Health and Environmental Impacts of Air Pollution: CBA of European Air Quality Policy

Mike Holland, EMRC

Air Pollution and Climate Workshop

Honolulu, April 2005

Acknowledgements: Fintan Hurley, IOM; Paul Watkiss, Steve Pye, AEA Technology; Alistair Hunt, University of Bath; Stale Navrud, ECO; Ari Rabl, Joseph Spadaro, Ecole des Mines

http://www.emrc.co.uk/
http://www.ihavepeace.co.uk/

Development of methods

- Major programmes
  - EC-US Fuel Cycles Study (1990-95)
  - ExternE Programme (1995-2000)
  - Newext, Methodex, NEEDS, etc. (2001-present)
  - Liaoning Integrated Environmental Programme (LIEP) (2000-2004)
  - CAFE Programme (2003-present)
    - www.cafe-cba.org
- Involving all relevant disciplines
- Subject to intense debate

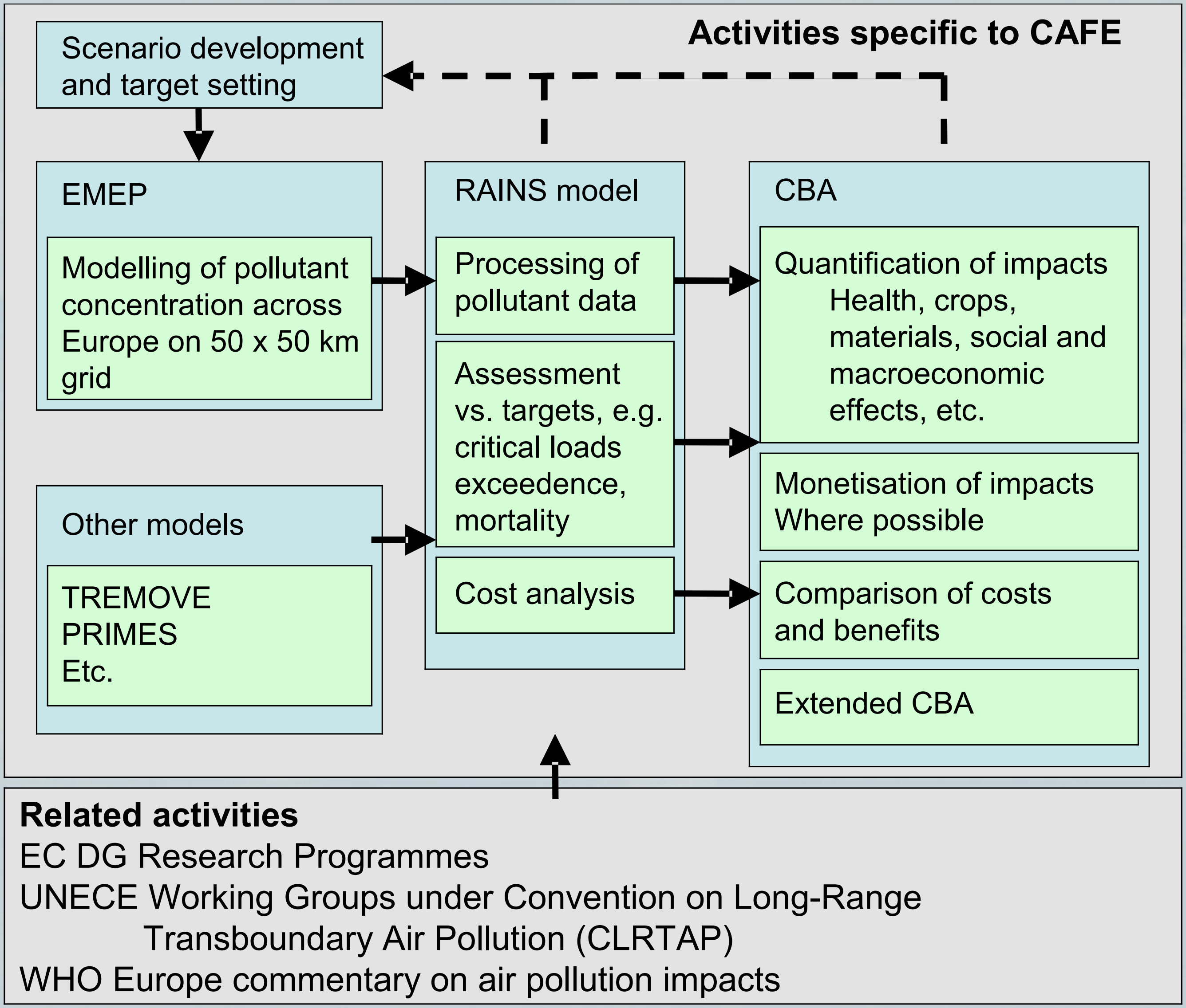
CAFE (Clean Air For Europe) Programme, 2003-2005

- Development of EU’s Thematic Strategy on Air Pollution…
- …which describes agenda for action on:
  - National emission ceilings for NH_3, NOx, primary $PM_{2.5}$, SO_2 and VOCs
  - $PM_{2.5}$ air quality standard
  - Vehicle emission standards
  - Etc.

Interactions between pollutants and effects

	NH_3	NOx	$PM_{2.5}$	SO_2	VOCs
Acidification	⌉	⌉		⌉	
Eutrophication	⌉	⌉			
Health (PM)	⌉	⌉	⌉	⌉	⌉
Health (ozone)		⌉			⌉
Vegetation (ozone)		⌉			⌉
Non-CAFE: Global warming	⌉	⌉	⌉	⌉	⌉

CAFE analytical framework



Benefits analysis: General approach

Identify sources and quantify emissions of NOx and VOCs

↓

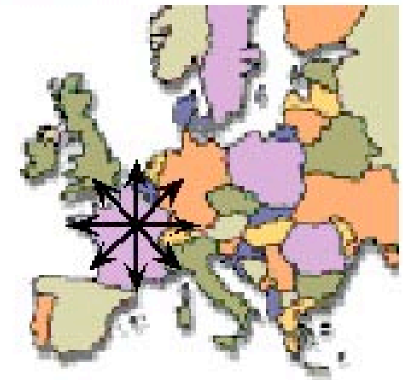
Calculate dispersion of precursors and ozone concentrations across Europe

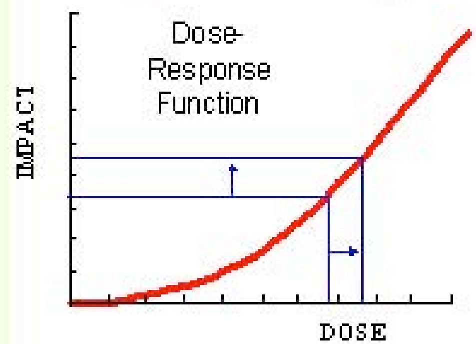
↓

Apply exposure-response functions to estimate yield loss

↓

Value yield loss using world market prices





http://www.emrc.co.uk/
http://www.ihavepeace.co.uk/

Impacts of interest to CAFE-CBA

- Mainly PM and ozone impacts

- Health – to valuation
- Ecosystems – to risk assessment
- Crops – to valuation
- Materials – to partial valuation
- Social factors – qualitative assessment
- Macroeconomic effects – general equilibrium modelling

Health impacts assessed, $PM_{2.5}$

- Mortality:
  - Chronic exposures (adults, >30)
  - Infant mortality (1 to 12 months)
- Morbidity, core:
  - Respiratory Hospital Admissions, all ages
  - Cardio Hospital Admissions , all ages
  - Restricted Activity Days, 18-64 years
  - Bronchitis, >27 years
  - Respiratory medication use, adults, children
  - Lower respiratory symptoms, adults, children
- Morbidity, sensitivity:
  - Consultations for asthma, adults, children
  - Upper respiratory symptoms, adults, children

Health impacts assessed, O_3

- Mortality:
  - Acute exposures
- Morbidity, core:
  - Respiratory Hospital Admissions, >65 years
  - Minor Restricted Activity Days, ages 18-64
  - Respiratory medication use, adults
- Morbidity, sensitivity:
  - Minor Restricted Activity Days, >65 years
  - Respiratory symptoms, adults

Baseline Health Impacts – EU25
Preliminary results (impacts, not monetised)

End point		Baseline in 2000	Current leg. 2020 (w/Climate Policy)	Difference 2020 and 2000
Acute Mortality	O_3	21 400	20 700	745
Respiratory hospital admissions	O_3	14 000	20 000	-6 000
Minor Restricted Activity Days	O_3	53 924 000	42 227 000	11 697 000
Respiratory medication Use (Children)	O_3	21 413 000	12 897 000	8 516 000
Respiratory medication Use (Adults)	O_3	8 837 000	8 136 000	701 000
Cough and LRS (children)	O_3	108 056 000	64 955 000	43 101 000
Chronic mortality *	PM	3 001 000	1 900 000	1 101 000
Chronic mortality *	PM	288 300	208 000	80 100
Infant mortality	PM	562	271	292
Chronic bronchitis	PM	135 700	98 400	37 300
Respiratory hospital admissions	PM	51 400	32 600	18 900
Cardiac hospital admissions	PM	31 700	20 100	11 600
Restricted activity days (RADs)	PM	288 292 000	170 955 700	117 337 000
Respiratory medication Use (children)	PM	3 510 000	1 548 700	1 961 000
Respiratory medication Use (adults)	PM	22 990 000	16 055 000	6 935 000
LRS among children	PM	160 349 000	68 819 000	91 529 000
LRS in adults with chronic symptoms	PM	236 498 000	159 724 000	76 774 000

Summary – Health Valuation – EU25

	2000 (€bn)		2020 (€bn)		Difference (€bn)	
	Low estimate	High estimate	Low estimate	High estimate	Low estimate	High estimate
O_3 m67t04ity	1.1	2.5	1.1	2.4	0.0	0.1
O_3 m67lidity	6.3	6.3	4.2	4.2	2.1	2.1
PM m67t04ity	157.7	582.3	99.7	420.1	58.0	162.2
PM m67lidity	77.9	77.9	49.3	49.3	28.6	28.6
Total	**243.0**	**669.0**	**154.3**	**476.0**	**88.7**	**193.0**

- The impact (the benefit) of implementing current legislation up to 2020 is valued at between <u>€89 billion to €193 billion</u>

Big debates on air pollution CBA methods in Europe

- Valuation of mortality
  - By death (VSL)
  - By years of life lost (YOLL, VOLY)
- Differentiation of effects by type of particle
- Valuation of damage to ecosystems and cultural heritage

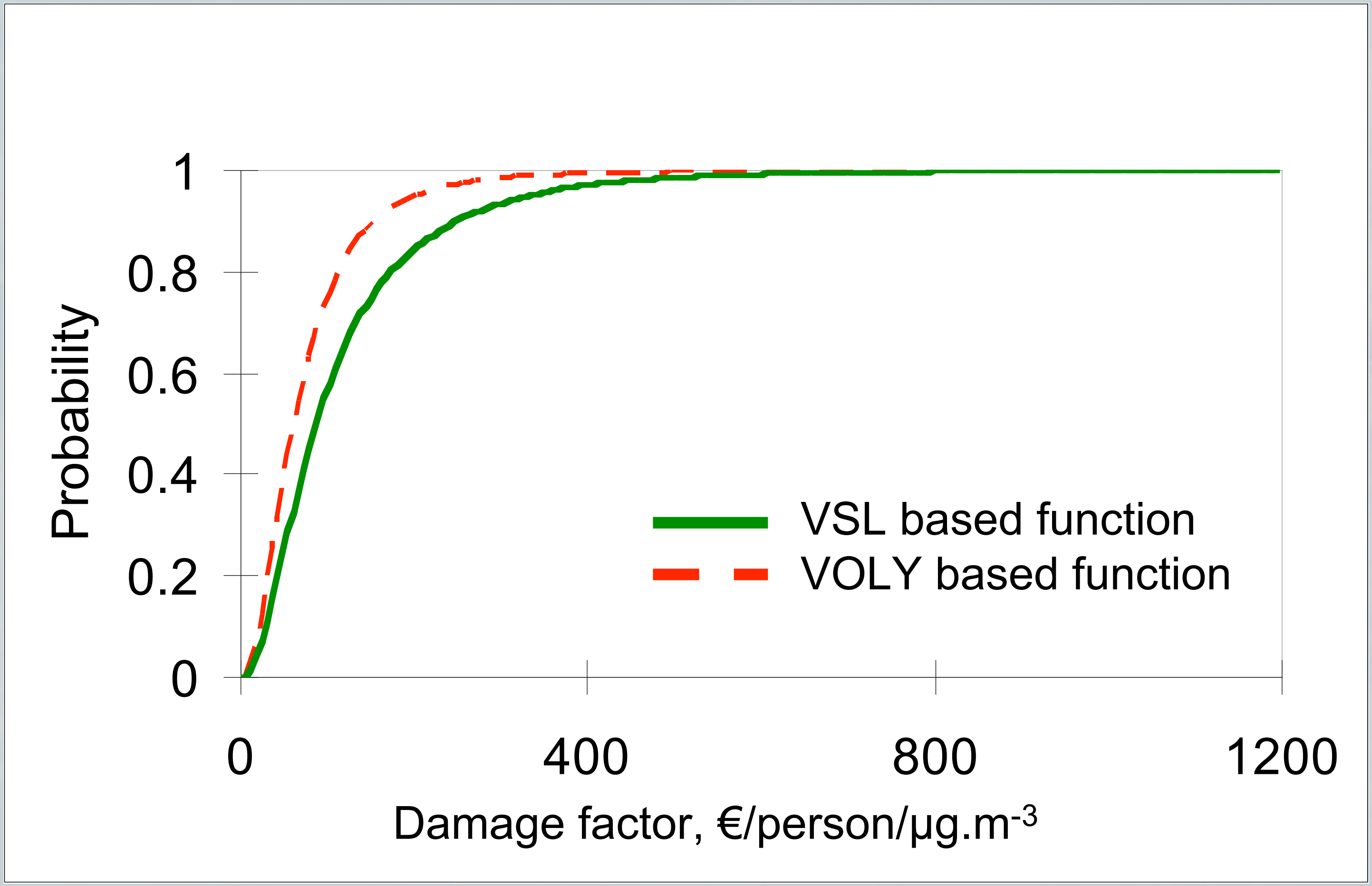

http://www.emrc.co.uk/
http://www.ihavepeace.co.uk/

Valuing mortality, VSL vs. VOLY

- European valuations significantly lower than US valuations
- Non-economists seem to prefer VOLY
- Economists generally prefer VSL

- Does it make a difference?
  - Take the separate elements of mortality quantification:
    - Incidence rate (I)
    - Exposure-response function (ERF)
    - Valuation (V)
  - Define probability distribution for product, I × ERF × V, referred to here as the 'damage factor'

Comparison of aggregated VSL and VOLY functions



http://www.emrc.co.uk/
http://www.ihavepeace.co.uk/

Differentiation of impacts by type of particle

- Not done in CAFE – could not get agreement
- Could be addressed through sensitivity analysis

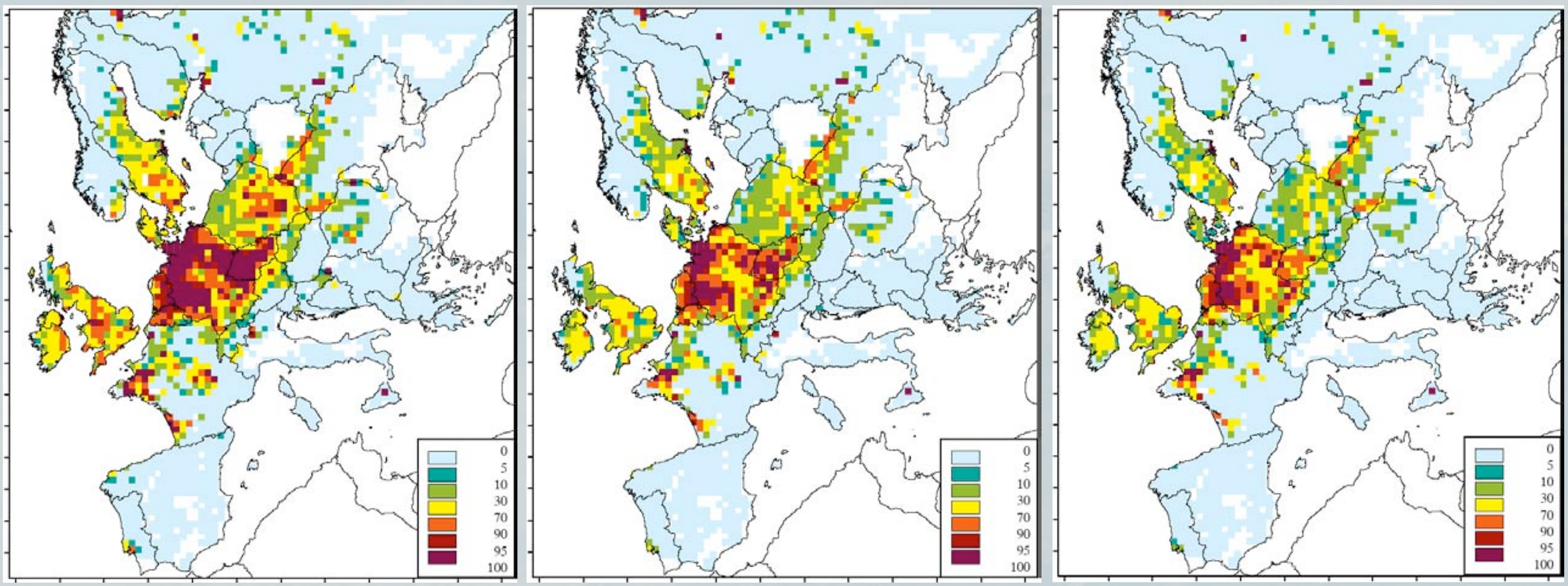
From the 20th Century Fox film 'The Adventures of Sherlock Holmes,

http://www.emrc.co.uk/
http://www.ihavepeace.co.uk/

Valuation of damage to ecosystems, cultural heritage

- Not done
- Qualitative approach, ‘extended CBA’
- Simply highlights which unquantified effects are likely to be important and which not
- Leaves decision makers to factor in their own views on the worth of damage to these receptors

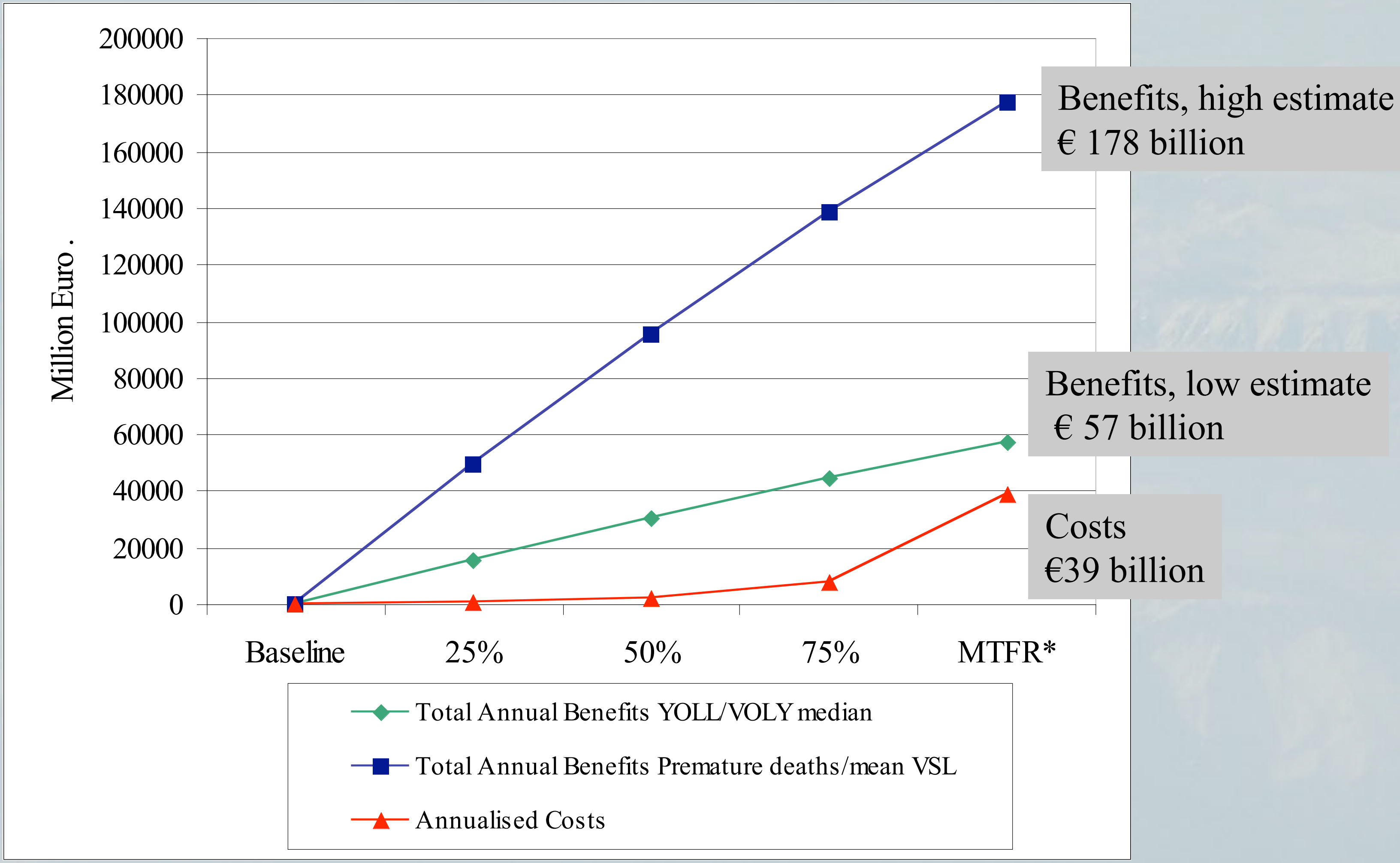
Excess of forest critical loads



2000 2010 2020

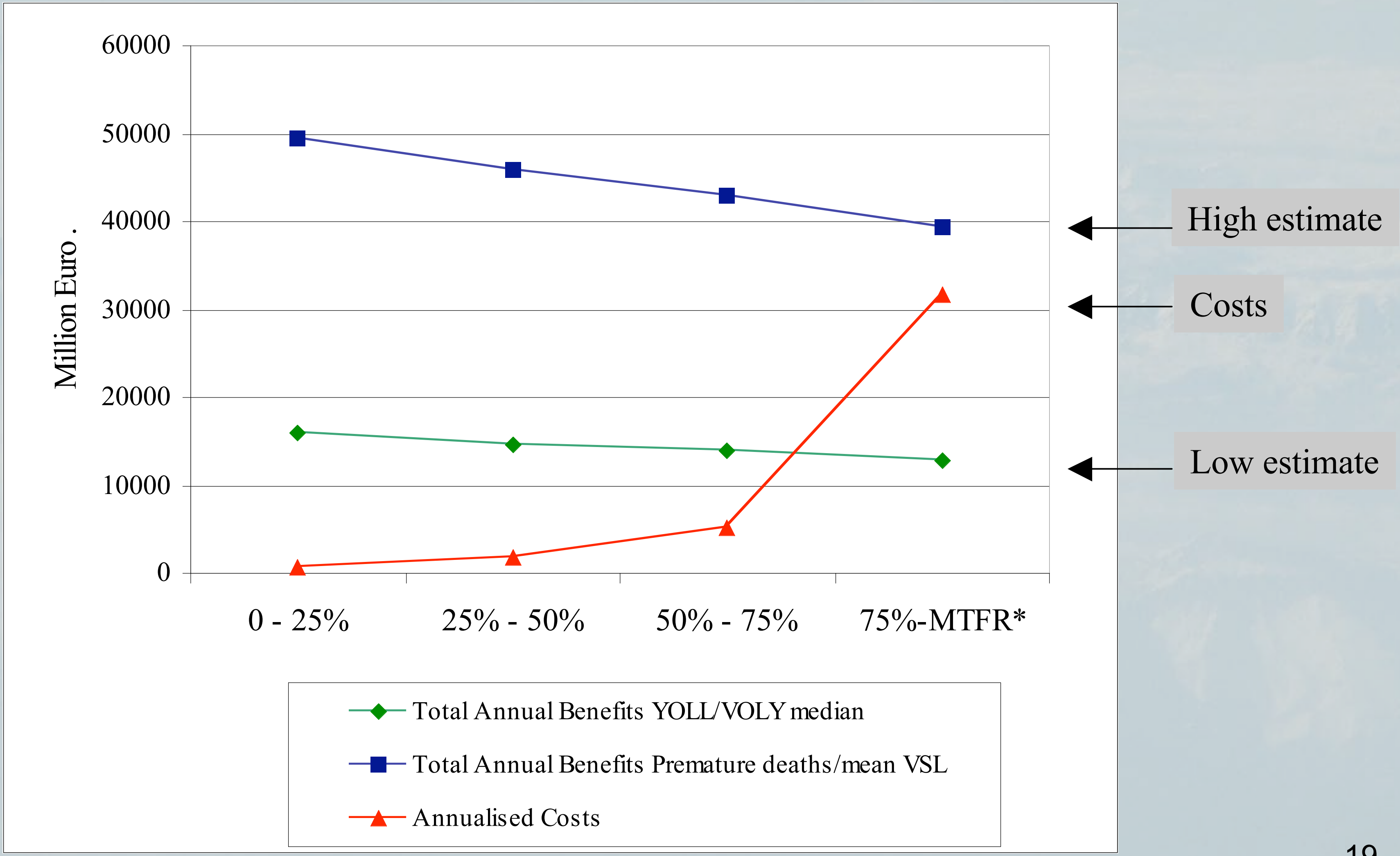
Percentage of forest area
with acid deposition above critical loads,
using ecosystem-specific deposition, mean meteorology

CAFE Programme results: Total annual health benefits EU25



http://www.emrc.co.uk/
http://www.ihavepeace.co.uk/

CAFE Programme results: Incremental annual health benefits EU25



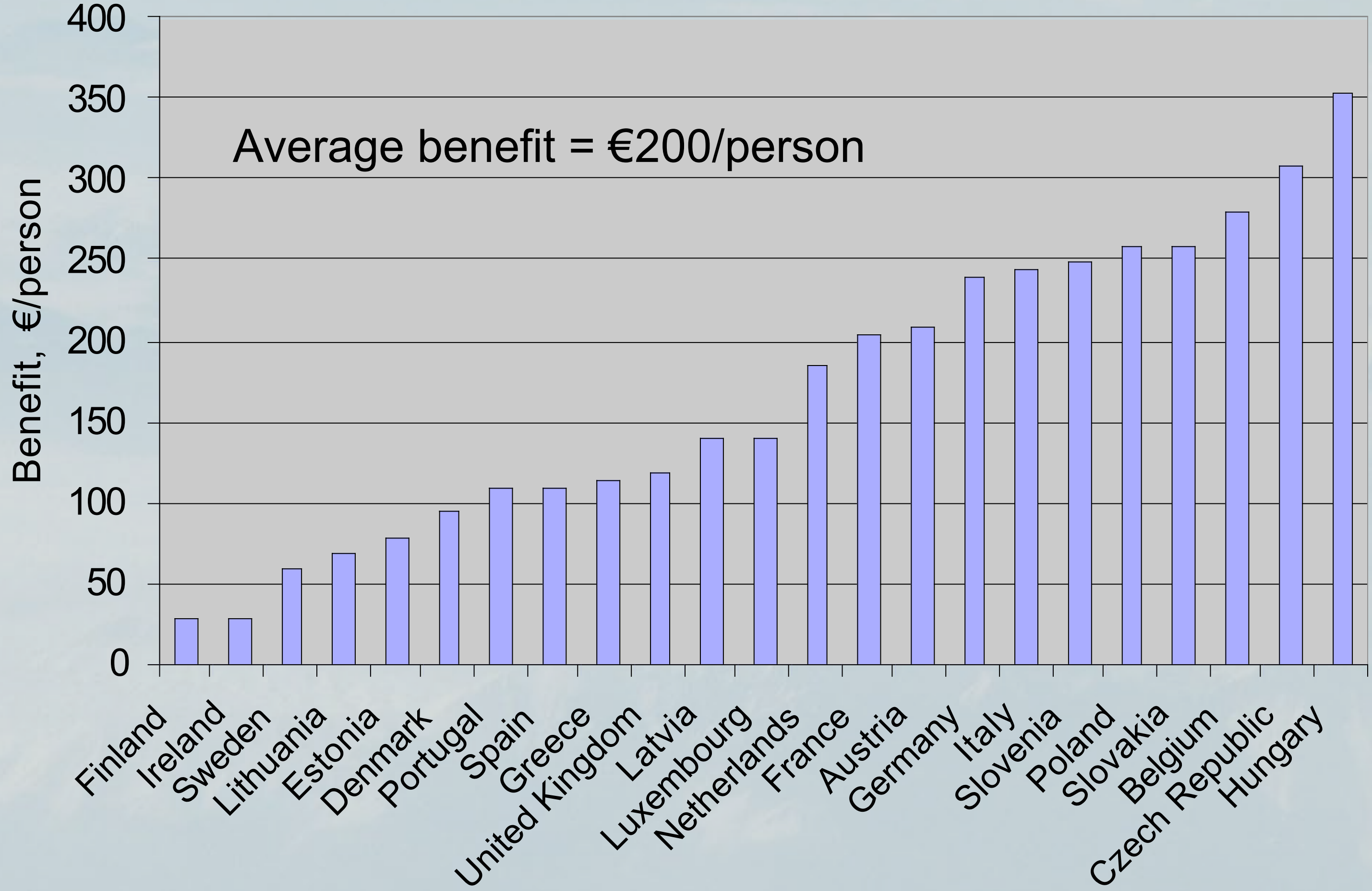
<u>Incremental</u> Health Valuation – EU25

Summary EU25 Health Valuation (Million) – benefits low & high estimate

	Baseline to 25% Gap Closure	25 to 50% Gap Closure	50 to 75% Gap Closure	75% to MTFR exc Euro 5/6
Incremental Annual Benefits	15870 to 49487	14668 to 45861	13841 to 42840	12697 to 39348
Incremental Annualised Costs	617	1825	5087	31594
Incremental Benefit:Cost Ratio	26 to 80	8 to 25	3 to 8	0.4 to 1.2

Need to consider additional benefits, effects of uncertainty

Health Benefits (Euro per Person)
Policies from 2000 to 2020 by Member State
Low Estimate (YOLL – VOLY, median)

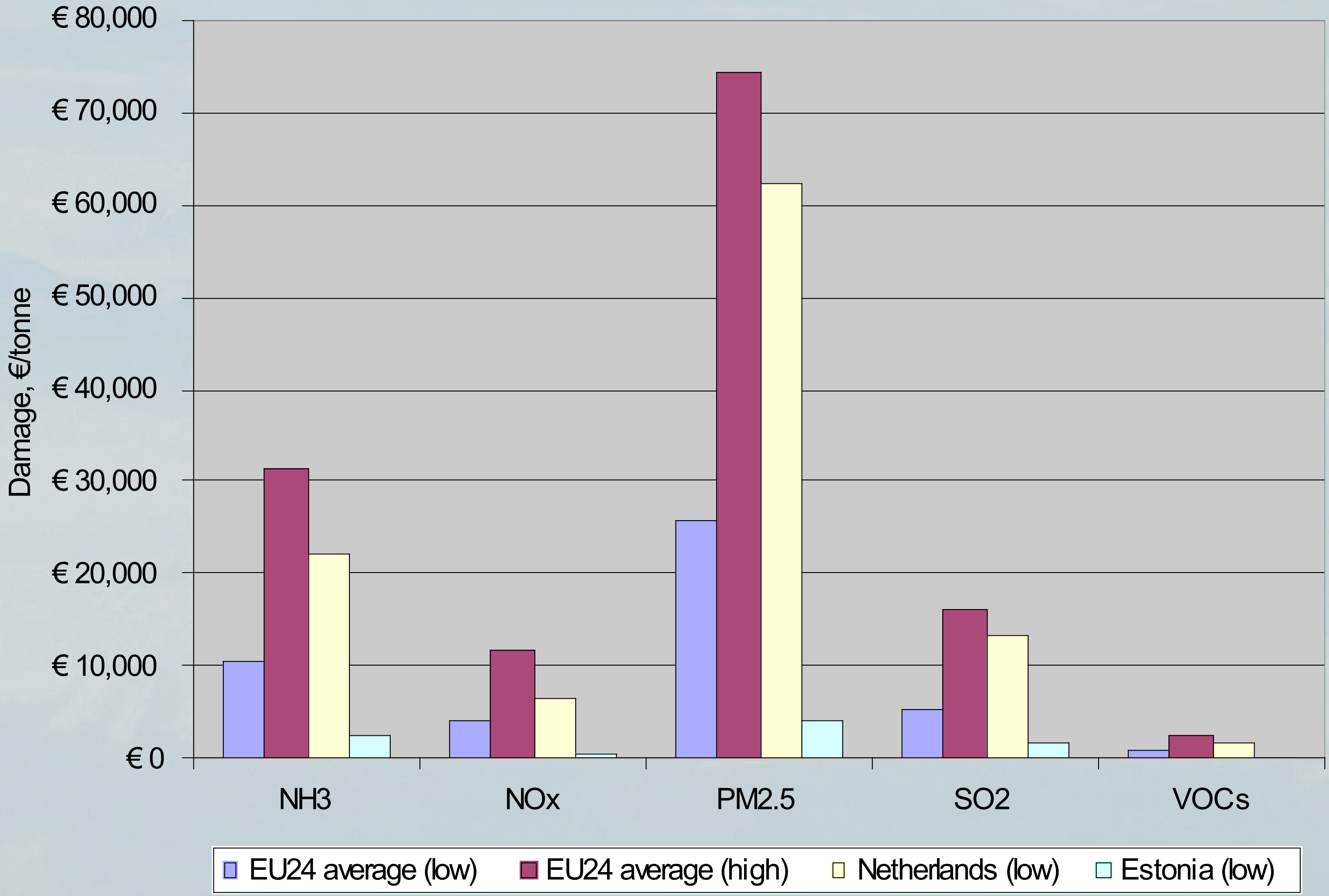


High estimate gives a value of 430 Euro per person per year

Note: €1 (1 euro) ~ $1US

http://www.emrc.co.uk/
http://www.ihavepeace.co.uk/

Damage per tonne pollutant, health crop and materials damage only



http://www.emrc.co.uk/
http://www.ihavepeace.co.uk/

Uncertainty analysis for the benefits assessment in CAFE

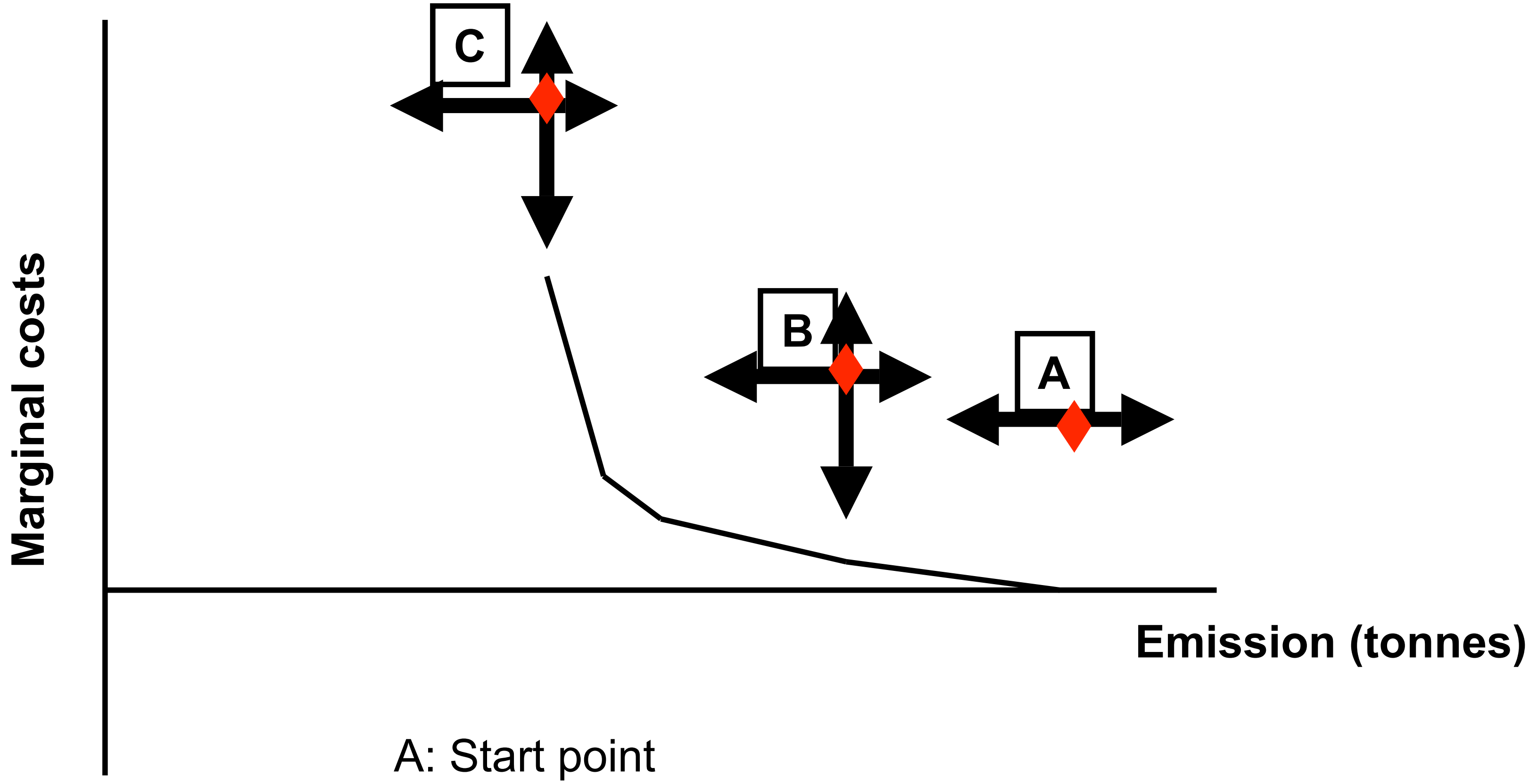
- Statistical analysis
  - ~factor 3 uncertainty in what is quantified
- Sensitivity analysis
  - E.g. compare VSL and VOLY results
- Bias analysis
  - E.g. leave impacts out – underestimate benefits

- See report on uncertainty at www.cafe-cba.org (to appear soon)

Why not rely solely on cost-effectiveness analysis (CEA) instead?

- CEA provides one half of the CBA, but:
  - CEA is about efficiency in reaching objectives, not how worthwhile it is to meet those objectives
  - Numerous studies show CEA based ex-ante data over-estimate costs
    - CARB, AEA Technology, SEI, etc.

Cost curve uncertainties



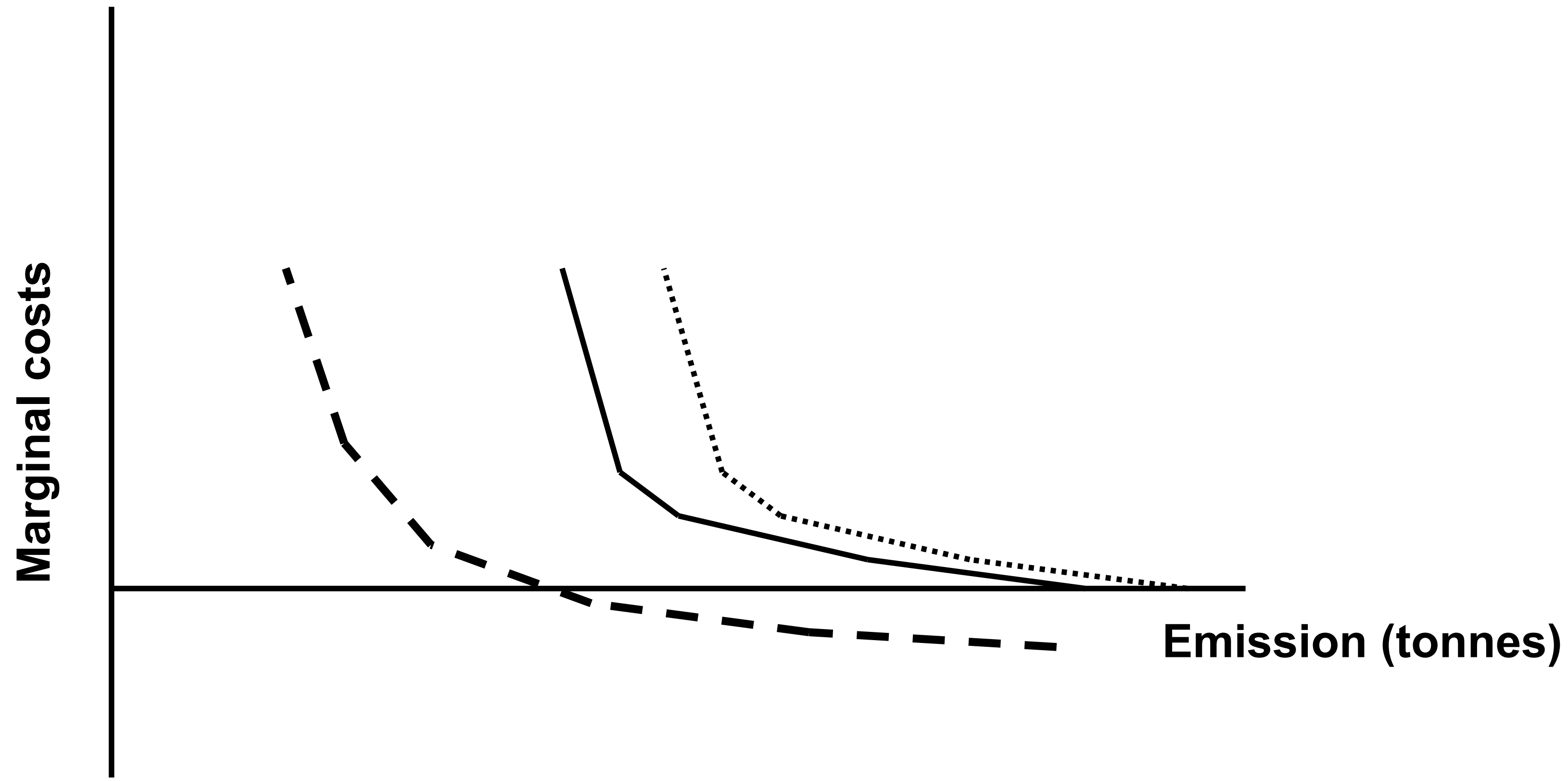
A: Start point
B: Costs and effectiveness for each measure
C: Position of maximum feasible reduction

http://www.emrc.co.uk/
http://www.ihavepeace.co.uk/

Cost curve uncertainties

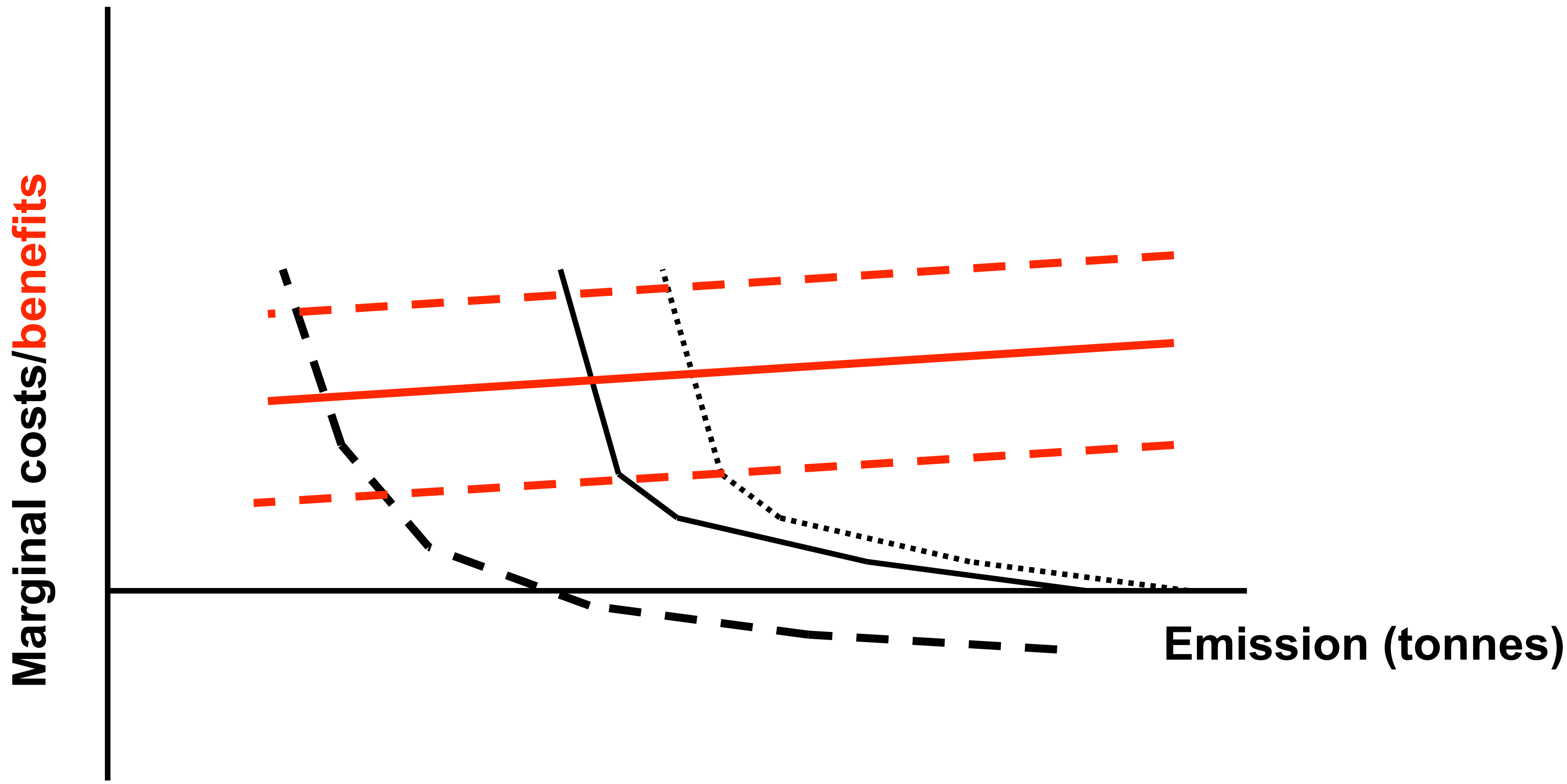
- Starting point errors
  - Projections of energy demand, fuel price, etc.
- Errors for individual measures
  - Routine variation in costs and effectiveness
  - Technology improvements
- Position of MFR
  - Exclusion of measures
  - Errors in effectiveness of individual measures

Alternative positions for the cost curve



http://www.emrc.co.uk/
http://www.ihavepeace.co.uk/

Alternative positions for the cost curve



Which to use?

- CEA is not perfect
- CBA is not perfect
- Use both, explore the different perspectives that they provide
- Recognise the uncertainties that are present in both costs and benefits

Other applications of ExternE based CBA methods

- European assessment
  - E.g. Air quality and emission standards, industry regulation through IPPC
- National assessment (e.g. UK, Jordan)
  - Scoping air pollution, assessment of European legislation
- Local assessment (e.g. UK, Georgia, China)
  - Developing local air quality action plans