The ExternE Project of the EU

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ExternE = "External Costs of Energy"

funded by European Commission DG Research, since 1991 (till 1995 with ORNL/RFF)

(current phases NewExt and ExternE-Pol)

>100 scientists in all countries of EU

Major publications **1995**, **1998**, **2000**

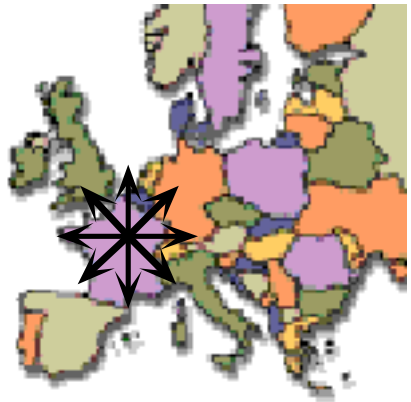
Methodology

1) Analysis of fuel chain (LCA)

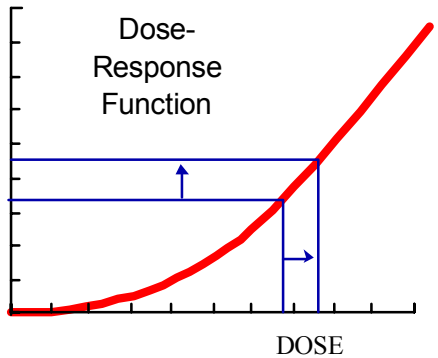
2) Site specific impact pathway analysis

SOURCE
(specification of site and technology)
⇒ **emission**
(e.g., kg/yr of particulates)

DISPERSION
(e.g. atmospheric dispersion model)
⇒ **increase in concentration**
at receptor sites
(e.g., μg/m^3 of particulates
in all affected regions)



DOSE-RESPONSE FUNCTION
(or concentration-response function)
⇒ **impact**
(e.g., cases of asthma due to ambient
concentration of particulates)



MONETARY VALUATION
⇒ **cost**
(e.g., cost of asthma)

Technologies and impacts evaluated

Technologies

Energy: coal, lignite, oil, gas, biomass, PV, wind, hydro, nuclear

Waste incineration

Transport: cars, trucks, bus, rail, ship*, (planes)*

Impacts

Due to air emissions (primary & secondary pollutants)

Health (morbidity & mortality)

Buildings & materials

Agricultural crops

Amenity (noise, visual impact, recreation)

Global warming

Beginnings of analysis for acidification & supply security

Key Assumptions

Local + regional dispersion models

Linear dose-response functions for health

Mortality in terms of LLE (loss of life expectancy) rather than number of deaths (VOLY derived from VSL = 3.4 M€)

Discount rate: *0%,* **3%** and *10%* for present generation,

1% to 3% for **global warming**

0%, *3% and 10%* for **nuclear** (really = difference discount rate - escalation rate of costs)

Air Pollution Mortality:
Number of Deaths or LLE?

number of deaths not meaningful:

- it makes no sense to add the number of deaths due to different **contributing causes,** by contrast to primary causes of death
- it fails to take into account for loss of life per death, very different between **air pollution** and typical **accidents**
- the total number of premature deaths attributable to air pollution is **not observable**
- probably most people affected (chronic mortality studies cannot distinguish whether a few lose much or many a little): real number of deaths may not change with pollution.

LLE avoids these problems;

meaningful for all risk factors.

Dispersion Models & Software

Local zone (<~50 km): **ISC**

(also RoadPol for traffic)

Regional (all of Europe)

For PM, SO2 & NOx and secondaries: Windrose Trajectory Model (adaptation of **Harwell Trajectory Model**)

Also verification by EMEP (= official program for acid rain policies in Europe)

For O3: **EMEP**

ISC, Windrose Trajectory Model, and EMEP O3 results are integrated into **EcoSense software of ExternE**, together with **databases** (population, crops, buildings, …), **dose-response functions** and **costs**

Site-specific --> typical results

For many policy decisions need typical or aggregated results

But policy makers have used site-specific results as if they were typical

For typical numbers 2 approaches

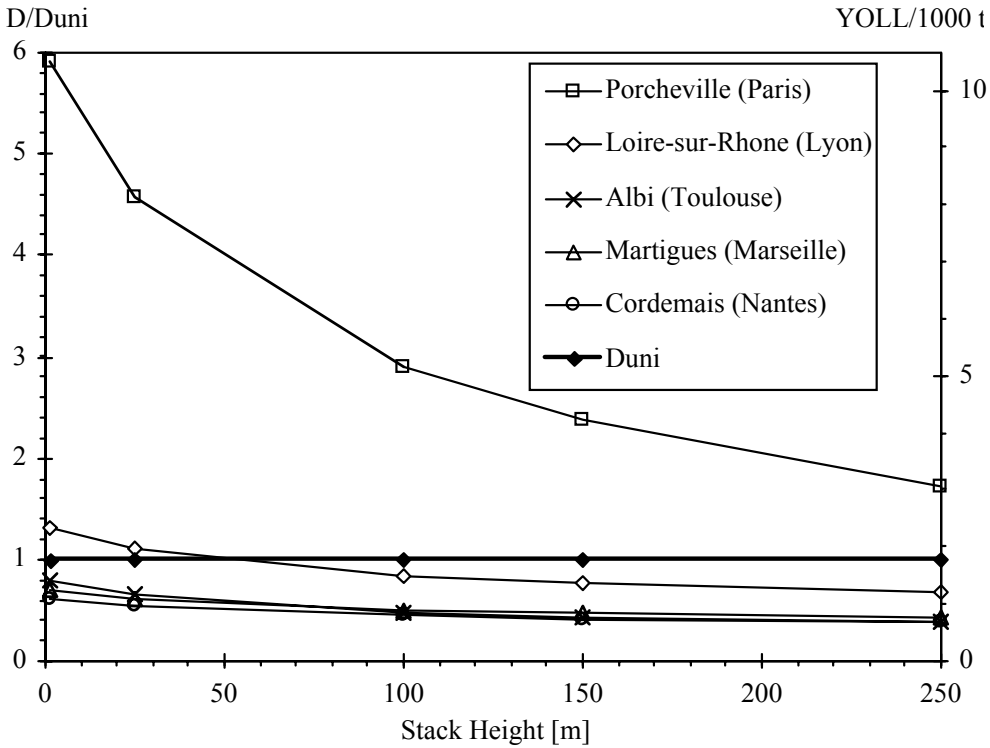
1) **Multisource EcoSense**, with total emissions of Europe

2) The "**uniform world model**" (UWM)

- by conservation of matter $\mathbf{D_{uni} = p\ \rho\ s_{CR}\ Q/k}$
- p = unit cost (price) of endpoint
- ρ= average population density within 1000 km
- s_{CR} = slope of concentration-response function
- Q = emission rate of pollutant
- k = depletion velocity (wet+dry deposition, transformation or decay)

UWM also for secondary pollutants (if k includes transformation rate)

Test of UWM for a primary pollutant:



Damage D from SO_2 for five sites in France, in units of D_{uni} of UWM (nearest big city, 25 to 50 km away, indicated in parentheses). Scale on the right indicates YOLL/yr (mortality) from emission of 1000 ton/yr. Plume rise included. Variation with site and stack height is **strong** for **primary** pollutants, **weak** for **secondary** pollutants.

Uncertainty

Calculation is approximately **multiplicative**

Uncertainty of product $y = x_1 x_2 \ldots x_n$

Uncertainty of sum $\ln(y) = \ln(x_1) + \ln(x_2) + \ldots + \ln(x_n)$

Central limit theorem

$\Rightarrow$ lognormal distribution is "natural" distribution for products

(if x is normal, ln(x) is lognormal).

$\Rightarrow$ distribution of errors approximately **lognormal**

(unless dominated by a distribution that is very different from lognormal)

characterized by **geometric standard deviation** σ_g

Multiplicative confidence intervals about **median** μ_G
(=geometric mean)

68% between μ_G/σ_G and $\mu_G \sigma_G$

Presentation of Results and Uncertainty