Overview of types of air pollution

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STRUCTURE OF THE PRESENTATION

- Key pressures on air quality in megacities
- Sources of air pollutants
- Ambient concentrations
- Air quality policy and management
- Air pollution and health

Pressures on air quality in Asian cities

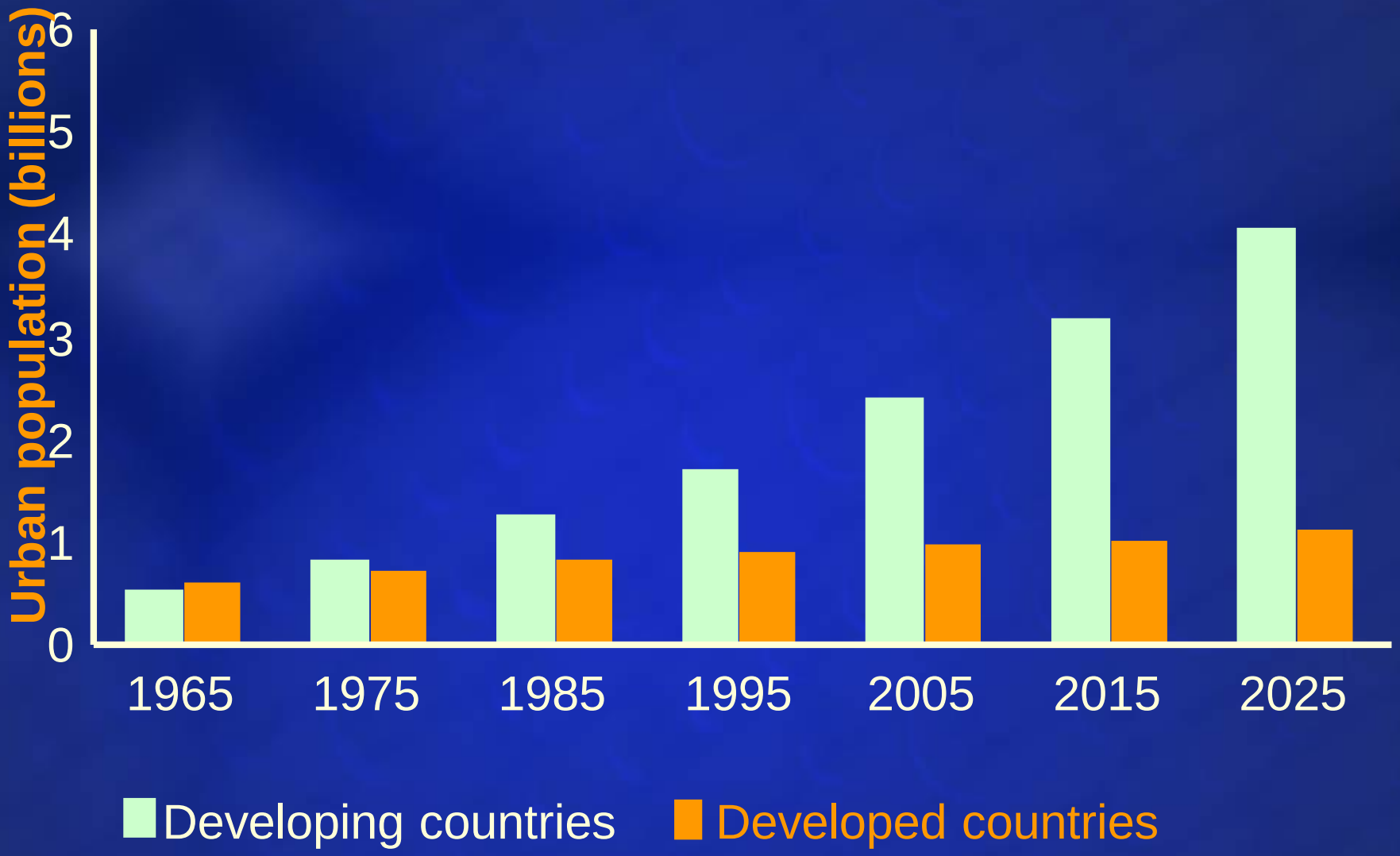
- Growing economies
- Growing population
- Growing urbanisation
- Growing use of transport and energy
- Growing industrialisation

Scenario for Asia

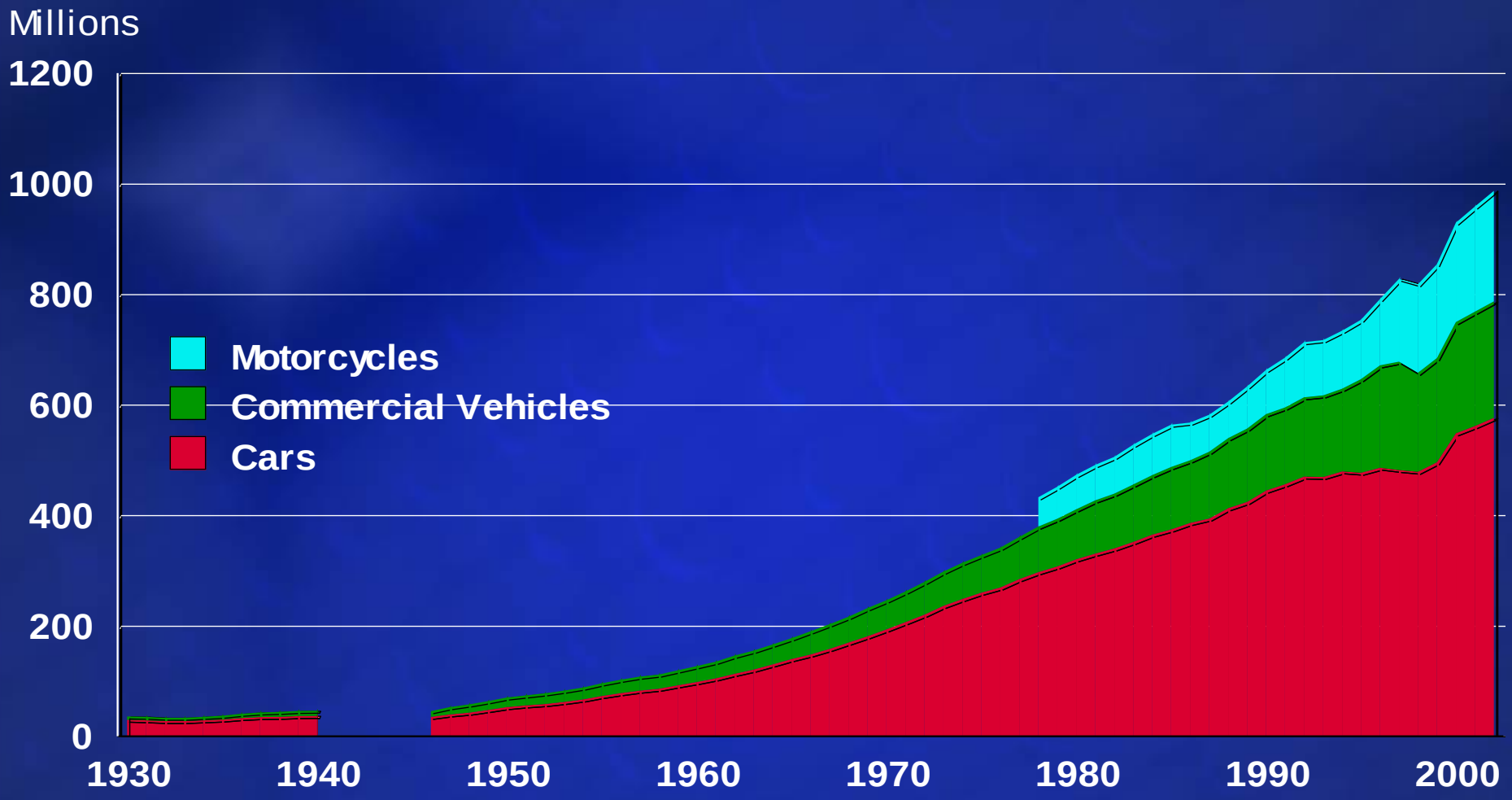
- Urbanization: Urban population will grow from 30% in 2000, to 60% by 2025. Ten megacities exceed 10 million in population.
- Motorization & Industrialization: Transport and industrial sectors to grow >10%/ year.
- Costs: Serious impacts on health and quality of life are measurable in cities. In Asian cities, impacts on health and environment already cost billions of dollars per year.

Source, ADB 2004

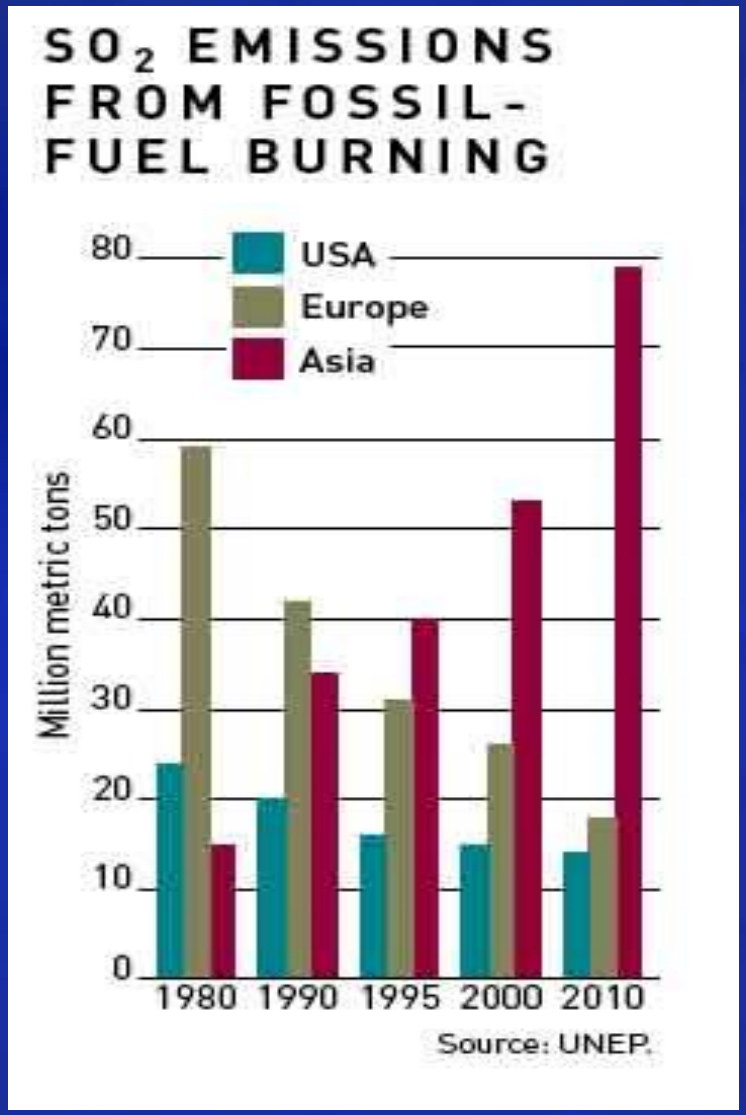
Global Urban Population Growth



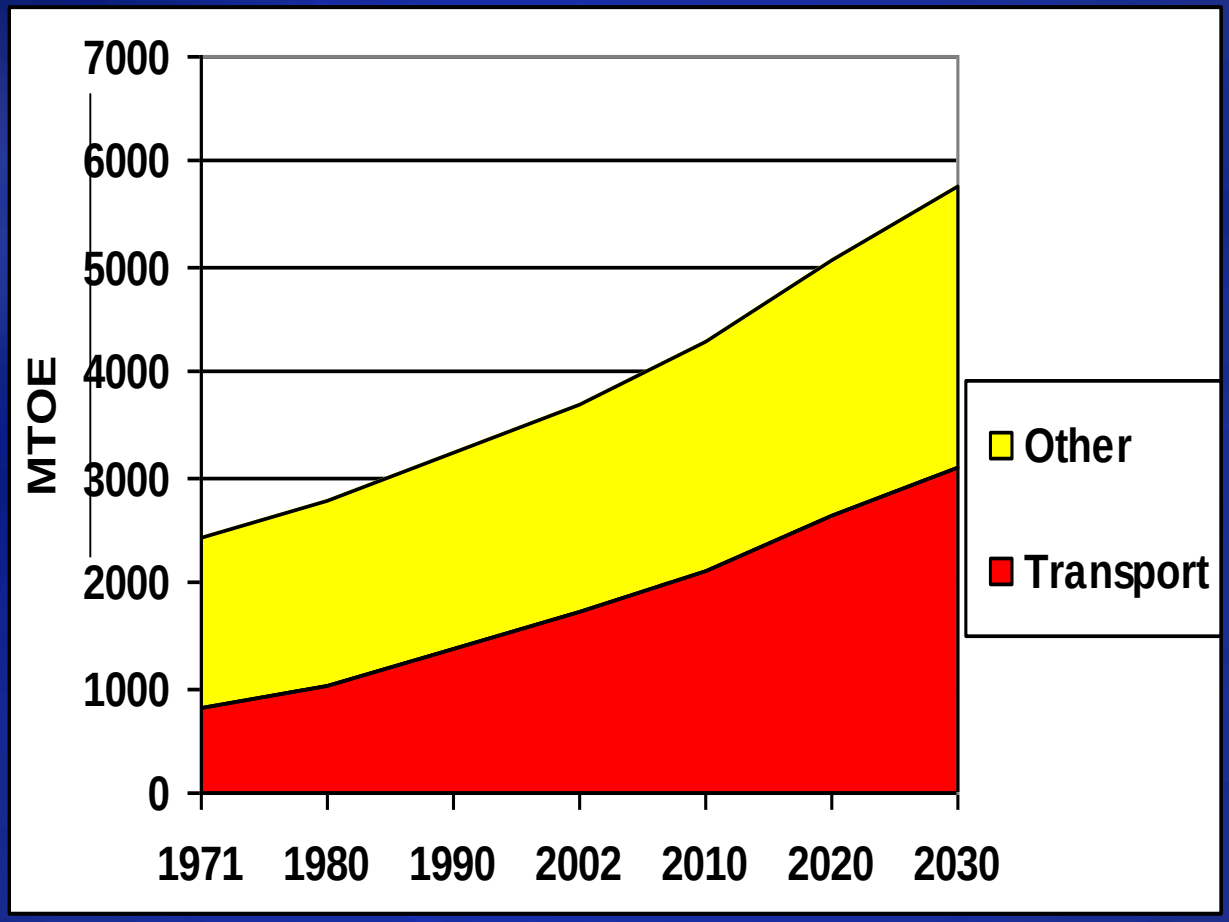
World Motor Vehicle Population



Changing sulphur dioxide emissions

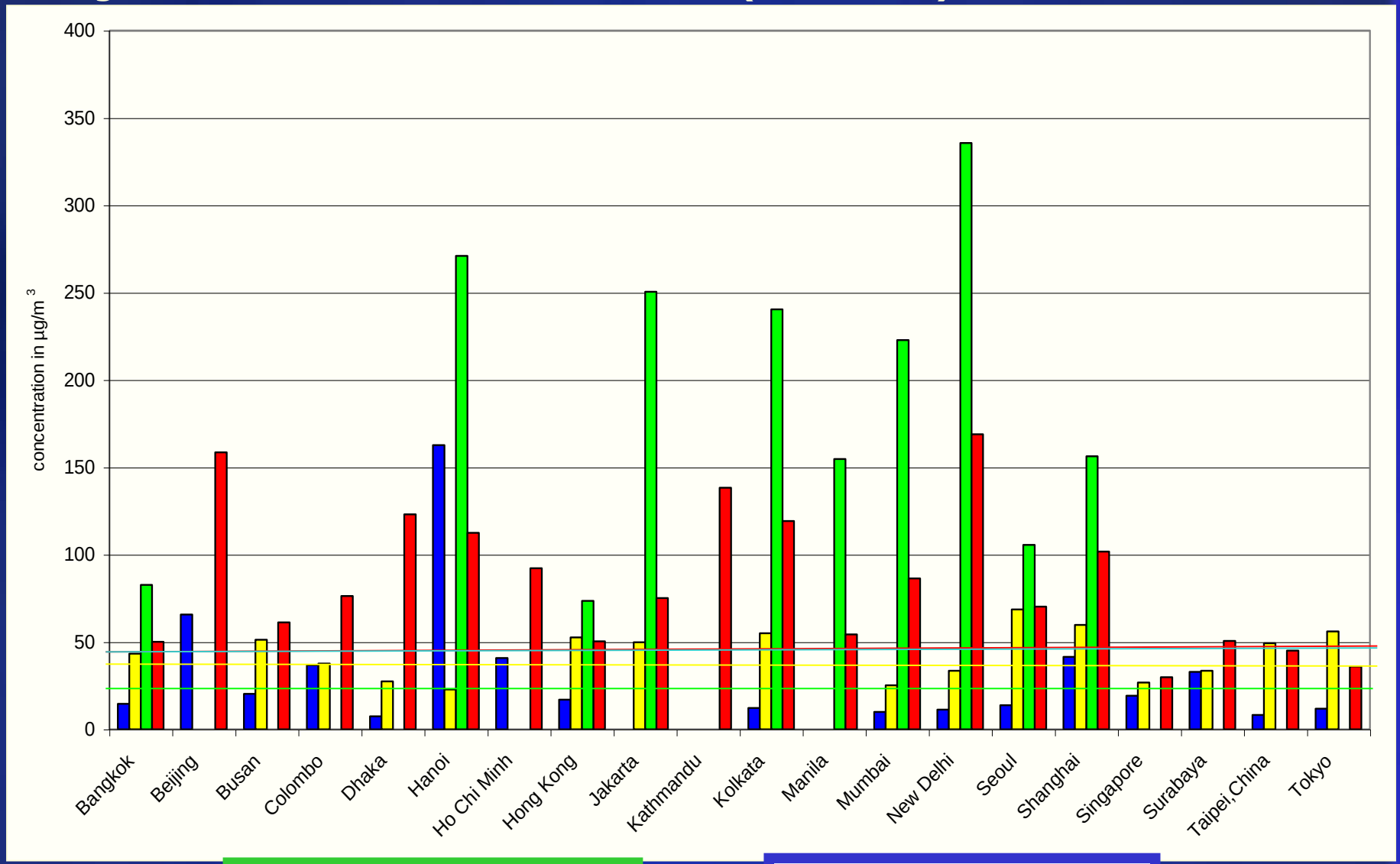


World Oil Use, 1971-2030
Transportation v. Other Sectors



Source: IEA historical data and projection from *World Energy Outlook 2004*

Average Annual Air Pollution Concentrations (2000-2003) in selected Asian Cities



PM10 Guidelines = 20 µg/m^3 (WHO, 2005)

PM$_{10}$ Limit = 50 µg/m^3 (USEPA, 1997)

SPM

PM$_{10}$

SO_2 Guideline = 50 µg/m^3 (WHO, 1999)

NO_2 Guideline = 40 µg/m^3 (WHO, 1999)

SO_2

NO_2

Source: CAI-Asia, 2004

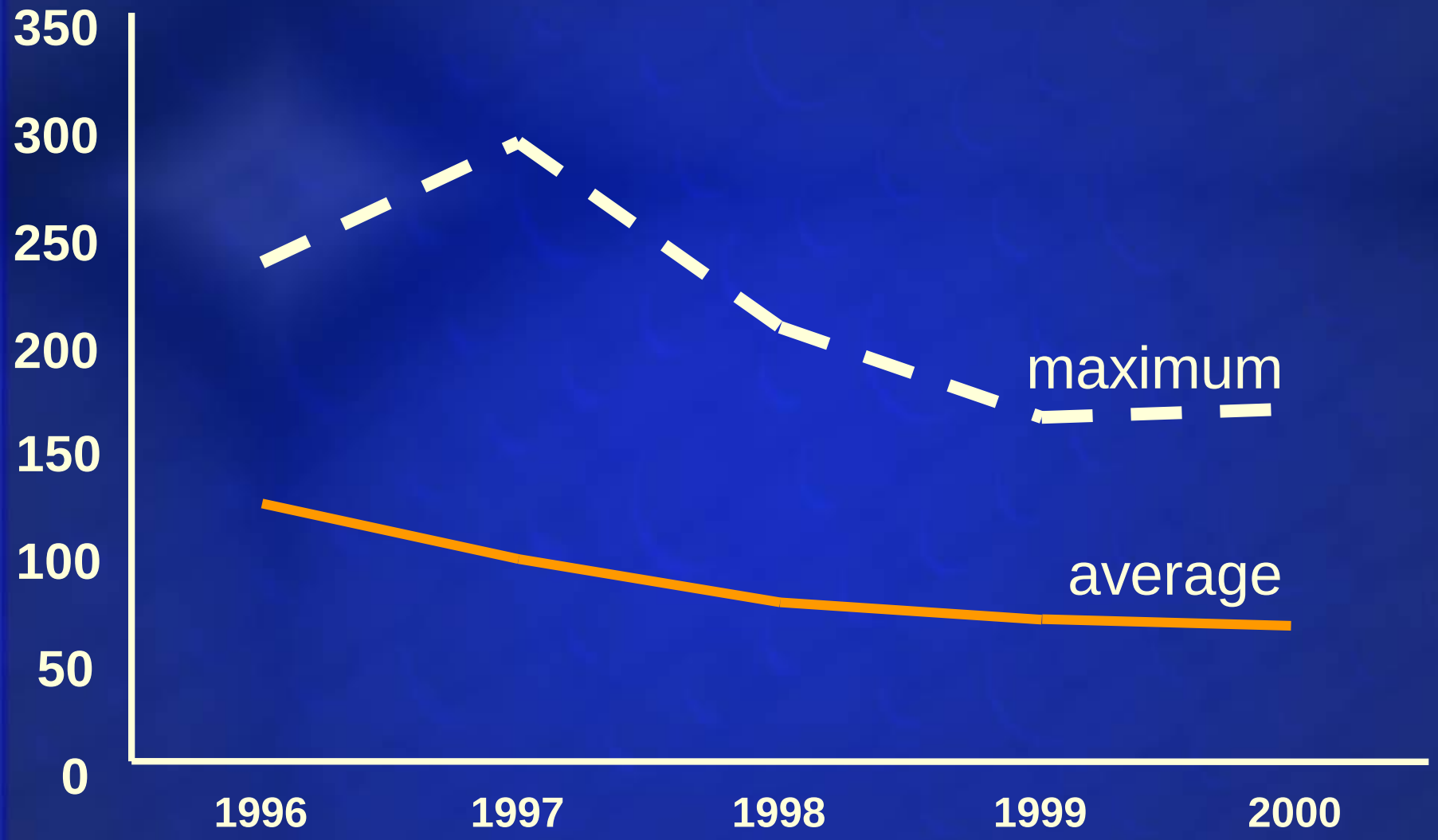
Air quality trends in Asian cities since 1990

- Most cities have been able to reduce levels of SO_2
- Almost all cities have been able to reduce particulate concentrations compared to the 1990s levels, however levels continue to remain well above the WHO guidelines
- NO_2 levels are gradually increasing and above the WHO guidelines

Bangkok Visibility Trends since 1964

Improvements in recent years

Annual Ambient PM10 Concentrations in Bangkok, Eight site averages 1996 - 2000 (ug/m^3)

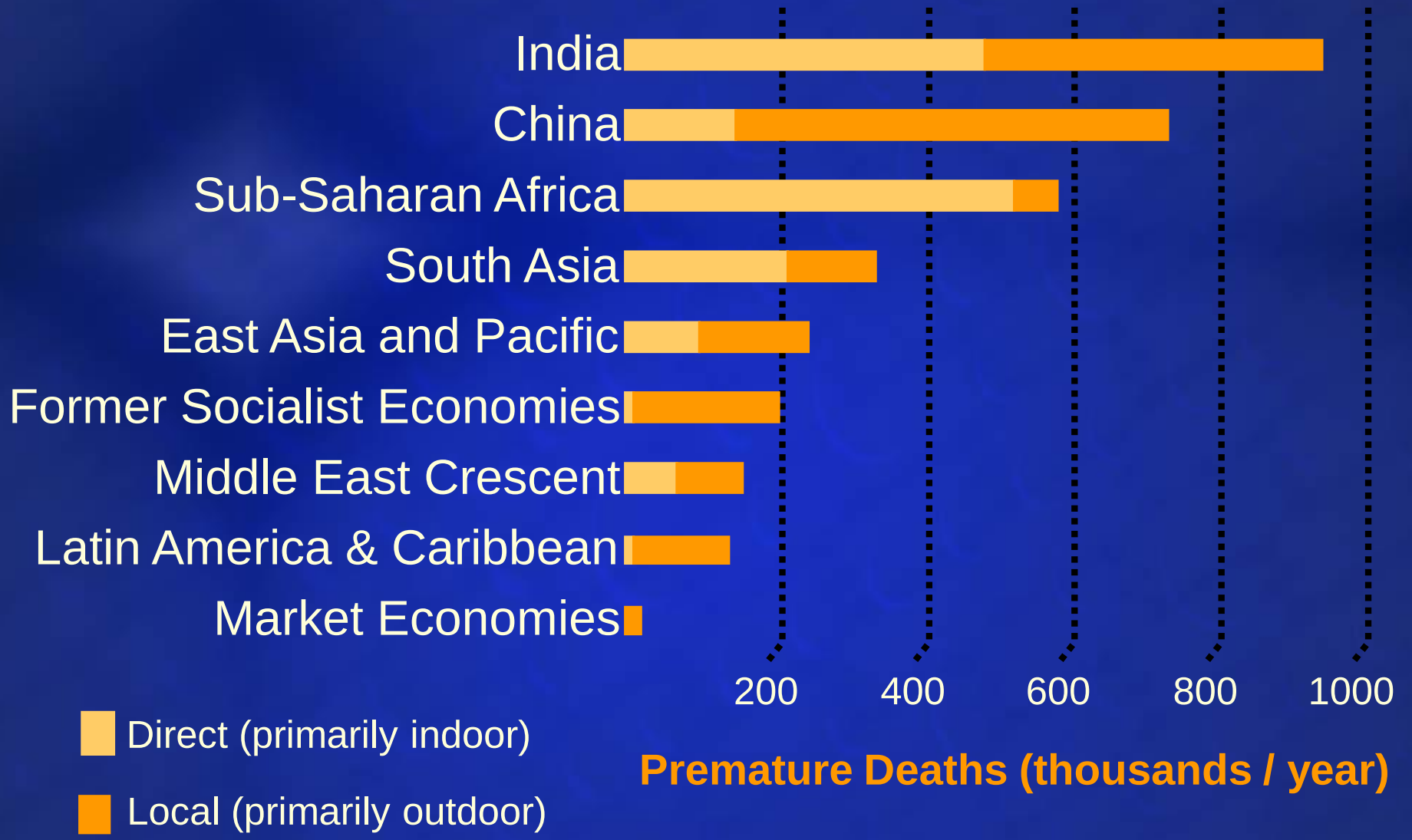


Air pollution comes at a high cost

Annual cost of health effects of air pollution in selected Asian cities (World Bank studies)

Region	Annual Costs - $US Million
Bangkok, Metro.	1,300 - 3,100
Seoul	6,154
Manila	1,800
Jakarta	400 - 800

Premature deaths due to air pollution



Regional surface level ozone is reducing crop yields in Asia

- Recent studies show an increase of 23% in ozone concentration from an ambient level of 56 to 69 ppb over two growing seasons, reduces soybean yield by 20%
- Various studies show East Asia is about to experience substantial reductions in grain production due to rising regional scale, surface-level ozone concentrations.

East Asian grain yield losses due to ozone

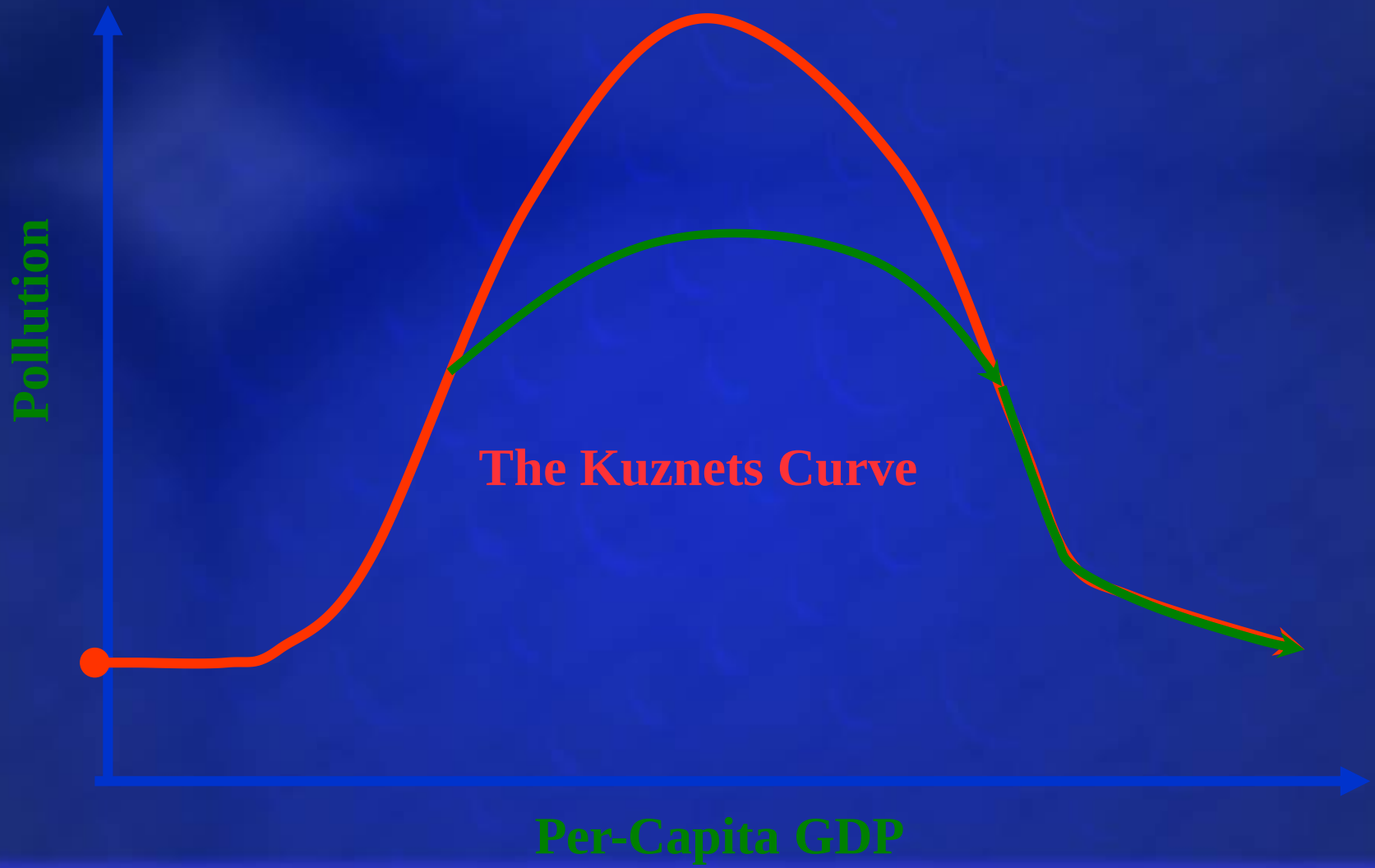
- By 2020 increasing ozone is expected to cause yield losses of 2-16% for wheat, rice and corn, and 28-35% for soybean.

Kuznets curve

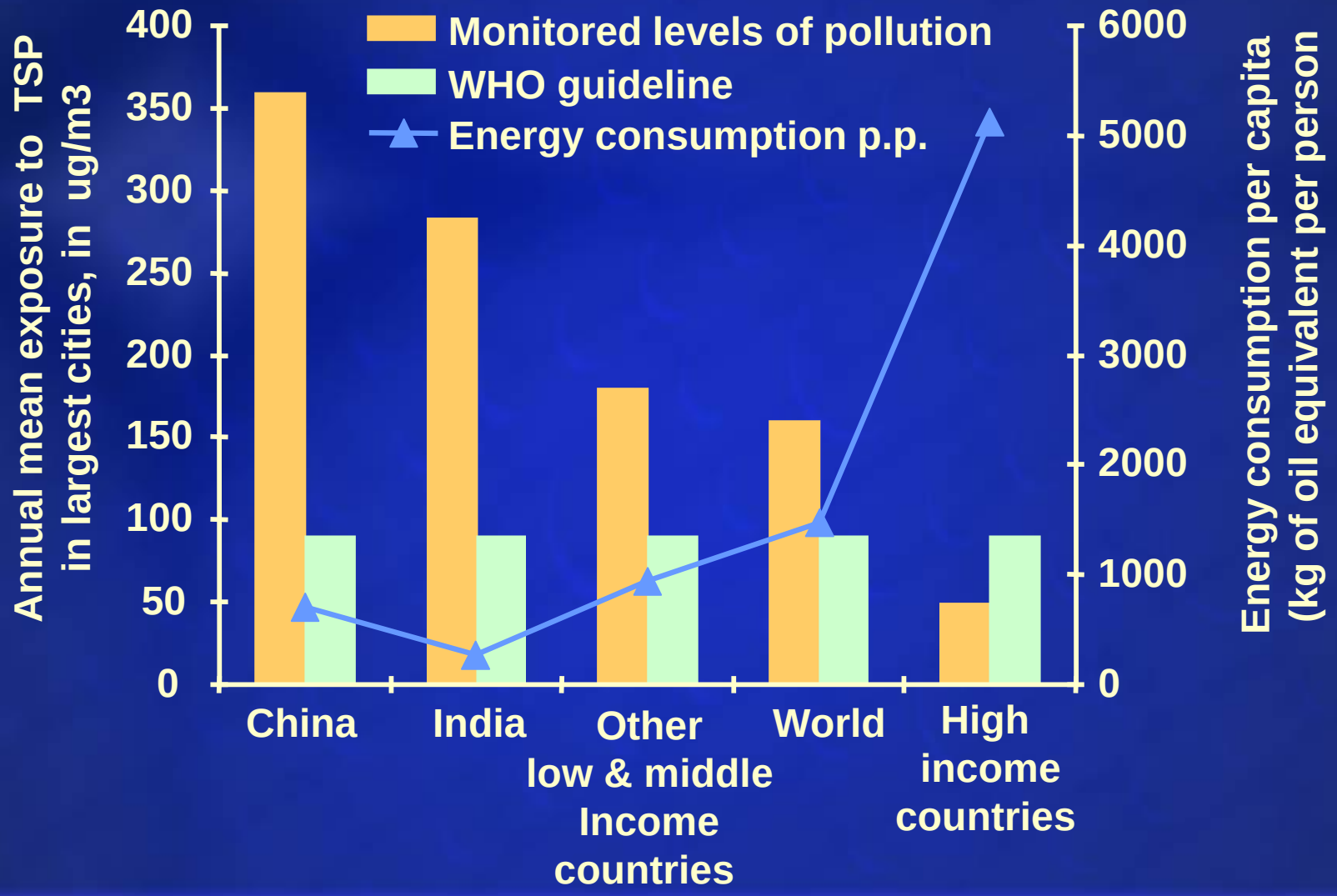
- The stage of development of a city is a critical factor in the capacity to prevent or control emissions.
- Uncontrolled industrialisation and transportation increases air pollution, but a point is reached at which there is enough social pressure and available resources to stabilise and then reduce emissions

Kuznets Curve, opportunities for cities to create a future with health, environmental and other benefits…

…by developing and implementing cost-effective policies, exploring innovative opportunities and learning from other city experiences...



Richer countries use more energy and produce less air pollution per capita



Policy options

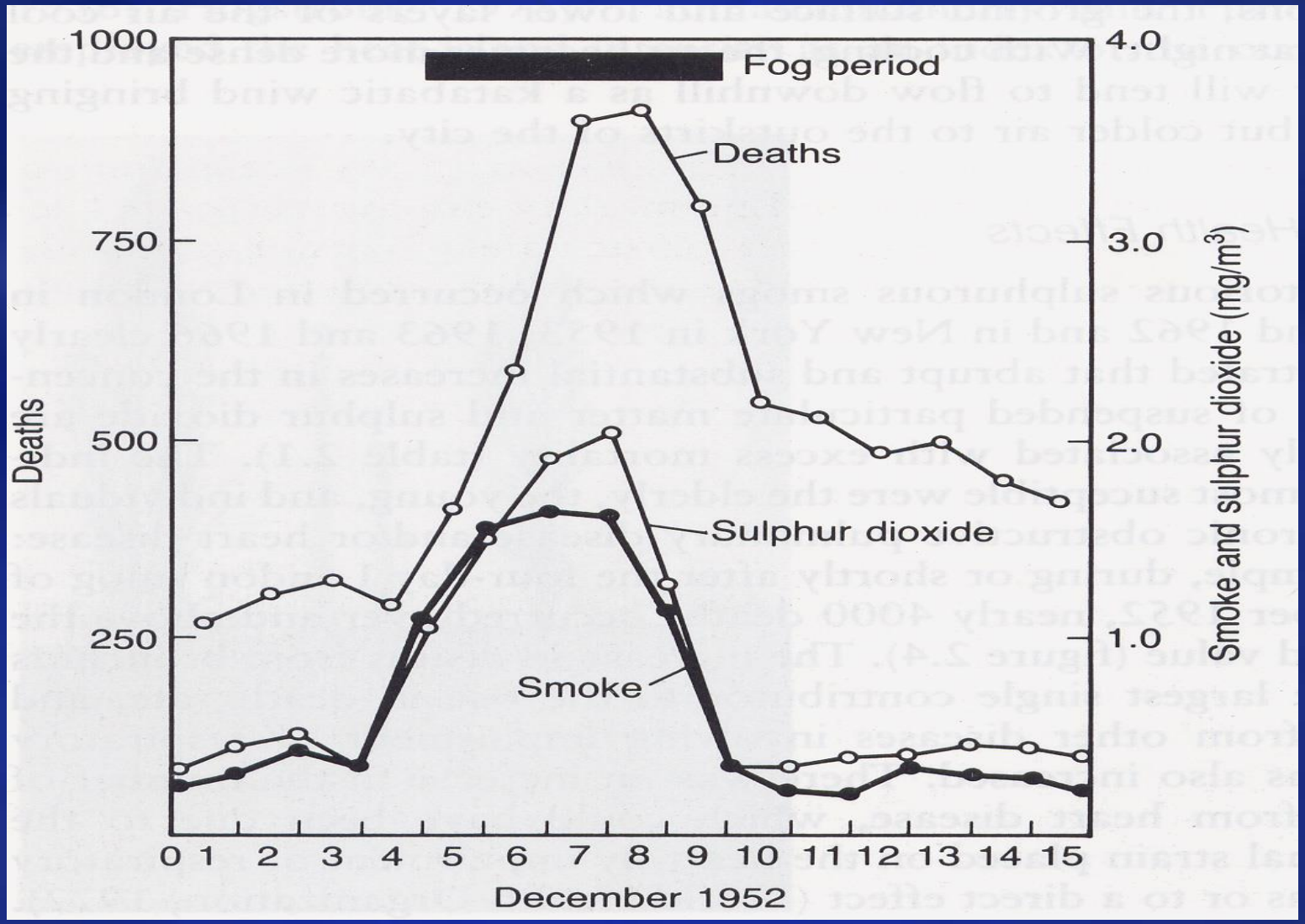
- Strategic planning
- Government regulations
- Economic incentives
- Education

A Case Study: Mobile Sources

Addressing mobile emissions requires a mix of regulatory controls, financial incentives, ***and*** prevention

- Key components:
  - Use of clean fuels
  - Use of available vehicle emissions technologies
  - Management of anticipating growth in travel
  - Improving public transport

Health Effects of Air Pollution



Air pollution abatement

- Deaths in London, Meuse Valley in Belgium, Donora in Pennsylvania, New York, Ruhr in Germany and elsewhere led to pollution abatement starting in the 1950s
- Clean Air Acts from the 1950s led to statutory planning to physically separate industrial and residential uses, and regulations requiring tall chimneys, fuel changes, licensing and emissions control initially directed at point sources
- The problem initially was mostly industrial emissions of SO_2 and smoke. The method of control was regulatory control of these emissions.

Photochemical smog and mobile sources of emissions

- The recognition of the health and environmental effects of photochemical smog, initially in Los Angeles, led to a different approach
- The State of California developed ambient air quality standards, and controls on vehicles emissions in 1959
- Catalytic converters and unleaded petrol introduced by USEPA in 1975.
- The problem was vehicles. The method of control involved emission and ambient standards

Epidemiological studies

- Early investigations in the UK in the 1960s developed cross-sectional (one point of time) and longitudinal techniques for comparing exposure and health effects, using standardised questionnaires and the spirometer
- They showed air pollution is associated with excess mortality, respiratory diseases, impaired lung function and use of hospital beds

US studies

- Large scale studies in the US in 1970s
- There were improvements in ambient air quality data and statistical techniques and a reduced frequency of extreme events.
- They enabled comparisons of the health of residents of cities at different ambient air quality. They estimated risks for the various pollutants, and estimates of mortality and morbidity at ambient levels
- Adequate control for confounding variables was an issue

Time Series and Cohort Studies

- By the late 1980s and early 1990s time series studies using Poisson regression models were structured to avoid the issues of confounding variables
- Time-series studies compare day-by-day changes in health variables in a single study population to daily measurements of air pollution
- Cohort studies follow long term outcomes of exposure to air pollution in a sample of a population

Results of studies in North America and Europe

A large number of recent time-series studies in North America and Europe have shown that an increase in daily ambient PM_{10} of 10 $\mu g/m^3$ was associated with increases of about 0.2-0.8% in total mortality.

Results of studies in US and Europe

An increase in daily ambient:

- **$PM_{2.5}$ at 10 $\mu g/m^3$ was associated with increases of about 1.5-4% in total mortality,**
- **ozone at 10 ppb was associated with increases of about 0.4-1.1% in total mortality.**
- **SO_2 at 10 $\mu g/m^3$ was associated with increases of about 0.5-1% in total mortality.**

Conclusions from US and European studies

The studies suggest

1. **interactions among pollutants, and**
2. **susceptible groups in the community, especially the aged and those with existing respiratory diseases.**

Relevance to Asia

- Asia is extremely diverse in social, economic cultural and climatic factors, so generalisations are difficult.
- Some highly populated cities in Asia experience high concentrations of ambient air pollution
- Asia has 7 of the 10 most populated countries in the world and some of the world's largest cities
- Asia has 12 of the 15 cities with the highest levels of particulate matter and 6 of the 15 cities with the highest levels of SO_2

Studies in Asia

- A wide range and number of studies on the impacts of air pollution on health have been conducted in Asia, including studies in China, Hong Kong SAR, India, Indonesia, Japan, Malaysia, Pakistan, Philippines, Singapore, South Korea, Taiwan, Thailand and others.
- Studies have been conducted on particles (TSP, PM_{10} and $PM_{2.5}$), NO, NO_2, SO_2, SO_4, CO, O_3, lead, benzene and other pollutants
- From a health impacts perspective, the priority pollutant in most Asian cities is particulate matter

Possible differences in exposure and response

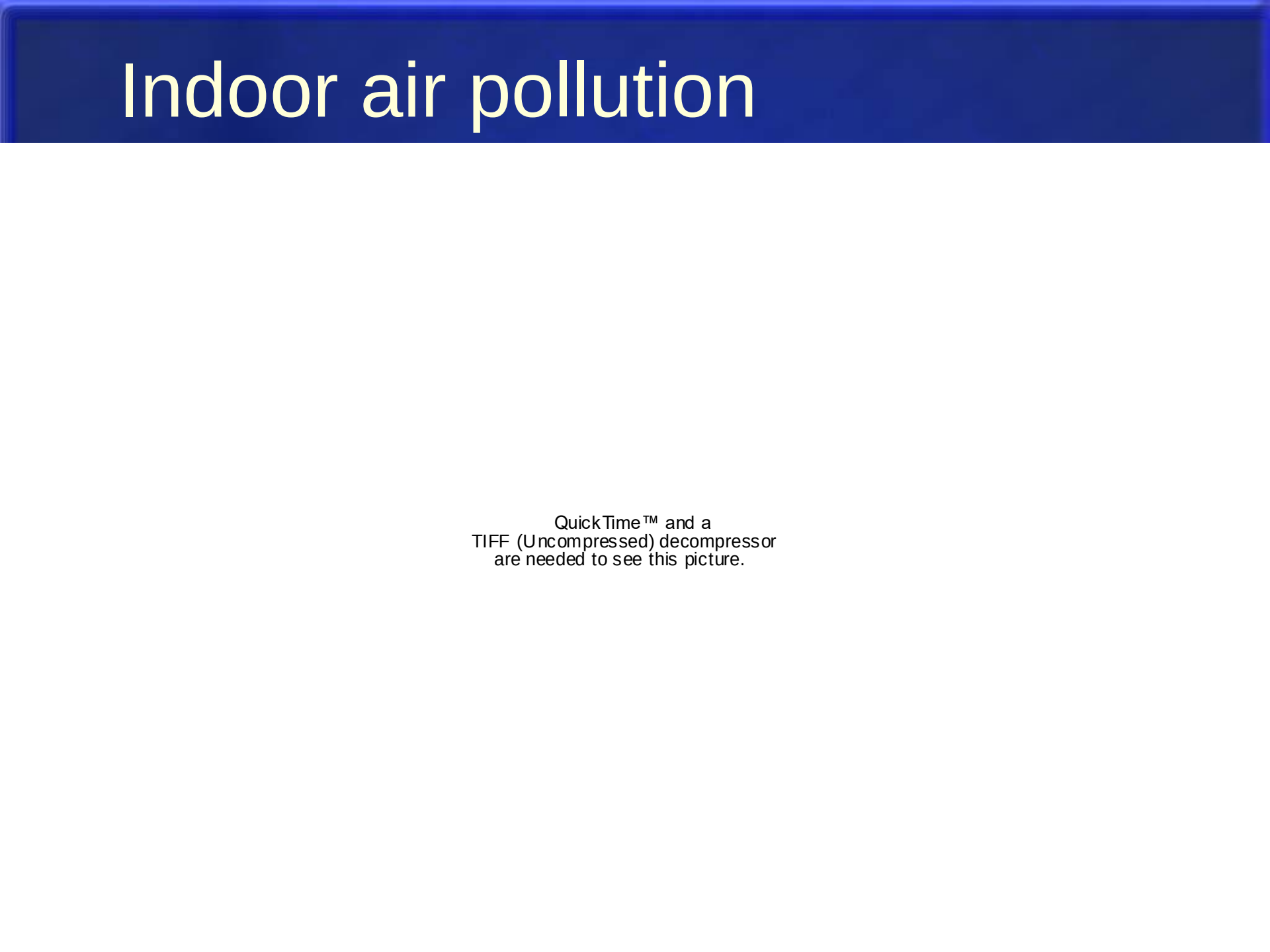
In principle, reasons for possible differences in exposure and response relationships between Asia and Europe/North America may include differences in:

- Chemical and physical properties of the air pollutants & their ratios (different fuels, vehicles etc)
- Levels of exposure to pollutants
- Demographics and other risk factors in the exposed population
- Health status of the exposed population
- and others

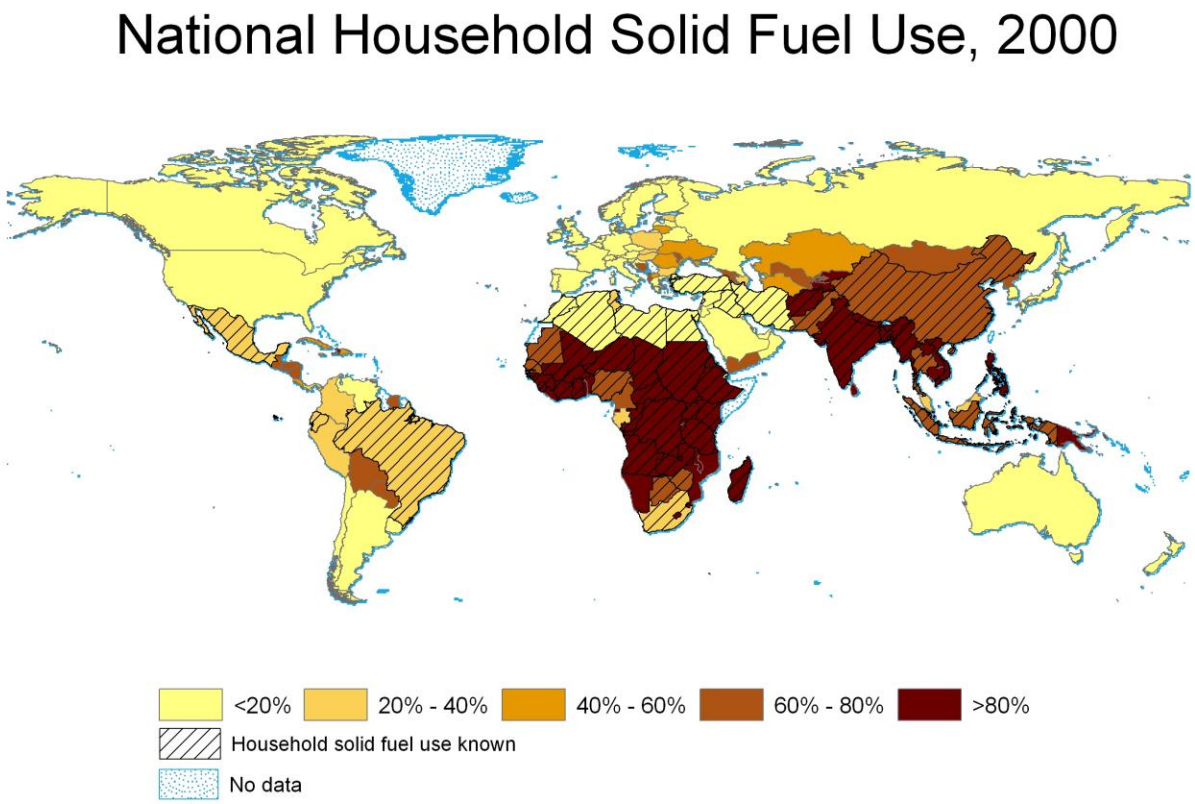
Time Series Studies in Asia

- A recent review of 28 time series studies conducted in Asia has shown that an increase in daily ambient PM10 of 10 $\mu g/m^3$ caused increases of about 0.5% in total mortality and 0.7% in cardiovascular mortality
- Many studies show similar concentration-response coefficients in developing countries to those found in developed nations
- There is a need for more studies to characterise risks in developing countries
- Not geographically representative (areas with high pollution, high poverty less well studied)

Indoor air pollution



Particulates from use of biofuels



Typical levels of key pollutants related to cook-stoves (wood fuel) in India

Pollutant	Average conc during cooking
PM_{10} (ug/m^3)	520-1200
$PM_{<5}$ (ug/m^3)	850-1500
CO (mg/m^3)	10-50

Conclusions: Air pollution in cities

- Air pollution has been deteriorating in urban areas
- Particulate matter is the most significant pollutant
- Other pollutants are SO_2, O_3, CO, NO_x, Pb
- Impacts on human health and the environment are serious
- Major changes are occurring with rapid economic growth often accompanied by emissions reductions in some countries

Conclusions

- As most Asian cities grow in population, vehicles and industry cost-effective and efficient measures need to be implemented to reduce the impacts of air pollution on health.
- The choice of measures needs to be informed by the assessment of health impacts, and cost-benefit analysis.

Conclusions: Air pollution in Asian cities

- Air pollution has been deteriorating in urban areas of Asia until recently
- Particulate matter is the most significant pollutant for health effects
- Impacts on human health and the environment are serious
- Major changes are starting to occur with rapid economic growth accompanied by emissions reductions in some countries

Conclusions

- The relationships between the common ambient air pollutants and health impacts in North America and Europe are reasonably well known
- In recent years there has been a rapidly growing knowledge of relationships between air pollution and health for the common pollutants in Asia. They suggest results generally similar to those found in North America and Europe, but more work in needed
- At ambient concentrations measured in Asian cities, many air pollutants have adverse impacts on health

Conclusions

- Air pollution is a major issue in developing nations as people move to megacities, where air pollution from vehicles and industry is growing
- Actions by some developed countries are slowly bringing this issue under control

Thank You!