Quantification of Environmental Benefits ExternE method

IDEA

We are not analysing environmental *pressures* (emission) nor *state* (concentration) but rather aiming at *impacts.*

Impact should be comparable with other economic assessment; derive utility equivalent of the impact, i.e. Externality (see Baumol and Oates, 1988)

Benefit (avoided damage) associated with certain process is technology-, site-, and time-specific.

METHOD

ExternE with Impact Pathway Analysis

Bottom-up approach for complex pathways

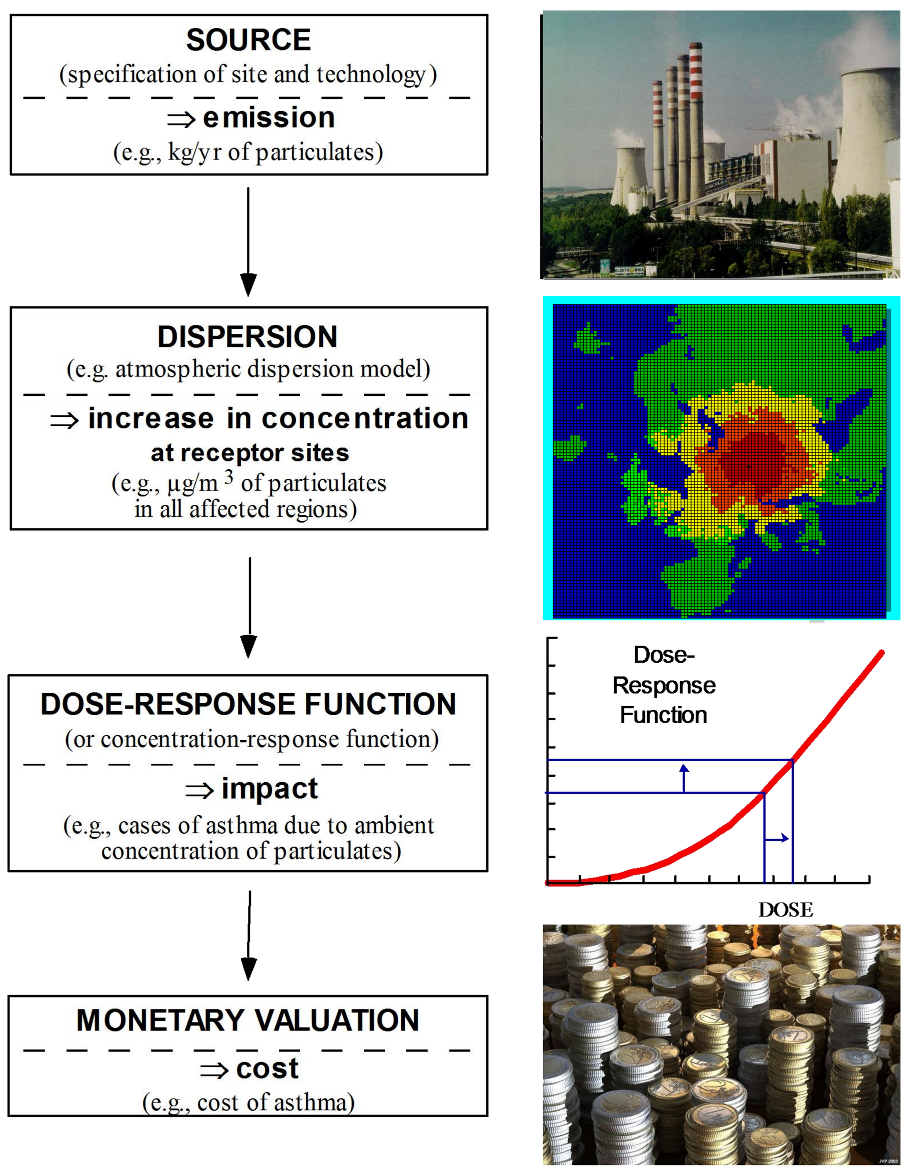
Taking into account preference structure.

Originally developed method to quantify external costs associated with airborne pollutants from power plants in the 90's.

ECOSENSE

EcoSenseWeb is an integrated atmospheric dispersion and exposure assessment model which implements the Impact Pathway Approach developed within ExternE. It was designed for the analysis of single point sources in Europe but it can also be used for analysis of multi emission sources in certain regions.
EcoSense was developed to support the assessment of priority impacts resulting from the exposure to airborne pollutants, namely impacts on human health, crops, building materials and ecosystems.
The current version of EcoSenseWeb, covers the emission of 'classical' pollutants SO_2, NO_x, primary particulates, NMVOC, NH_3, and most important heavy metals. It includes also damage assessment due to emission of greenhouse gases.
EcoSenseWeb has been developed within NEEDS and CASES project by University of Stuttgart, IER.

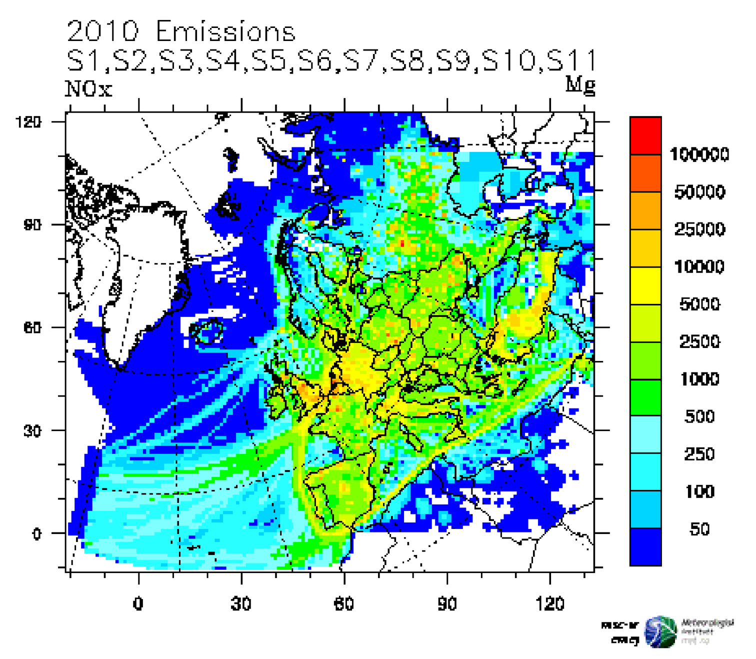
IMPACT PATHWAY APPROACH



Step 1: EMISSIONS

The IPA starts with the emission of a pollutant at the location of the source. Two emission scenarios are modelled: a reference scenario background concentration of pollutants (with an optional choice on the EMEP 2010 or EMEP 2020 emission scenario), and a case scenario.

Figure: Gridded emission of NOx in 2010 for all sectors for the reference scenario.



Source: IER taken from http://ecosenseweb.ier.uni-stuttgart.de.

Step2: CHEMICAL TRANSPORT MODELS

Air quality is estimated by means of atmospheric dispersion models. Total impacts assessment considers a double counting that is avoided.

Local range analysis: The Industrial Source Complex Model, a Gaussian plume model, developed by the US-EPA, is used for transport modelling of primary air pollutants (SO_2, NO_x, particulates) on a local scale (100 x 100 km around the site).

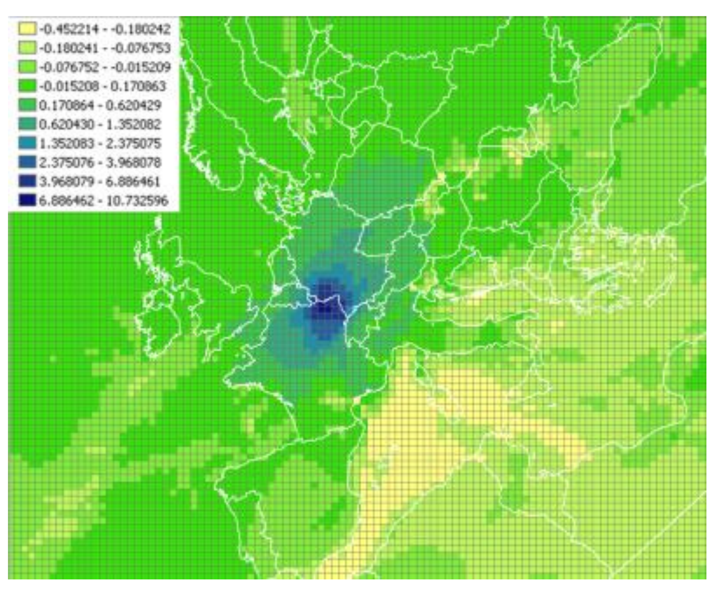
Regional range analysis is based on the large EMEP-grid cells and covers the whole of Europe. Impact assessment is done with regional source-receptor matrices, that is a parameterised result of model runs – performed by MET.NO – with the EMEP/MSC-West Eulerian dispersion model. A reduction of each pollutant by 15% for each source of emission within a corresponding 66 sub-region is modelled. The result is a matrix covering the resulting concentration of a primary or secondary air pollutants on the 50 km x 50 km EMEP grid.

Hemispheric range analysis: Analysis is based on corresponding EMEP/MSC-West Eulerian dispersion model runs which produced source-receptor relationships at the hemispheric scales for four regions of the Northern Hemisphere. The effect of reductions of six different pollutants (NO_x, SO_x, NMVOC, NH_3, $PM_{2.5}$ and PM_{co}) is computed.

Step3: CONCENTRATION OF RELEVANT POLLUTANTS AND CHANGE IN CONCENTRATION

Concentrations for all relevant pollutants are modelled for the reference and case scenario by the in EcoSenseWeb integrated dispersion modells.

Figure: Change in concentration of SOMO35 due to emissions of a facility in France (near Lux)

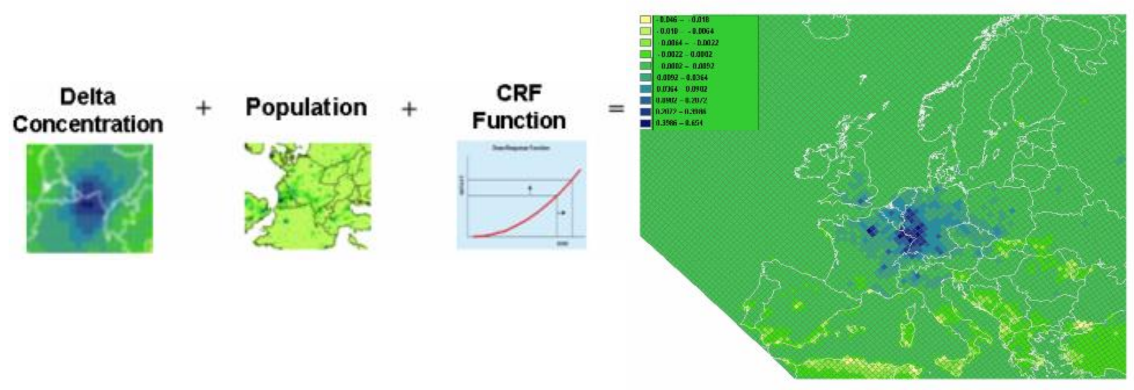


Source: IER taken from http://ecosenseweb.ier.uni-stuttgart.de.

Step4: APPLICATION OF CONCENTRATION RESPONSE FUNCTIONS

Physical impacts are derived by using exposure-response models that combine concentration levels of air pollutants, the concentration-response functions and receptor data to get the impact (*Example: years of Life Lost due to emision of the facility in France*).

Figure: Expose response model



Source: IER taken from http://ecosenseweb.ier.uni-stuttgart.de

Figure: Impact functions in general population, HEIMTSA/INTARESE Case studies - illustration.

Pollutant	Health effect	Relative Risk	Background Rate of Disease (per year)	Age Group	Population	Impact Function
$PM_{2.5}$						
	Mortality (all cause)	6% (95% CI: 2%, 11%) change per 10 µg/m³ $PM_{2.5}$	Impact Function via lifetables	Adults 30 years and older	General Population	Impact Function via lifetables
	Restricted activity days (RADs)	4.75% (95% CI: 4.17%, 5.33%) change per 10 µg/m³ $PM_{2.5}$	1,900,000 RADs per 100,000 people aged 18-64 per year	18-64 Years	General Population	90,200 (95% CI: 79,200, 101,300) additional RADs per 10 µg/m³ increase in $PM_{2.5}$ per 100,000 adults aged 18-64 (general population) per year
	Work loss days (WLDs)	4.6% (95% CI: 3.9%, 5.3%) increase per 10 µg/m³ $PM_{2.5}$	450,000 WLDs per 100,000 people aged 15-64 per year	15-64 Years	General Population	20,700 (95% CI: 17,600, 23,800) additional work lost days per 10 µg/m³ increase in $PM_{2.5}$ per 100,000 people aged 15-64 in the general population per year
	Minor Restricted Activity Days (MRADs)	7.4% (95% CI: 6.0%, 8.8%) change per 10 µg/m³ $PM_{2.5}$	780,000 MRADs per 100,000 people in employment aged 18-64 per year	18-64 Years	General Population	57,700 (95% CI: 46,800, 68,600) additional MRADs per 10 µg/m³ increase in $PM_{2.5}$ per 100,000 adults aged 18-64 (general population) per year

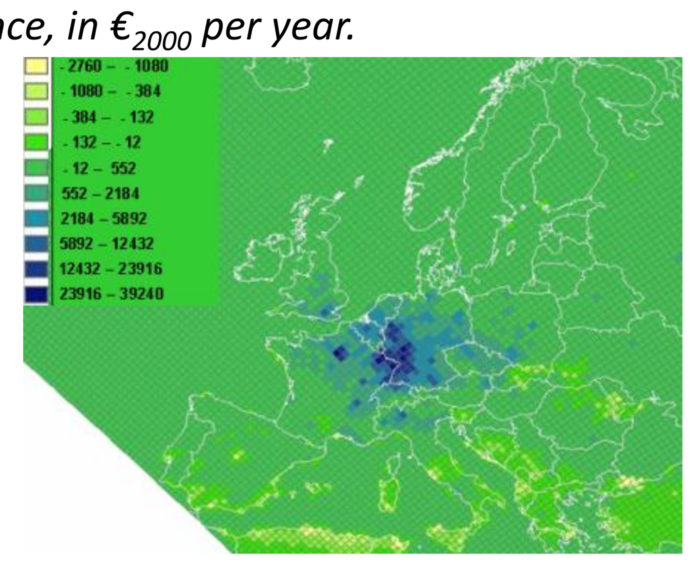
Source: IOM-TNO-JRC (2011)

Step5: MONETARY VALUATION

The physical impacts are evaluated in monetary terms.

For some of the impacts (crops, materials, cost of illness), market prices are used to evaluate the damages. However, non-market goods are valued by using non-market valuation techniques.
In some cases where uncertainty is still large or data are not available , avoidance costs are used, e.g. for valuation of ecosystem damage resulting from acidification. Valuation of climate change impacts considers as social costs of carbon as marginal abatement costs.

Figure: Damages due to changes in the ozone concentration caused by a facility in France, in €$_{2000}$ per year.



Source: IER taken from http://ecosenseweb.ier.uni-stuttgart.de.

Figure: Summary of Unit Values for Health endpoints in HEIMTSA.

Health End-Point	Low	Central	High	Unit (2010) per case	Reference
Sleep disturbance	480	1,240	1,570	Euro/year	Godet-Cayré et al (2006); Ozminkowski et al (2007)
Hypertension	880	950	1,110	Euro/year	Ramsey et al (1997); Berto et al (2002)
Acute myocardial infarction	4,675	86,200	436,200	Euro	Moïse et Jacobzone, 2003; Yasunga et al (2006)
Increased mortality risk (infants)	1,120,000	2,475,000	11,200,000	Euro	Holland et. al (2004)
Chronic bronchitis	43,000	60,000	100,000	Euro	Krupnick and Cropper (1992)
Severe COPD	70,000	120,000	260,000	Euro	Maca et al (2011)
Increased mortality risk - Value Of Life Years acute	60,820	89,715	220,000	Euro	Alberini et. al (2006)
Increased mortality risk - Value of Prevented Fatality acute	1,120,000	1,650,000	5,600,000	Euro	Alberini et. al (2006)
Life expectancy reduction - Value of Life Years chronic	37,500	60,000	215,000	Euro	Alberini et. al (2006); Desaigues et. al (2011)
Respiratory hospital admissions	2,990	2,990	8,074	Euro	Navrud (2001); Holland et. al (2004)
Cardiac hospital admissions	2,990	2,990	8,074	Euro	Navrud (2001); Holland et. al (2004)
Work loss days (WLD)	441	441	441	Euro	Navrud (2001); Holland et. al (2004)
Restricted activity days (RADs)	194	194	194	Euro	Navrud (2001); Holland et. al (2004)
Minor restricted activity days (MRAD)	57	57	57	Euro	Navrud (2001); Holland et. al (2004)
Lower respiratory symptoms	57	57	57	Euro	Navrud (2001); Holland et. al (2004)
LRS excluding cough	57	57	57	Euro	Navrud (2001); Holland et. al (2004)
Cough days	57	57	57	Euro	Navrud (2001); Holland et. al (2004)
Medication use / bronchodilator use	74	80	96	Euro	Maca et al (2011)
Lung cancer	70,000	720,000	4,200,000	Euro	Weissflog et al (2001); Serup-Hansen et al (2003); Scasny (2008); Jeanrenaud and Priez (1999); Aimola (1998)
Leukaemia	2,050,000	4,000,000	7,000,000	Euro	Aimola (1998)
Neuro-development disorders	4,500	15,000	33,000	Euro/year	Ščasný et. al (2008)
Skin cancer	11,000	14,000	27,000	Euro	Aimola (1998)
Osteoporosis	3,000	5,700	8,100	Euro	Kudrna and Krška (2005); Werner and Vered (2002)
Renal dysfunction	23,000	30,400	41,000	Euro	Bartaskova et al (2005); Sun-Mi et al (2006)
Anaemia	750	750	750	Euro	Ossa et. al (2007)

Source: Hunt, Navrud, Máca, Ščasný (2011)

DEFINE Kick-off project meeting, Vienna, 14-15 June 2012