Energy and air pollution: Lessons from the past, challenges for the future

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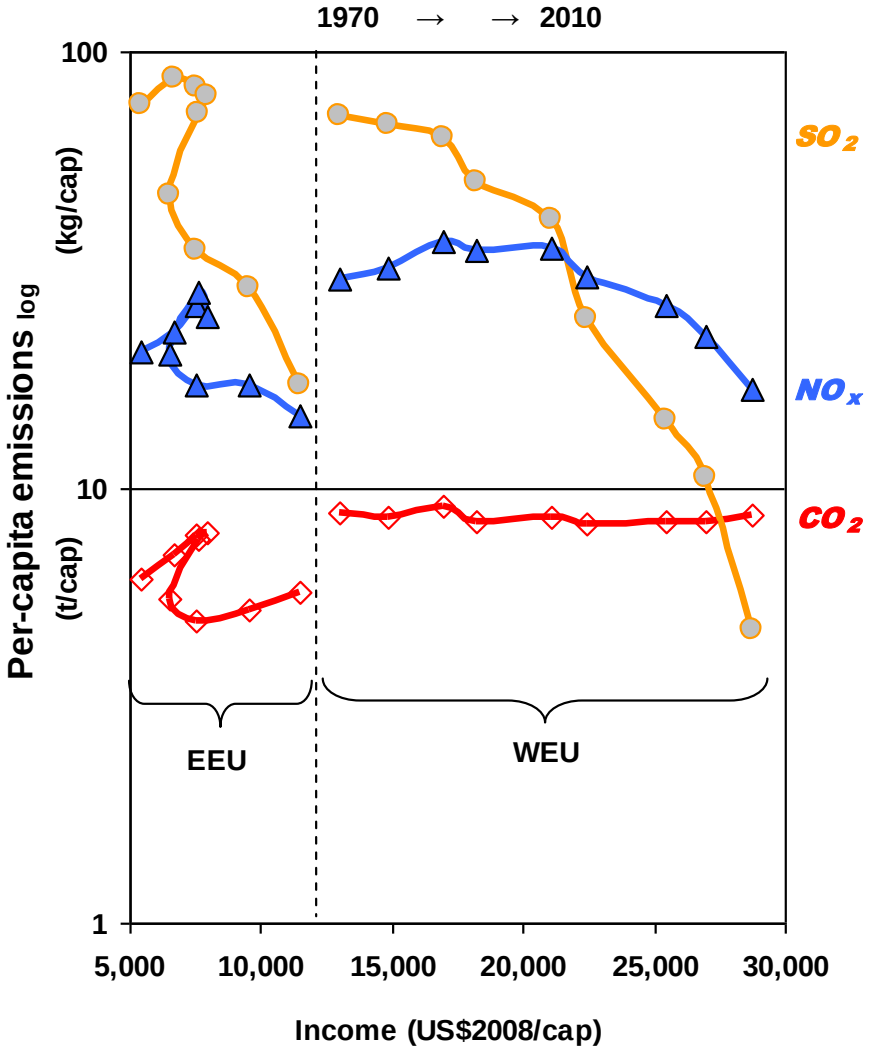
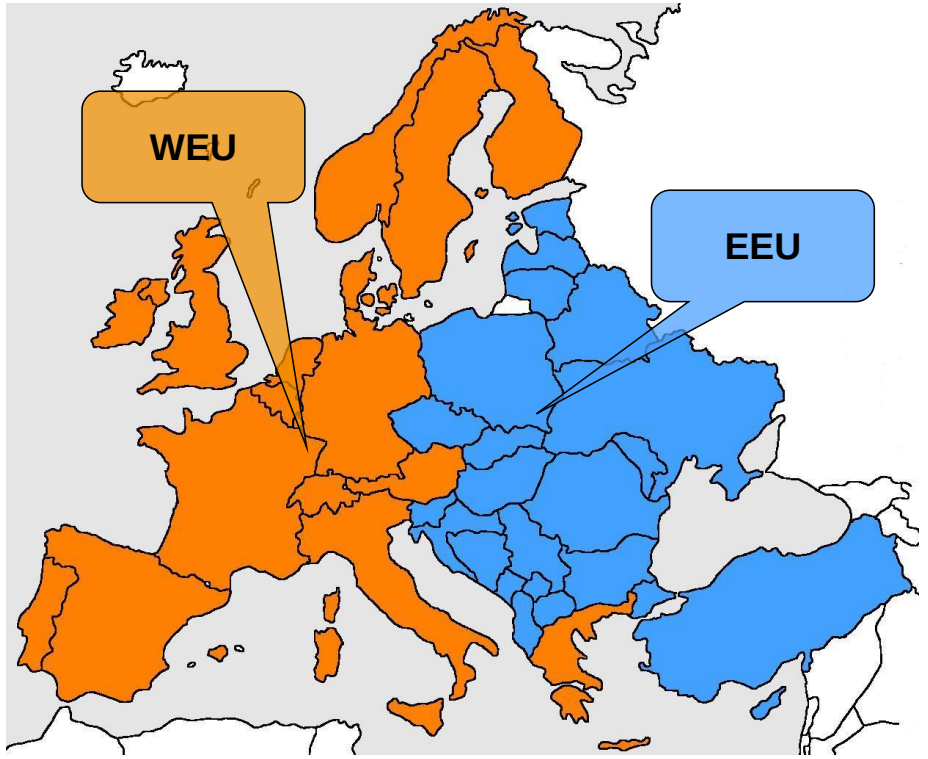
Outline

1. Learning from the past: decomposition analysis
2. Future emissions: two approaches to scenarios
3. Where energy and air pollution challenges meet: three projects on China (with Princeton)

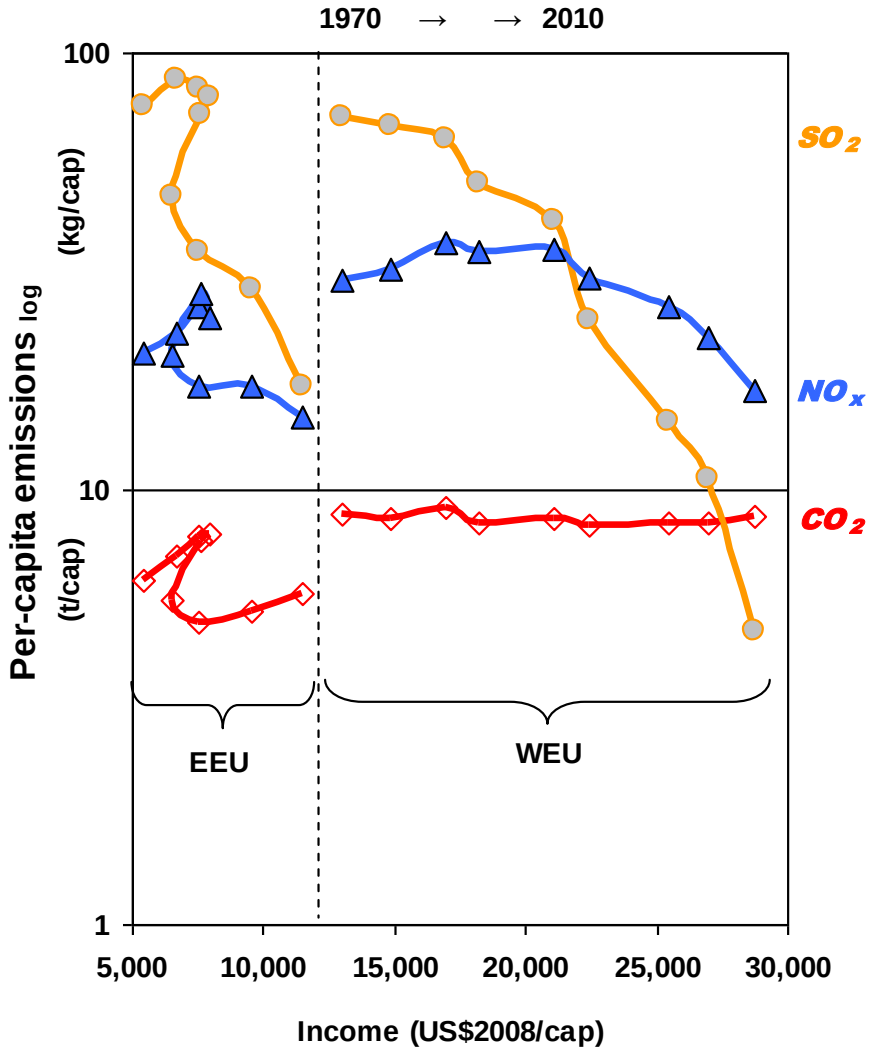
Emissions as a function of income

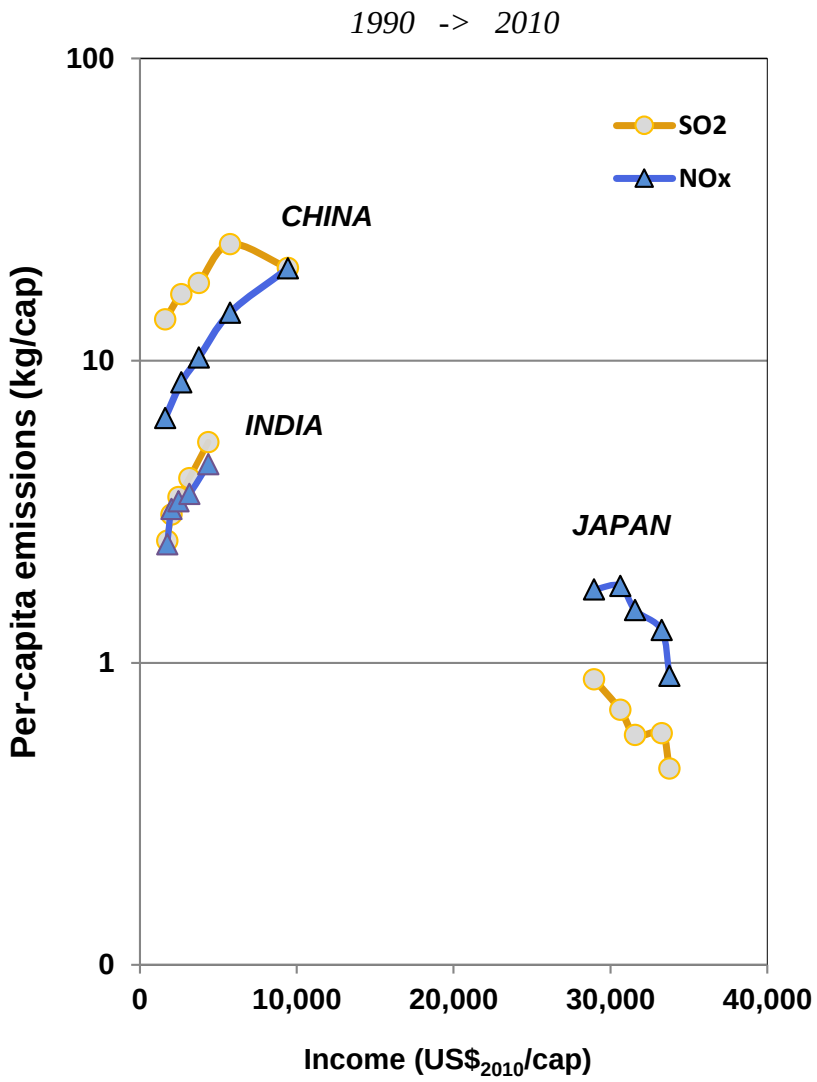




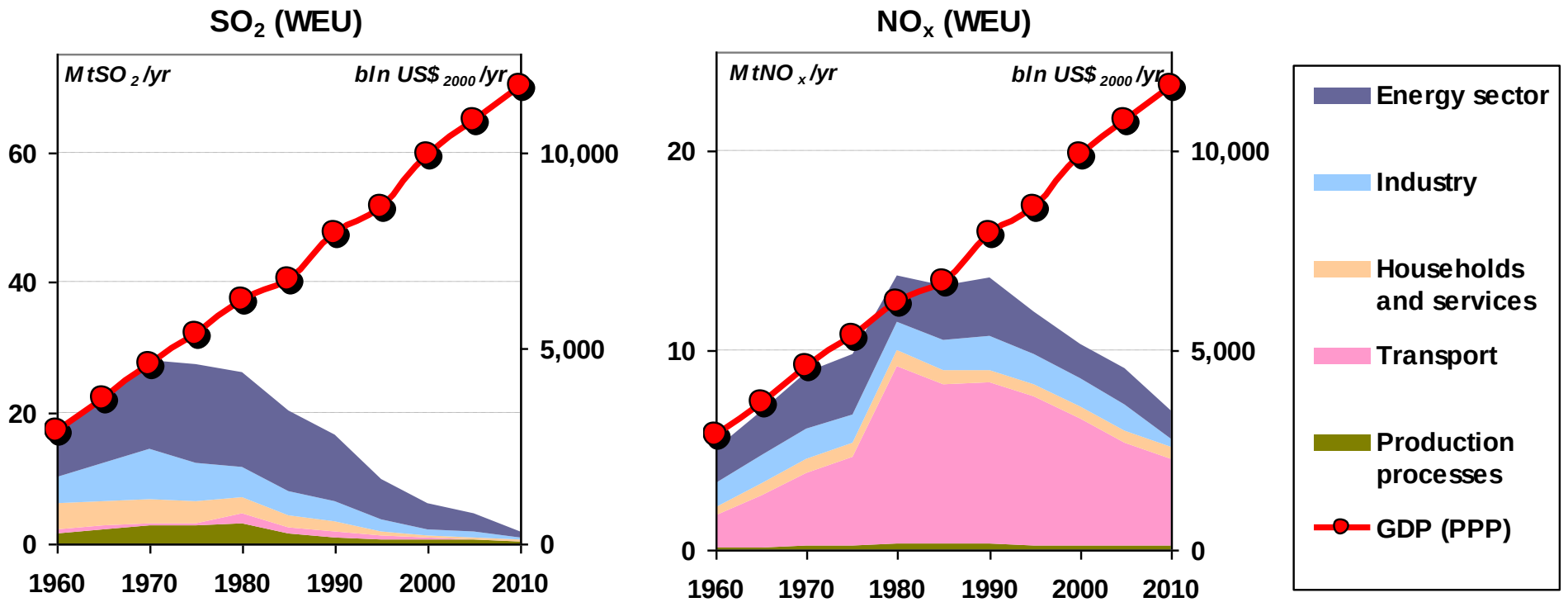
Rafaj et al. (Climatic Change, 2014)

Emissions as a function of income





Evolution of GDP and emissions of SO_2 and NO_x



Rafaj et al. (Climatic Change, 2014)

Factors contributing to changes in emission levels

$$\Delta EMIS = GDP * \Delta\left(\frac{ENE}{GDP}\right) * \Delta\eta * \Delta\left(\frac{EMIS}{ENE}\right) * (1 - eff) * \Delta X$$

1. Change in the energy intensity

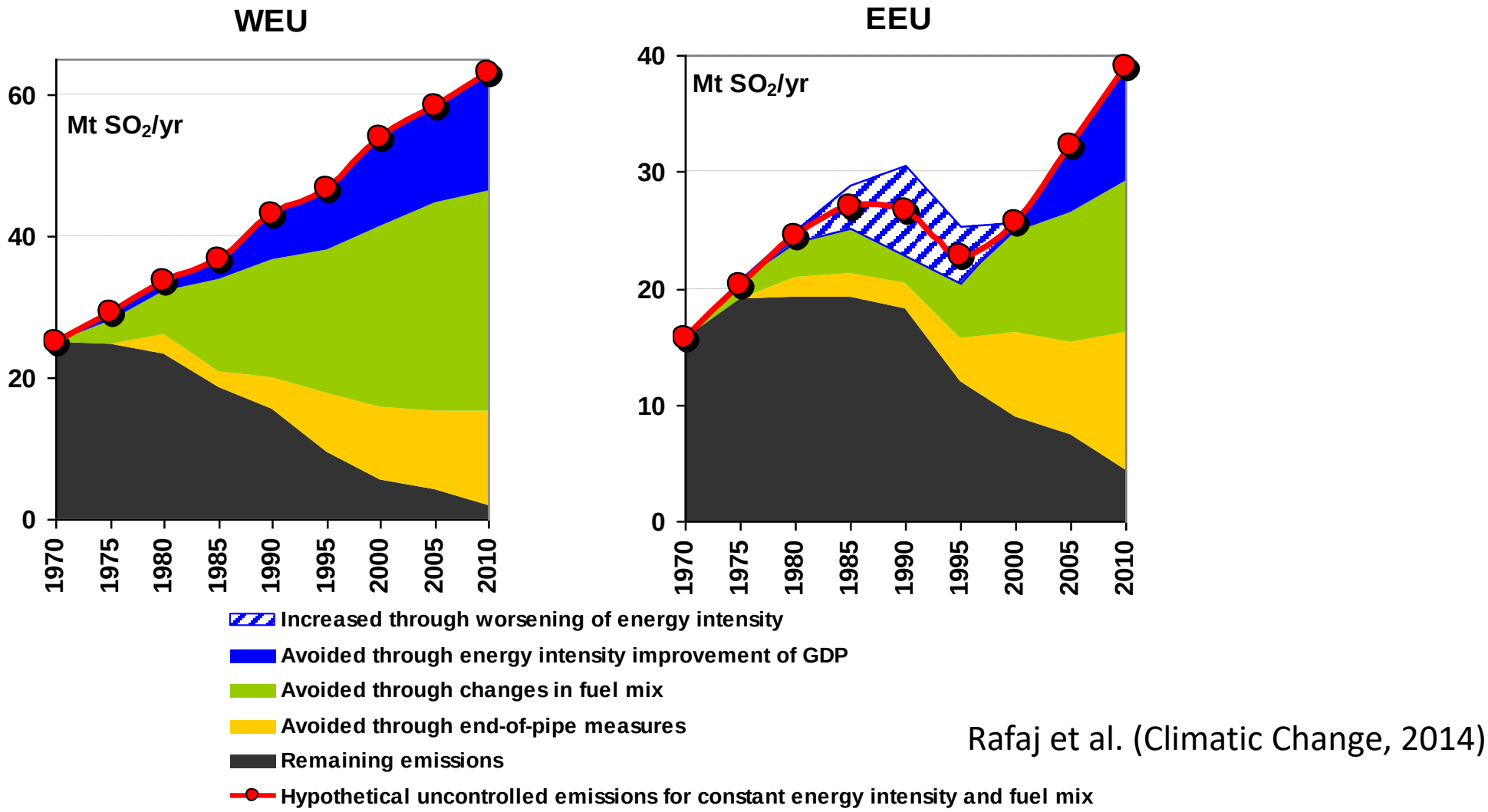
2. Efficiency improvement

3. Fuel switch

4. Abatement with removal efficiency eff and application rate X

Rafaj et al. (Climatic Change, 2014)

Factors determining European SO_2 emissions 1970-2010



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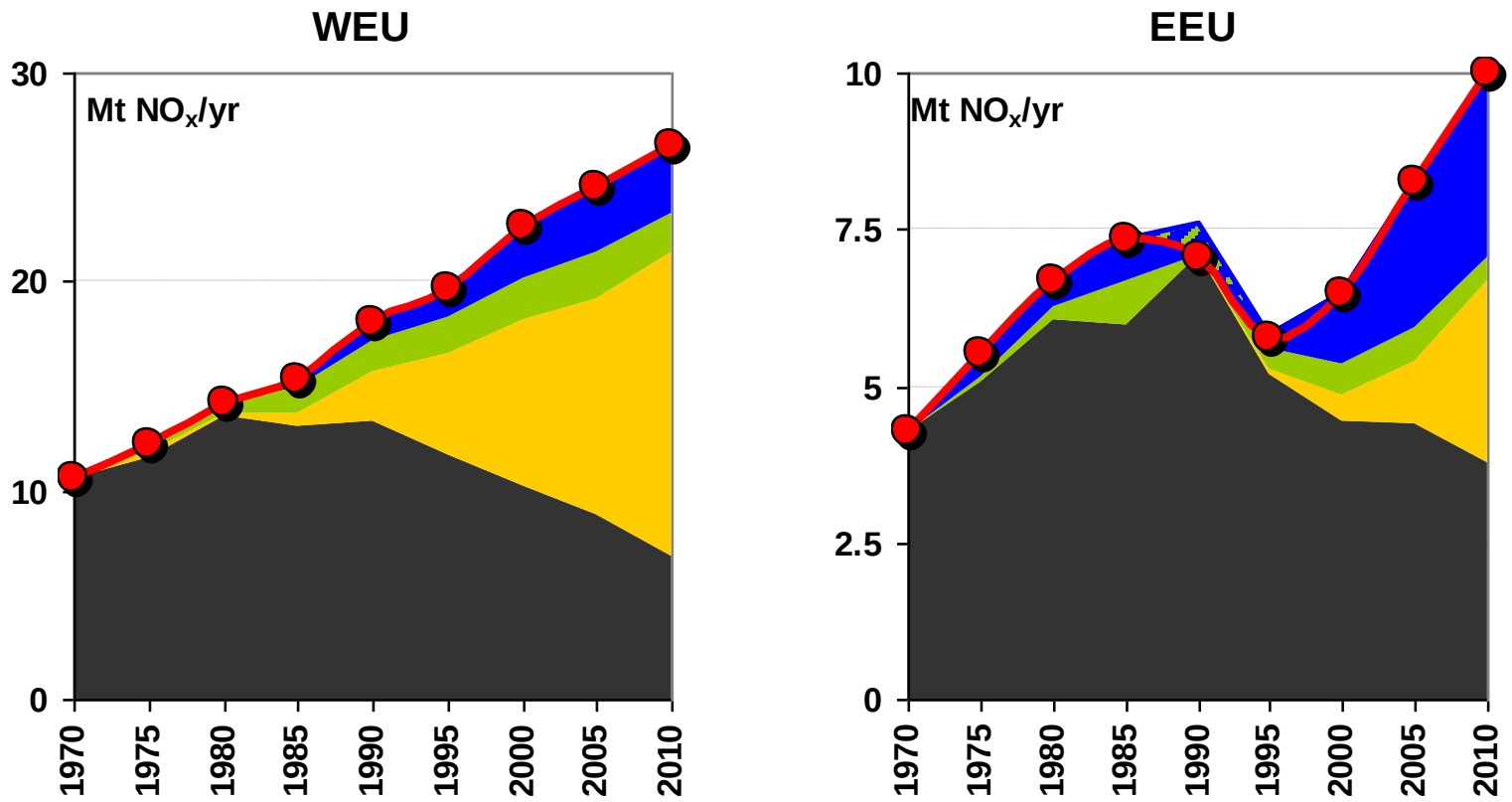
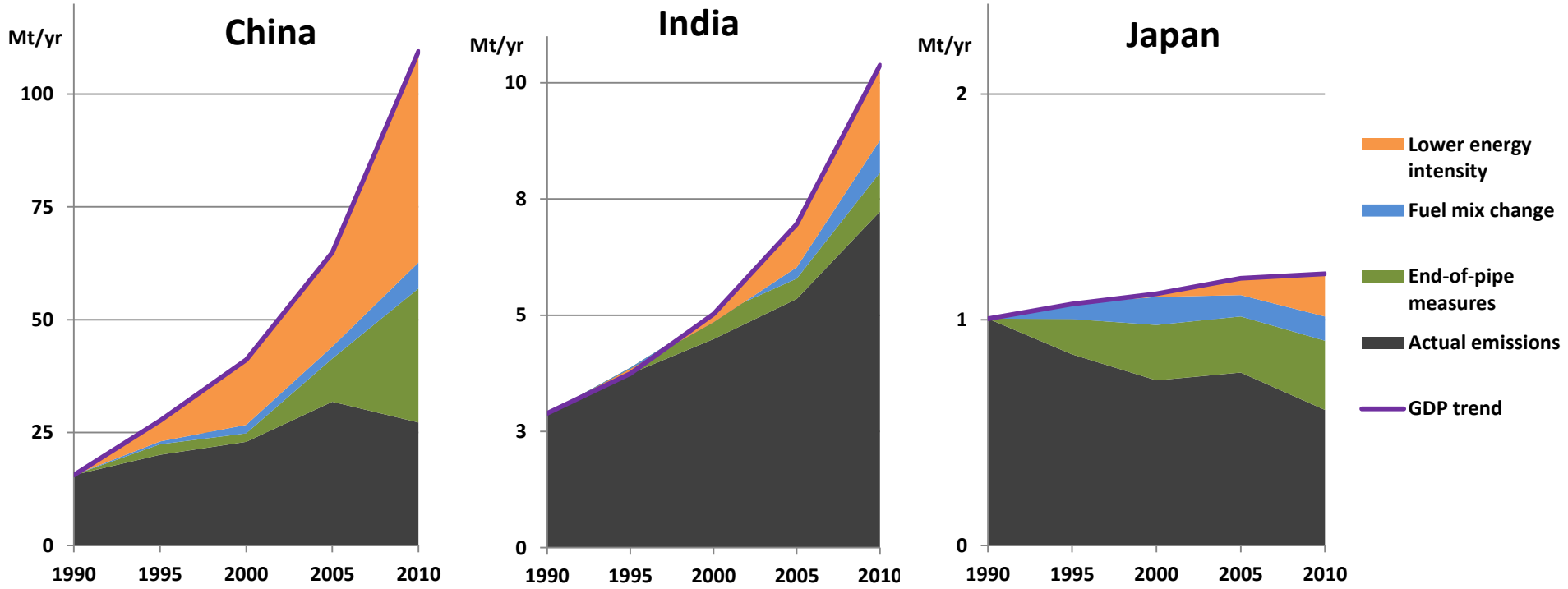
Factors determining European NO_x emissions 1970-2010



Determinants of SO2 emission changes



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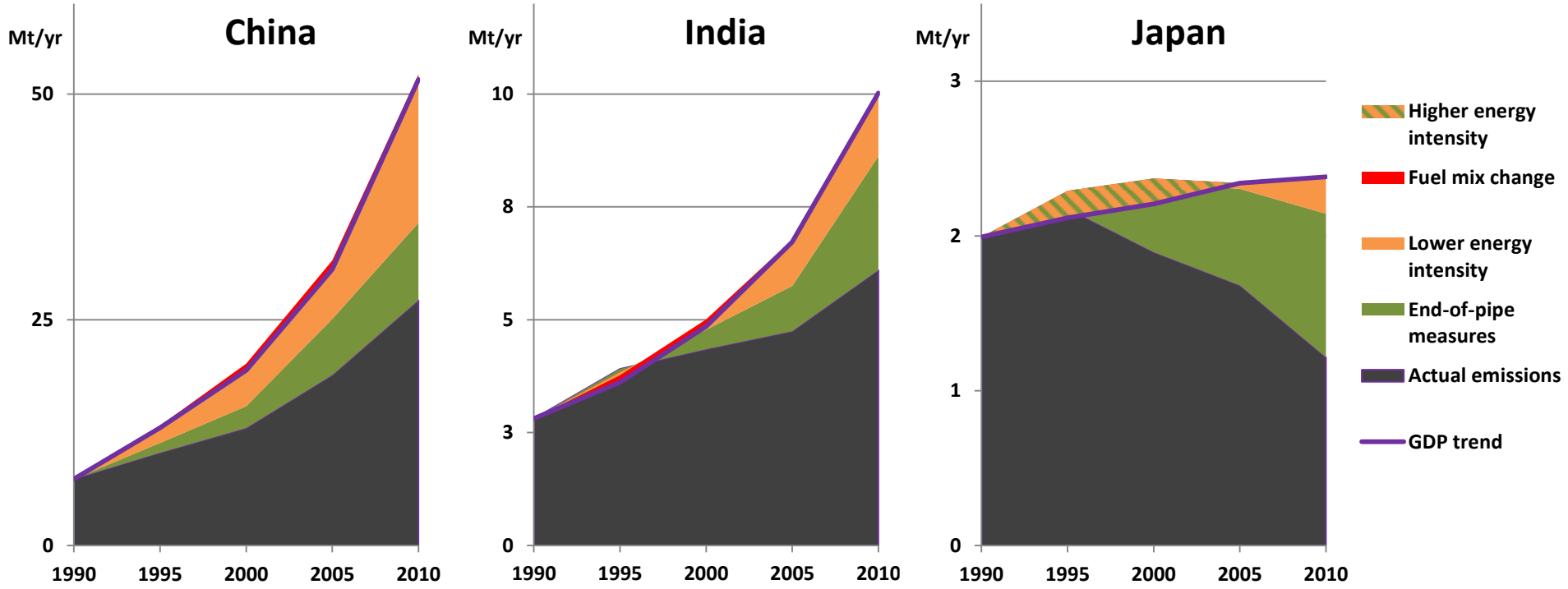
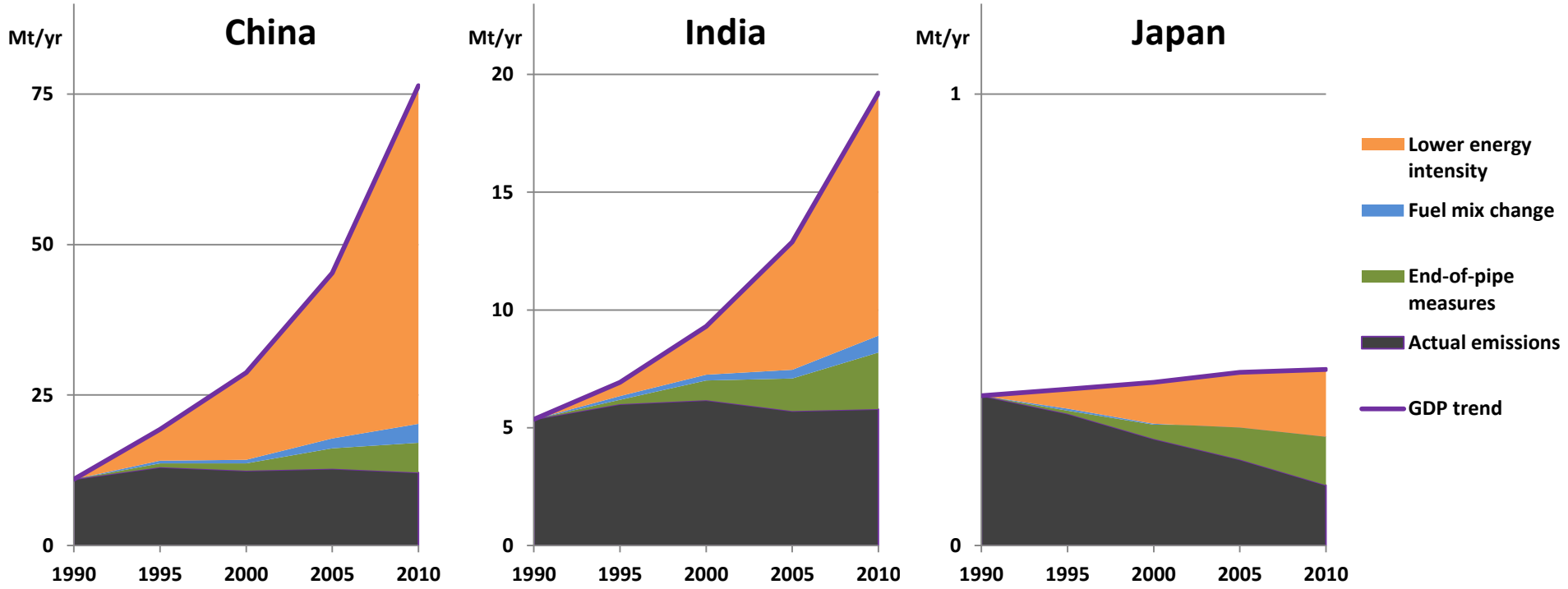
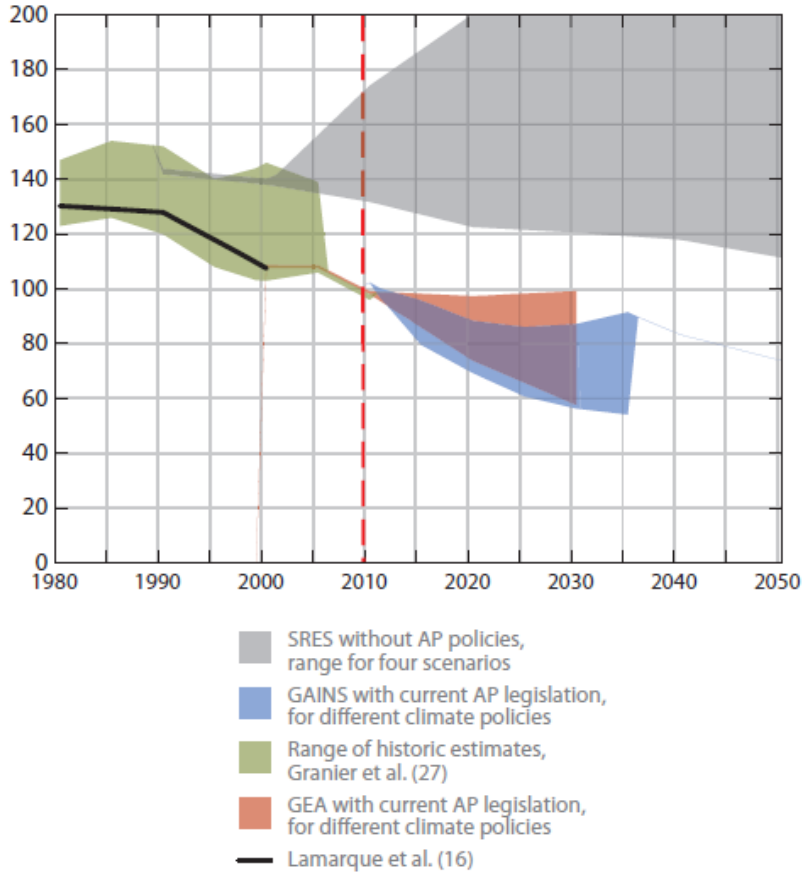
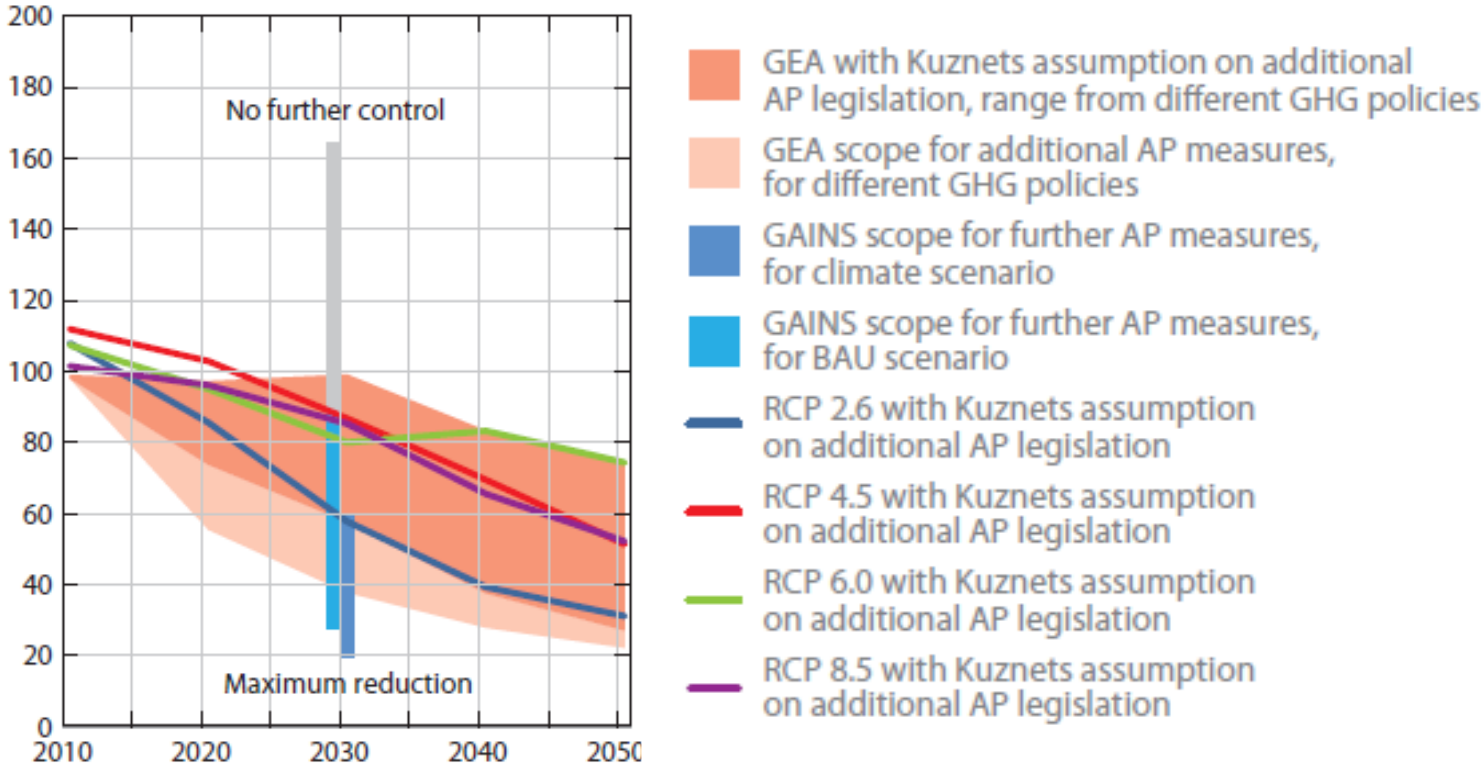


Determinants of PM2.5 emission changes



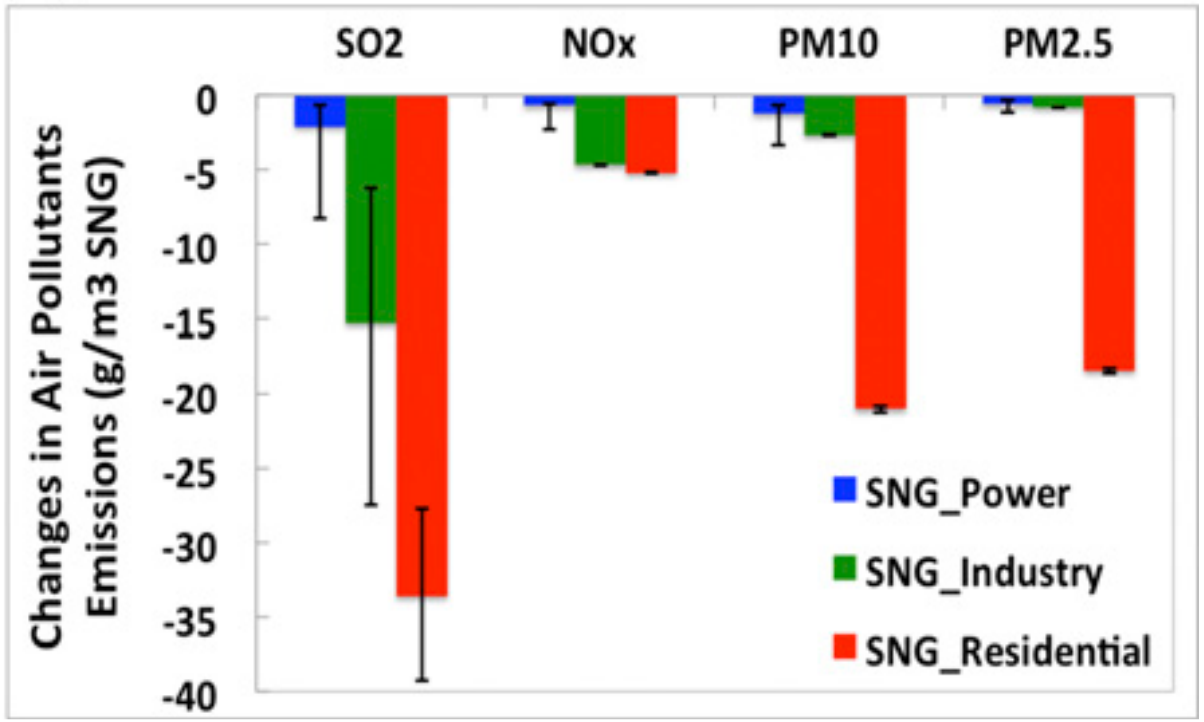
Future global emissions of SO_2

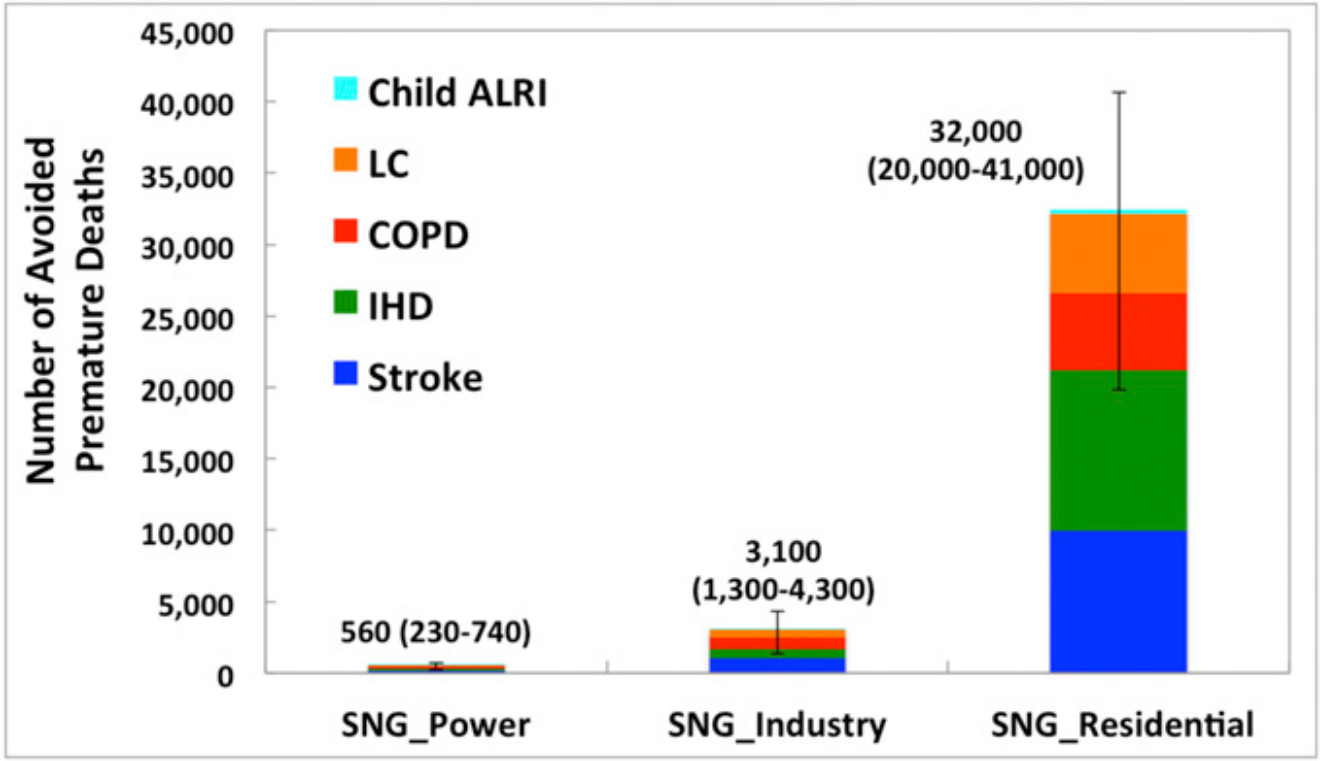




Amann et al. (2013, Annu. Rev. Environ. Resourc.)

Project 1:
Does it matter in which sector China uses additional gas supply if available?

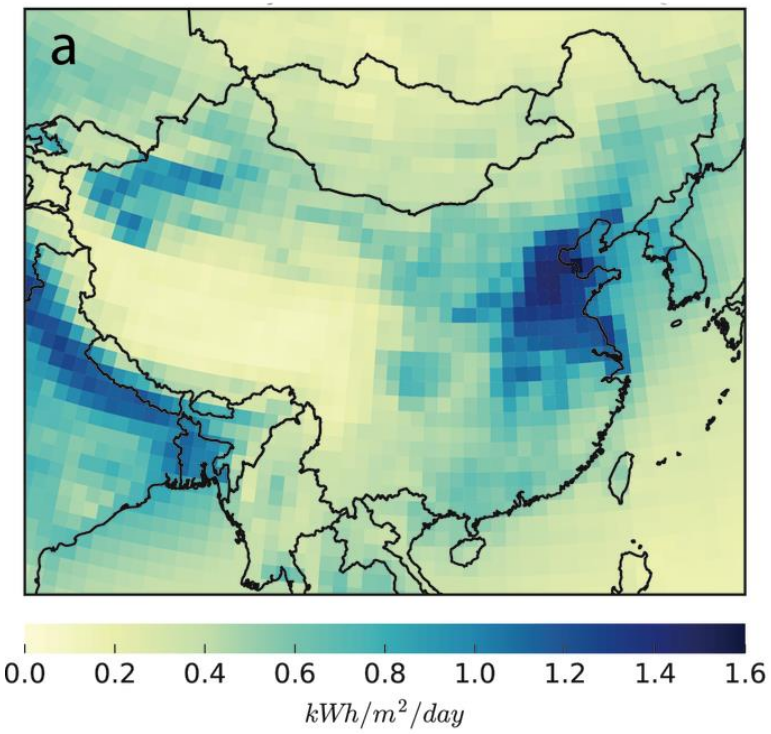




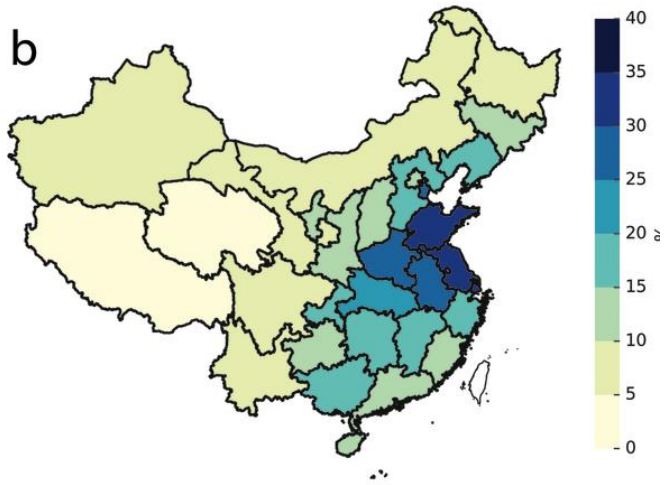
Air pollution considerations would recommend to use additional natural gas in the residential sector!

Qin et al. (2017, PNAS)

Project 2:
How is solar PV output affected by air pollution in China?



Losses in energy at the surface, 12-year average



Up to 38% averaged over each province!

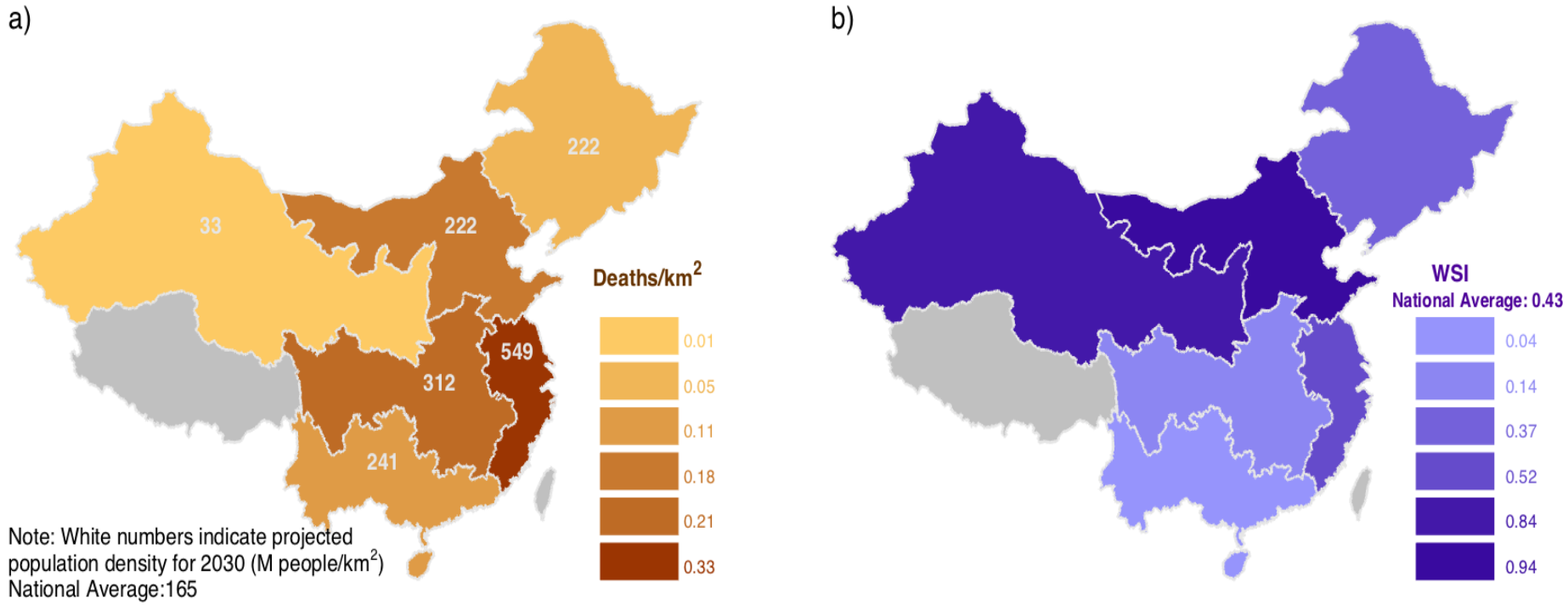
Up to 25% averaged over each electricity grid!

Li et al. (submitted, PNAS)

Project 3:

In China both air pollution and water stress are of concern.

What are the implications for the optimal transmission network?

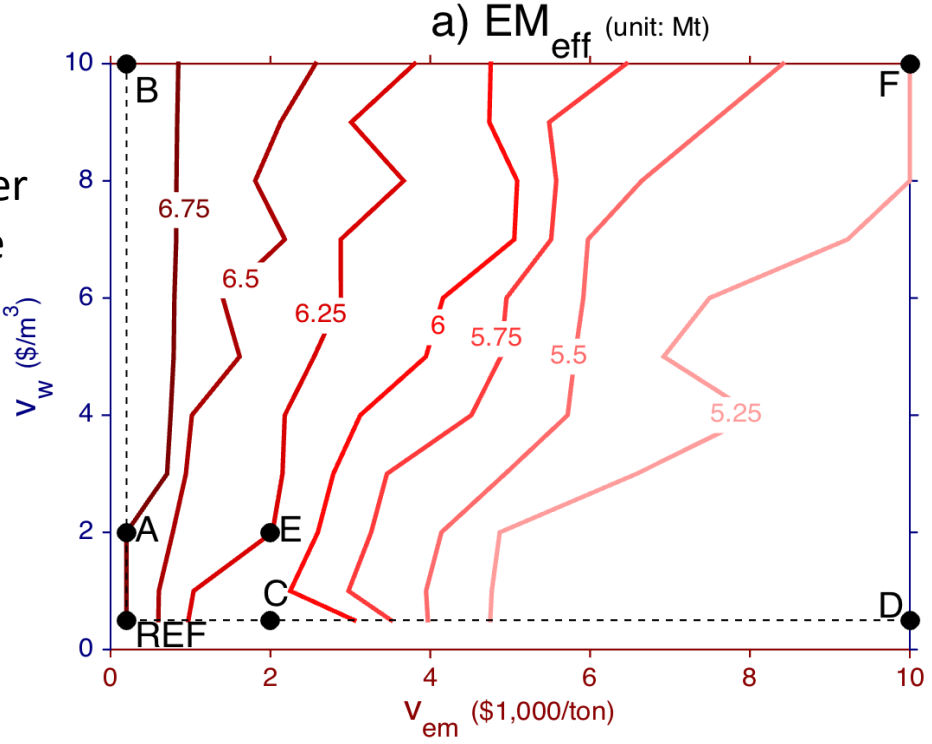


Peng et al. (submitted, STOTEN)

Project 3 (continued)

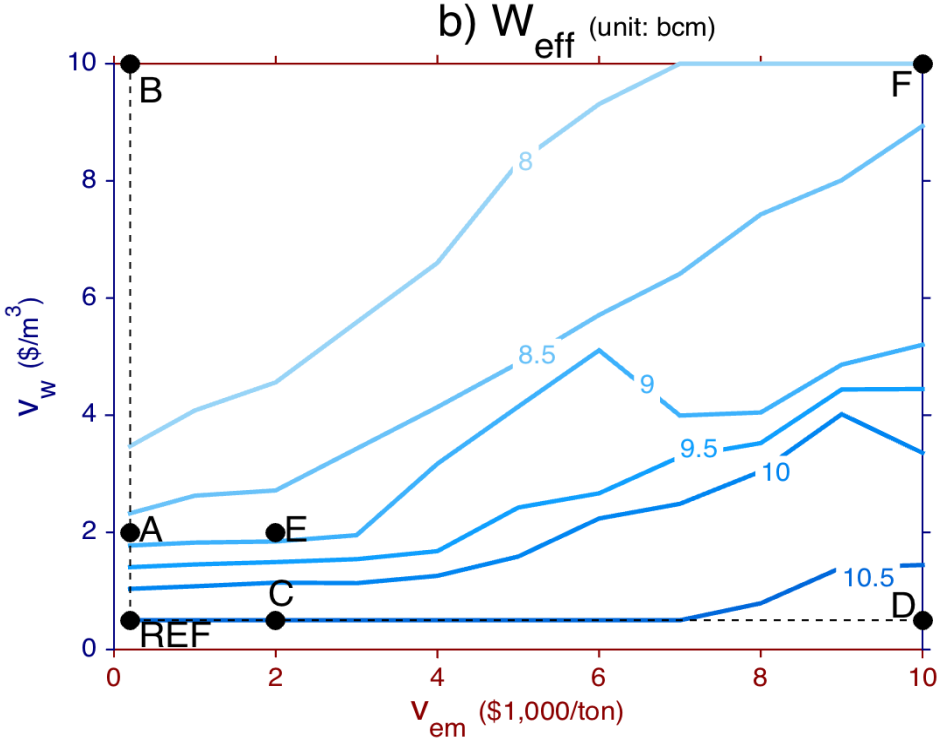
Peng et al. (submitted, STOTEN)

Water price



Emission tax

In the presence of a high water price, the emission tax is less effective for reducing emissions



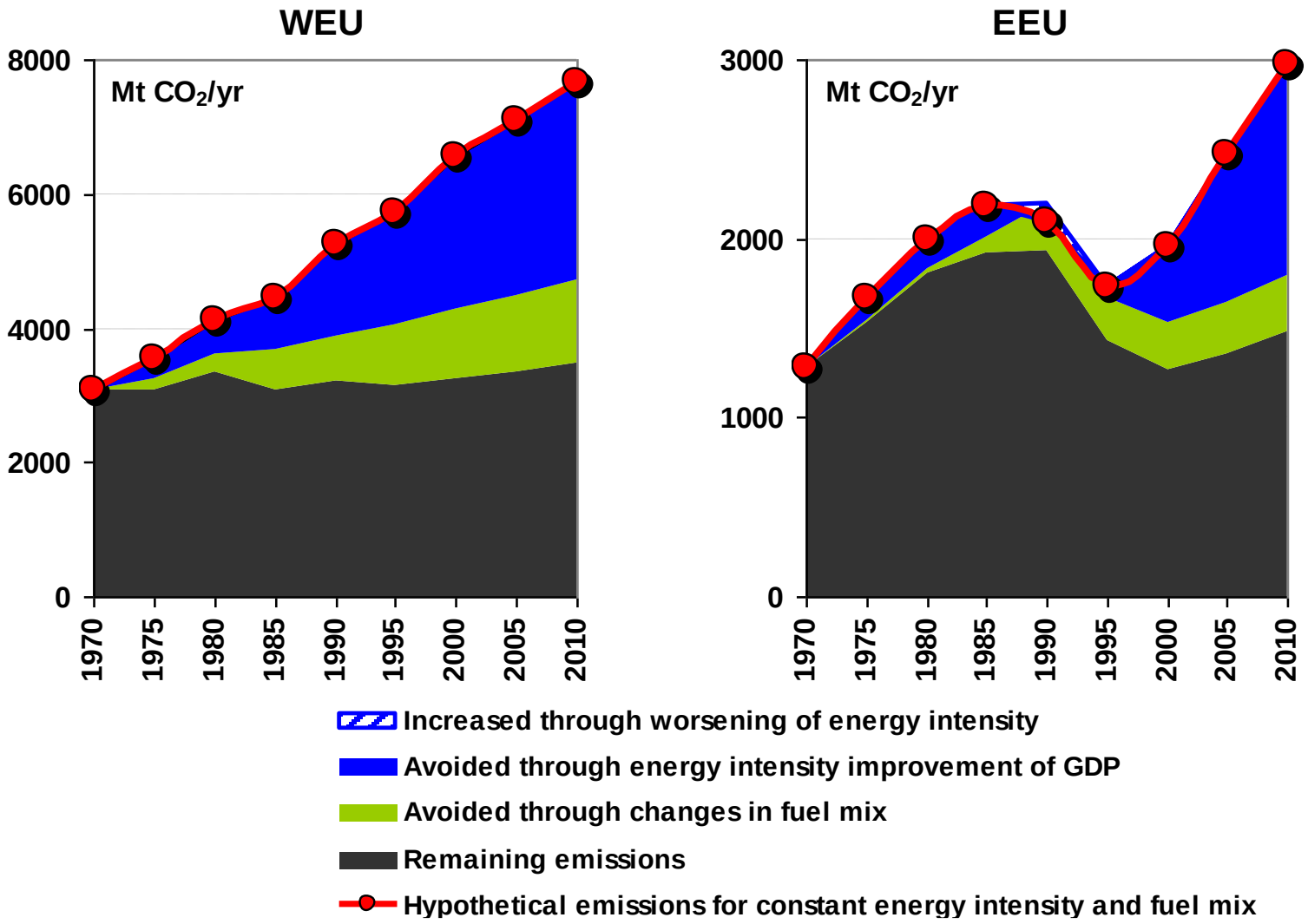
In the presence of high emission taxation, a water price is less effective for reducing water consumption

Summary

- Changes in the energy system have significant explanatory power for the observes reductions in air pollutant emissions
  - Esp for SO2, esp for fast growing countries
  - Nowadays we call this effect: “co-benefits”
- Two approaches to scenarios:
  - (1) Plausible stories to explore possible futures (eg SSPs)
  - (2) Concrete strawmen to study impact of specific policy interventions (eg GAINS model analysis used by the EU and other international bodies)
  - The latter may explore a course of action that is already assumed to be taken autonomously in the former -> (1) may be too optimistic or blind to the actual challenges
- Energy and air pollution (and water) have strong interactions, not just through co-benefits

Extra slides

Factors determining European CO_2 emissions 1970-2010



Determinants of SO_2 and CO_2 emission reductions compared to 1970 in the UK and Poland