Swiss Tropical Institute
Institut Tropical Suisse
Schweizerisches Tropeninstitut

Air Pollution

Guy Hutton, PhD

Swiss Centre for
International Health,
Swiss Tropical Institute
Basel, Switzerland

DSI Development
Solutions International
guy.hutton@dev-sol-int.com

Presentation Overview

- The problem
- The range of solutions
- The costs of selected solutions
- The benefits of selected solutions
- Benefit-cost ratios
- Interpretation of results
- Issues in scaling up the solutions

The problem: introduction

- Suspended particulate matter (dust, soot, fumes, mist, smoke, liquid droplets), gaseous pollutants (lead, SO_2, NO_2, O_3, CO), odours
- Transportation, energy generation, industrial operations, processing industries, domestic cooking & heating
- Air pollution impacts
  - Human and animal health (respiratory, heart)
  - Buildings and materials
  - Agricultural production
  - Biodiversity
  - Visibility
  - Greenhouse gases

The problem: causes

Indoor air

- Household use of biomass for cooking and heating
  - Open fires or traditional stoves
  - Conditions of low combustion efficiency, poor ventilation
- Problem more in rural areas (biomass)
  - *Also* other "modern" indoor air pollutants (e.g. sick-building syndrome)
  - *And* environmental tobacco smoke, exposure to chemicals or gases in indoor workplaces
- “Rule of 1000”: pollutant released indoors is 1000 times more likely to reach people’s lungs than one released outdoors

The problem: causes

Outdoor air

- Combustion of petroleum products or coal
  - Motor vehicles, industry, power generation
  - Mainly around cities and industrial areas
- Associated with advancing economic development
- Implies also a corresponding underdevelopment
  - Affording technologies that reduce pollution
  - Subsidizing public transport schemes
  - Enforcing regulations

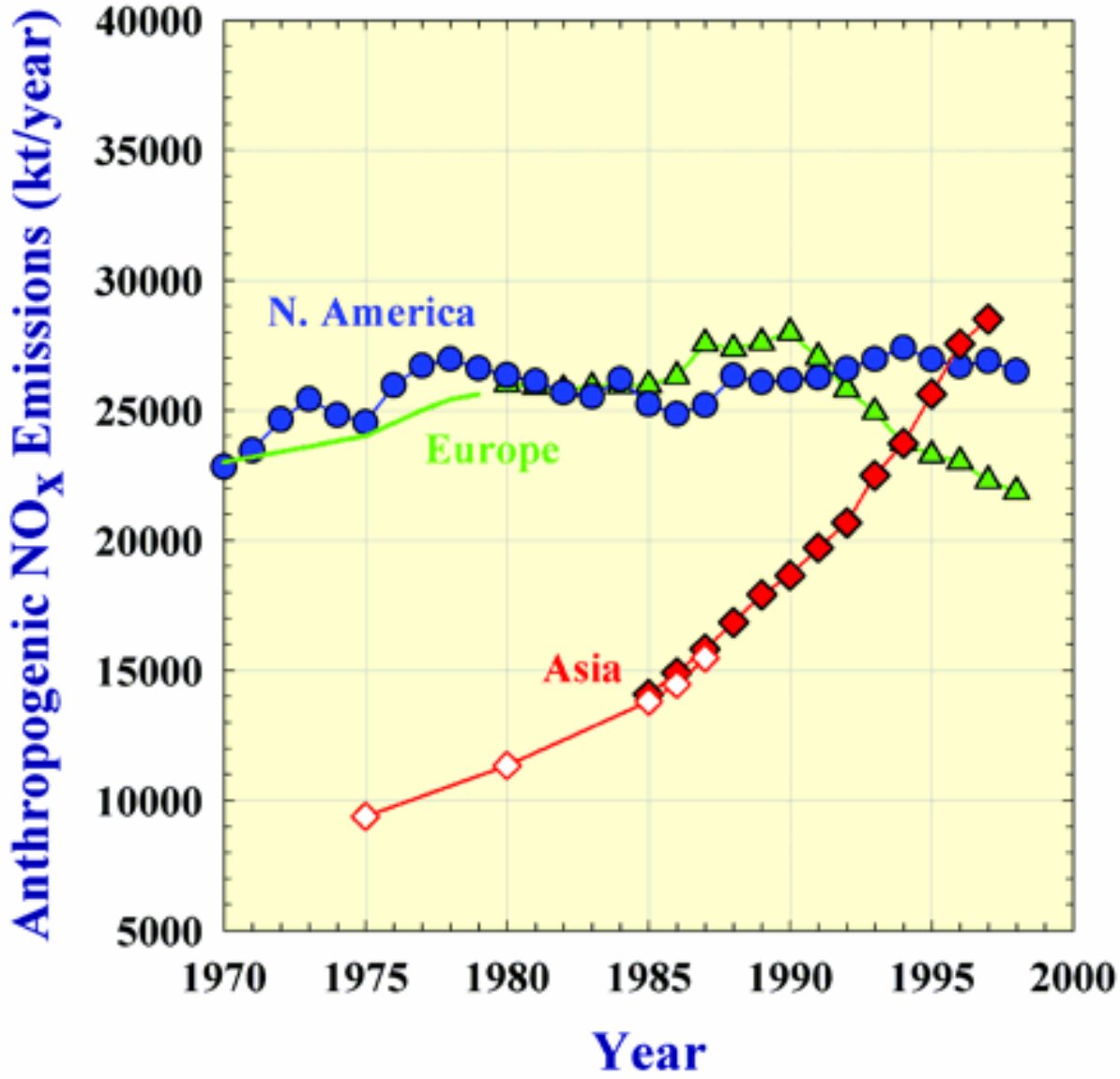
The problem: the numbers

Indoor air

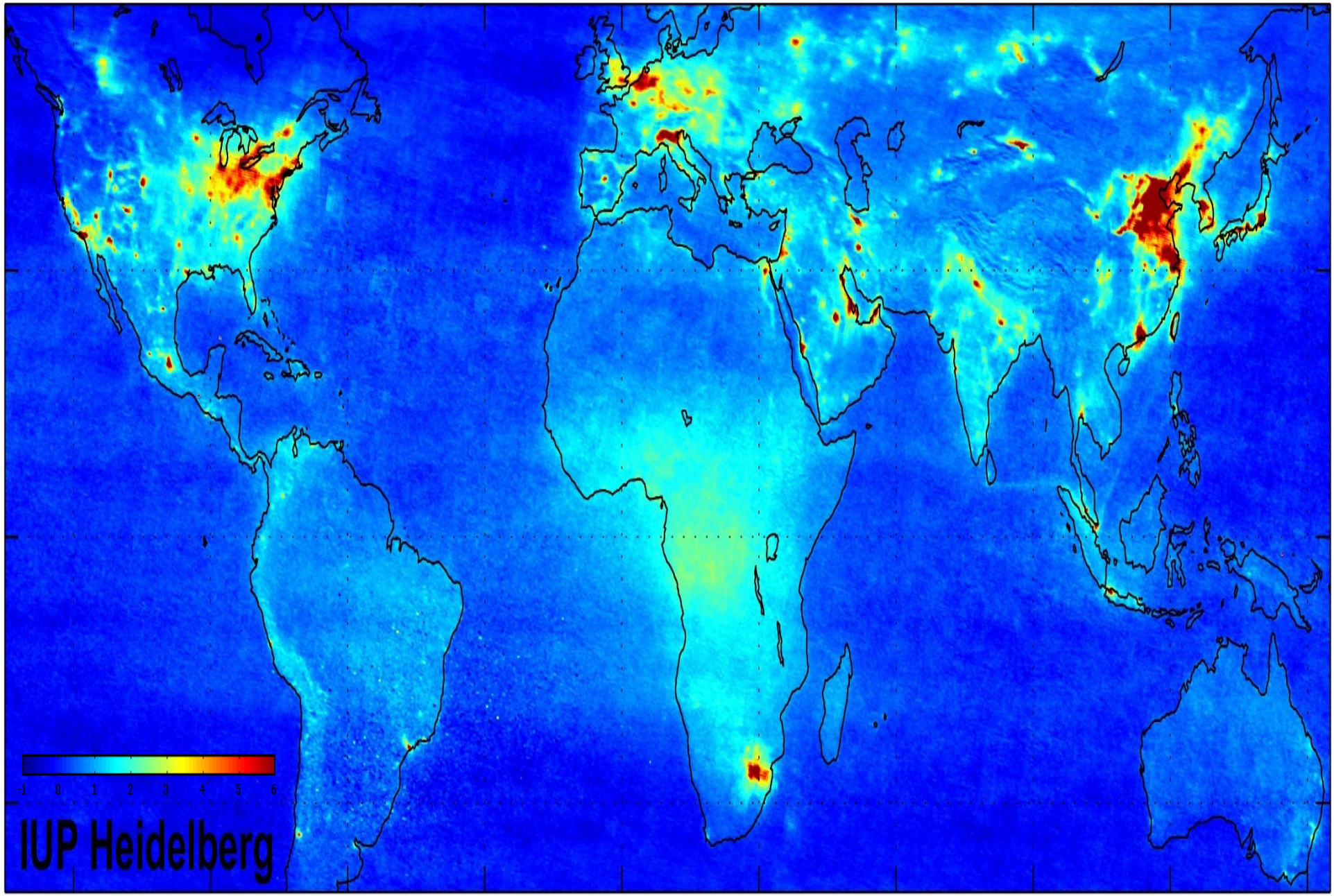
- > 3 billion people depend on solid fuels
- In rural areas, unimproved domestic fuels account for 66% (WPR) to >85% households (SSA & SEA)
- > 1.5 million annual deaths attributed to solid fuel use within the home

Outdoor air

- 1.5 billion pop. breathe air > WHO standard
- 800,000 annual deaths
  - 65% in developing Asia
- 0.6% - 1.4% disease burden in LDCs
- Lead pollution contributes further 0.9%
- Omits air pollution from forest fires and industrial or nuclear accidents



Akimoto H
Global Air Quality and Pollution
Science, 2003



Global mean tropospheric NO2 vertical column density (VCD) 01/2003 – 06/2004. University of Heidelberg.

Air pollution in the MDGs

- Health — goals 4, 5 and 6
- Environmental sustainability — goal 7
- Gender equality — goal 3
- Overall poverty rates — goal 1

Swiss Tropical Institute
Institut Tropical Suisse
Schweizerisches Tropeninstitut

Indoor Air

The solutions: indoor air

- Reducing the source of pollution
  - Improved cooking devices
  - Cleaner burning fuel
  - Reduced need for fire
- Altering the living environment
  - Ventilation
  - Kitchen design
  - Stove placement
- Alter user behaviour
  - Fuel drying
  - Stove and chimney maintenance
  - Use of pot lids to conserve heat
  - Keep children away from the smoke

Costs and benfits of the solution

- Few cost-benefit studies of indoor air pollution interventions
- One study by WHO evaluated global and regional costs and benefits of selected indoor air pollution interventions:
  - Solid fuels to LPG or ethanol
  - Improved stoves

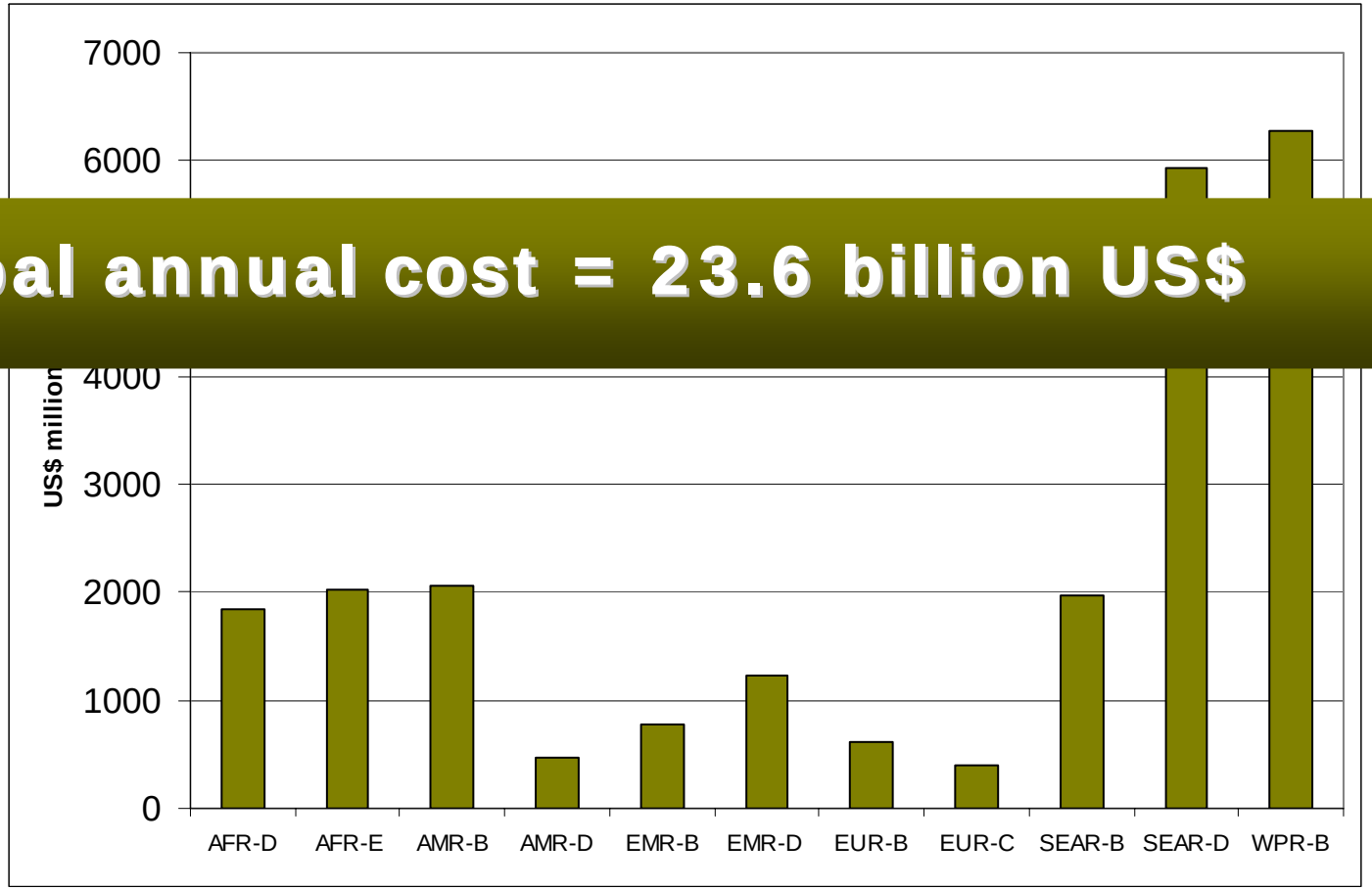
All evaluated for MDG target and universal access,

also with a separate pro-poor analysis

This presentation shows the MDG analysis

Total costs of solutions (US$ m)

LPG

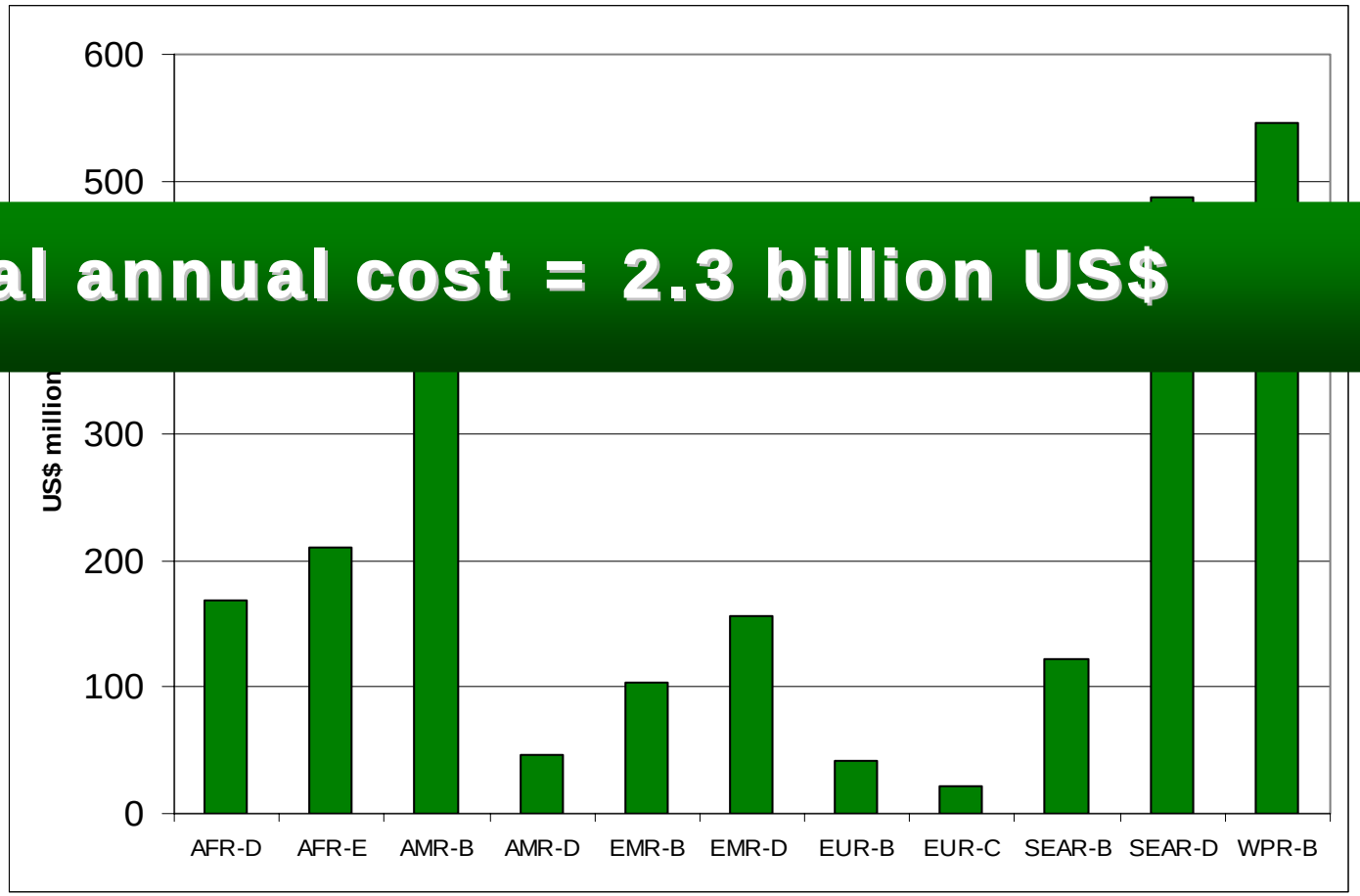


Global annual cost = 23.6 billion US$

Total costs of solutions (US$ m)

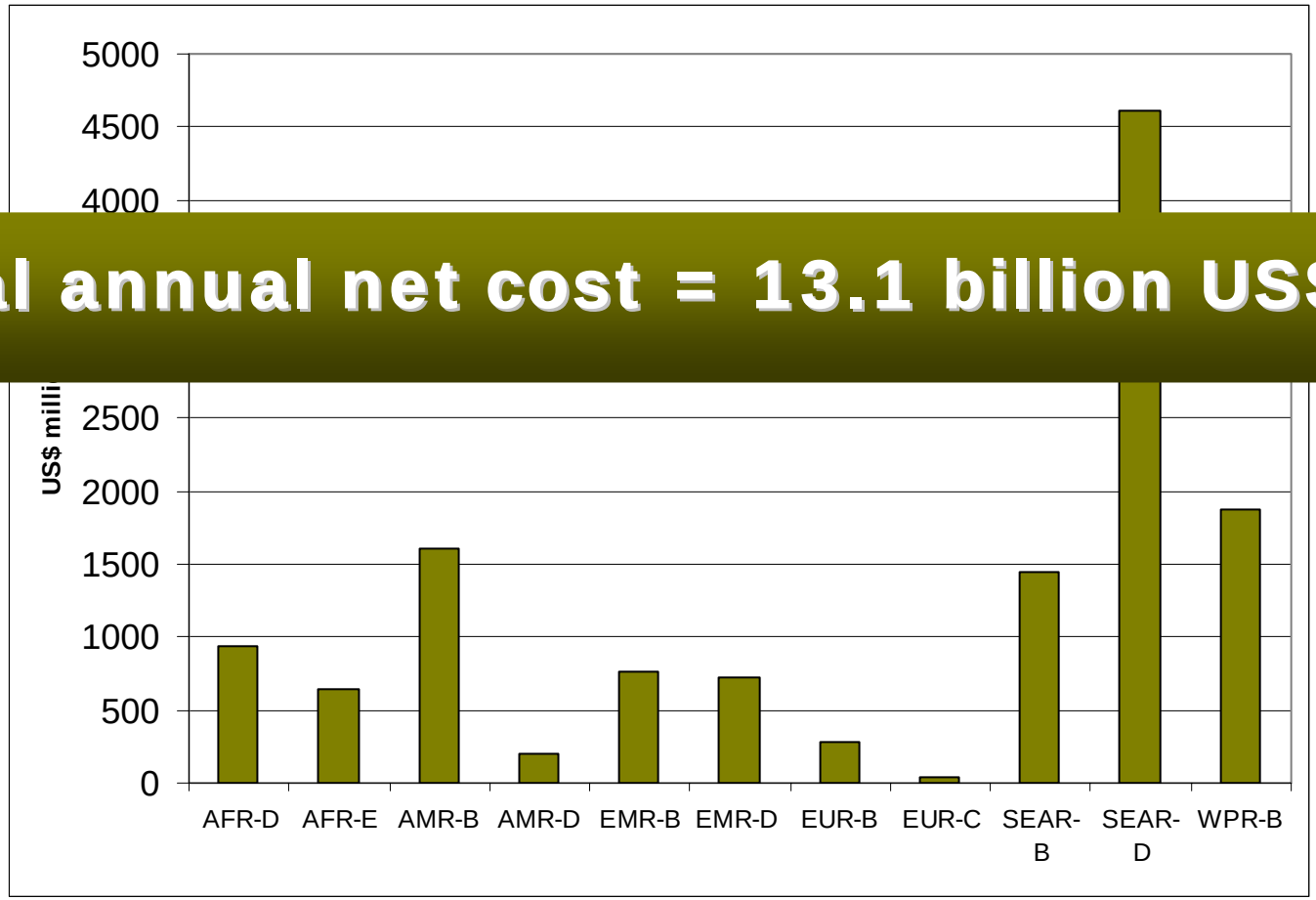
Stove

Global annual cost = 2.3 billion US$



Net costs of solutions (US$ m)

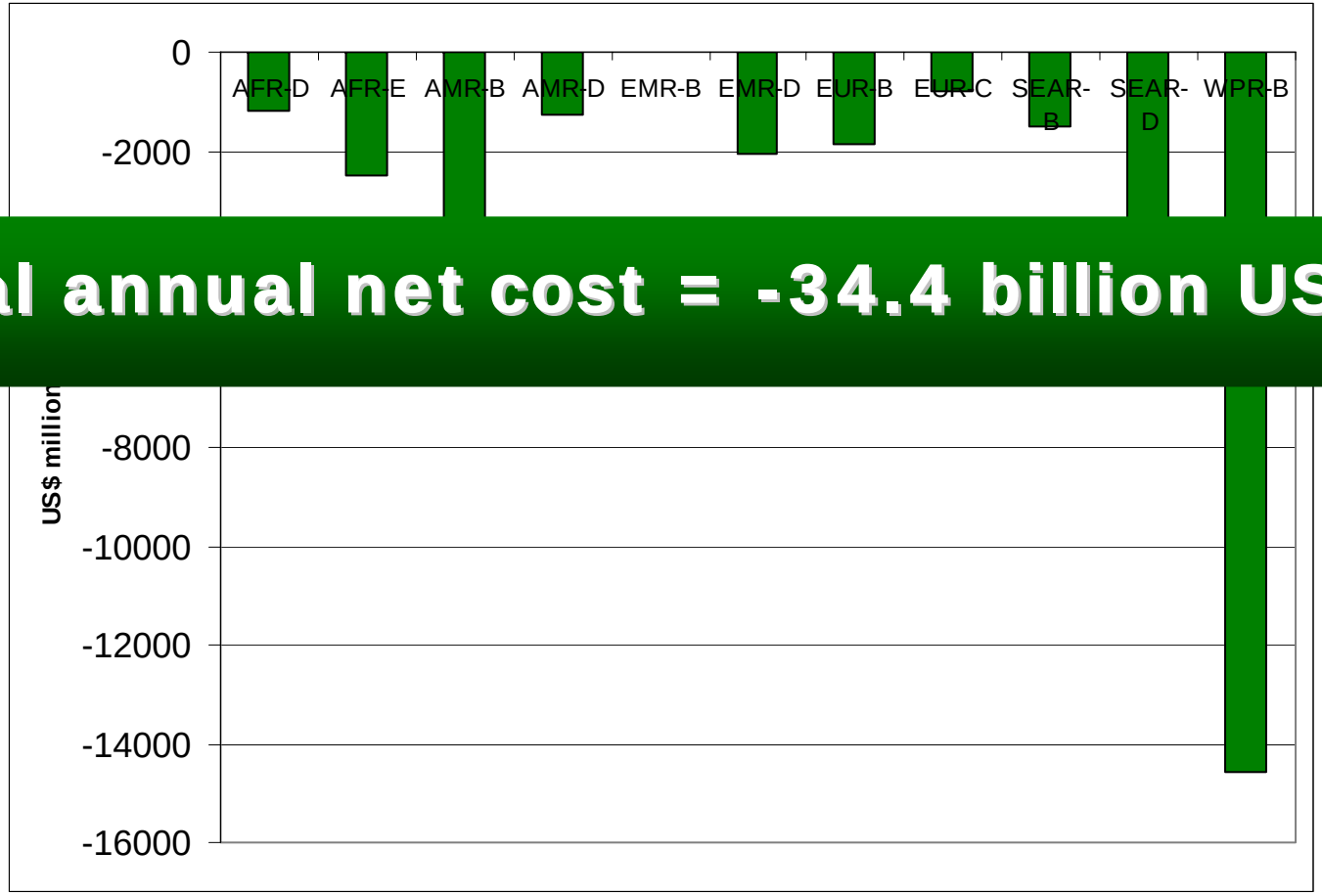
LPG



Global annual net cost = 13.1 billion US$

Net costs of solutions (US$ m)

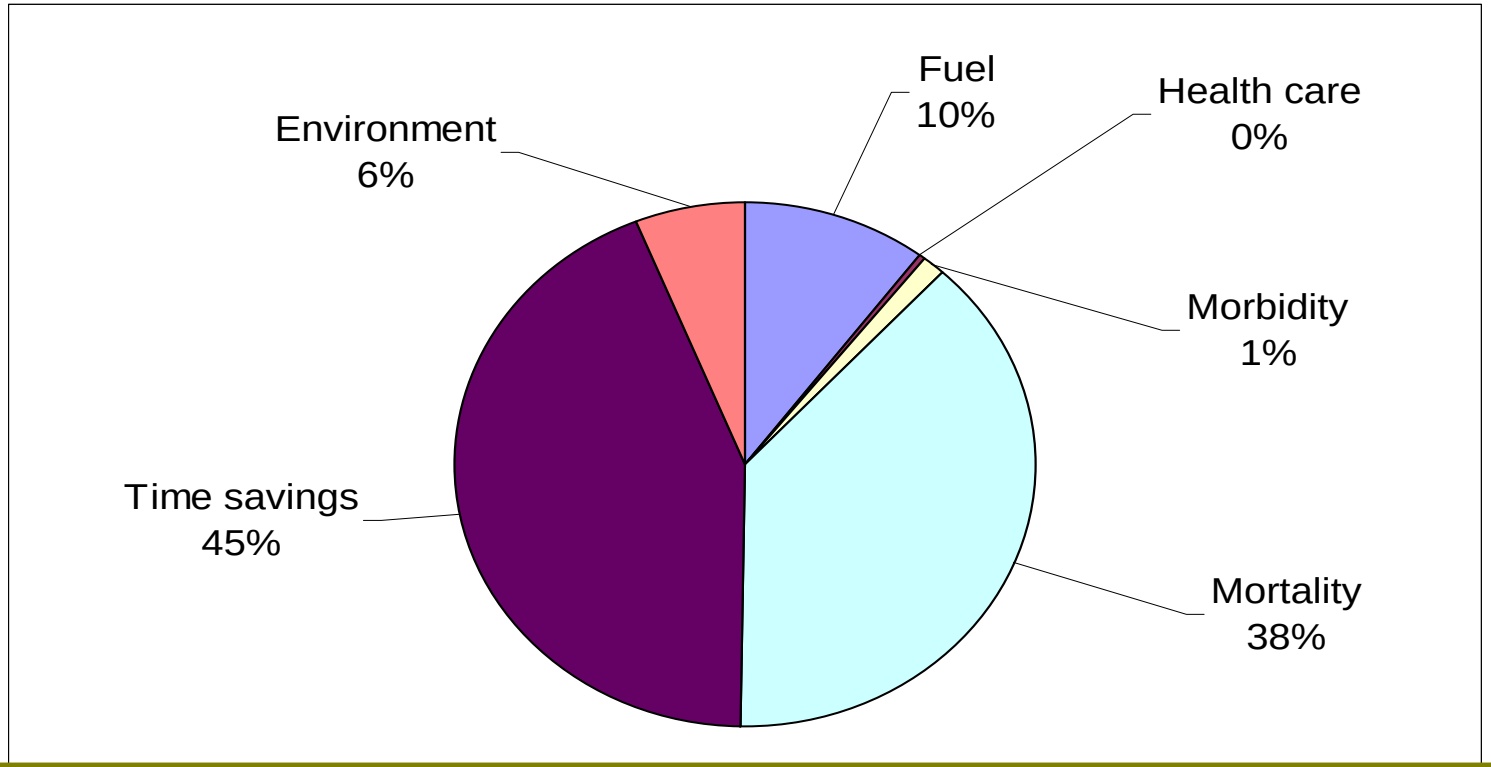
Stove



Global annual net cost = -34.4 billion US$

Total benefits of solutions (%)

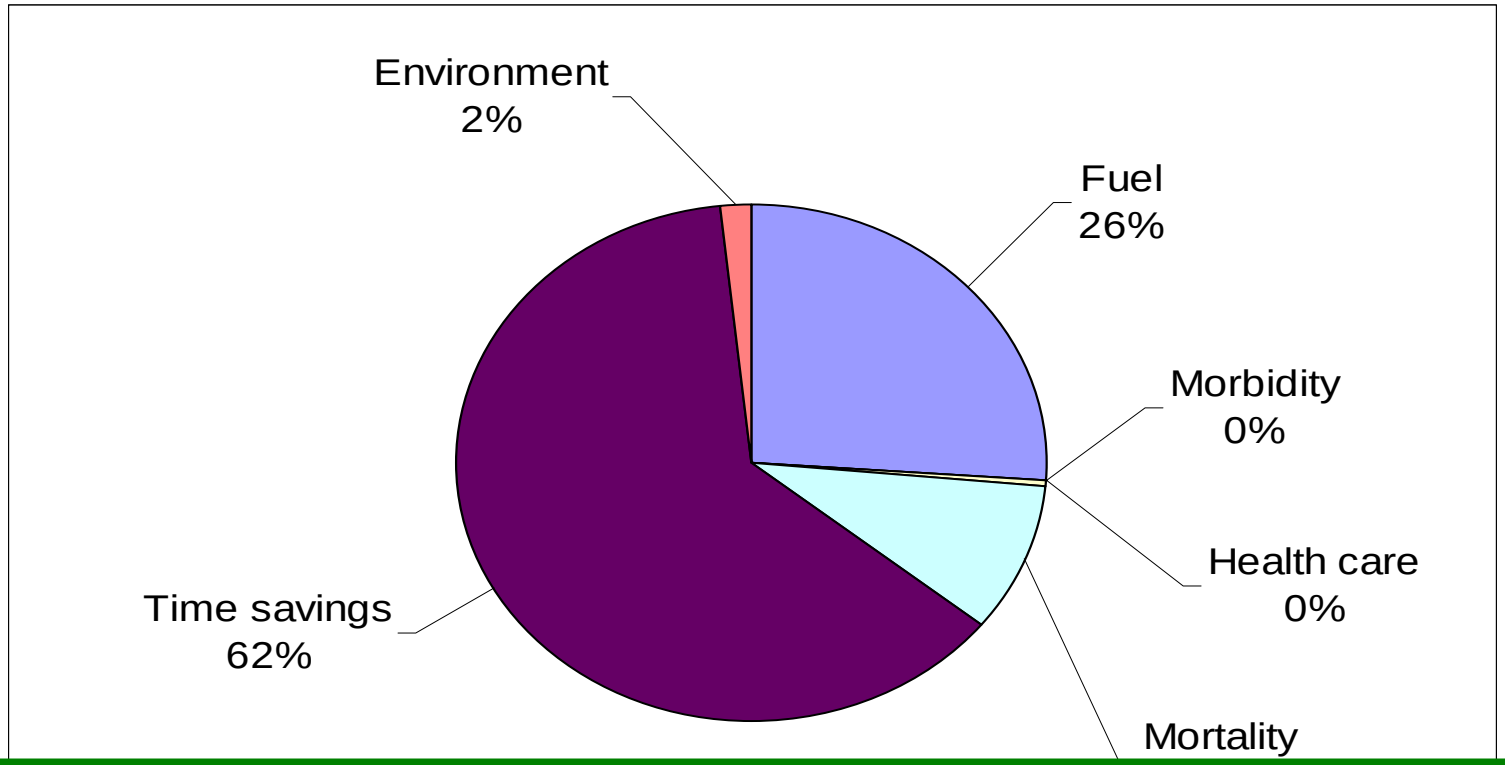
LPG



Global annual benefit = 101 billion US$

Total benefits of solutions (%)

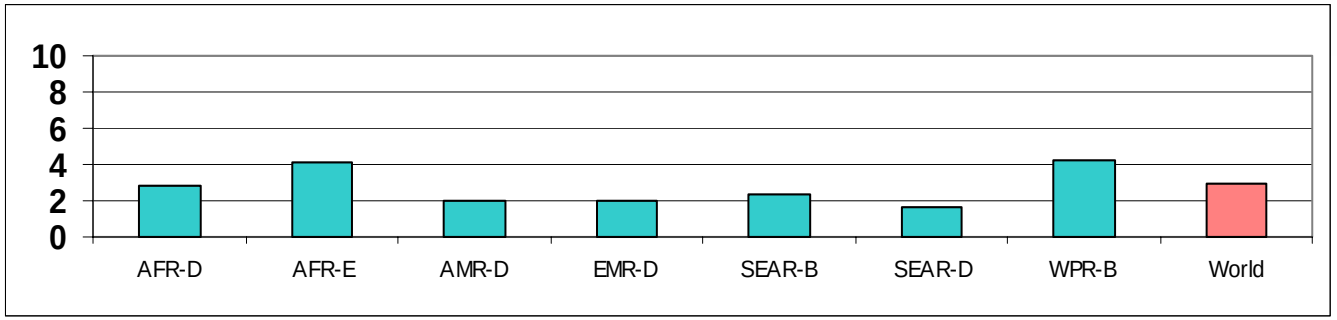
Stove



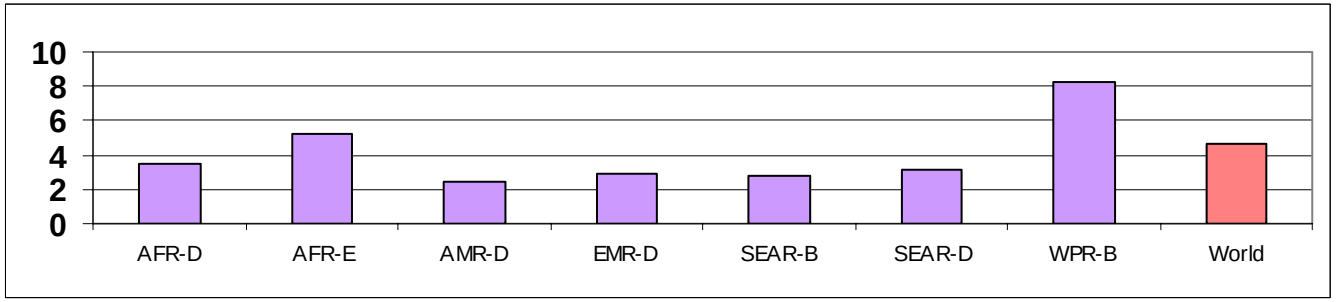
Global annual benefit = 141 billion US$

Benefit-cost ratios: LPG

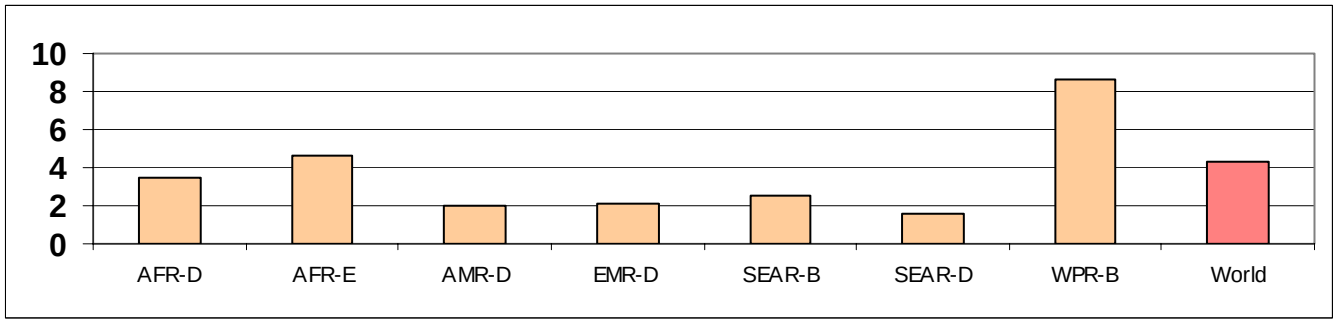
DALY = US$1,000



DALY = US$5,000

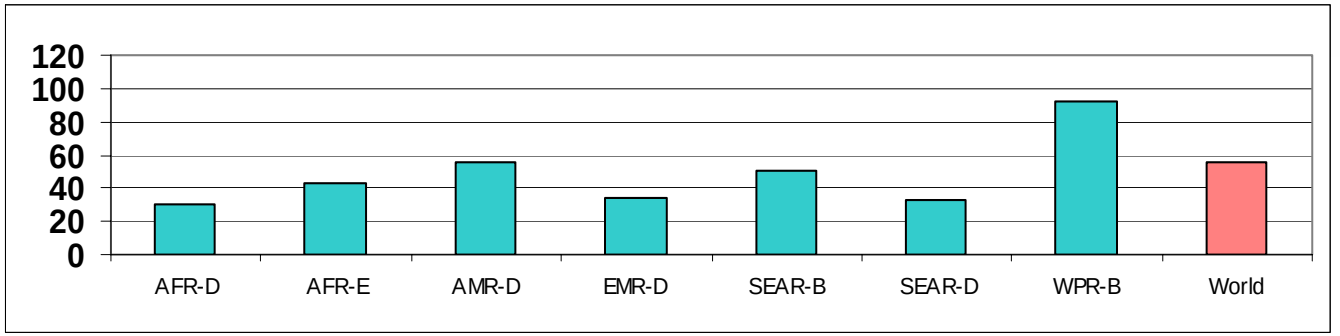


Value Productivity & VOSL

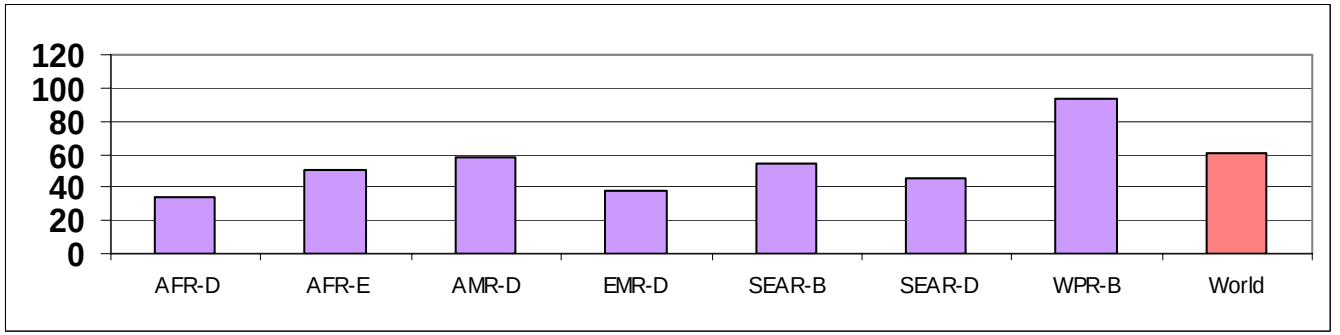


Benefit-cost ratios: stove

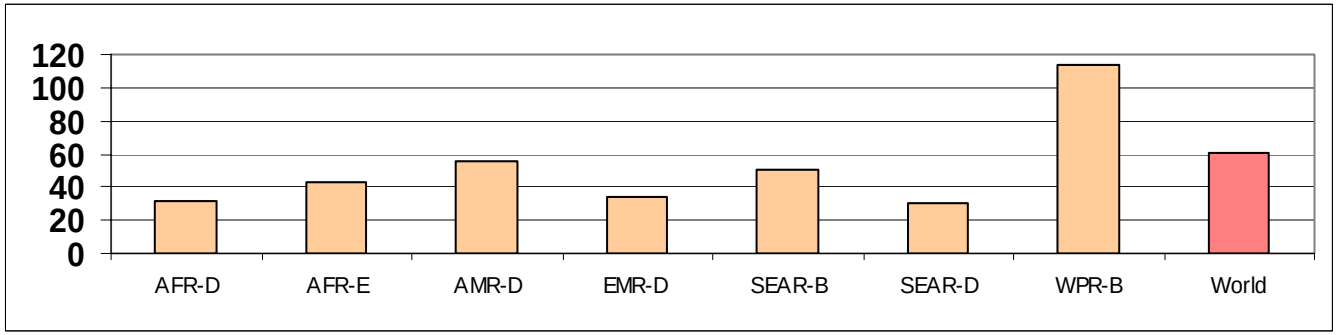
DALY = US$1,000



DALY = US$5,000



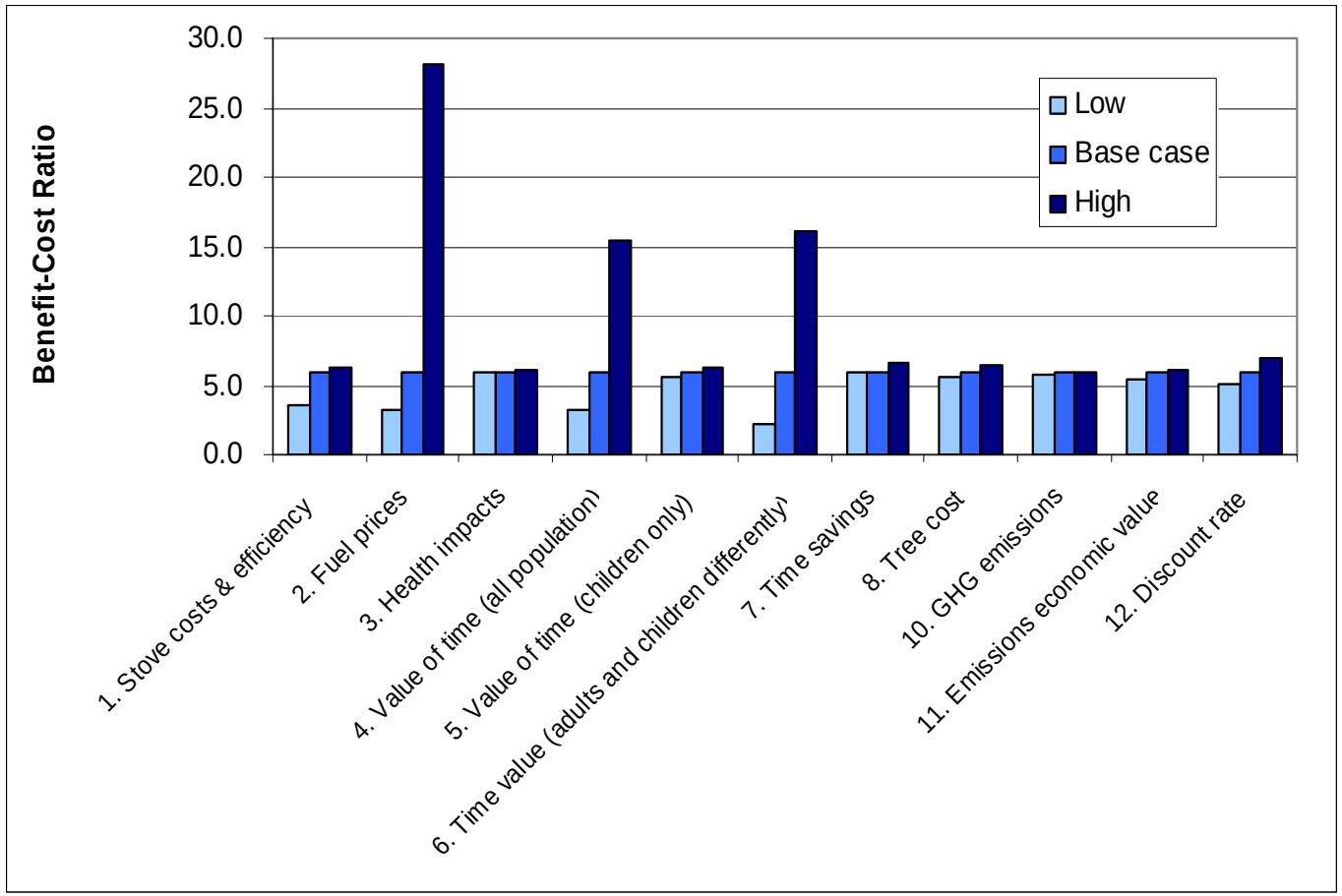
Value Productivity & VOSL



One-way sensitivity analysis

AFR-D Region

LPG



Outdoor Air

The solutions: outdoor air

- Remove pollution at its source - e.g. transport
  - Fewer vehicle kilometers traveled
    - Reduce need to travel
    - Switch to public transport or car pooling
  - Less fuel use per vehicle km traveled
    - Lighter vehicles
    - More efficient engine
  - Less pollution per unit of fuel used
    - Switch to cleaner fuel
    - Catalytic converter
- Filtering pollution away from the source (chimneys, re-location)

The solutions: outdoor air

- Policy options
  - Illegal to use a polluting fuel or substance (e.g. bans on leaded gasoline or asbestos)
  - Increase the costs of using polluting fuels (polluter pays principle – fuel tax or road tax)
  - Disseminate information on best practices
    - Less polluting technologies
    - Fuel efficiency
    - Changing behaviour

Costs and benfits of the solution

- Considerable diversity of studies in literature
  - National versus city-level studies
  - Comprehensive air pollution control versus single regulatory measures
  - Single versus multiple pollutant interventions
  - Industry-wide versus single industry measures
- Interventions presented focus mainly on fuel switching or technological solutions
- Studies mainly from developed countries

Outdoor air pollution control case studies:

1. US Federal Regulations

- **Policy** National emissions standards for hazardous air pollutants
- **Scope** Country-wide
- **Year** 1994-2004
- **Cost** US$15 - US$17 billion annually
- **Benefit** *Health*
  US$41 - US$218 billion annually
- **BCR** 2.72 - 13.0

Outdoor air pollution control case studies:

2. United States EPA Clean Air Act

- **Policy** Clean Air Act
- **Scope** Country-wide
- **Year** 1990 - 2010
- **Cost** US$19 billion annually in 2000
  Rising to US$27 billion annually in 2010
- **Benefit** *Health, crop damage, visibility*
  US$71 billion annually in 2000
  Rising to US$110 billion annually
- **BCR** 3.8

Outdoor air pollution control case studies:

3. European clean air targets

- **Policy** Reductions in emissions to meet air quality targets for CO, heavy metals, ozone, hydrocarbons
- **Scope** Europe-wide
- **Cost** Euro 7 billion annually
- **Benefit** *Mortality, morbidity, hospital admissions (from PM and ozone)*
  Euro 42 billion annually
- **BCR** 6.0

Swiss Tropical Institute
Institut Tropical Suisse
Schweizerisches Tropeninstitut

Outdoor air pollution control case studies:

4. UK Air Quality Strategy review

- **Policy** 17 policy measures to achieve AQS
- **Scope** Country-wide
- **Year** 2005 - 2020
- **Cost** £374 - £866 million annually
- **Benefit** *Health*
  £566 - £2021 million annually
- **BCR** 0.9 – 3.8

Outdoor air pollution control case studies:

5. China natural gas project

- **Policy** Substituting natural gas for coal in residential and commercial uses
- **Scope** Beijing and Chongqing
- **Year** 1998 - 2018
- **Cost** *Capital investment – year 0*
  Beij. 3.5 bn RBM; Chong. 0.7 bn RMB
- **Benefit** *Health – annual figures*
  Beij. 2.1 bn RBM; Chong. 4.9 bn RMB
- **NPV** Beij: 6.9 bn RMB; Chong: 18.6 bn RMB
- **IRR** Beij: 29%; Chong: 75%

Outdoor air pollution control case studies:

6. Shanghai Emission Control

- **Policy** Emissions control in power and industry
- **Scope** Shanghai
- **Year** 2010-2020
- **Cost** Power: US$395 million annually
  Industry: US$94 million annually
- **Benefit** *Mortality, morbidity, work days (PM_{10})*
  Power: US$417 million annually
  Industry: US$266 million annually
- **BCR** 2.0 (power) and 5.4 (industry)

Outdoor air pollution control case studies:

7. Japan sulphur emissions control

- **Policy** Comparing SO_2 emissions control in 3 policy epochs
- **Scope** Country-wide
- **Year** 1968-73; 1974-1983; 1984-93
- **Cost** (1) 5,576 bn Yen; (2) 15,991 bn Yen (3) 9,354 bn Yen
- **Benefit** *Morbidity, work days* (1) 30,058 bn Yen; (2) 18,818 bn Yen; (3) 3,854 bn Yen
- **BCR** (1) 5.39; (2) 1.18; (3) 0.41

Outdoor air pollution control case studies:

Other studies presenting BCRs

- Air pollution reductions in Hungary: **3.0 – 17.0**
- Emissions reductions in the oil extraction industry in Kazakhstan: **5.7**
- Nitric oxide and NO_2 emissions reductions in Tokyo (1974 to 1993): **6.0**
- Pollution control programme in Canada: **3.0**

Interpreting the results

- Outdoor air pollution studies estimate mainly health-related costs, omitting
  - Quality of life indicators
  - Material damage and costs of cleaning up
  - Agricultural production
  - Biodiversity
  - Global environment
- Large uncertainties in health impact estimations
- Economic results highly dependent on valuation techniques – e.g. value of life

Scaling up the solutions

- **Priority setting**
  - Multiple factors influence decision makers
- **Financing**
  - Cost savings make some interventions attractive
  - Environmental benefits are externalities
- **Other issues**
  - Regulations need to be respected (policing costs)
  - Access to markets and technologies