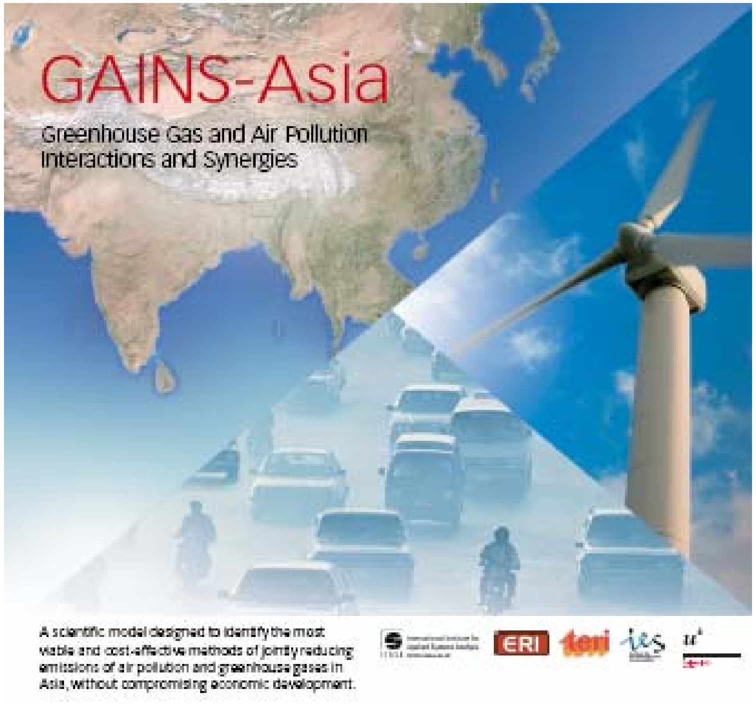
Markus Amann
International Institute for Applied Systems Analysis (IIASA)

GAINS-Asia: Greenhouse gas – Air pollution Interactions and Synergies



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EU 6th Framework Programme for Research

GAINS: GHG-Air pollution INteractions and Synergies

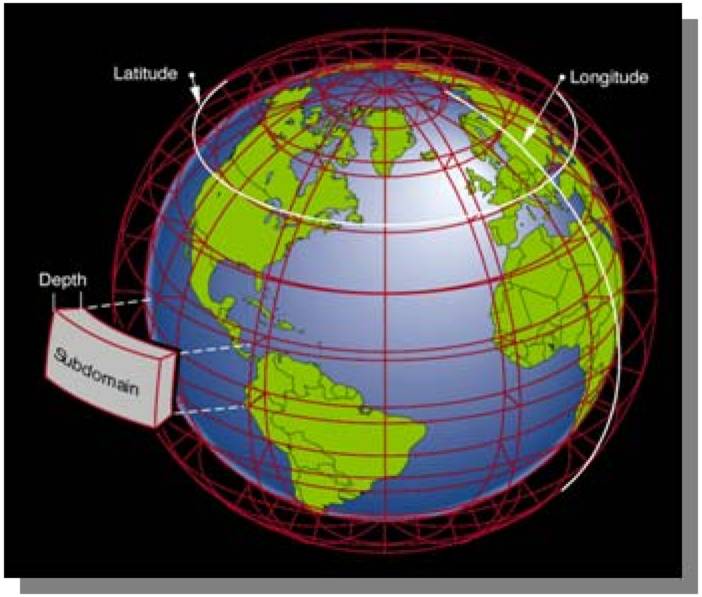
A new tool to analyze synergies between air pollution and GHGs

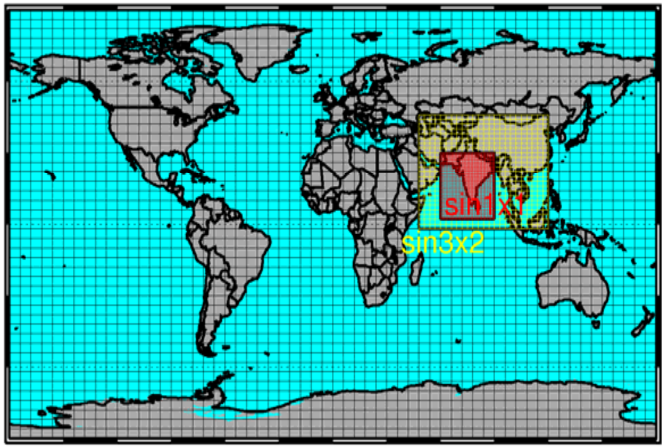
- Focus on cost-effective emission control strategies to improve air quality with maximum co-benefits on GHG emissions.
- Extension of IIASA's RAINS integrated assessment model for air pollution to GHGs
- GAINS covers SO_2, NO_x, PM, NH_3, VOC and CO_2, CH_4, N_2O, (HFC, CFC, SF_6)
- Implementation for Europe completed and used for policy analysis by the EU
- Implementation for India and China is near completion

The GAINS model: The RAINS multi-pollutant/ multi-effect framework extended to GHGs

	PM	SO_2	NO_x	VOC	NH_3	CO_2	CH_4	N_2O	HFCs PFCs SF_6
Health impacts: PM	√	√	√	√	√				
O_3			√	√			√		
Vegetation damage: O_3			√	√			√		
Acidification		√	√		√				
Eutrophication			√		√				
Radiative forcing: - direct						√	√	√	√
- via aerosols	√	√	√	√	√				
- via OH			√	√			√		

TM 5 model set-up





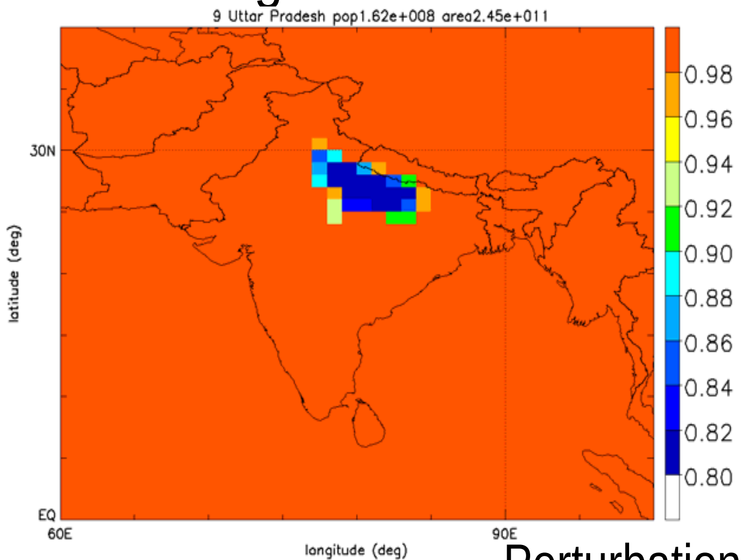
TM5 is a global 3D CTM with regional two-way nesting, developed by Utrecht University and JRC

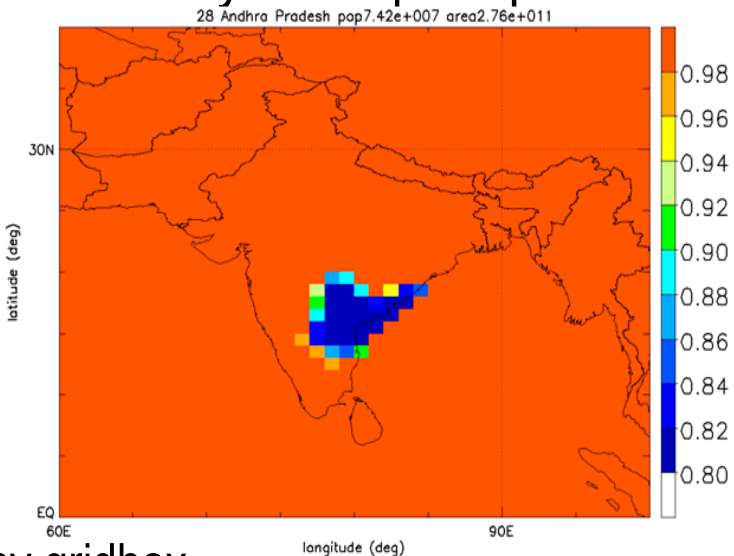
- For GAINS-Asia operated by JRC
- 6°x4; 3°x2°,1°x1°; 25 vertical layers
- Aerosol and photo-chemistry
- ECMWF meteorology; output every hour
- Participated in AEROCOM, PHOTOCOMP, HTAP intercomparisons

TM5 experimental set-up for GAINS-Asia

Source-receptor relationships derived for:

- 26 regions in China
- 32 regions for India; Bangadesh, Pakistan and Sri Lanka
- Perturbation by -20 % of anthropogenic emissions per region
- Emissions: GAINS/EDGAR3.2; BC/POM: Bond (2004).
- 2 separate cases: NO_x-BC-POM; and SO_2-CO-VOC
- Altogether ca. 120 simulations of 1 year+ spin-up 2 months





Perturbation by gridbox

Subgrid (urban) scaling of PM concentrations in TM5

- Observations show that diurnal and daily variabilities of RN222 and PM concentrations are correlated

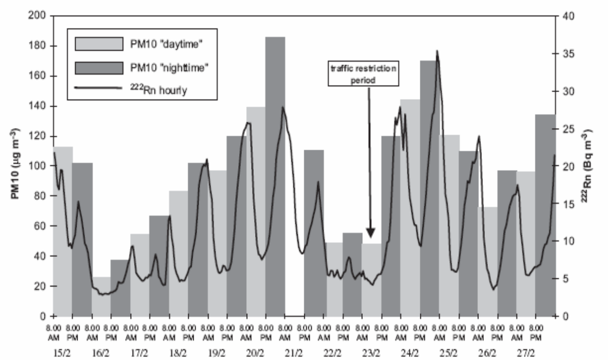


Fig. 1. PM10 concentrations (light grey, daytime; dark grey, nighttime) together with hourly ^{222}Rn concentration (solid line) represented for the period 15–27 February 2003.

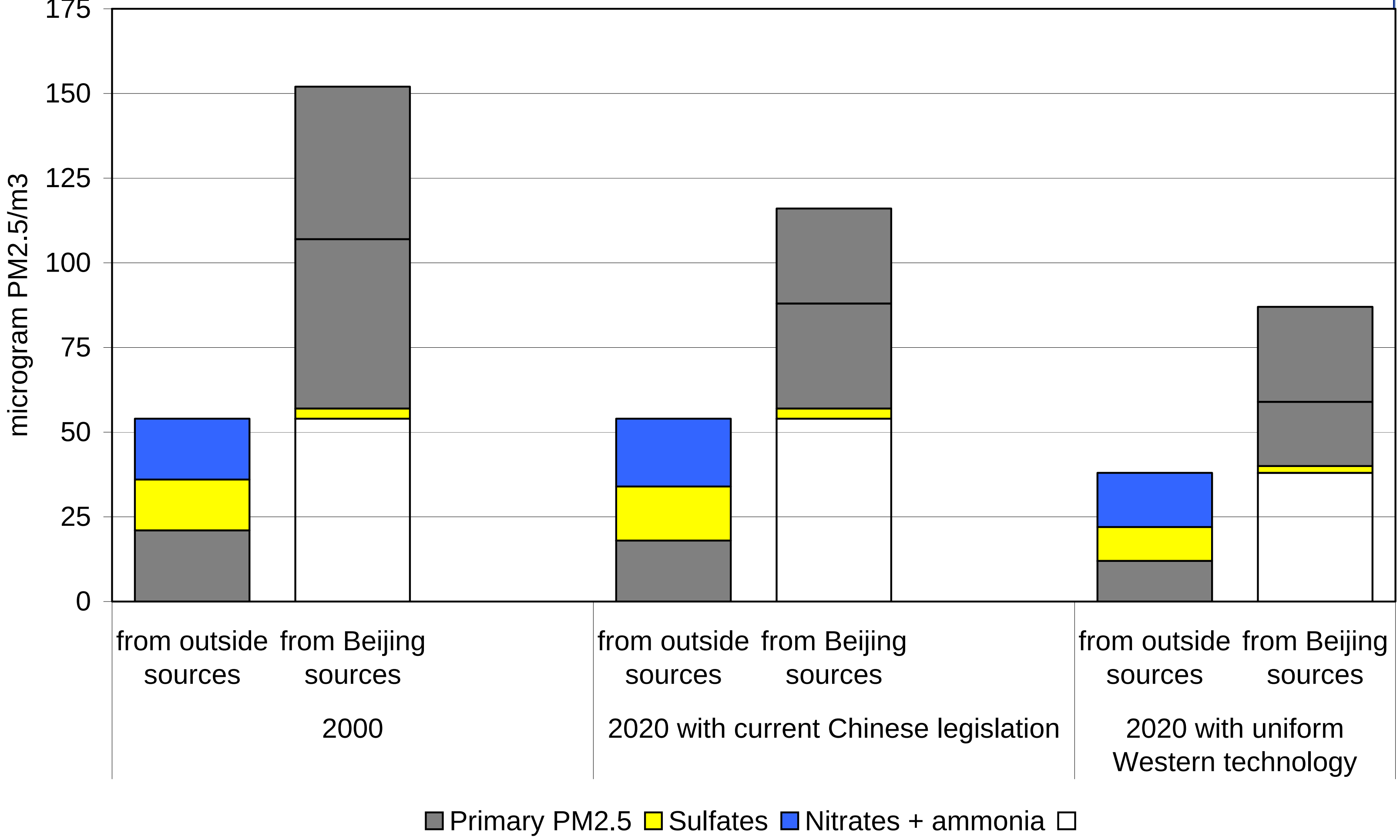
Correlation of particles and Rn222 in Milano, Italy (Vecchi et al, Atmos. Env., 2005)

- TM5 calculates for each city the dispersion characteristic of an inert tracer (Rn222) based on vertical mixing

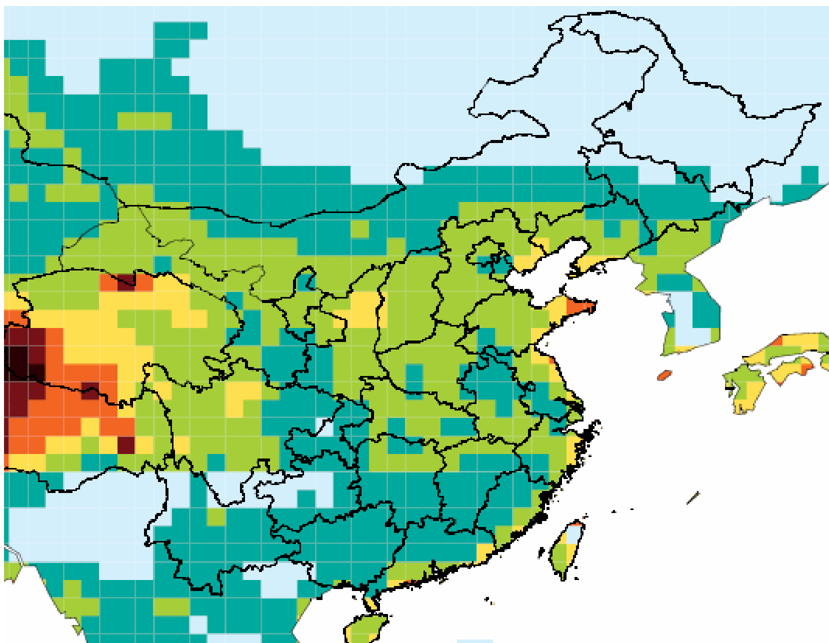
- This is then used by GAINS to compute the “urban increment” of PM2.5, linked to urban primary PM2.5 emissions from low level sources (domestic, transport, local industries)

Chemical composition of PM2.5

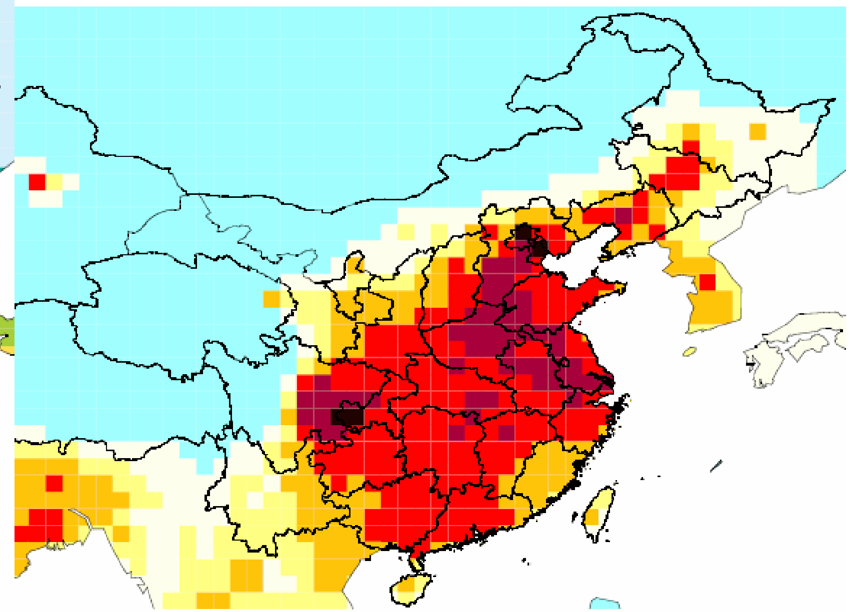
GAINS/TM5 model results for Beijing



Modeled ozone and PM2.5 concentrations for 2000



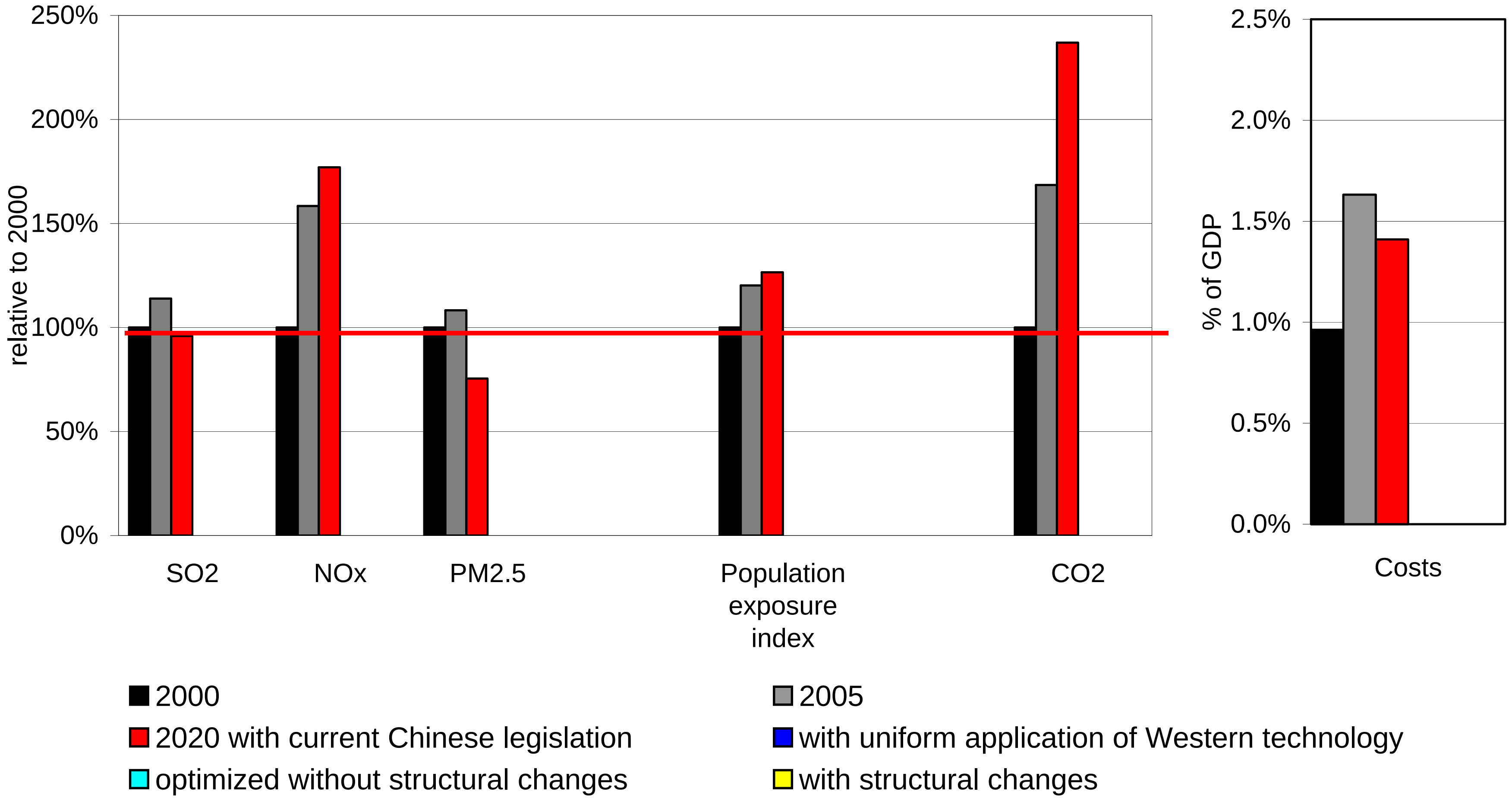
Ozone, SOMO35



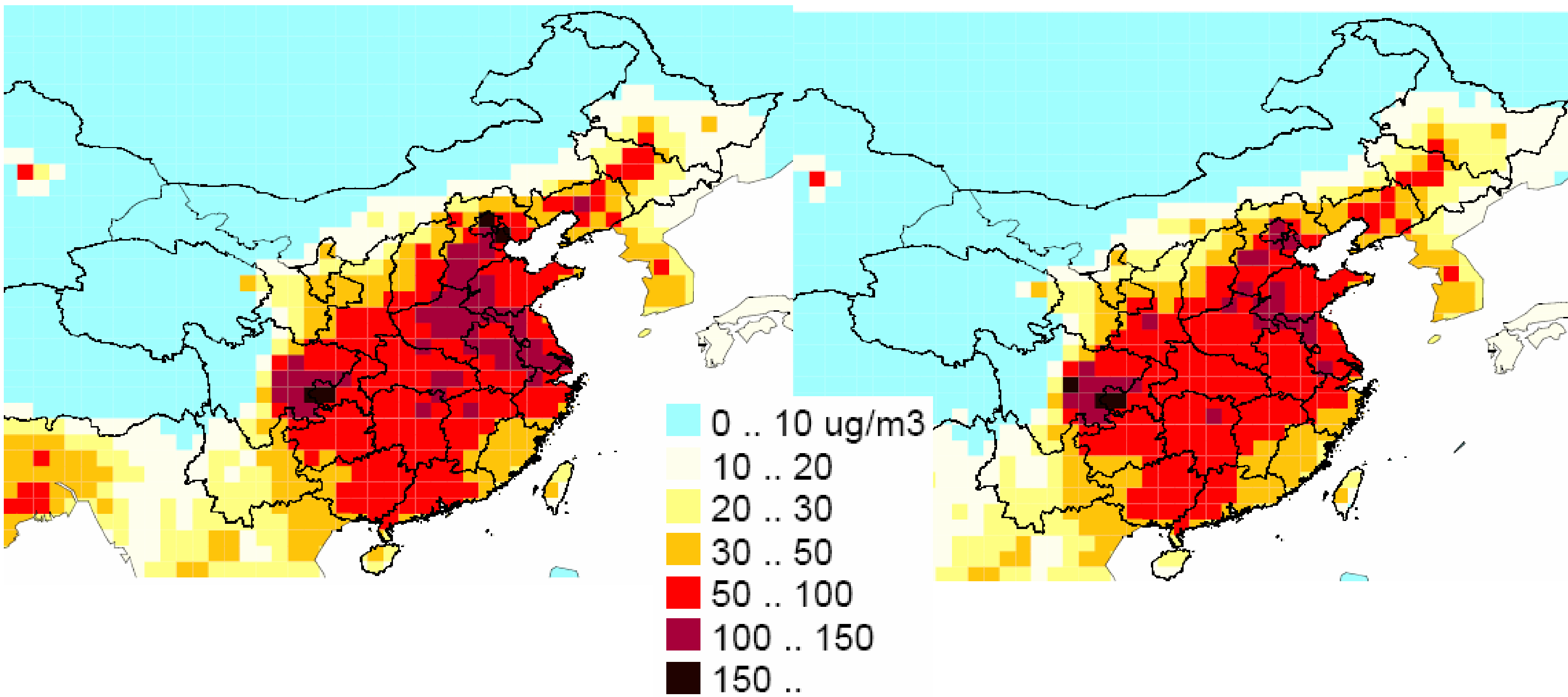
PM2.5

Current Chinese legislation

Emissions, PM exposure and mitigation costs in 2020



Modeled PM2.5 concentrations
2000 and 2020 current legislation



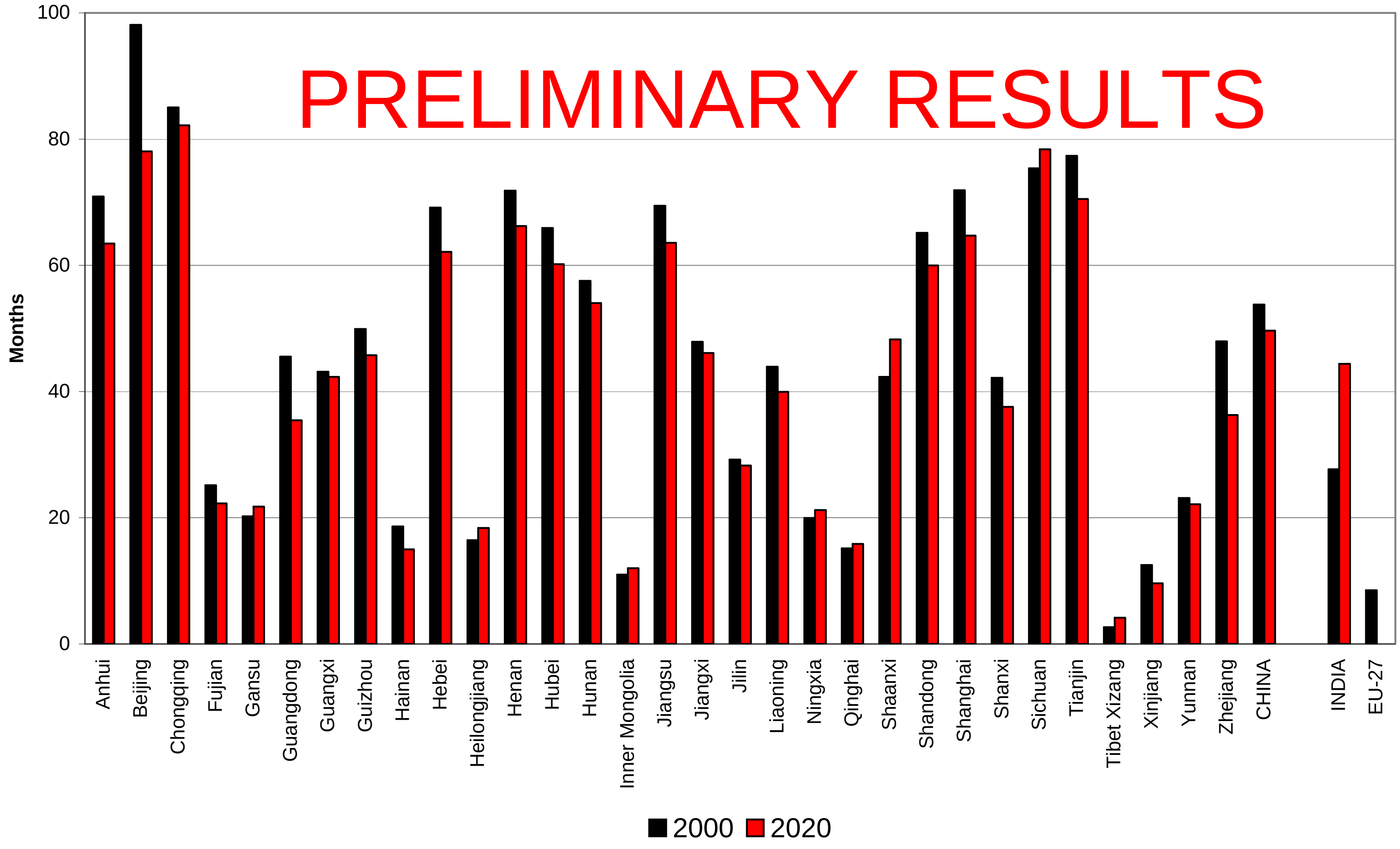
2000 **Current legislation 2020**

Population exposure index [ppb*bn persons]

2675 3385

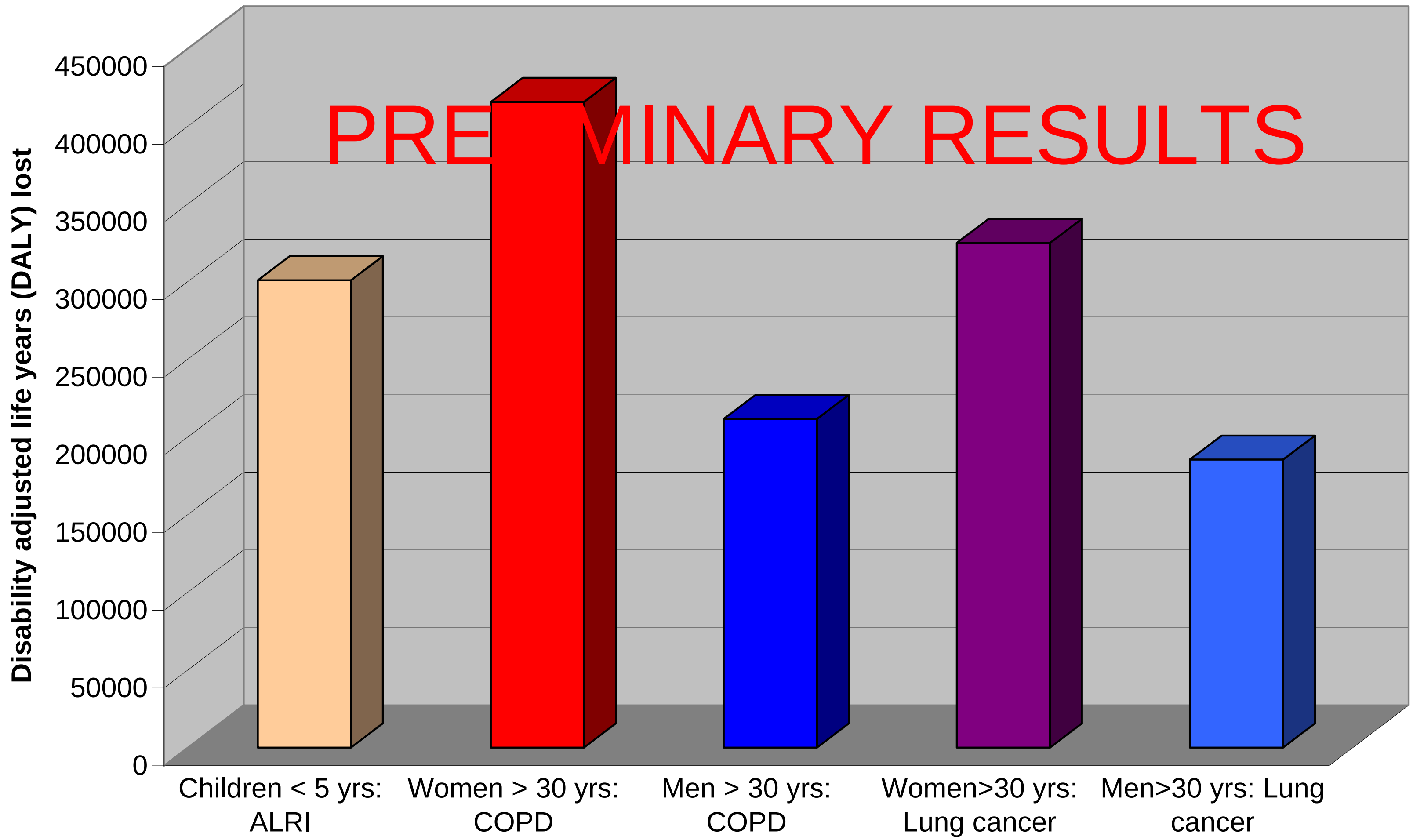
Preliminary estimates of loss in statistical life expectancy due to PM2.5

assuming linear C-R function

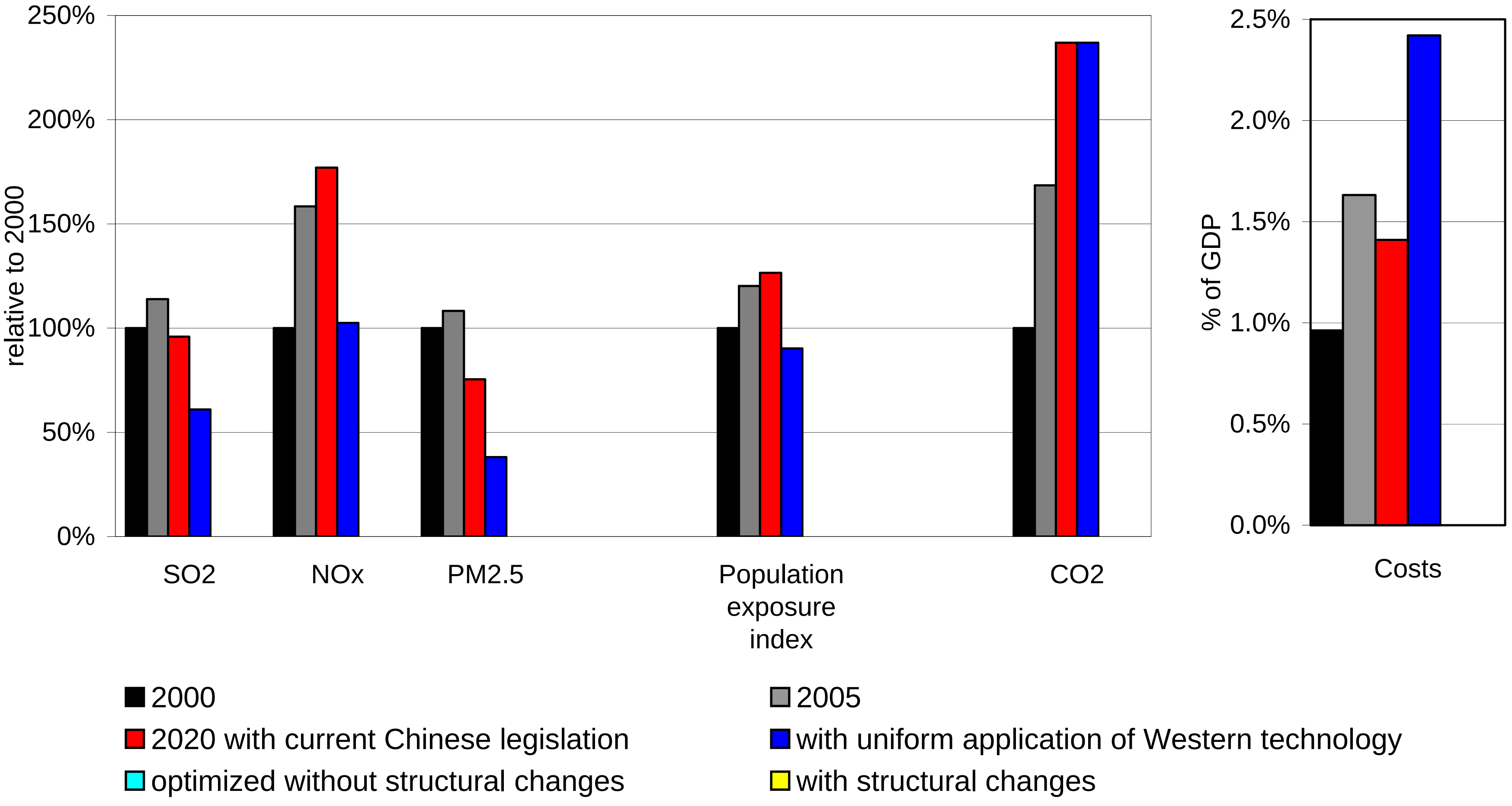


Initial estimates of health impacts from indoor pollution caused by solid fuels

using the WHO “Global Burden of Disease” methodology

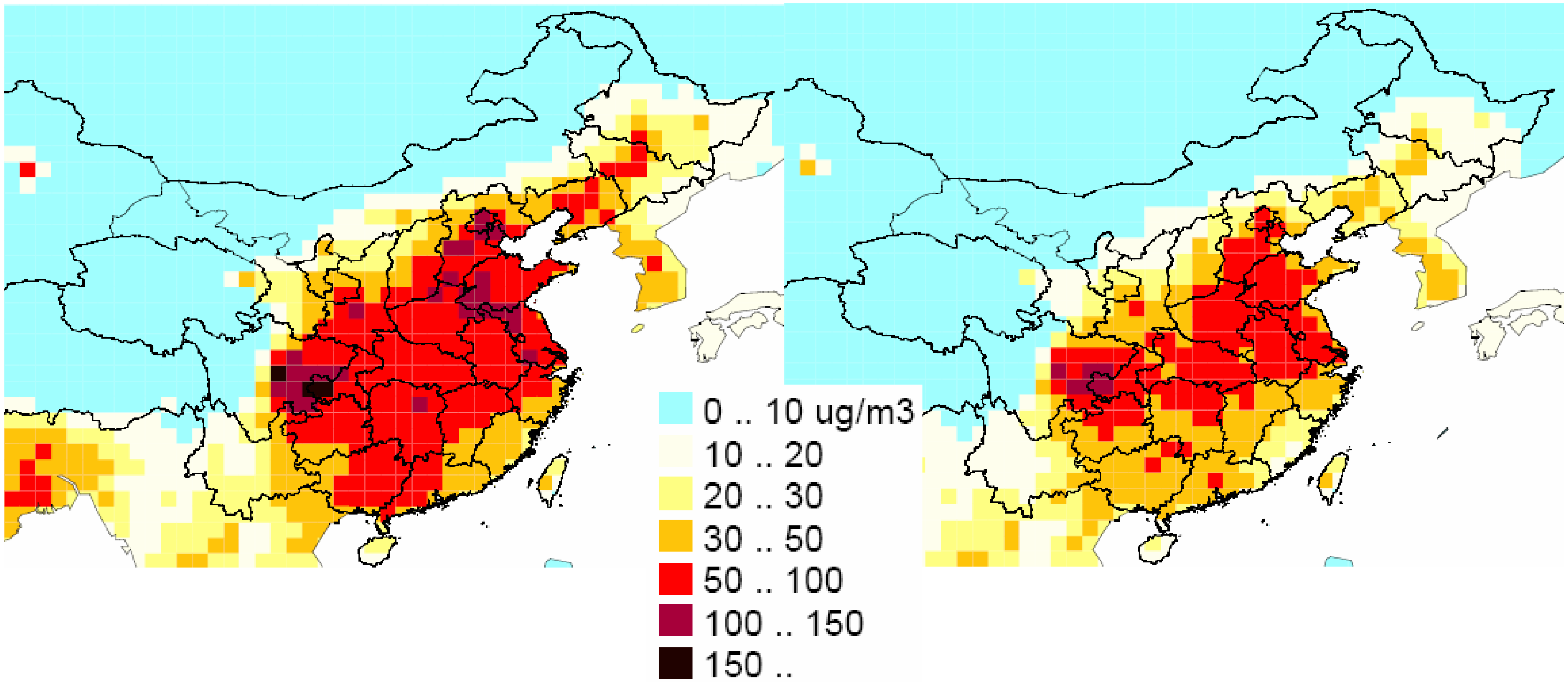


Uniform application of Western technology
Emissions, PM exposure and mitigation costs in 2020



PM2.5 concentrations

2020 current legislation and uniform application of Western technology



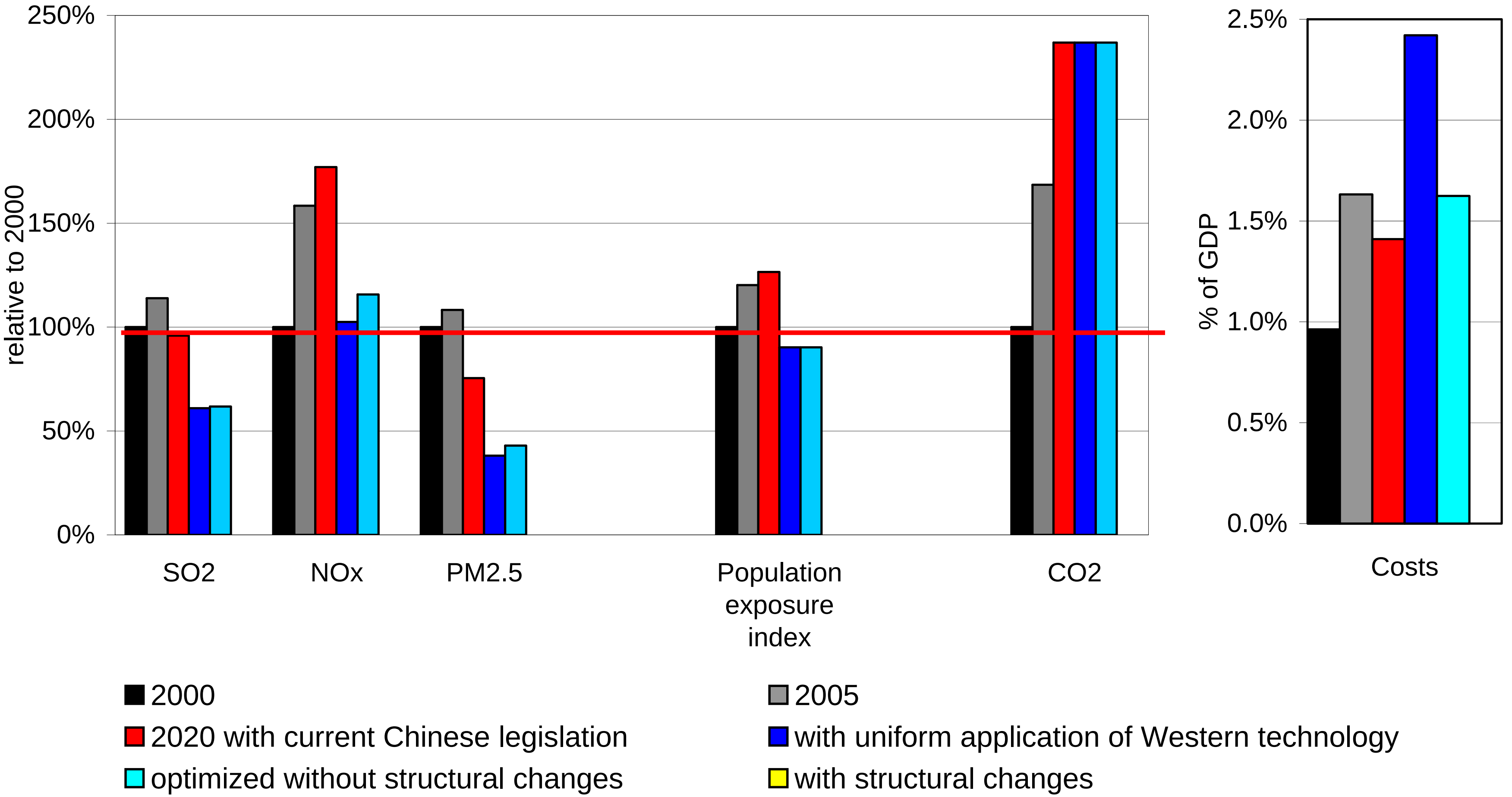
Current legislation **Uniform application of Western technology**

Population exposure index [ppb*bn persons]

3385 2415

Cost-effective allocation of end-of-pipe controls

Emissions, PM exposure and mitigation costs in 2020



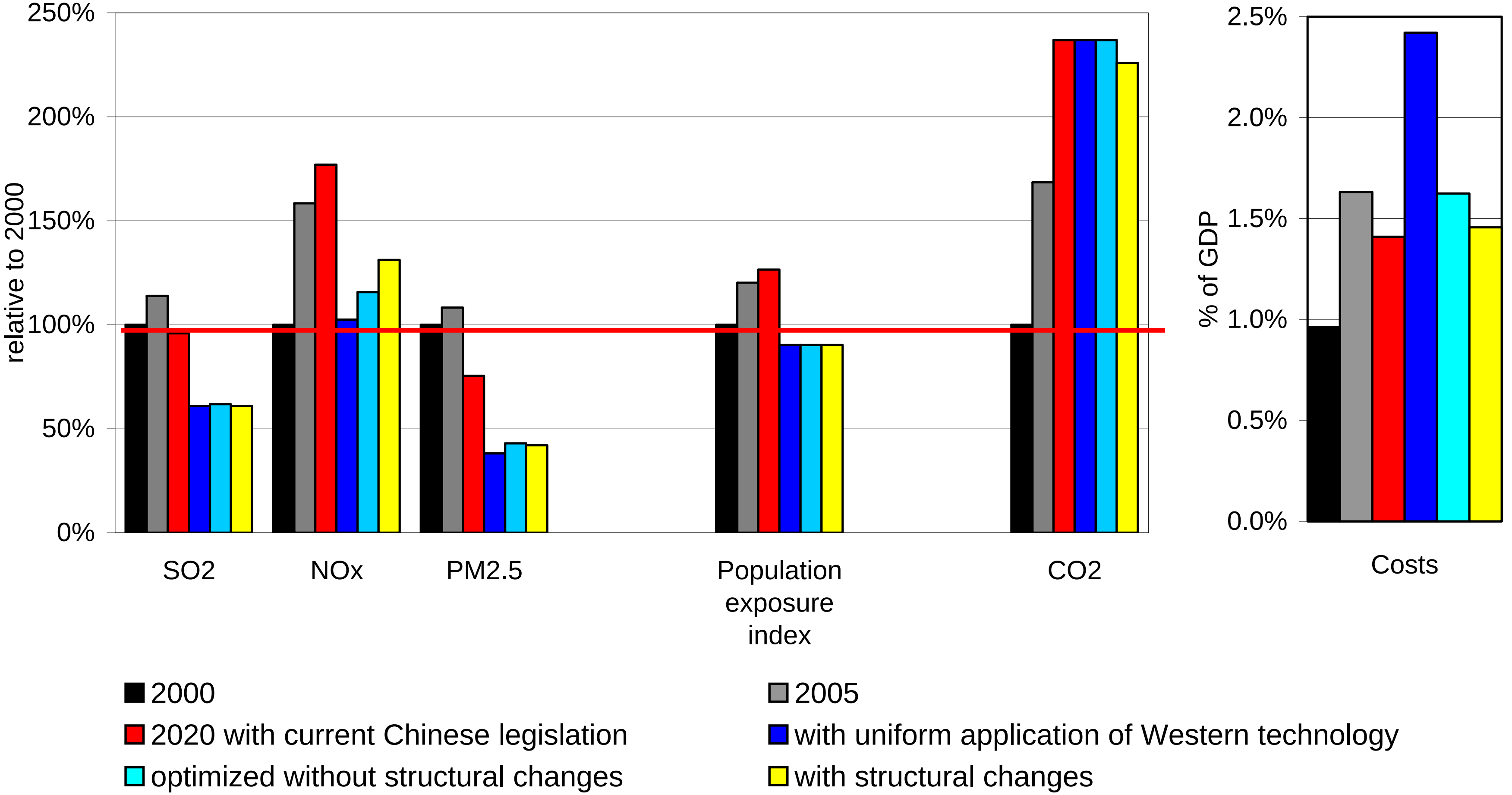
GAINS optimization for PM health targets allowing structural changes

- The GAINS optimization also allows modifications of the energy system:
  - increase in energy efficiencies,
  - fuel substitution (within province-specific limits),
  - clean coal technologies (IGCC),
  - phase-out of solid fuels in households, etc.

- Such measures have impacts on GHG emissions too.

- Example: Targets for air pollution as before (i.e., PM exposure index as in the Western technology scenario), but no targets for GHGs. Optimization considers structural measures in addition to end-of-pipe measures.

Cost-effective structural measures
Emissions, PM exposure and mitigation costs in 2020



Main cost-effective measures with synergies
for air pollution control and GHG mitigation

- Efficiency improvements (for direct end-use and for electricity use)
- Combined heat and power generation
- Integrated Gasification Combined Cycle plants (IGCC)
- Phase-out of coal in the domestic sector
- Supply increased energy demand by natural gas instead of coal

Conclusions

- GAINS has now been implemented for Europe, China and India.
- TM5 is used for atmospheric calculations in Asia for PM2.5 and ozone. GAINS addresses now health impacts from PM2.5 in cities too.
- There are important measures with co-benefits for controlling air pollution and greenhouse gases.
  A low-CO_2 strategy can improve air quality at lower costs than conventional control measures.
- GAINS will be freely accessible on the Internet:

  www.iiasa.ac.at/gains