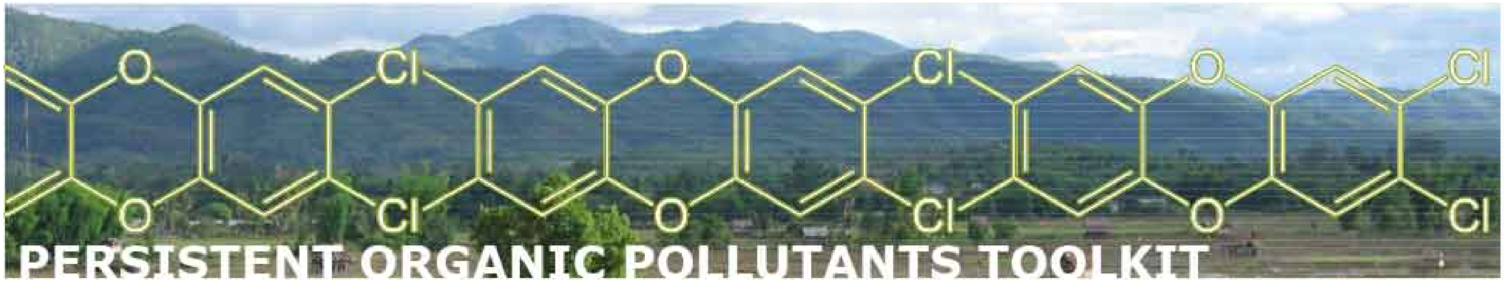

Economic Valuation of Risk Management Measures

Ideal Cost-Benefit Analysis Approach

The ideal cost-benefit analysis r amounts of data
Source: Stefano Mortell

This section outlines the ideal approach that would be applied to the project if there were no limitations in terms of data or knowledge gaps. The purpose of doing so is to assess the gap between what should be done in an optimal situation, and what could be done in practice (Lvovsky *et al.*, 2000; Pearce and Koundouri, 2003).

The ideal approach to the economic analysis of the POPs Toolkit would be to implement a **comprehensive cost-benefit analysis** (CBA). A cost-benefit analysis is defined as:

*a technique that **compares the monetary value of benefits with the monetary value of costs in order to evaluate and prioritize issues** …. In its simple form,* cost-benefit analysis *uses only financial costs and financial benefits…. **A more sophisticated cost-benefit analysis approach attempts to put a financial value on intangible costs and benefits** (e.g., the cost of environmental damage or the benefit of quicker and easier travel to work)* (World Bank, 2009)[1].

The cost-benefit analysis is a widely used and recognized technique for assessing public policies and projects from an economic perspective (Arrow et al., 1996). The cost-benefit analysis allows decision-makers to determine whether financial resources should be allocated to these policies or projects[2]. In the POPs Toolkit, a cost-benefit analysis would ideally be used to assess if the risk management scenarios proposed for the site will provide more benefits than they will cost.

In an ideal scenario, project costs and benefits are estimated separately and compared using present value techniques, as described in the following pages.

Next: Ideal Approach: Step 1 - Inventory of Project Benefits

References:

[1] http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS /ENVIRONMENT/0,contentMDK:21324891~isCURL:Y~pagePK: 148956~piPK:216618~theSitePK:244381,00.html [Accessed March 9, 2009].

[2] For that purpose, a CBA is more suitable than a cost-effectiveness analysis (CEA). A CEA would have identified the most effective way of spending available resources to address the POP – contamination without indicating whether allocating these resources to this issue is "worthwhile" per se.

Ideal Approach: Step 1 - Inventory of Project Benefits

In the ideal approach, the benefits of the risk management scenarios including human health and environmental components, are estimated.

In the ideal approach, the benefits of the risk management scenarios including human health and environmental components, are estimated.
Source: Ellie VanHoutte

Calculation of Health benefits

Scientific evidence indicates that exposure to POPs - even at low concentrations - may cause a wide range of adverse effects to human health (Strawson 1997; Strober 1998). **The reduction of negative health impacts due to POPs on the hotspot population represents a primary benefit (a "saved cost") of the proposed risk management scenario.**

Calculation of Environmental benefits

Contamination has various environmental impacts, including:

- Direct use (such as through reduced fish harvesting);
- Indirect use (such as through the loss of biodiversity); and
- Non-use (such as through the loss of aesthetic and recreational values).

Reduction in contamination will translate into better quality of environmental resources and services (i.e., in environmental benefits).

Quantification of Health and Environmental Benefits

Quantification of the human and environmental benefits requires understanding:

- the extent to which the risk management scenarios will reduce human and environmental exposure; and
- the reduction of health and environmental impacts caused by the reduction in exposure; that is, an exposure-response relationship.

Next: Ideal Approach - Step 2: Valuation of Project Benefits

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Ideal Approach - Step 2: Valuation of Project Benefits

Environmental and Health benefits can be gained by remediating a site. However, to put a value on each of these items requires large amounts of data.

Valuing Health and Environmental benefits requires a large amount of data
Source: Gret@Lorenz

Valuation of Health benefits

T**o estimate health benefits in monetary terms**, a standard technique, used by the World Health Organization (WHO), is the **valuation of disability-adjusted life-years (DALY).** The DALY combines in one measure the **time lived with a disability**, and the **time lost due to premature mortality**, both of which are plausible outcomes of contaminant exposure (WHO 2008). The DALY concept is further described on this page.

The DALY approach is deemed the most appropriate because of

- its conceptual simplicity; and
- the availability of DALY estimates.

Valuation of Environmental benefits

T**he selection of a environmental benefit valuation method depends whether a market exists for it** (such as fish production) or not (e.g., maintenance of biodiversity). **When markets are not available, prices must be derived from hypothetical markets,** using a variety of techniques, such as the **contingent valuation method** (World Bank 1998). This method requires extensive data requirements.

Total Economic Value

From an economic perspective, the environment is seen as providing **a flow of goods and services**, physical as well as aesthetic, intrinsic, moral, etc. **The total economic value (TEV) is defined as the (discounted) sum of the net values associated with each of these goods and services** (Turner et al., 2003; Cavuta 2003). Consequently, estimating the environmental benefits (or costs) of a given project amounts to measuring the variation of the TEV of the environmental assets impacted by the project (i.e., the value of the change caused by the project in the flow of environmental goods and services).

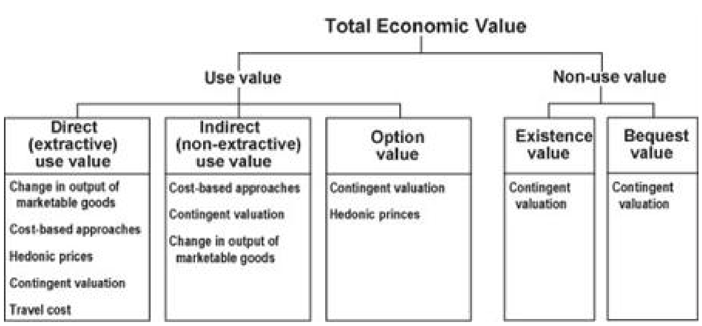

Figure Source: World Bank, Environmental Assessment Source Book Update #23, 1998

The valuation of the various types of environmental benefits could be achieved by using the methodologies listed in the Figure above. However, the key criterium for choosing the most appropriate methodology are the data requirements.

Next: Ideal Approach - Step 3: Assessing Project Costs

References:

[1] For a more comprehensive description of the Total Economic Value, see: Freeman (1993); Perman (2003); Tietemberg T., (1996) Pearce and Warford (1993) and http://www.mfe.govt.nz/publications/water/waitaki-option-existence-values-jan05/html/page3.html.

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Ideal Approach - Step 3: Assessing Project Costs

Project costs include:

- **Direct costs** (including investment costs and operating costs) associated with design and implementation and monitoring and evaluation; and
- **Indirect costs**, including:
  - **economic costs** (e.g. loss of productivity due to more stringent safety procedures);
  - **social costs** (e.g., adverse health impacts); or
  - **environmental costs** (e.g., deforestation, land-use changes, greenhouse gas emissions, loss of biodiversity, etc.).

Source: McKay Savage

A cost estimate is obtained through the following steps:

- *Identify Cost Categories*: the risk management scenarios is broken down into cost categories;
- *Gather cost data*: unit costs must be assessed for each of the cost category identified. This unit cost list can be drawn from various data sources (market survey, statistical collection, etc.) or from direct consultation with providers. Cost studies conducted for similar projects can also be used; and
- *Adjust costs to local conditions*: where applicable, cost data must be adjusted to take into account local conditions, including timing (costs estimated in past years must be escalated to account for inflation), local market conditions, etc.

The quality of the estimate depends on the availability and accuracy of quantitative data at each of these steps.

Next: Ideal Approach - Step 4 - Comparing Costs and Benefits

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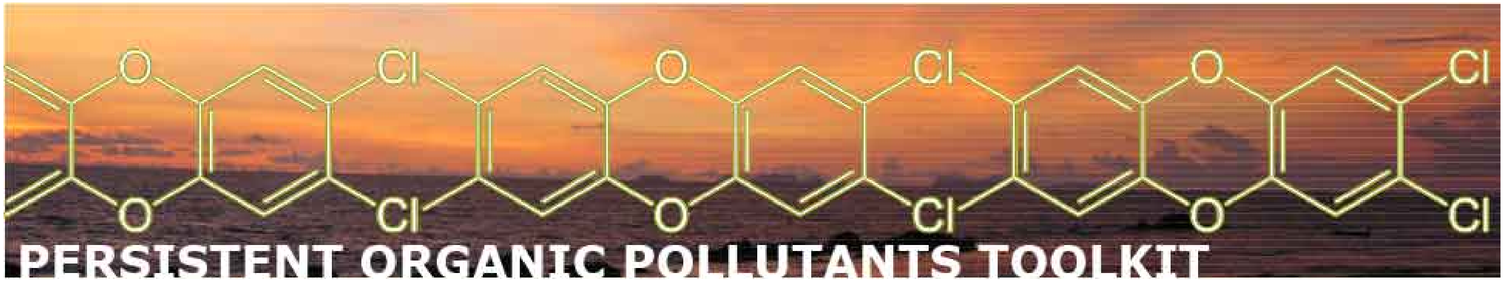

Economic Valuation of Risk Management Measures

Ideal Approach - Step 4 - Comparing Costs and Benefits


Costs and Benefits are compared using measures of project viability
Source: Migikata

Determining Present Value of Project Costs and Benefits

Project costs and benefits are incurred at different times during a project's life. As such, the process of discounting allows the expression of a stream of costs or benefits as one number in present value terms.

Comparing Costs and Benefits

Benefit and cost streams form the basis of several measures of project viability:

Net Present Value (NPV): NPV is the value resulting from **subtracting the expected cost from the expected benefits**. Projects with a **NPV greater than zero are worth undertaking**.

Benefit – Cost Ratio (BCR): the BCR is the **ratio of the present value of benefits to the present value of costs**. The ratio should be greater than 1.0 for a project to be acceptable[1]. For example, a BCR of 1.25 indicates that for every $1 of cost, the project will return $1.25 of benefit. BCR is a *relative* measure of viability.

Internal Rate of Return (IRR): the IRR is the discount rate at which the present value of costs equals the present value of benefits. Alternatively, **IRR is the discount rate at which NPV = 0 and BCR = 1.0**. If IRR exceeds the opportunity cost of the capital, the project is considered to be economically sound and worth pursuing. [2]

Using Excel to calculate cost-benefit

Value to Calculate	Excel Function	Function Help
$PV_{Benefit}$ & PV_{Cost}	NPV()	Excel help
Net Present Value	NPV()	Excel help
Benefit Cost Ratio	n/a	n/a
Internal Rate of Return	IRR()	Excel help

Next: Limitations To Implementation Of The Ideal Approach

References:

[1] *It is not in any way inconsistent for a project to have a low positive NPV (because it is a small project) at the same time as it has a high BCR.*

[2] *The IRR is a criteria to be used with caution because: (i) it cannot be calculated for all projects (e.g. projects where the stream of net benefits is strictly positive for each year or projects with multiple IRR); and, (ii) "it is a mathematical concept and not an investment criterion for evaluating alternative cash flows. When the cash flows are irregular, with net costs*

occurring in the later years of the project, it will give unreliable results in the ranking of alternative options"(Treasury Board of Canada 2007).

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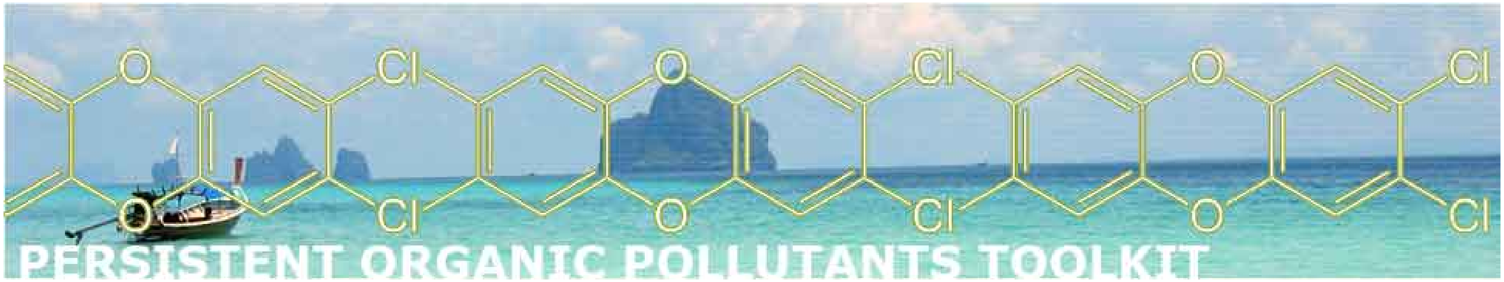

Economic Valuation of Risk Management Measures

Training Module

- Ideal Cost-Benefit Analysis Approach
  - Step 1 - Inventory of Project Benefits
  - Step 2 - Valuation of Project Benefits
  - Step 3 - Assessing Project Costs
  - Step 4 - Comparing Costs and Benefits
  - **Limitations To Implementation Of The Ideal Approach**
- Adapted Methodology

Economic Valuation Tool

Limitations To Implementation Of The Ideal Approach

Several limitations prevent the implementation of the ideal Cost Benefit Analysis process where data is limited:

Several limitations prevent the implementation of the ideal CBA process
Source: Carol Mitchell

Difficulty of establishing a dose-response or exposure-response function for health impacts due to POPs: despite the recognized link between POPs exposure and health impacts, establishing an unequivocal relationship between POPs-exposure and adverse health impacts has yet evaded scientists (Herkovits, 1998). There is no available exposure-response or dose-response equation that would allow us to derive a quantitative estimate of a disease incidence (and severity) in the population from its level of exposure to, or contamination by, POPs.[1]

Difficulty of estimating the reduction in exposure achieved through a risk management scenario: the multiple exposure pathways between the environment and human population make it difficult to draw a quantitative link between the risk management scenario and exposure reduction.

Limited data and knowledge gathering: in most developing countries, data are not available and the cost of data collection is economically prohibitive.

In consideration of these points, the ideal approach needs to be redefined or adapted. **Therefore a refined and simplified methodology was developed in order to proceed with the economic analysis.**

Next: Adapted Methodology

References:

[1] *"Although several studies seem to indicate a dose-response ratio for POPs […], it seems irresponsible to suggest a threshold concentration for adverse effects of these substances" (Herkovits, 1998).* *http://www.chem.unep.ch/pops/POPs_Inc/proceedings/Iguazu/herkovits.html*

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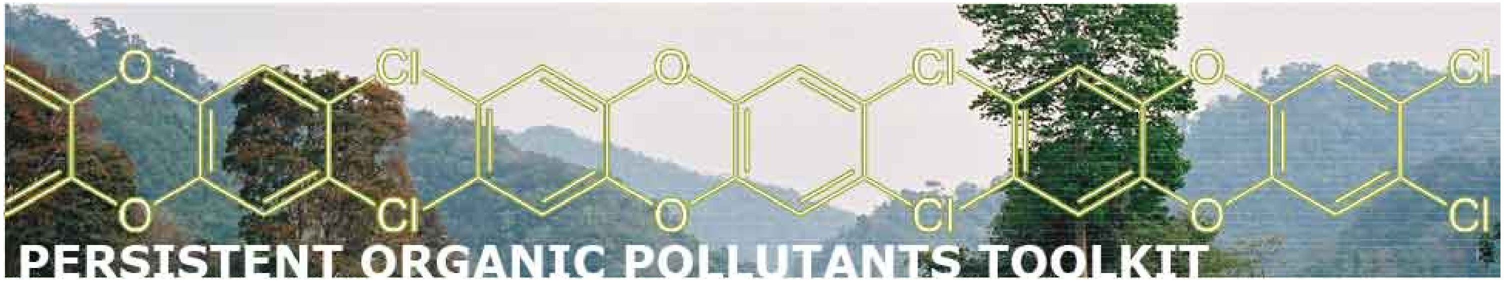

Economic Valuation of Risk Management Measures

Adapted Methodology Overview

The overall goal of doing an economic analysis is:

- to develop and implement a simplified economic evaluation process to help decision-makers assess whether implementing risk management measures at POPs (and other hazardous substance) contaminated sites represents a sound allocation of public resources; and,
- to assess whether the benefits expected from such mitigation measures would, at a minimum, cover the costs.

Costs are calculated in terms of human health benefits
Source: John Brawley

To obtain these goals, the ideal approach to the economic analysis was reformulated to address the following:

Given the costs of the various risk management scenarios, how significant do the positive health impacts need to be to ensure the scenario would pass the cost–benefit analysis test where Net-Present-Value (NPV) > 0?

The key steps of the methodology employed are as follows:

- Risk Management Scenario Development;
- Benefit Valuation; and
- Forming Conclusions.

Next: Risk Management Scenario Development

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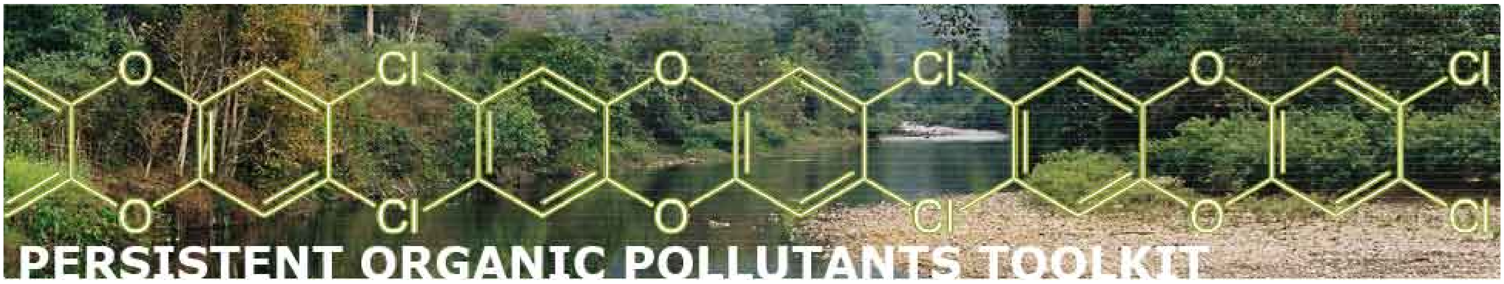
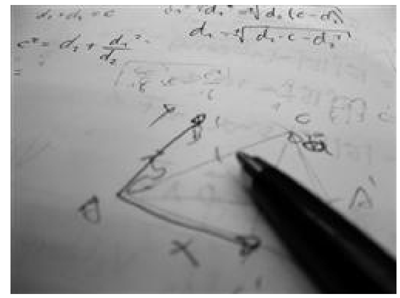


Economic Valuation of Risk Management Measures

Determine the stream of benefits


Source: Max Braun

In order to calculate the stream of benefits that would enable the Net Present Value ($NPV_{Benefit} - NPV_{cost}$) to be $\geq$ 0 for the risk management scenario, the following assumptions are made:

- The time horizon over which benefits occur is set at 20 years;
- Benefits start in Year 2 (benefits are zero in year 1); and
- The benefits are the same each year from Year 2 to 20.

Using these assumptions, the annual benefit for years 2-20 can be calculated using the following formula (where *r* is the discount rate):

$$\text{AnnualBenefit} = \frac{NPV_{cost}}{[(1+r)^2 + (1+r)^3 + (1+r)^4 + \ldots + (1+r)^{20}]}$$

Where:

- *AnnualBenefit* is the benefit calculated for years 2-20 that satisfies the economic valuation test
- NPV_{cost} is the Net-Present-Value of the risk management scheme's costs
- *r* is the discount rate

Next: Quantify the benefits in terms of human health impacts

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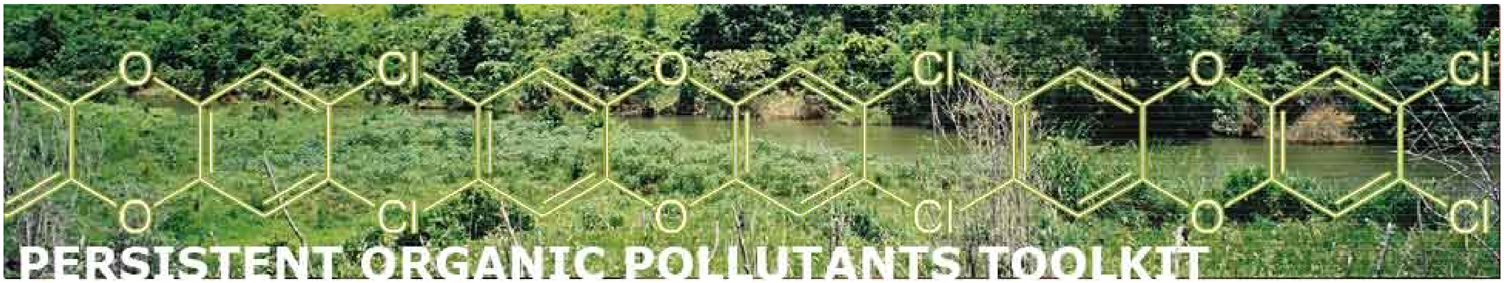

Economic Valuation of Risk Management Measures

Training Module
- Ideal Cost-Benefit Analysis Approach
- Adapted Methodology
  - Risk Management Scenario Development
  - Benefit Valuation
    - Determine Stream of Benefits
    - Quantify the benefits in terms of human health impacts
    - **Valuation of Health Impacts**
  - Forming conclusions

Economic Valuation Tool

Valuation of Health Impacts

Disability Adjusted Life Years (DALYs) are used previously to quantify the stream of benefits in terms of human health impacts. In order **to convert this value into economic terms, an economic value of a DALY must be determined.**

The value of a DALY in the US, in 2008, is estimated to be US$ 120,000
Source: Peter Hellberg

Value of a DALY

A reliable estimate of a Value of a Statistical Life (VSL) can be retrieved from a work by Mrozek & Taylor (2002), in which they reviewed more than 40 studies providing over 200 Value of a Statistical Life estimates. The key finding was that VSL estimates range from approximately US$ 1.5 million to US$ 2.5 million (in 1998). **Using the mid-point of this range, an average VSL of US$ 2 million in 1998 can be taken as reference.** This figure is escalated to reflect price inflation between 1998 and 2008 , and translates into a **VSL in 2008 of US$ 2.64 million.**

To obtain the value of a DALY, the Value of a Statistical Life must be d**ivided by the number of DALY** corresponding to a p**remature death.** This number varies in **function of the age at which death occurs**, which itself depends on the nature of the risk considered (here, POPs-related health impacts). However, no information is available about age-specific mortality caused by exposure to POPs; and, there is no basis to assume that POP-related diseases would impact a given age class more than another . As a result, the average population is assumed to stand **an average loss of 22 DALYs per premature death** according to the age-distribution of DALYs.

The value of a DALY in the US, in 2008, is estimated to be US$ 120,000 (2.64 million/22).

This estimate **needed to be adjusted to reflect the present day situation in the local country**. In order to accomplish this, the **per-capita gross national product** indicator is used to translate the value of a DALY in the US to the local country.

Valuing benefits in terms of health impacts

The benefits previously calculated will be measured in terms of health impacts by dividing their value in dollars by the value of a localized DALY. This benefit also needs to be estimated *in relative terms*; that is, expressed as a percentage reduction in the total DALYs at the site.

Next: Forming Conclusions

References:

Mrozek, J. and Taylor, L. (2002). What Determines the Value of Life? A Meta Analysis. Journal of Policy Analysis and Management. Vol21 (2): 253-270.

Training Module

Ideal Cost-Benefit Analysis Approach

Adapted Methodology

Risk Management Scenario Development

Benefit Valuation

Forming conclusions

Economic Valuation Tool

Forming conclusions

At the completion of the benefit quantification step, the benefits of the risk management scenario have been quantified in terms of health impacts and as a percentage reduction in the total DALYs at the site.

The EU's REACH policy is assumed to result in a in a decrease in DALYs in the range of 0.06% – 0.25%
Source: Wikimedia Commons

Pearce and Koundouri (2003; Section 4.2, p. 28,) used the assumptions made by Lvovsky (2001) to estimate that the DALY potentially "targeted" by REACH account for 0.6% to 2.5% of the total DALYs for UK and Europe. Then, they assumed that the implementation of REACH will result in a 10% decrease in the targeted DALYs. In other words, the authors stated that it is reasonable to expect that an investment in reduced chemicals exposure may be expected to result in a decrease in DALYs in the range of 0.06% – 0.25%.

As such, the percentage reduction in the total DALYs at the site can be compared to this 0.06% – 0.25% range. (Values falling below 0.06% are deemed to be economically feasible, those between 0.06% and 0.25% are probably feasible, and those above 0.25% are not feasible).

Other benefits

Other economic benefits, other than reductions in human health risks, may also exist for the risk management scenario. These other benefits are not included in our current analysis, but may play a role in making an risk management scenario economically feasible.

Examples of other benefits include:

Economic benefits:

- Land value benefits
- Agricultural product benefits
- Forest product benefits

Environmental benefits:

- Benefits to protected sites
- Benefits to cultural sites

Social benefits:

- Cultural/historical landmark benefits
- Minority group benefits
- Disadvantaged groups benefits

Next: Risk Management Economic Valuation Tool

References:

Pearce & Koundouri - "The Social Cost of Chemicals" (pdf - external link -

internal link) 2003

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