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Scenarios for the Negotiations on the Revision of the Gothenburg Protocol

with contributions from Imrich Bertok, Jens Borken-Kleefeld, Janusz Cofala, Chris Heyes, Lena Höglund-Isaksson, Zbigniew Klimont, Peter Rafaj, Wolfgang Schöpp, Fabian Wagner

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emep

Co-operative programme for monitoring
and evaluation of the long-range
transmissions of air pollutants in Europe



Contents



- Updates of input data
- Target setting
- Emission control costs
- Emission ceilings and implied reduction measures
- Sensitivity cases
- Conclusions

Important changes since the last analyses



Update of NH₃ cost information based on material provided by TFRN:

- Small farms (<15 LSU) are now excluded
- Generally, costs are lower for low protein feed, exhaust air purification (acid scrubbers) and manure spreading (due to work done by contractors and reduced need for mineral fertilizer).
- But manure storage costs not changed

Compared to Draft version of CIAM 1/2011 (presented at TFIAM 39):

- Swiss activity projection
- PRIMES 2009 for EU countries that have not supplied national projections
- No further measures for off-road sources up to 2020

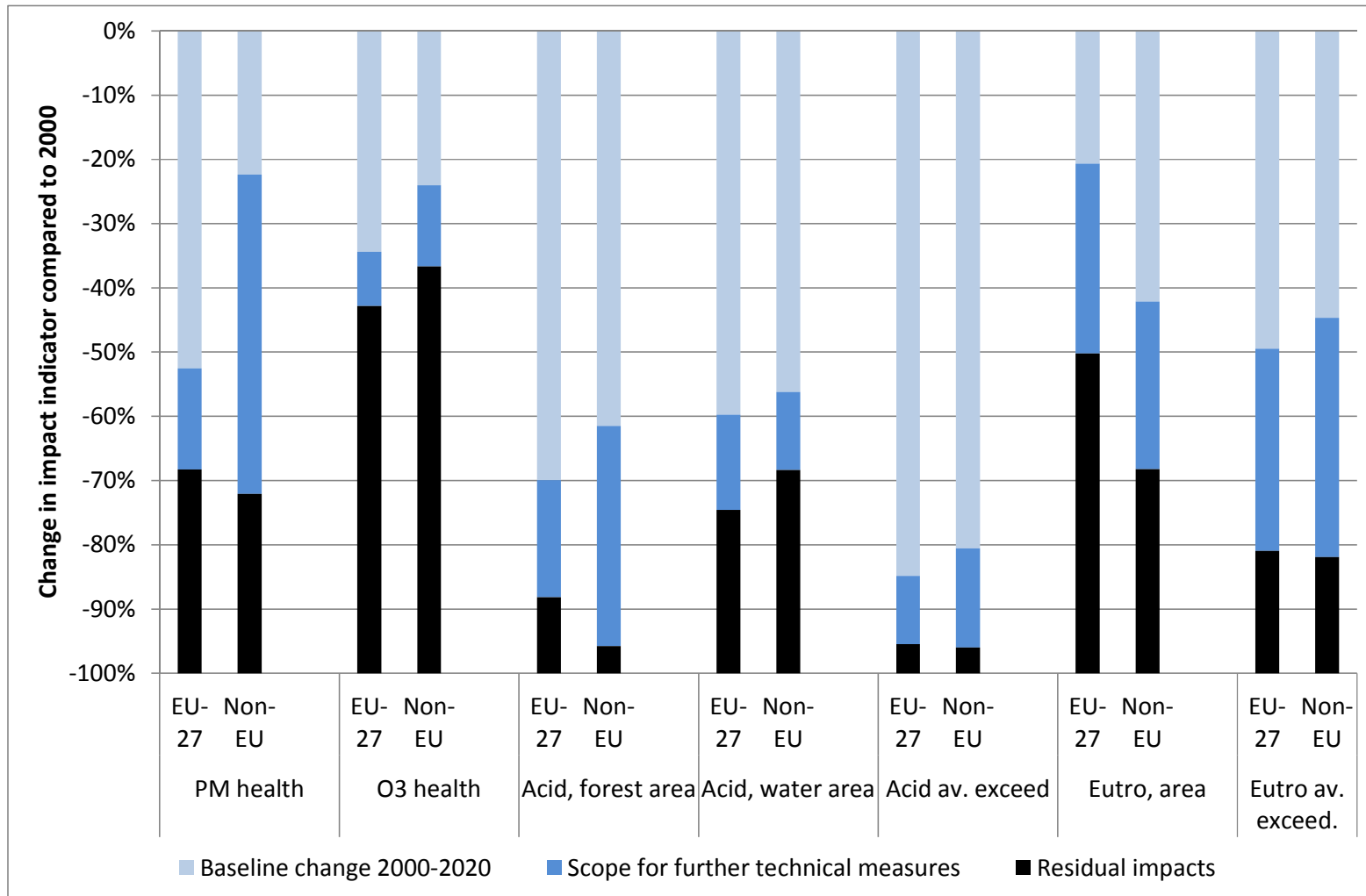
Activity projections - sources



| | <i>Europe-wide PRIMES 2009 scenario</i> | <i>National scenario</i> |
|---------------------------|---|--|
| <i>Energy projections</i> | | |
| PRIMES 2009 baseline | EU-27, CR, MK, NO | BE, BG, CY, EE, FR, DE, HU, MK, LV, LT, LU, MT, PL, RO, SK, SI |
| National projections | CH | AT, CR, CZ, DK, FI, GR, IE, IT, NL, NO, PT, ES, SE, CH, UK |
| IEA WEO 2009 | AL, BY, BA, MD, RU, RS, UA | AL, BY, BA, MD, RU, RS, UA |
| <i>Agriculture</i> | | |
| CAPRI 2009 | EU-27, AL, BA, CR, MK, NO, RS | AL, BA, BG, CY, CZ, DK, EE, FR, DE, GR, HU, LV, LT, LU, MK, MT, NO, PL, PT, RS, SL |
| National projections | CH | AT, BE, CR, FI, IE, IT, NL, RO, SK, ES, SE, CH, UK |
| FAO 2003 | BY, MD, RU, UA | BY, MD, RU, UA |

The Europe-wide PRIMES 2009 scenario is adopted as the central case, and sensitivity analyses are carried out for the National scenario

Scope for further environmental improvements



Impact indicators and target setting rules

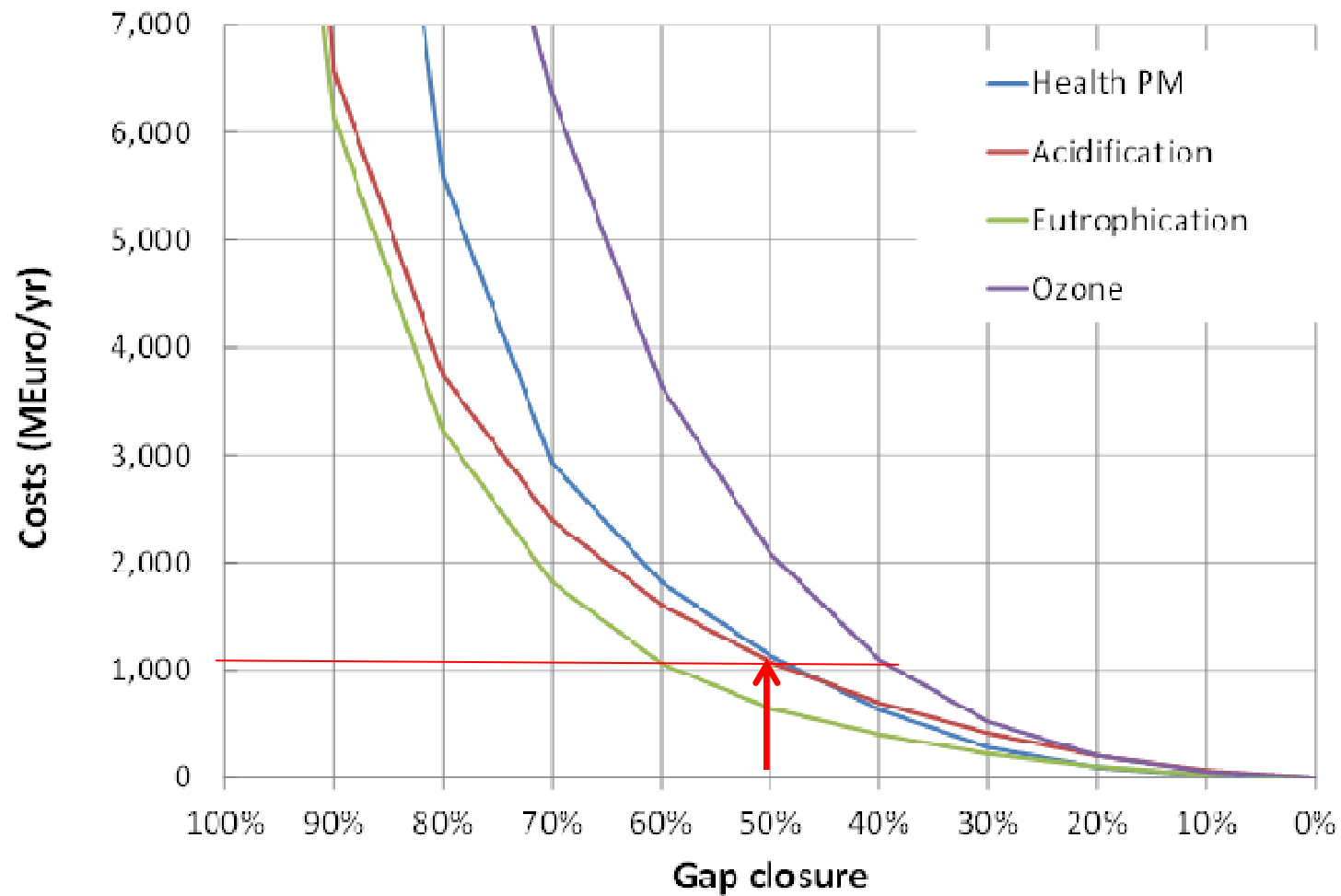
used for this report



- Health impacts of PM2.5:
 - YOLL (with actual population)
 - *Europe-wide gap closure between CLE and MTR*
- Eutrophication:
 - Excess deposition accumulated over all ecosystems in a country
 - *For each country same gap closure % between CLE and MTR*
 - Area of protected ecosystems calculated ex-post
- Acidification
 - Excess deposition accumulated over all ecosystems in a country
 - *For each country same gap closure % between CLE and MTR*
 - Area of protected ecosystems calculated ex-post
- Ozone:
 - For health effects: SOMO35
 - *For each country same gap closure % between CLE and MTR*
 - Vegetation and crop impacts calculated in ex-post analysis

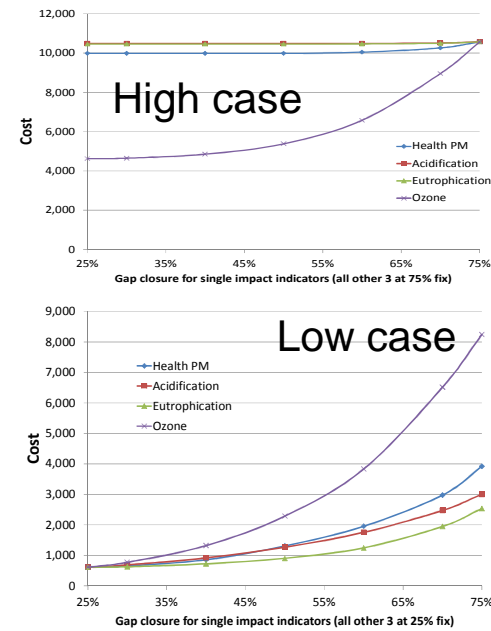
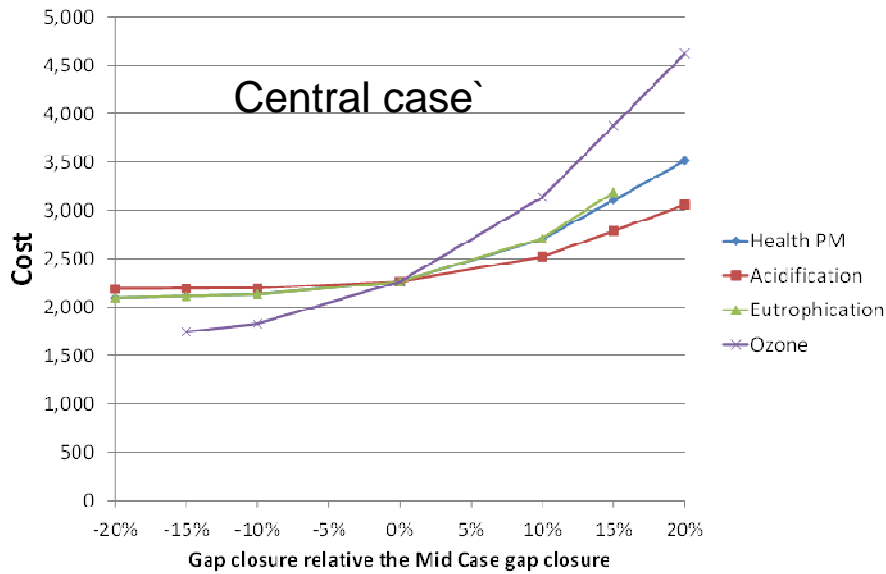
Choosing an ambition level

Costs for improving individual effects



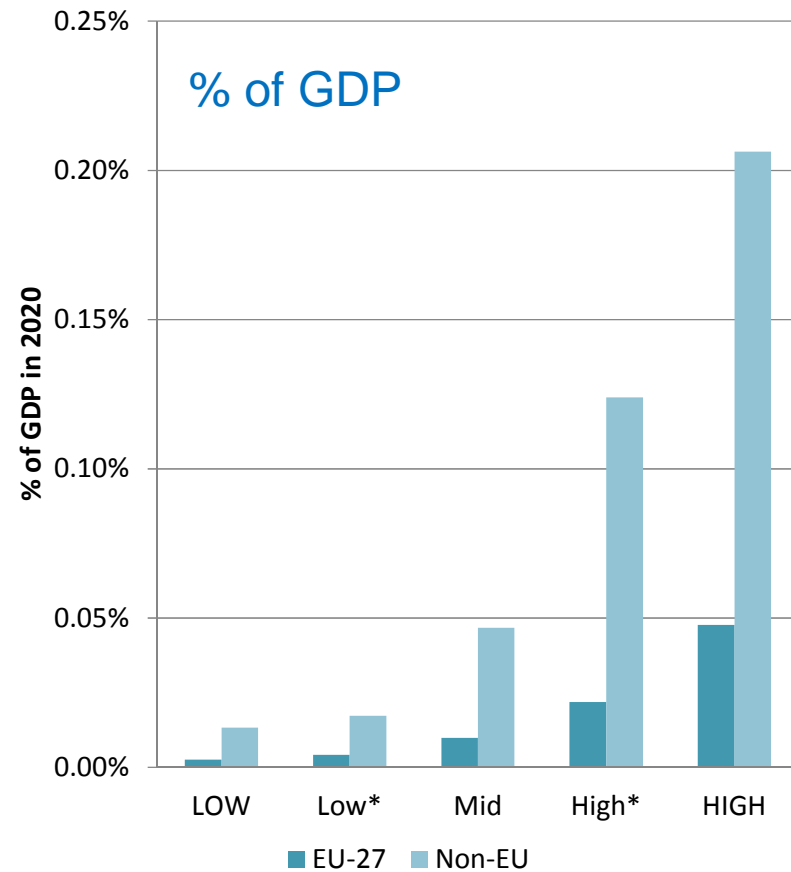
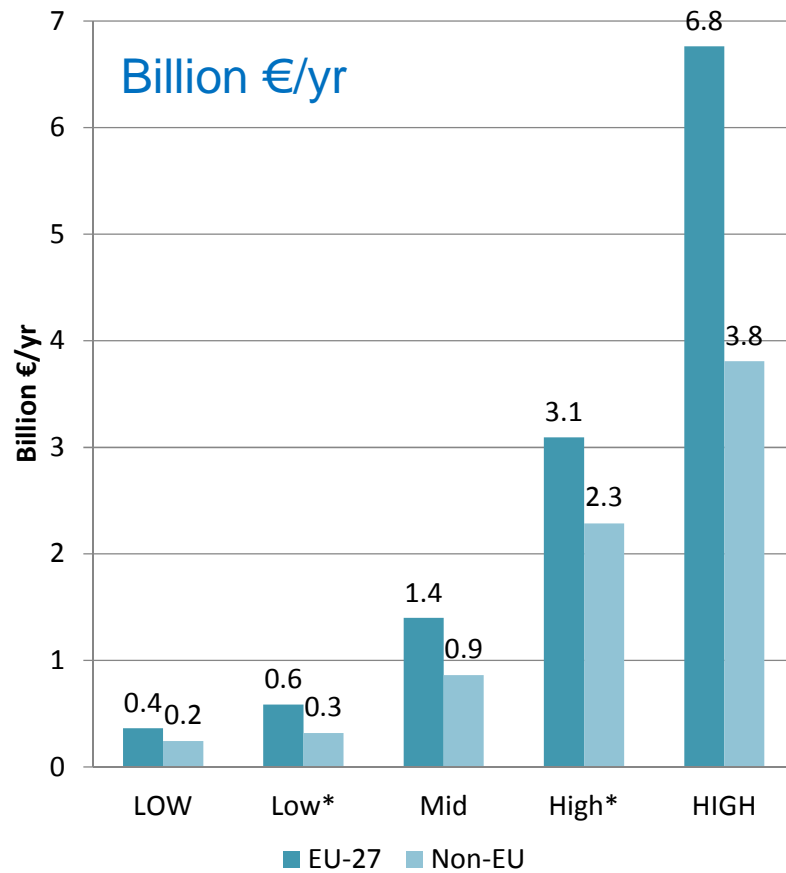
Five sets of targets

derived from sensitivity analyses for modifications of ambition levels of a single effect



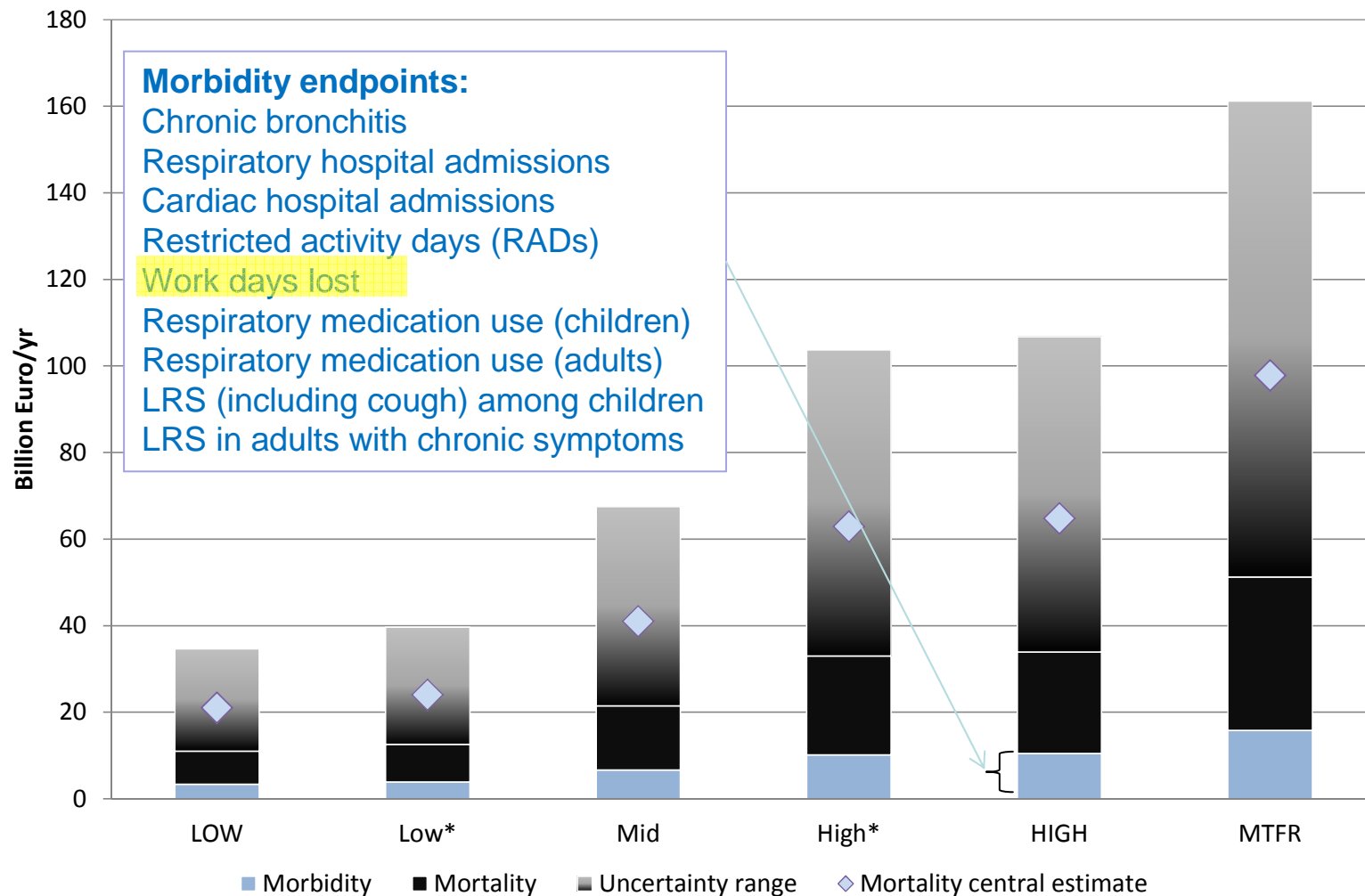
| | Health-PM | Acidification | Eutrophication | Ozone |
|-------|-----------|---------------|----------------|-------|
| HIGH | 75% | 75% | 75% | 75% |
| High* | 75% | 75% | 75% | 50% |
| Mid | 50% | 50% | 60% | 40% |
| Low* | 25% | 25% | 50% | 25% |
| LOW | 25% | 25% | 25% | 25% |

Additional air pollution control costs (on top of baseline)

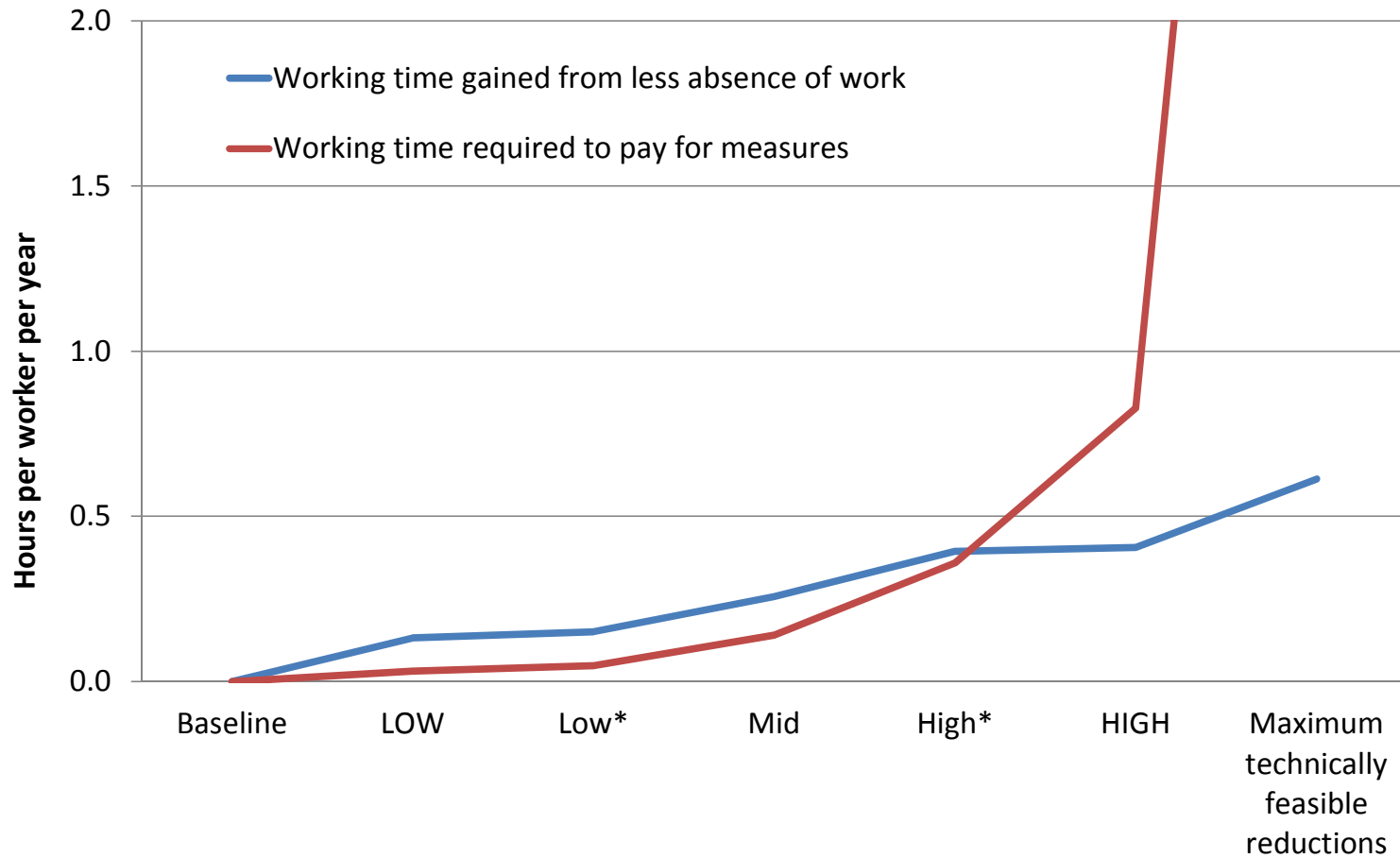


Health benefits (compared to baseline case)

EU-27 only, based on Holland et al., 2010

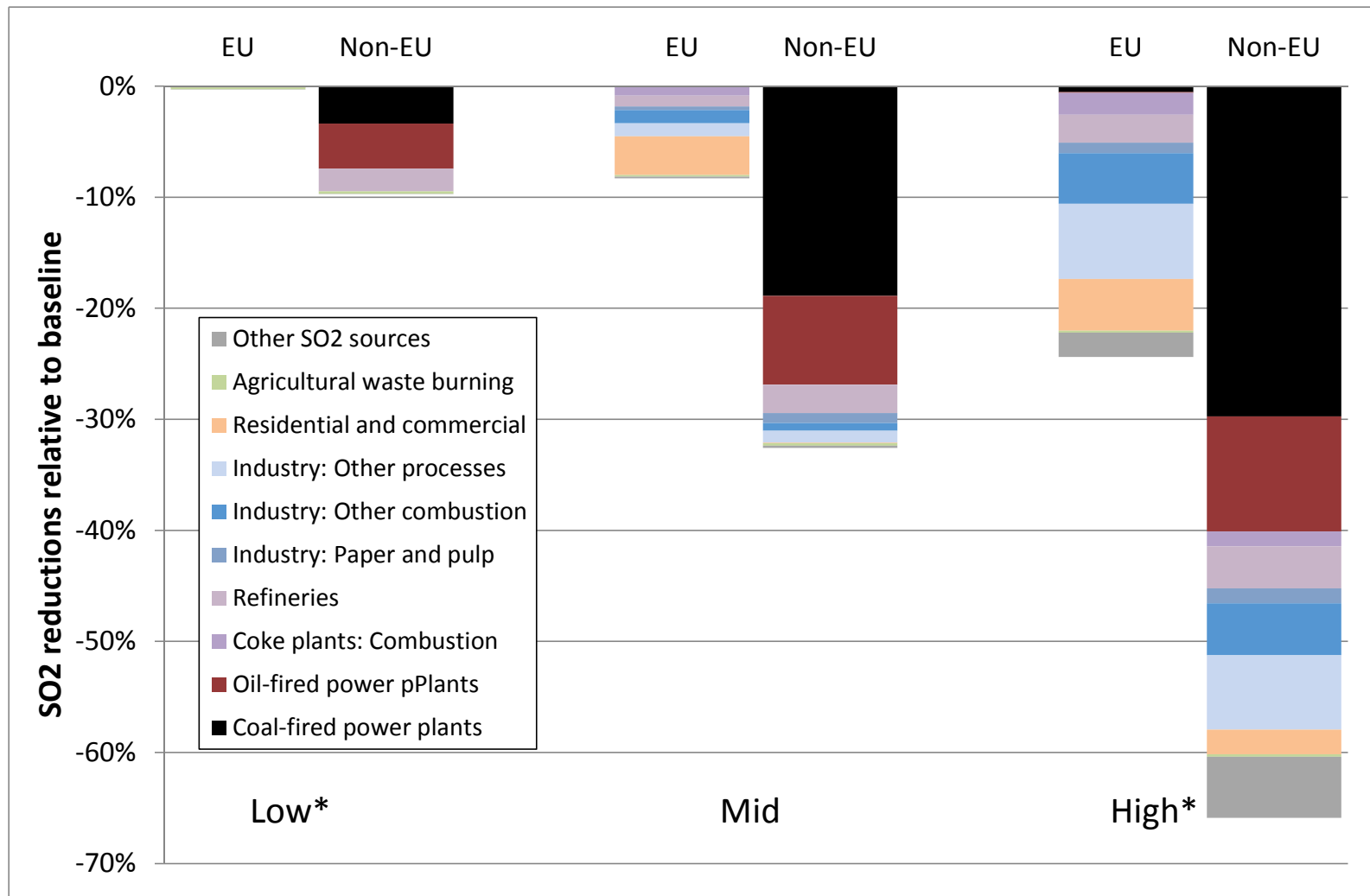


Work time gained from better air quality vs. Work time spent to pay for additional emission controls

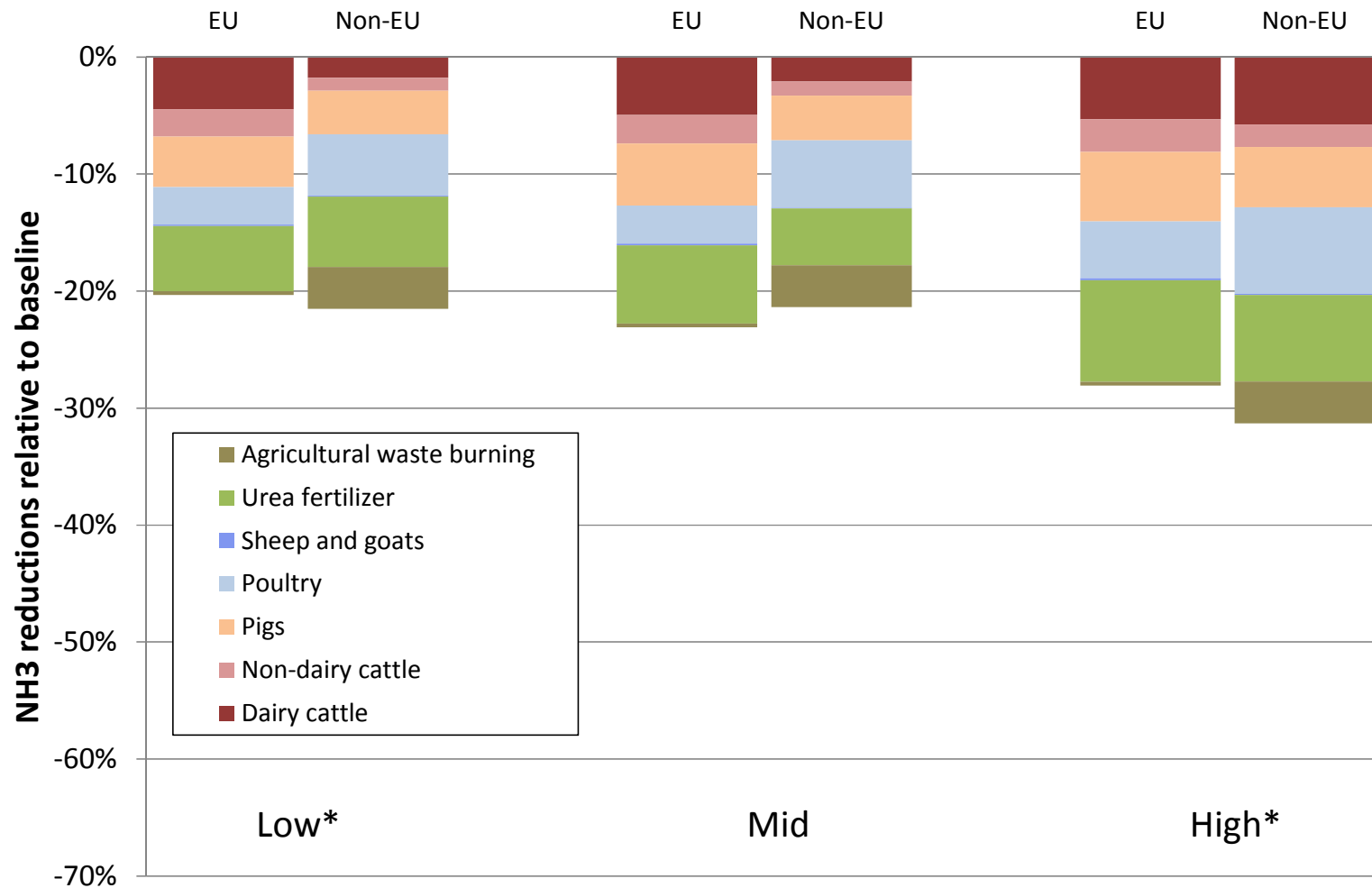


Emission control cases in CIAM 1/2011 report

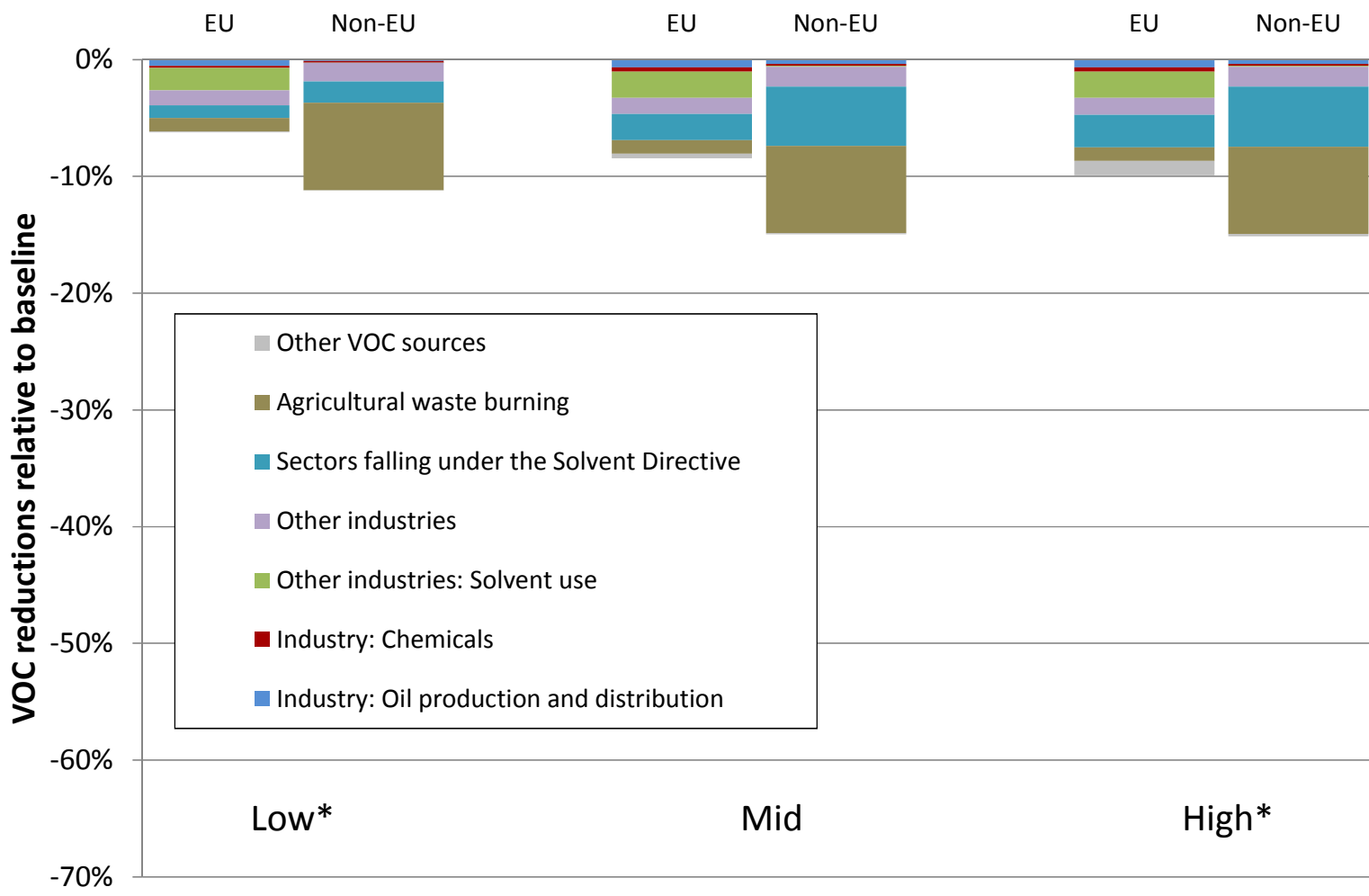
Additional measures for SO₂ (on top of baseline)



Additional measures for NH₃ (on top of baseline)



Additional measures for VOC (on top of baseline)



Key measures for the mid case



SO₂:

- FGD for power plants in non-EU

- Low S coal in domestic sector in new EU Member States

NO_x:

- SCR for power plants in non-EU

- NO_x controls in some industrial sectors (e.g., cement) (EU and non-EU)

PM_{2.5}:

- Dust control for iron & steel industry in non-EU

- Agricultural waste burning (EU and non-EU)

NH₃:

- Measures for cattle, pig and poultry farms

- Substitution of urea fertilizer

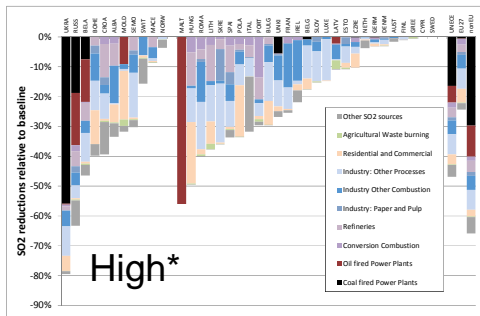
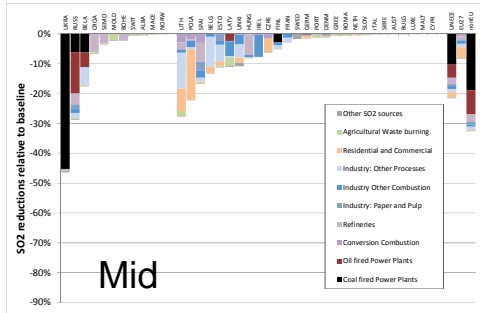
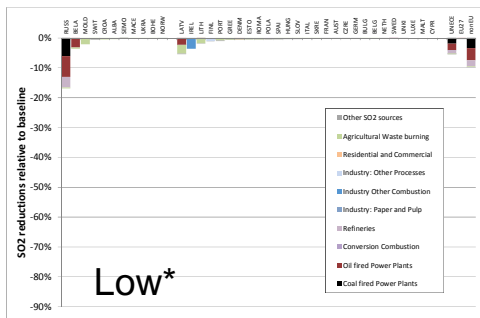
- Agricultural waste burning (EU and non-EU)

VOC:

- Additional measures for sectors falling under the Solvents Directive

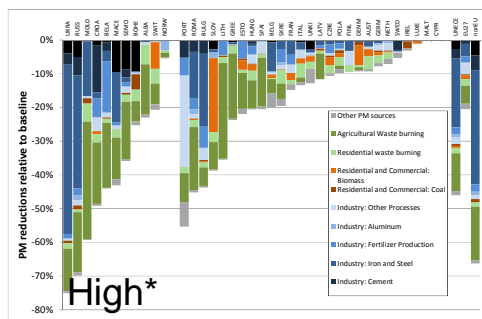
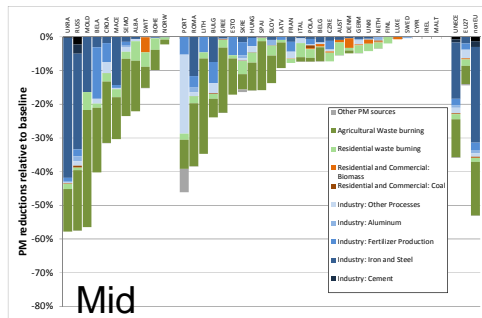
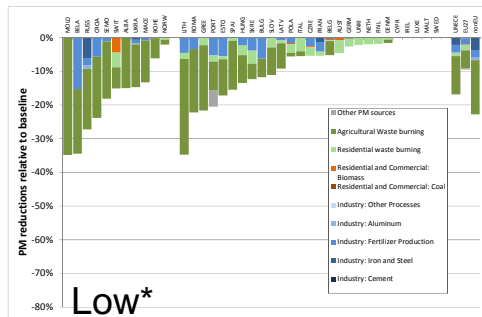
- Agricultural waste burning (EU and non-EU)

Additional measures for SO₂ by country



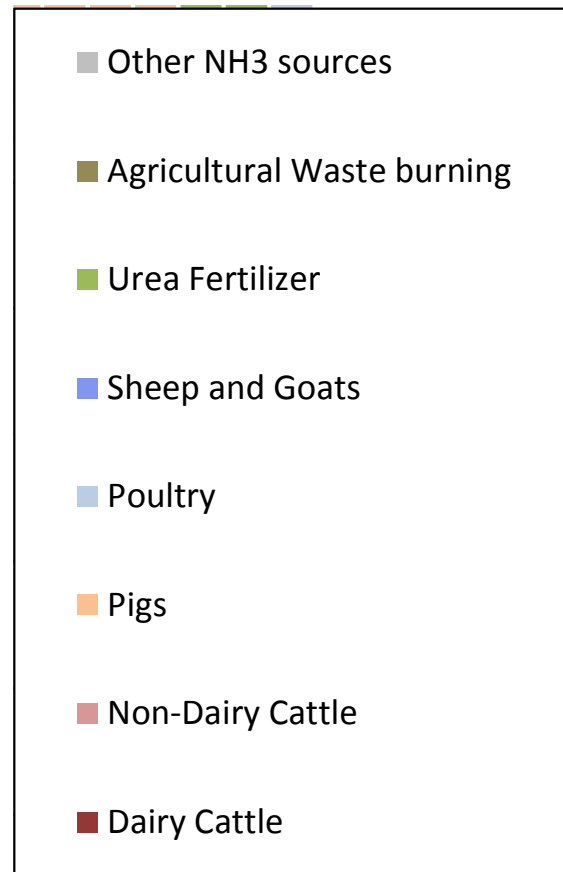
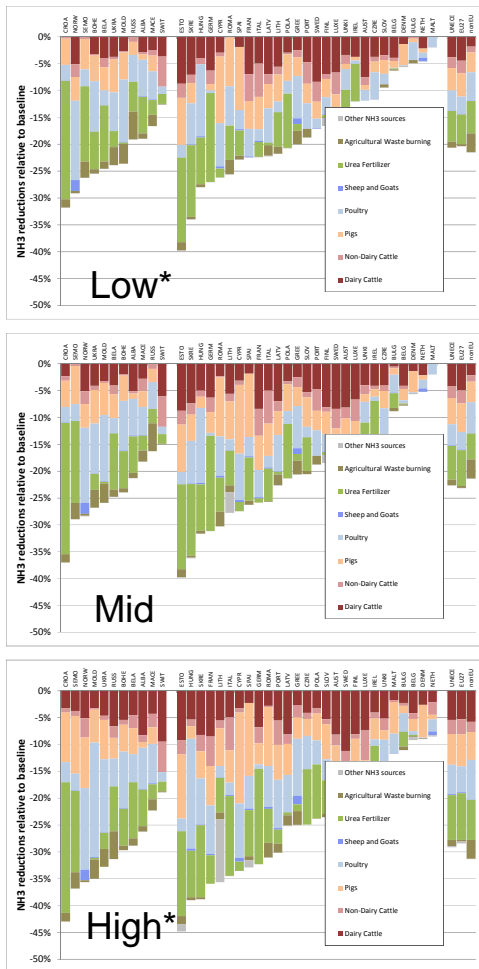
- Other SO₂ sources
- Agricultural Waste burning
- Residential and Commercial
- Industry: Other Processes
- Industry: Other Combustion
- Industry: Paper and Pulp
- Refineries
- Conversion Combustion
- Oil fired Power Plants
- Coal fired Power Plants

Additional measures for PM2.5 by country

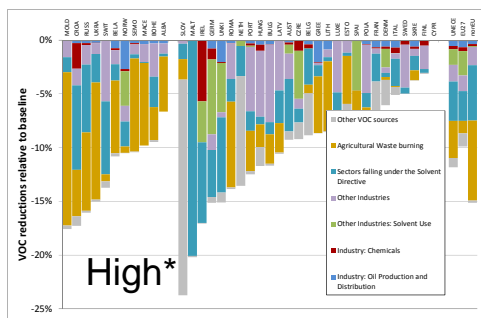
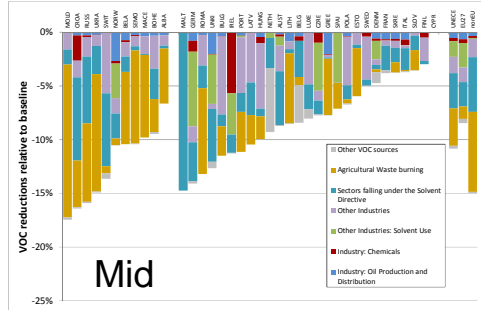
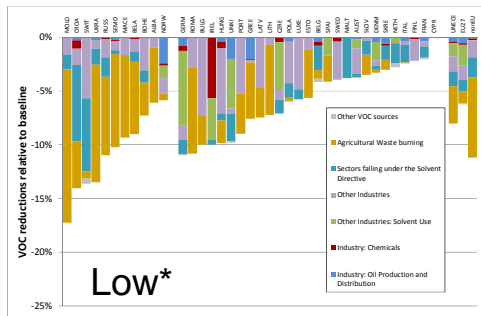


- Other PM sources
- Agricultural Waste burning
- Residential waste burning
- Residential and Commercial: Biomass
- Residential and Commercial: Coal
- Industry: Other Processes
- Industry: Aluminum
- Industry: Fertilizer Production
- Industry: Iron and Steel
- Industry: Cement
- Coal fired Power Plants

Additional measures for NH₃ by country



Additional measures for VOC by country



- Other VOC sources
- Agricultural Waste burning
- Sectors falling under the Solvent Directive
- Other Industries
- Other Industries: Solvent Use
- Industry: Chemicals
- Industry: Oil Production and Distribution

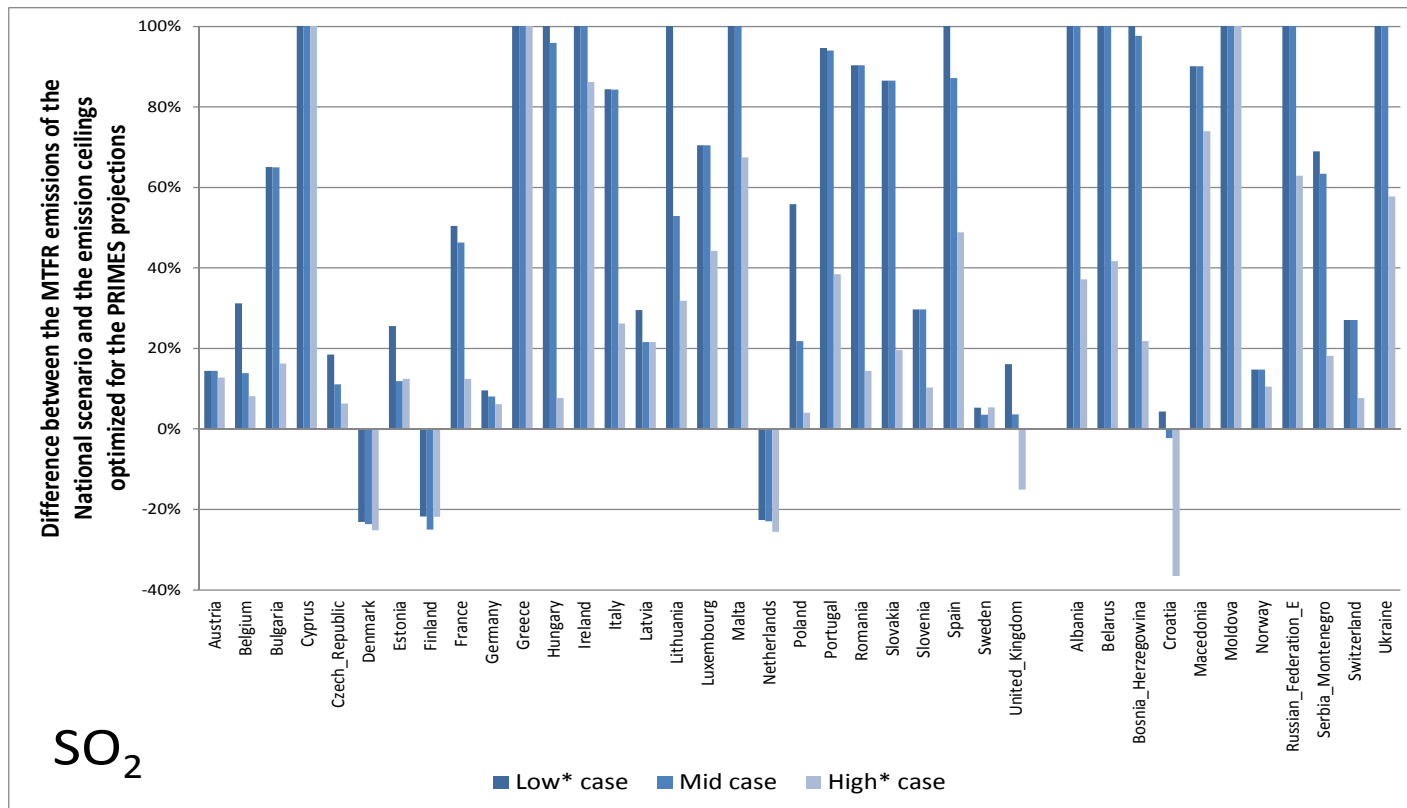
Three sensitivity analyses



1. For national activity projections
2. Additional targets on radiative forcing
3. Excluding the urban increment for PM

Sensitivity analysis 1 – National activity projections:

Distance between optimized cases and MTR of national scenario



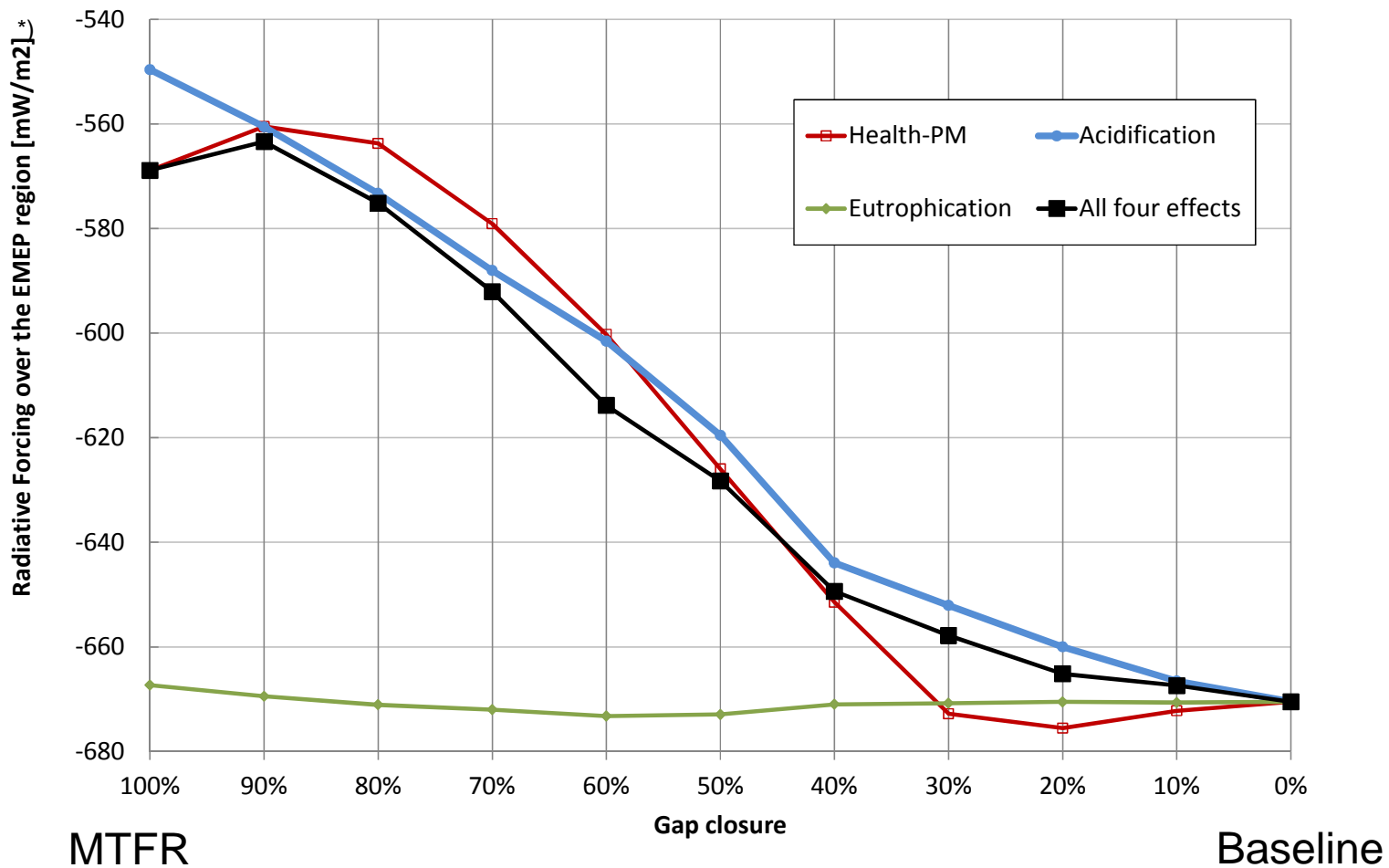
- Emission ceilings could become unachievable for fundamentally different assumptions on energy and agricultural policies (compared to PRIMES/CAPRI)

Sensitivity analysis 2 – Radiative forcing:

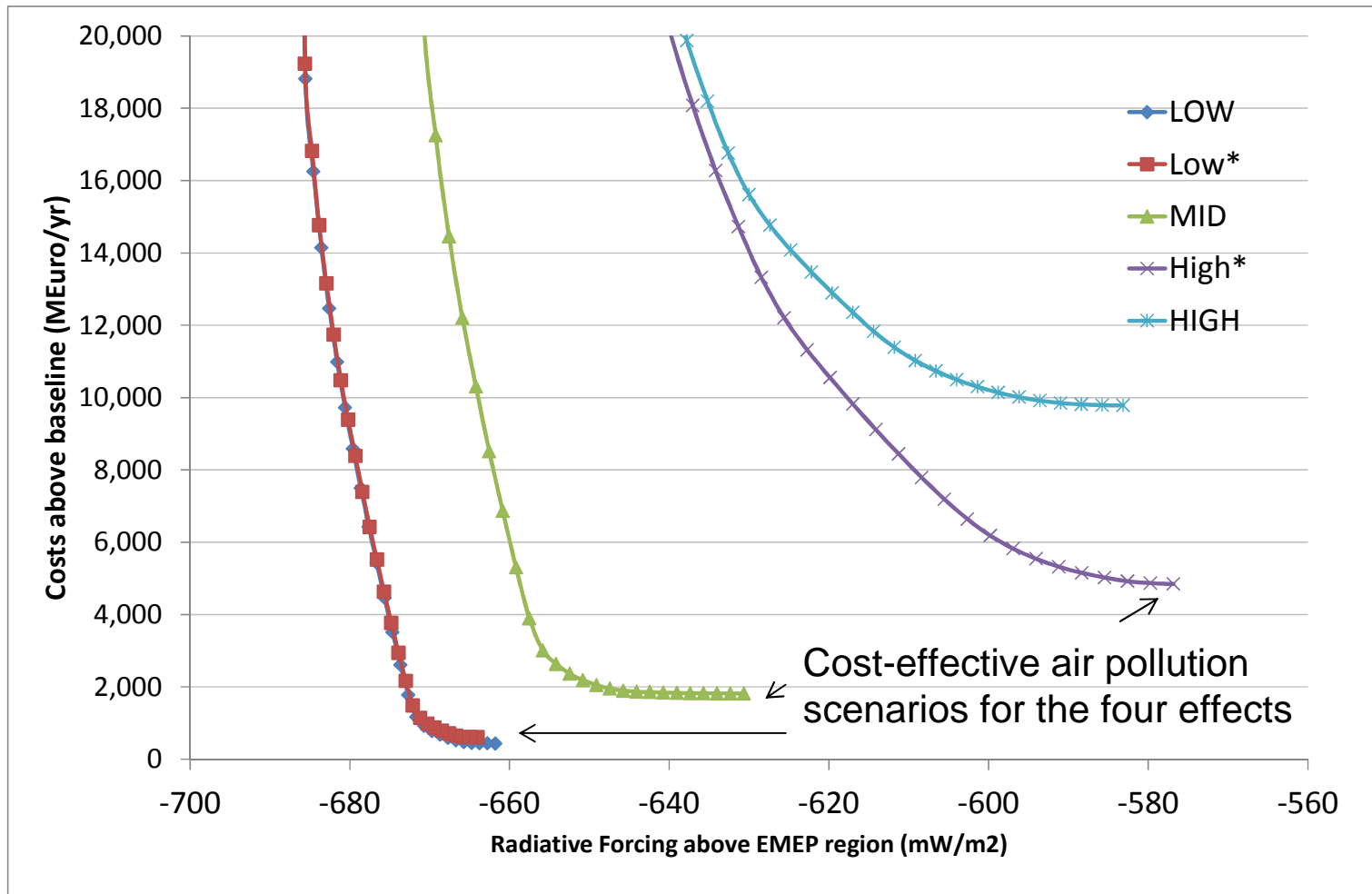
Instantaneous radiative forcing over the EMEP region for cost-effective air pollution scenarios (from aerosol emissions)



For comparison: total forcing from long-lived GHGs: $\sim -2.7 \text{ W/m}^2$

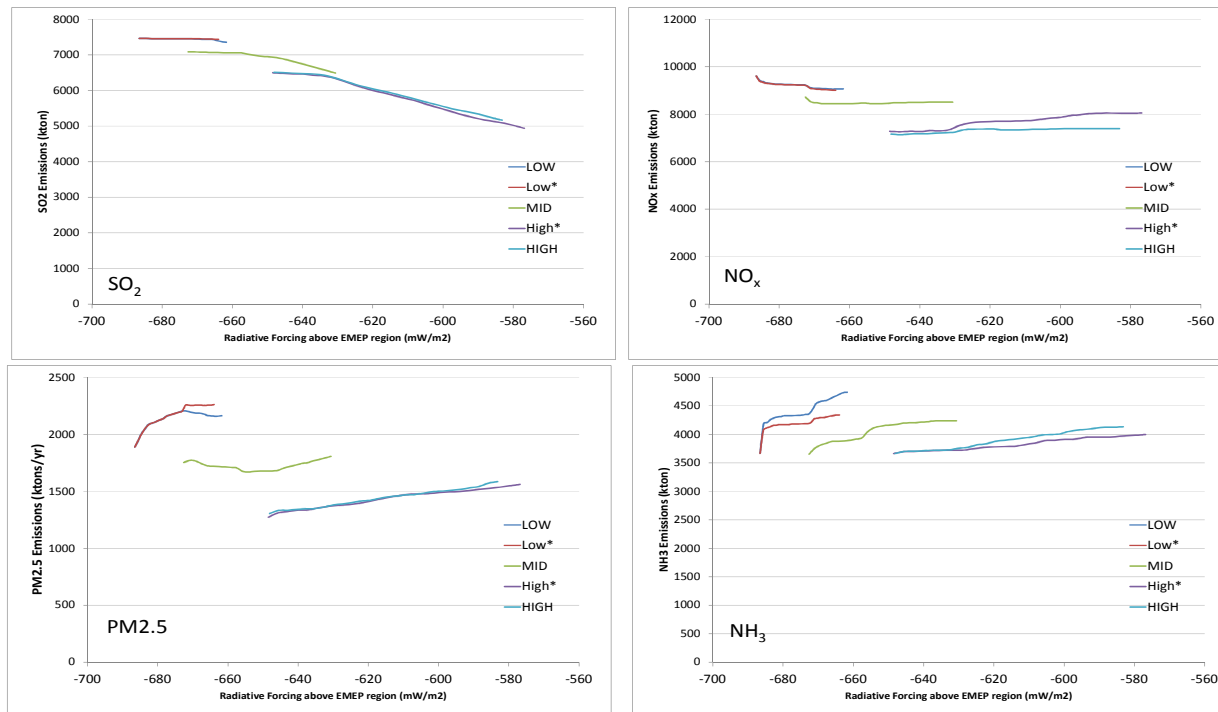


Sensitivity analysis 2 – Radiative forcing: Costs for reducing radiative forcing in addition to the air quality targets



Sensitivity analysis 2 – Radiative forcing:

Cost-effective changes in emissions for reducing radiative forcing, in addition to the targets for air quality impacts



- To reduce radiative forcing at low costs:
 - SO₂ emissions are cut to a lesser extent (mainly in non-EU countries).
 - The resulting increase in PM_{2.5} levels is compensated by additional cuts in NH₃ emissions.

Sensitivity analysis 3:

No urban increment for EU (and non-EU) countries



Emissions in the EU-27 for the mid case and the variant without urban increment (kilotons)

| | SO ₂ | NO _x | PM _{2.5} | NH ₃ | VOC |
|--|-----------------|-----------------|-------------------|-----------------|-------|
| Mid case (original) | 2508 | 5046 | 907 | 2819 | 5437 |
| Sensitivity case without urban increment | 2513 | 5046 | 910 | 2820 | 5436 |
| <i>Difference (absolute)</i> | -5 | 0 | -3 | -2 | 0 |
| <i>Difference (%)</i> | -0.18% | 0.00% | -0.33% | -0.06% | 0.00% |

- Urban increments do not have large influence on national emission ceilings for optimized scenarios based on a gap closure approach
- However, urban increments affect absolute estimates of health effects

Conclusions



- Despite significant reductions in emissions in the baseline, there remains scope for cost-effective further air quality improvements in 2020.
- The report presents five scenarios aiming at 25% to 75% of the feasible improvements for each air quality effect, with additional emission control costs ranging from 0.6 to 10.6 billion €/yr. Modified targets for ozone would have largest impact on control costs.
- Between 60 and 70% of these costs emerge in the EU-countries. However, relative efforts in most non-EU countries are higher than in the EU.
- The scenarios reduce the negative forcing (and thus increase radiative forcing) in the EMEP domain by up to 0.1 W/m^2 (compared to a current total forcing from long-lived greenhouse gases of about 2.7 W/m^2). Low cost options are available that could reduce these negative impacts on near-term climate change to some extent.

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- FGD for power plants in non-EU

- Low S coal in domestic sector in new EU Member States

NO_x:

- SCR for power plants in non-EU

- NO_x controls in some industrial sectors (e.g., cement) (EU and non-EU)

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VOC:

- Additional measures for sectors falling under the Solvents Directive

- Agricultural waste burning (EU and non-EU)

Access to all data via GAINS-Online



URL: <http://gains.iiasa.ac.at>

Version: GAINS-Europe

Scenario group: CIAM 1/2011-March

Scenarios:

Data for the year 2000: GOTH_2000

Optimized scenarios:

- PRIMES baseline: GOTH_PRIMESBL2009_baseline_rev1
- LOW case: GOTH_PRIMESBL2009_LOW_rev1
- Low* case: GOTH_PRIMESBL2009_Low-star_rev1
- Mid case: GOTH_PRIMESBL2009_MID_rev1
- High* case: GOTH_PRIMESBL2009_High-star_rev1
- High case: GOTH_PRIMESBL2009_HIGH_rev1
- Maximum feasible reductions: GOTH_PRIMESBL2009_MFR_rev1