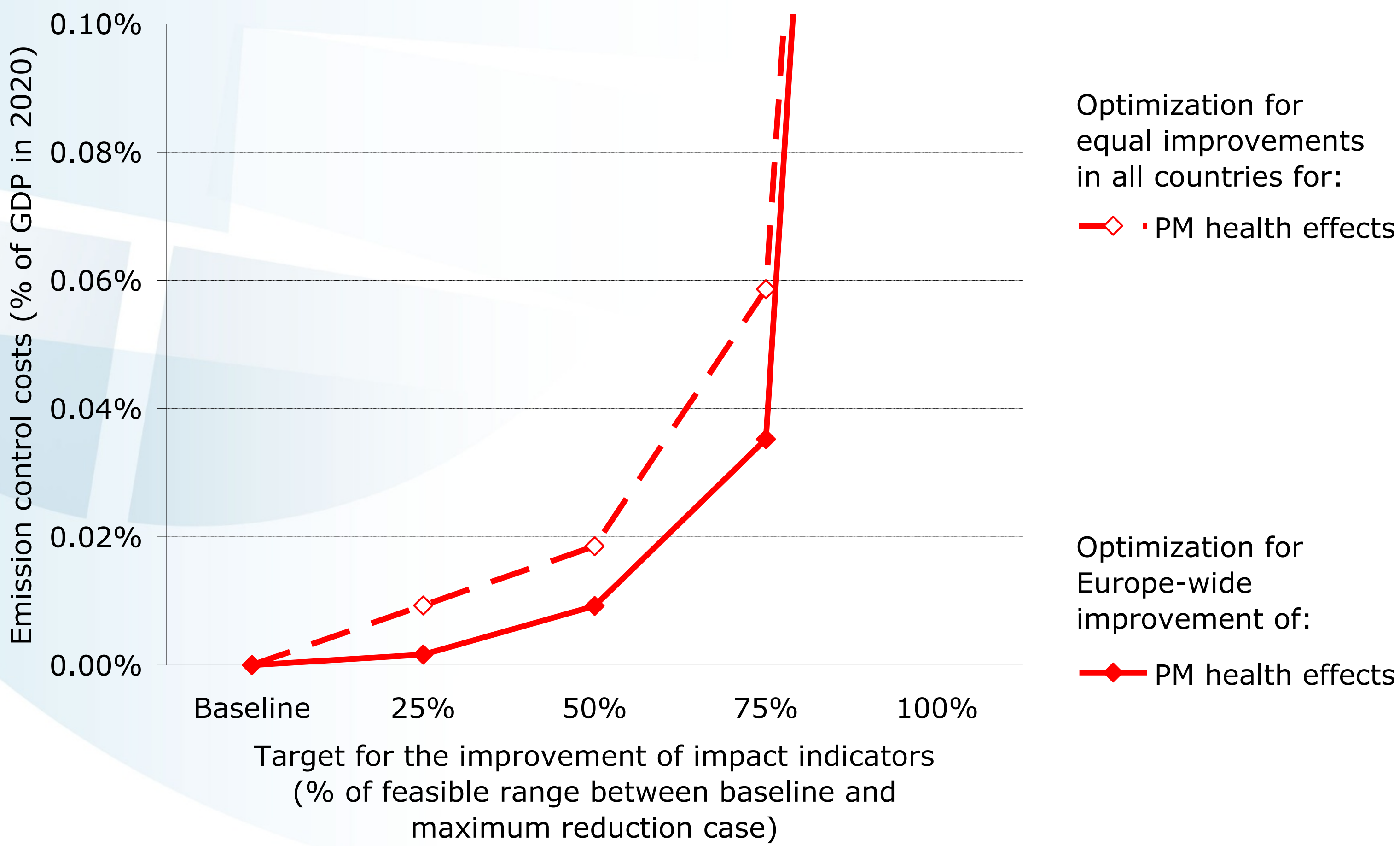

Provisional results!

More details and background available from:

- General GAINS policy portal: http://www.iiasa.ac.at/web/home/research/researchPrograms/MitigationofAirPollutionandGreenhousegases/Overview.en.html
  - GAINS model: http://gains.iiasa.ac.at
- UNECE Gothenburg Protocol revision work
  - http://gains.iiasa.ac.at/index.php/policyapplications/gothenburg-protocol-revision
- Review of the EU Thematic Strategy on Air Pollution (TSAP); towards revision of National Emission Ceiling Directive (NECD)
  - http://gains.iiasa.ac.at/index.php/policyapplications/tsap

Discrete options for ambition levels

Closing the gap

	Health-PM	Acidification	Eutrophication	Ozone
HIGH	75%	75%	75%	75%
High*	75%	75%	75%	50%
Mid	50%	50%	60%	40%
Low*	25%	25%	50%	25%
LOW	25%	25%	25%	25%

100% means: impact is reduced from Baseline to Maximum Technically Feasible Reduction

Example from current process of
EU Revision of the Thematic Strategy on Air Pollution /

(new) Directive on National Emission Ceilings

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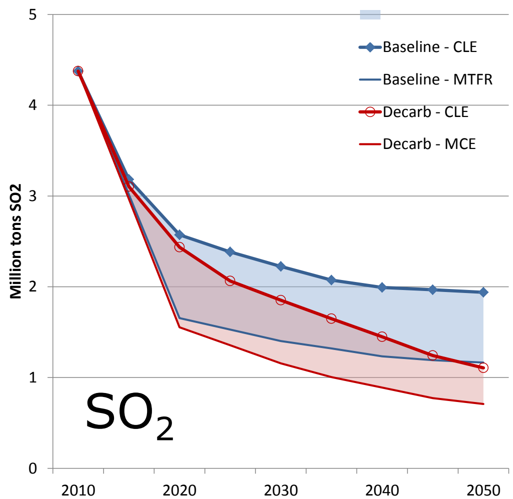
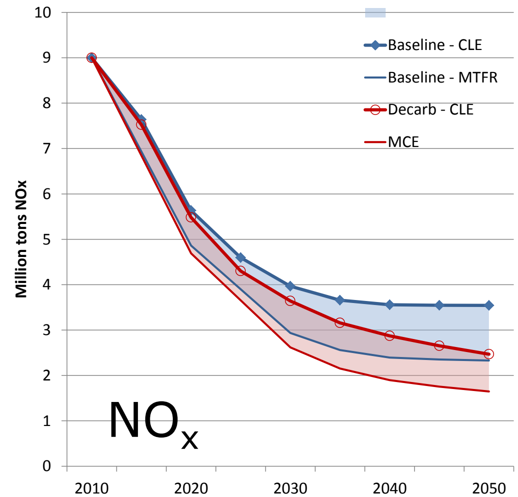
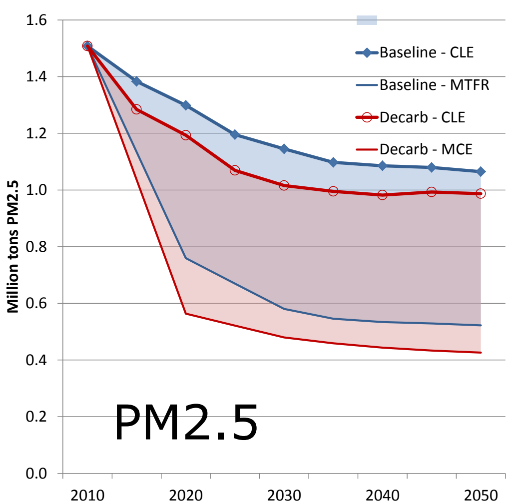
TSAP-2012 emissions

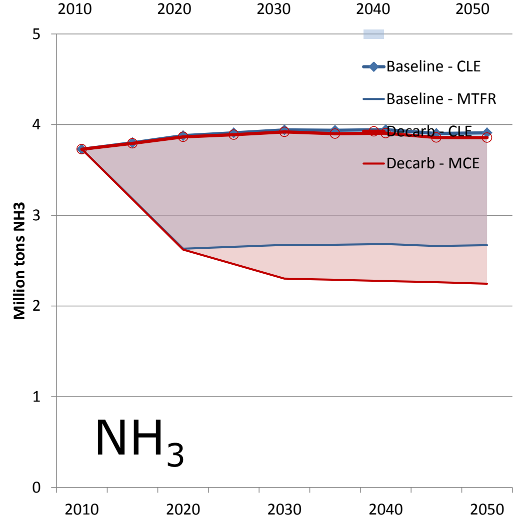
2010-2050

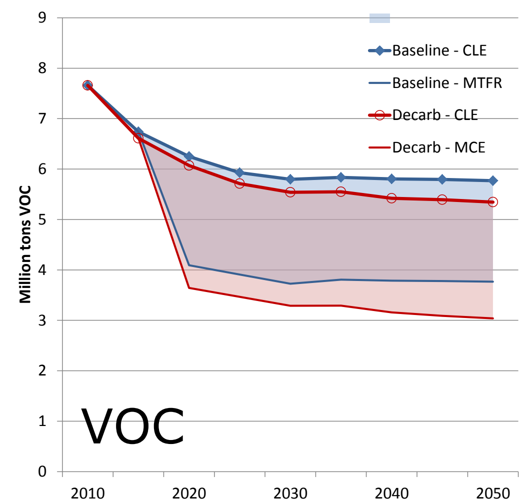




- Blue ranges:
  TSAP-2012 CLE-MTFR
- Red ranges:
  Decarb CLE-MCE
- After 2025/30 progress only from decarbonisation







Health impacts PM

Methodology

- Exposure calculations with new EMEP model
  - 28*28 km
  - downscaled to 7*7 km with CHIMERE
    (replaces earlier City-Delta approach)
  - includes now secondary organic aerosols (SOA)

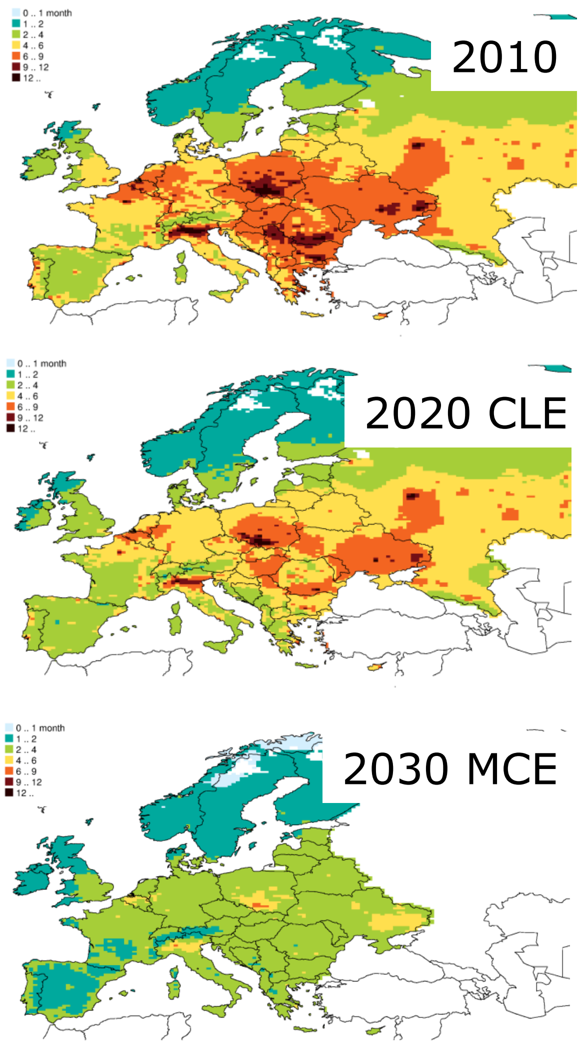
- Health impacts
  - Based on Pope et al. 2002 (as in earlier calculations),
    i.e., linear exposure-response for all-cause mortality
  - Preliminary estimates, since WHO REVIHAAP report not yet available

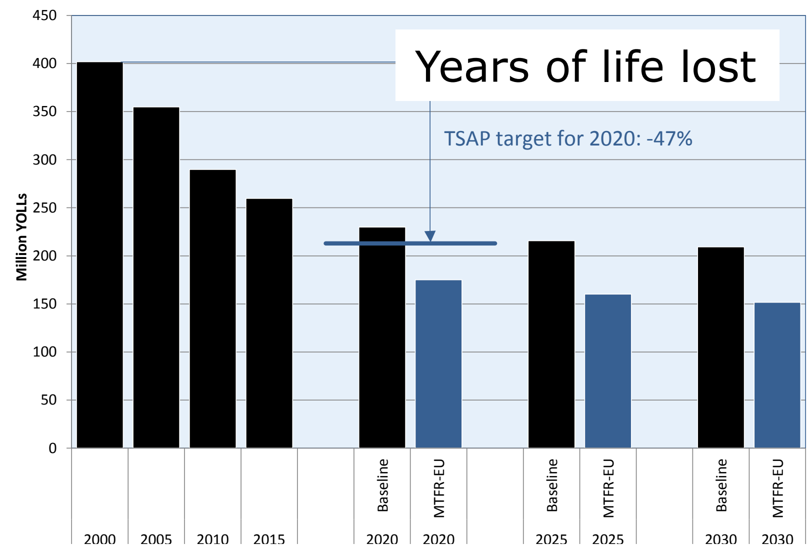
- Years of life lost (YOLLs)
  - Now calculated for all people older than 30 years
    (before only people older than 30 in 2010 were considered)

Health impacts PM2.5

Results

Loss in statistical life expectancy (months)





Baseline implies ~5 months shortening of statistical life expectancy after 2020

Additional MTFR measures could save ~55 million years of life of European population

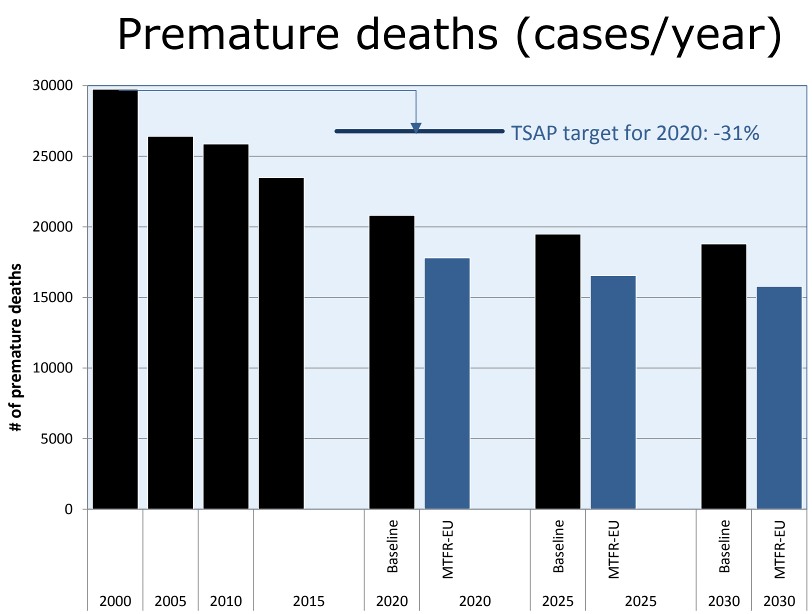
Health impacts O_3

Methodology

- Ozone exposure calculated with new EMEP model 28*28 km
- HTAP advice on future O_3 hemispheric background:
  - -1 to +3 ppb between 2000 and 2020/2030, recommended central case with 0 ppb
  - Lower increase than earlier advice to CAFE from ACCENT Urbino questions (+4.5 ppb between 1990 and 2020)
- Premature mortality due to short-term exposure
  - Estimated based on SOMO35, as before in CAFE
- New evidence on mortality due to chronic exposure not yet included
  - Could be potentially significant
  - Advice from WHO REVIHAAP expected

Health impacts from ground-level ozone

Results



Baseline implies ~20,000 cases of premature deaths from short-term exposure to ozone after 2020

Additional MTFR measures could save 3,000 cases of premature deaths/year

WHO/REVIHAAP will propose health impact approach for long-term exposure

Ecosystems impacts

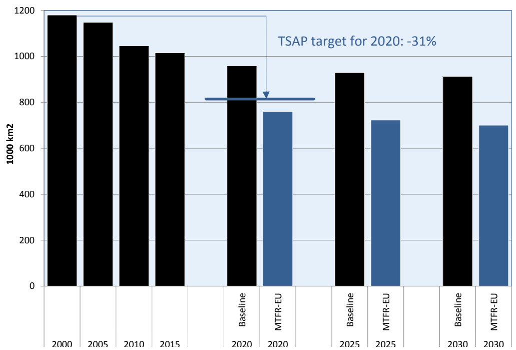
Methodology

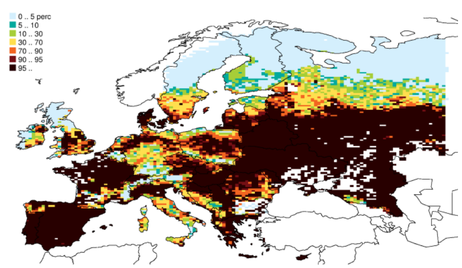
- New EMEP source/receptor relationships (28*28 km)
- New 2012 set on critical loads
  - Improved harmonization of methodologies
  - Less focus on managed forests
- Critical loads also provided for protected areas (Natura2000)
- Vegetation damage from ozone will be estimated in GAINS via ozone flux approach. Information has been received from EMEP, but not yet incorporated in GAINS for this report

Ecosystems impacts

Results

Eutrophication
(unprotected area)





% of unprotected
ecosystems area

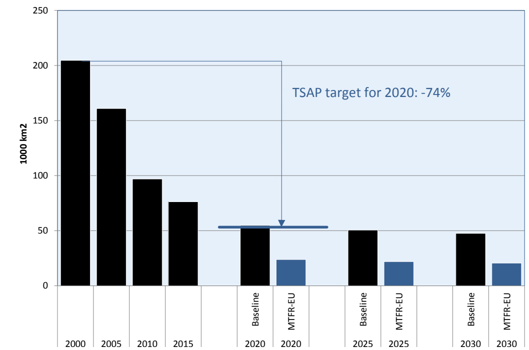
Baseline leaves biodiversity unprotected at 950,000 km² (55%) of all ecosystems area

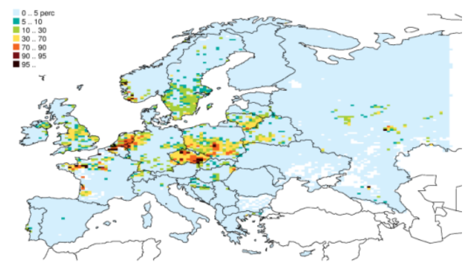
MTFR measures could provide protection to another 200,000 km² after 2020

Soil acidification will remain a threat to 50,000 km² (~4%) of European forests.

MTFR measures could protect another 30,000 km²

Acidification
(unprotected forest area)



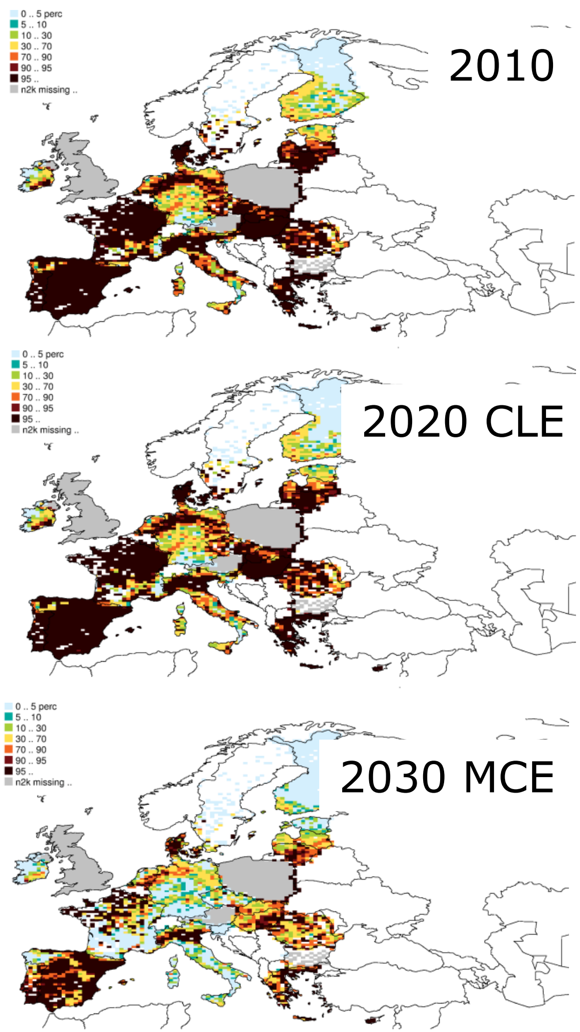


% of unprotected
forest area

Natura2000 areas

Threat to biodiversity from excess nitrogen input

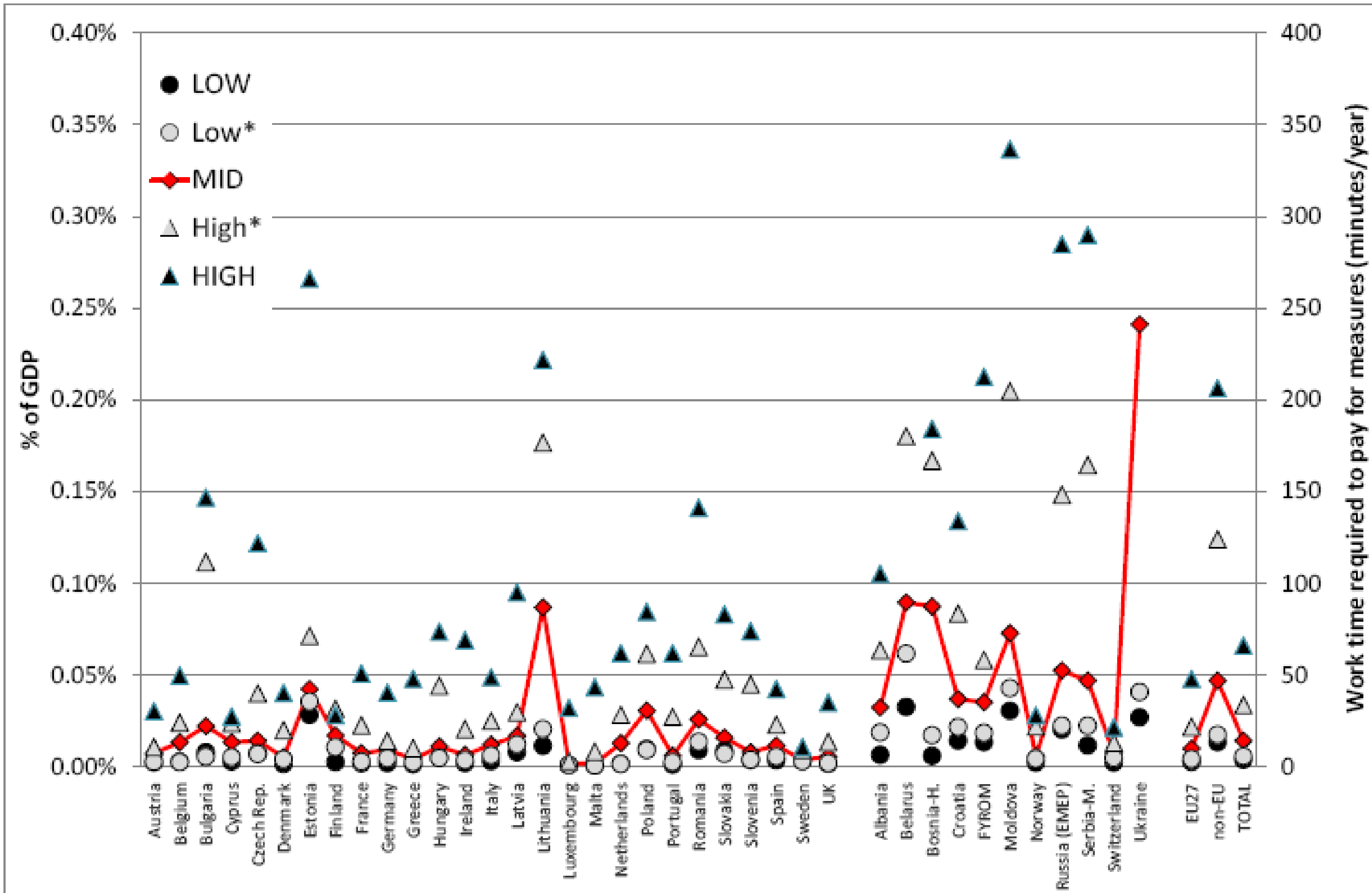
% of unprotected ecosystems area



- Nitrogen input will continue to threaten biodiversity at about two thirds (350,000 km^2) of these nature protection zones in the baseline case.
- MTFR measures could provide protection to another 100,000 km^2 after 2020
- An incomplete assessment, as not all countries have reported critical load data for Natura2000 areas

Additional air pollution control costs

as a percentage of GDP in 2020



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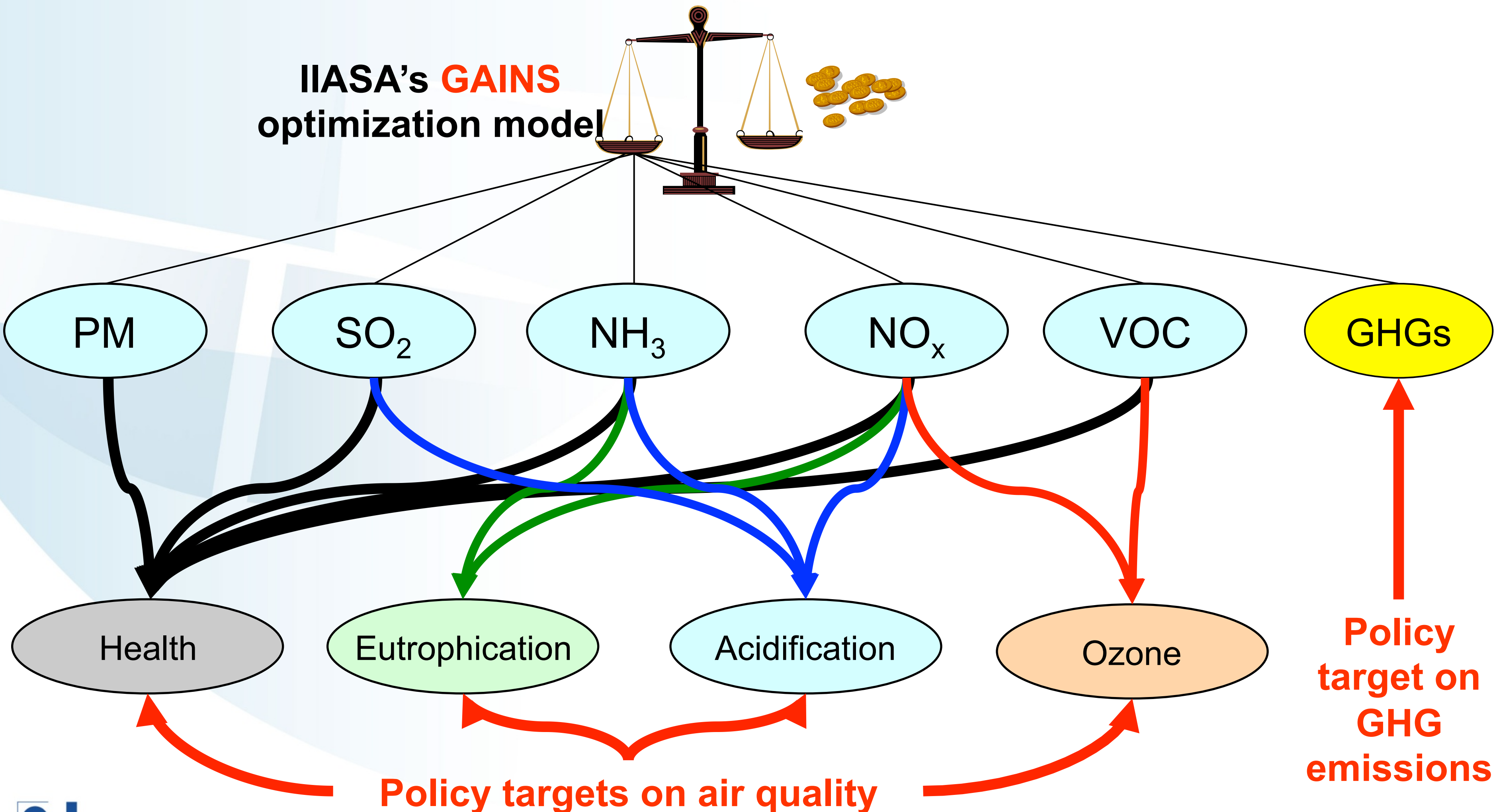
GAINS MODEL

The **GAINS** approach

for identifying cost-effective emission control strategies

(**G**HG-**A**ir pollution **IN**teractions and **S**ynergies)



Extension of the GAINS multi-pollutant/multi-effect framework to include near-term climate impacts (http://gains.iiasa.ac.at)

	PM (BC, OC)	SO_2	NO_x	VOC	NH_3	CO	CO_2	CH_4	N_2O	HFCs PFCs SF_6
Health impacts: PM (Loss in life expectancy)	√	√	√	√	√					
O_3 (Premature mortality)			√	√		√		√		
Vegetation damage: O_3 (AOT40/fluxes)			√	√		√		√		
Acidification (Excess of critical loads)		√	√		√					
Eutrophication (Excess of critical loads)			√		√					
Climate impacts: Long-term (GWP100)							√	√	√	√
Near-term forcing (in Europe and global mean forcing)	√	√	√	√	√	√				
Black carbon deposition to the arctic	√									

Method – ***emission factors***

- "Unabated" emission factors for anthropogenic sources only
- Country/region specific factors taken into account wherever possible, i.e.:
  - For SO2: fuel characteristics
  - For PM: fuel and installation characteristics
  - For NH3: N-excretion and volatilization, production efficiency, housing period
  - For NMVOC: climatic conditions, volatility of fuels, solvent content of products

Method – ***abatement techniques***

- Economic and technical information for "technical" measures
- For most techniques efficiency assessed from literature and communication with experts, however, country/ region specific factors taken into account when necessary and available, i.e.:
  - For NH3: geophysical conditions, feeding strategies
  - For NMVOC: sector "composition", solvent content of products
- Introduction of "applicability" parameter, i.e., maximum technically feasible application rate of control option
- Actual and projected penetration rate of control technology

What is the origin of GAINS data?
[activities and activity parameters]

- **Historical (1990,1995,2000, 2005)**
  - Statistics (IEA, Eurostat, FAO, IFA, EFMA)
  - Communication with national experts (consultations)
  - UNECE and UNFCCC submissions,
  - Industrial data (consultations CEPE, EFMA, other)
  - Models (PRIMES, TREMOVE, CAPRI),
  - Literature studies, and
  - Own assessments
- **Forecasts (until 2030)**
  - Communication with national experts (consultations)
  - UNECE and UNFCCC submissions,
  - Industrial data (consultations),
  - Models (PRIMES, TREMOVE, CAPRI, FAO, EFMA),
  - Literature studies

What is the origin of GAINS data?

[emission factors and ef parameters, reduction efficiencies and costs of abatement]]

- Guidebooks (CORINAIR/EMEP, AP-42, BUWAL)
- UNECE Expert Groups
- National submissions (consultations)
- International databases, e.g., CEPMEIP
- Industrial associations
- Peer-reviewed literature
- Grey literature
- Own expertise

Scope for optimization...

- Some sources are more strongly linked than others via the atmosphere to sensitive receptors
- Some sources are cheaper to control than others

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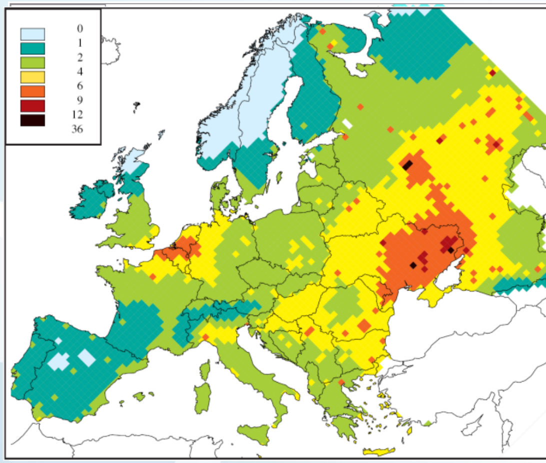
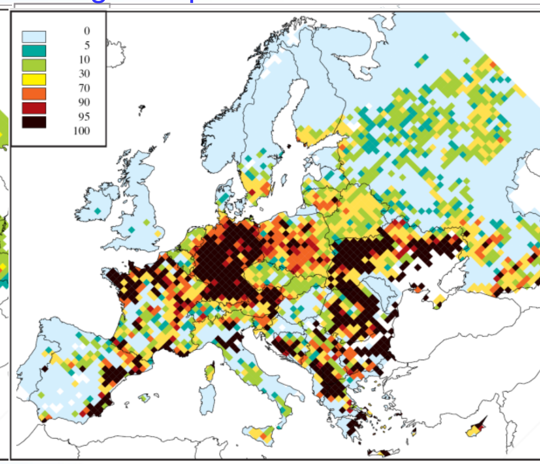
Integrating over different effects:
Air quality impacts in 2000 and policy for 2020

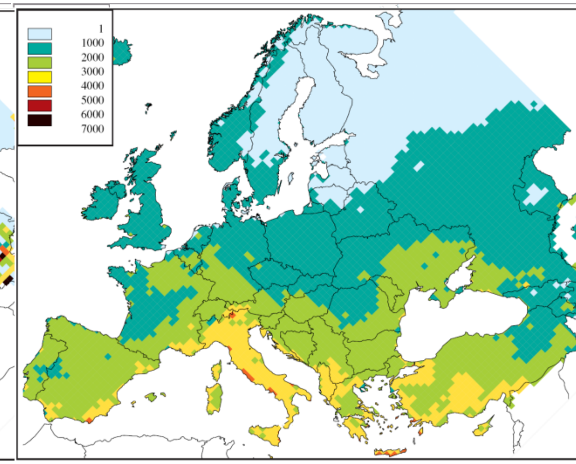
Health impacts from fine PM

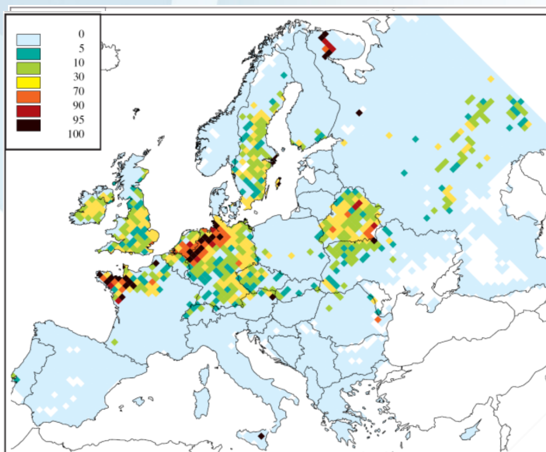


Biodiversity threat from excess nitrogen deposition

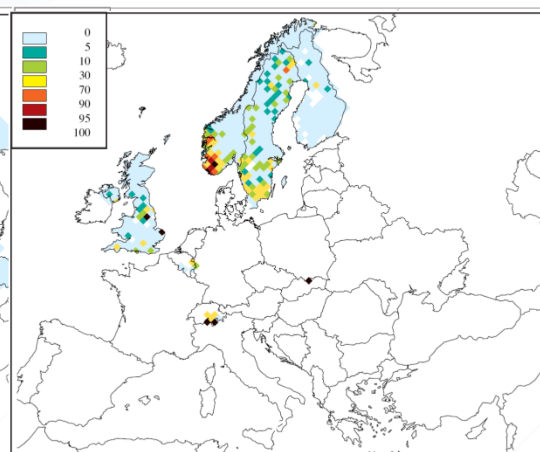


Health impacts from ozone

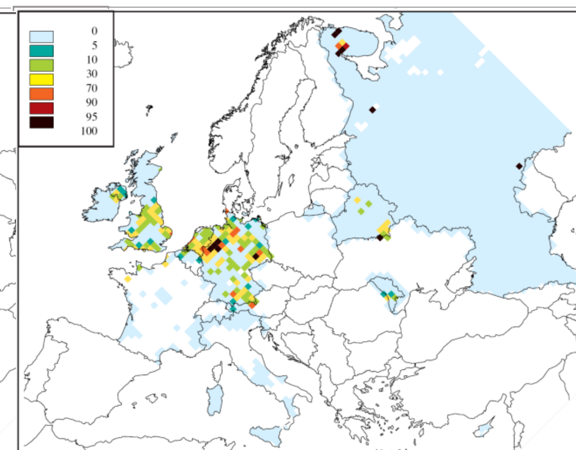




Acidification of forest soils

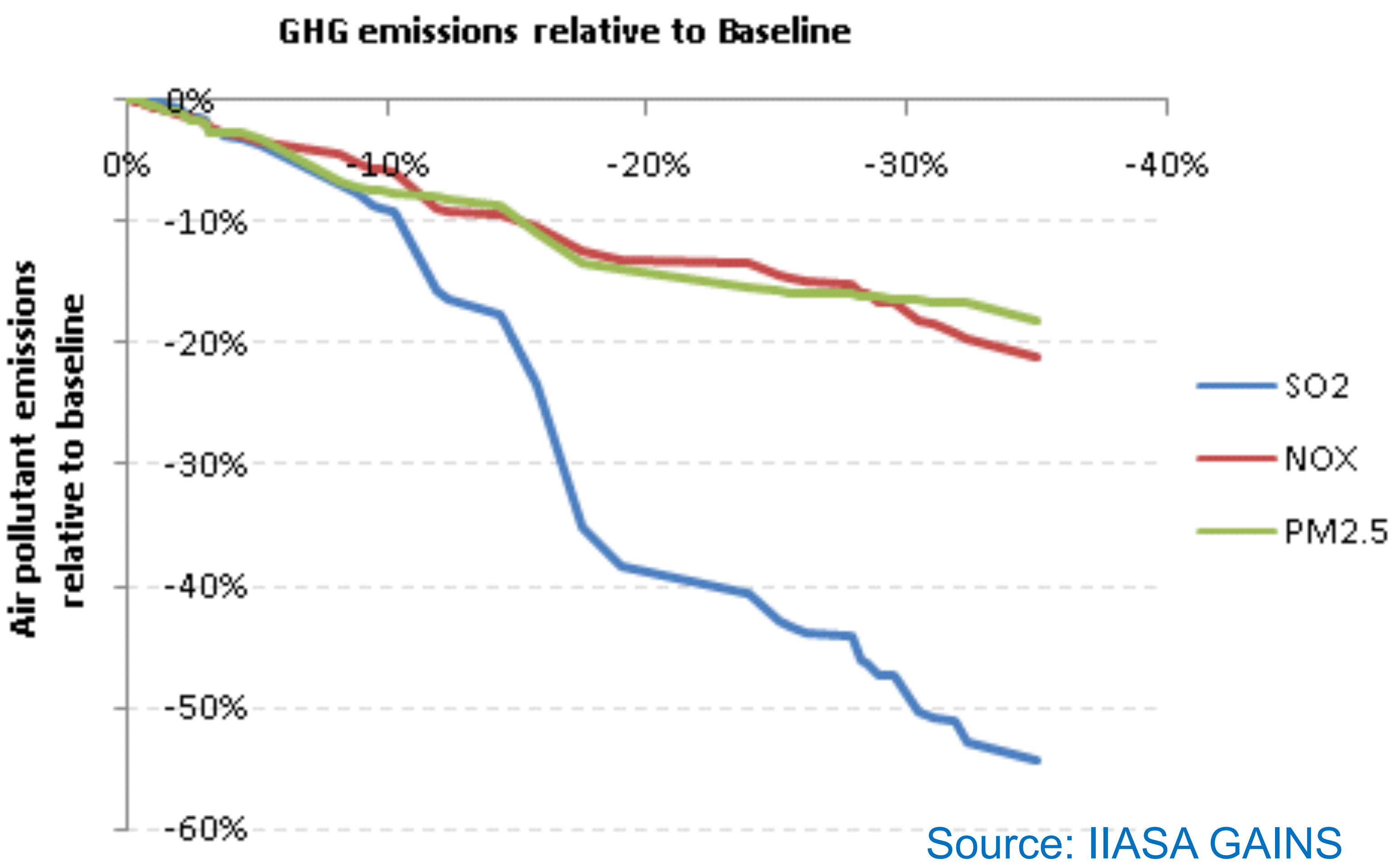


Acidification of rivers and lakes



Acidification of nature protection areas

Co-control of GHGs and air pollutants



Source: IIASA GAINS
http://gains.iiasa.ac.at

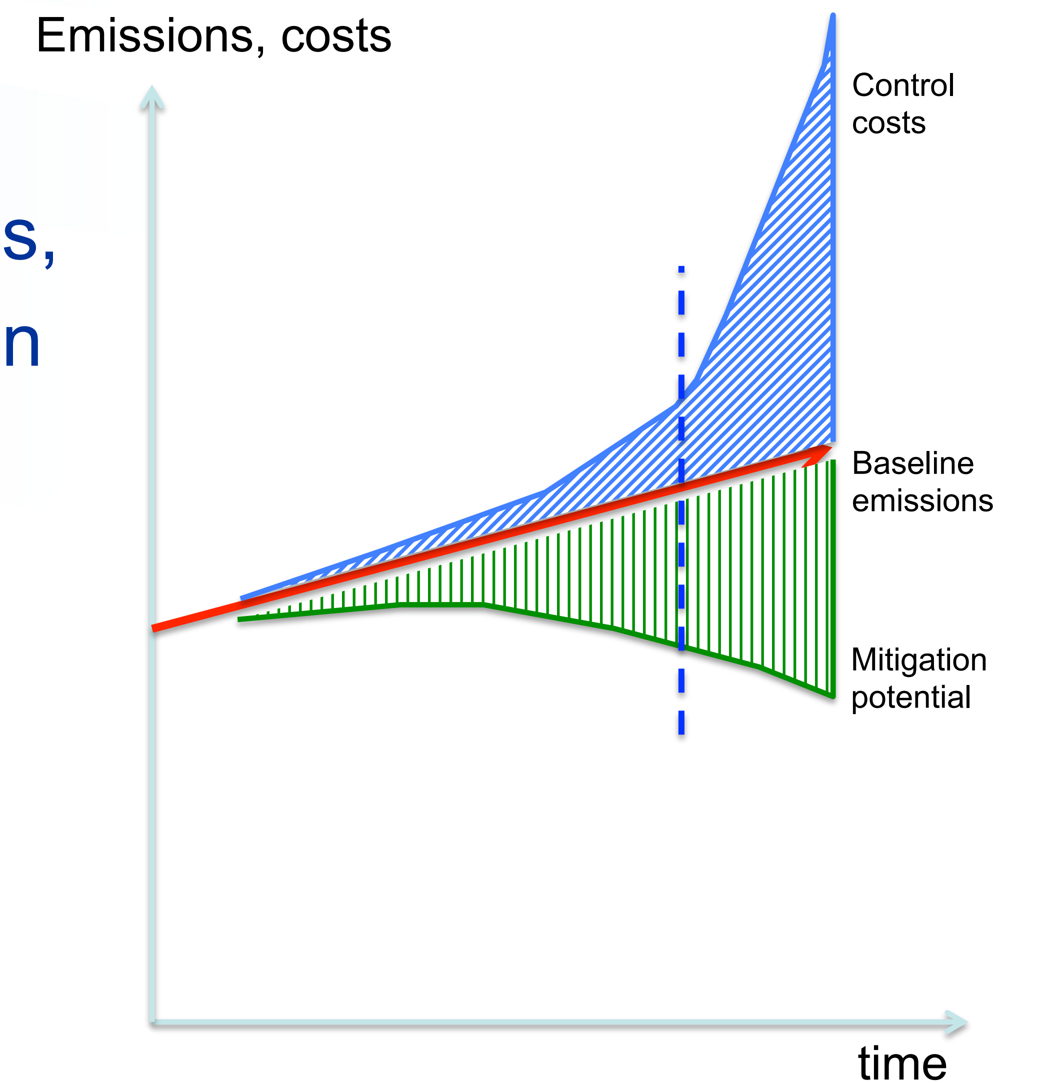
GAINS model and emission inventories

- GAINS is not an emission inventory model
- We are not reviewing the inventories but use them (and other sources) to validate GAINS estimates
  - We try to understand and reproduce the inventory (with GAINS resolution)

Why?

<u>We are interested in:</u>

- projecting emissions,
- Assessing mitigation potential,
- calculating control costs,
- searching for cost-optimal strategies considering constraints/targets



The cost-effectiveness approach

Models help to separate policy and technical issues:

Decision makers	Models
Decide about •Ambition level (environmental targets) •Level of acceptable risk •Willingness to pay	**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

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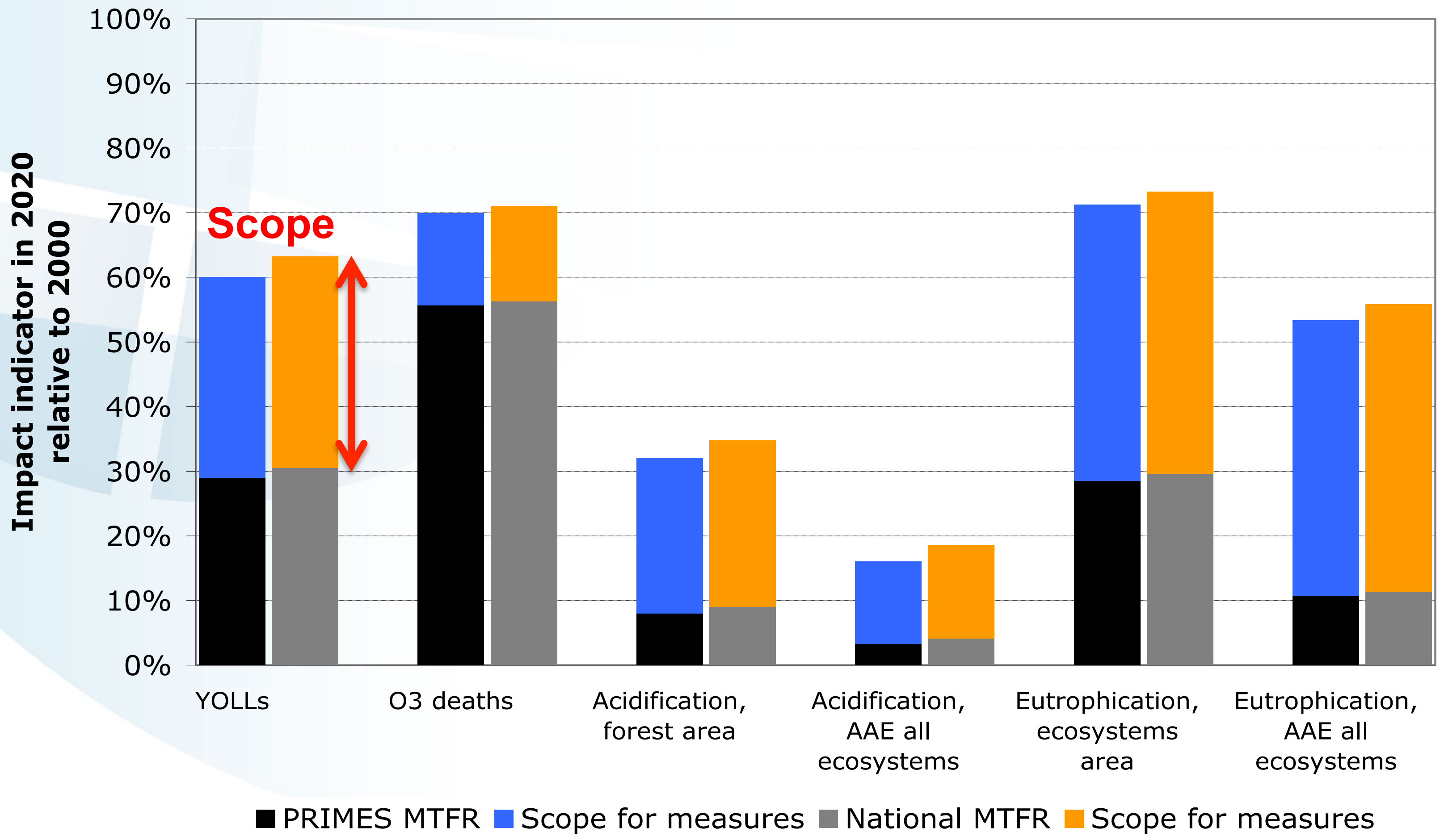
Central question for policy makers

To what level should the emissions of air pollutants be reduced in the year 2020?

- Where will emissions and effects be in 2020 without further policies?
- What reductions are technically feasible?
- How much do they cost? – optimal/non-optimal
- Who (which countries) pay(s)?
- How much are they willing to pay?
- Who benefits?
- Is it enough?
- Is it fair?

Scope for further environmental improvements across all (quantified) effects



Conclusions on target setting

- 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 MTFRs.
  4. Larger spatial flexibility will reduce total costs, but result in uneven environmental benefits. (Might be acceptable for YOLLs, but questionable for ecosystems.)