

## 8 Valuation

The presented methodology not only tries to assess the impacts of hazardous substances on human health but also values them. The way how this valuation is performed is described in this Chapter. Principally there are different ways of valuing. In this study, valuation is performed in monetary terms in order to support cost-benefit analyses for instance. Monetised externalities are termed external costs when they are negative and external benefits when they are positive.

### 8.1 Temporal aspects of monetary valuation and discounting

Unless dealing with acute health effects, a delicate question arises when performing a cost-benefit analysis: how can future costs or benefits be compared with present costs or benefits? Economists usually employ discounting in order to give future benefits or costs present values. Also, the European Commission recommends the involvement of discounting “whenever positive and negative impacts can be expressed in monetary terms” (European Commission, 2002, p. 16). A generalised formula for discounting is (Pearce and Moran, 2001):

$$W_t = \frac{1}{(1+r)^{f(t)}} \quad (8-1)$$

where

$W_t$  : *discount factor* which is the weight to be attached to a cost or benefit in year  $t$

$r$  : *discount rate*

$f(t)$  : *function of the perception of the speed at which time  $t$  passes.*

According to the formulation of  $f(t)$ , the discount factor depends hyperbolically or exponentially on the time elapsed until an asset occurs that is to be val-

ued. The conventional way of discounting is exponential in which case  $f(t)$  is equal to the time  $t$ . The formulation of the conventional discount factor can be derived in a descriptive example considering the development of the value of one unit of a currency. For instance, 1 € next year is not worth the same as 1 € now because 1 € now can be invested at a certain interest rate  $r_i > 0$  to become  $1 \cdot (1+r_i)$  € next year. Consequently, 1 € next year is worth  $1/(1+r_i)$  € now. Discounting, thus, is a weighting scheme to convert future costs or benefits into their present monetary values. One has to note that discounting is always conducted when valuing costs at different points in time because 'no discounting' simply means to use a discount rate of zero with a resulting discount factor of one. Thus, discounting is always performed when dealing with intertemporal matters, either explicitly or implicitly.

Discount rates exist for individuals as well as for societies. The discount rate for individuals is generally based on the Individual Time Preference (ITP) whereas for societies different approaches exist like the Social Time Preference (STP) measuring the reduction of the consumption benefit over time from a consumer perspective or the Opportunity Cost of Capital (OCC) taking the return rate of the best available alternative to an investment from a producer perspective (e.g., Rennings, 1997). Both discount rates should be identical in a perfect market. This is not the case for instance owing to the incompleteness or failures of markets and the fact that an individual experiences an increase of income due to becoming more qualified in the course of a life whereas a society does not 'grow wisdom' to the same extent.<sup>21</sup> Generally the social discount rate is smaller than that of an individual. However, how much smaller is it?

Another question related to this one touches upon the way of discounting in those cases where costs or benefits are to be valued that occur in the far future.

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<sup>21</sup> However, also societies can principally age. The ITP and the STP principally consist of the same components (see text for the formulation of the STP). Generally it is said that the *social growth rate of real consumption per capita* is smaller than that of an individual. This is because the former results as the sum of its member's growth rates of real consumption per capita. Due to lower birth rates and a higher life expectancy, there is a shift in the age structure of the population or demographic distribution of many western industrialised countries. This will usually lead to an even lower increase in the social growth rate of real consumption per capita than presently assumed. Additionally, unless a real catastrophe of historical or even astronomical size happens, societies do not 'die' whereas individuals do. An individual's *pure time preference* is, thus, larger than that of a society due to preferring to secure benefits now rather than later. This phenomenon sometimes is also called *impatience* or *irrational behavior* or *intertemporal myopia of individuals* although personally it might be less irrational due to uncertainty about the possibility to enjoy future benefits.

There are several considerations why the valuation of deep-future costs or benefits should be valued differently from those occurring in the near future that are described in the following.

The social discount rate  $r_s$  is preferably to be based on the STP (European Commission, 1999a) which is defined as:

$$r_s \cong STP = \rho + \theta \cdot g \quad (8-2)$$

where

- STP : social time preference
- $\rho$  : pure social time preference
- $\theta$  : elasticity of marginal utility of consumption
- $g$  : growth rate of real consumption per capita.

The STP consists of two terms which take into account the preference for present over future consumption (pure social time preference:  $\rho$ ) and the growth of the economy  $g$ , respectively. The growth of the economy is modified by  $\theta$  which depends on the form of the utility function and gives the percentage fall in the *additional* utility derived from each percentage increase in consumption. A typical value would be 1 due to the fact that the utility function in many cases is assumed to be logarithmic.

With this brief introduction to the STP, the question from above shall be taken up again.

In the context of long-term impacts, Azar and Sterner (1996) conclude that there is no rationale for a constant discount factor in time. Also Weitzmann (1999) suggests different discount rates for different episodes. He explores the question “what is our best prediction of the real rate of interest into the deep future?” (p. 24). Guided by this question, Weitzmann argues that the real interest rate is based on the productivity of investment which in turn strongly depends on the technical progress. While everything in the future is uncertain, he concludes that the “most fundamental uncertainty of all concerns is the discount rate itself” (ibid., pp. 28f). He argues that it is not the discount *rate* that needs to be averaged over a period of time but the discount *factors*. This is because the effective weight to be given to future costs and benefits results from averaging the discount factors and not the discount rates (cf. illustrative example by Pearce and Moran, 2001). As regards the question which value to assume, it is obvious that costs and benefits in the far future are valued the highest when taking the lowest discount rate to be expected. Therefore, Weitzmann considers this value “the only relevant limiting scenario” since “all of the other states at that far-distant time, by comparison,

**Table 8-1:** Declining discount rate scheme suggested by Weitzmann (1999)

Time horizon [years]	Discount rates suggested by Weitzmann (1999)
0-25	'low-normal' real annual interest rate of around 3-4 %
25-75	within-period instantaneous interest rate of around 2 %
75-300	within-period instantaneous interest rate of around 1 %
> 300	within-period instantaneous interest rate of around 0 %

are relatively less important now" (Weitzmann, 1999, p. 29) due to the compound interest effect. The discount rate should decline depending on the period of time considered in the future due to the increasing uncertainty about the predictability of future interest rates (see Table 8-1). When assuming 3.5 % for the first 25 years, the resulting discount factors are computed according to:

$$\begin{aligned}
 W_t &= \frac{1}{(1 + 0.035)^t} && \text{for: } 0 < t \leq 25 && (8-3) \\
 W_t &= \frac{1}{(1 + 0.035)^{25}} \cdot \frac{1}{(1 + 0.02)^{t-25}} && \text{for: } 25 < t \leq 75 \\
 W_t &= \frac{1}{(1 + 0.035)^{25}} \cdot \frac{1}{(1 + 0.02)^{50}} \cdot \frac{1}{(1 + 0.01)^{t-75}} && \text{for: } 75 < t \leq 300 \\
 W_t &= \frac{1}{(1 + 0.035)^{25}} \cdot \frac{1}{(1 + 0.02)^{50}} \cdot \frac{1}{(1 + 0.01)^{225}} \cdot 1 && \text{for: } t > 300
 \end{aligned}$$

Such decreasing discount rates which are in line with European Commission (1999a) for long-term effects can either be formulated as a step-function (e.g., Rabl, 1996; Weitzmann, 1999) or as a hyperbolic formula (e.g., Pearce and Moran, 2001). Pearce and Moran (2001), furthermore, argue that conventional discounting is only applicable if the good to be valued is money. In agreement with Rabl (1996) and Weitzmann (1999), they recommend hyperbolic discounting for non-money goods. The use of different discounting schemes for different goods appears justified since people show different time preferences for them (Pearce and Moran, 2001). Additionally, behavioural research suggests that many people show positive discount rates, but that they attach less importance to a difference between two times the further into the future these times are moved. In line with the above mentioned discounting schemes, the individual discount rate is decreasing as a function of time (Harvey, 1994).

As just indicated, Rabl (1996) points into the same direction emphasizing that discount rates for intergenerational effects should be defined from the perspective of future generations. When conventionally relying on the STP, the pure social time preference  $\rho$  of the discount rate is treated as if it represented creation of wealth while it merely involves redistribution within the present generation (cf. Schelling, 2000). The time horizon of this redistribution is limited by the duration of market transactions, especially loans. As a result, it is suggested by Rabl to split the social time preference into two periods while disregarding the pure social time preference: 1) one for the short term in which market transactions are usually made which is about 30 years (at the most) and 2) one beyond the former time period. The suggested value for the discount rate in the short term  $r_{short}$  is equal to  $r_{growth}$ . The rate  $r_{growth}$  is derived based on long-term average Gross National Products (GNP) per capita adjusted by information on Net Economic Welfare (NEW) to account for welfare aspects not considered in the GNP. It is suggested by Rabl to assume values between 1 and 2 %. After 30 years, a range from just larger than zero to the value of  $r_{short}$  is suggested for the discount rate  $r_{long}$ . This recommendation is based on the consideration about the present value of future costs which in turn is estimated from present costs according to:

$$\begin{aligned}
 C_0(t) &= C_0(0) \cdot \frac{\exp(r_{\text{escalation}} \cdot t)}{\exp(r_{\text{discount}} \cdot t)} & (8-4) \\
 &= C_0(0) \cdot \exp((r_{\text{escalation}} - r_{\text{discount}}) \cdot t) \\
 &= C_0(0) \cdot \exp(r_{\text{effective}} \cdot t)
 \end{aligned}$$

where

$C_0(t)$  : costs occurring at time  $t$  given in present values

$C_0(0)$  : present costs given in present values

$t$  : time at which future costs occur

$r$  :  $r_{\text{discount}}$ : rate at which future costs are discounted

$r_{\text{effective}}$ : effective rate at which present costs are projected to present values of future costs

$r_{\text{escalation}}$ : rate at which present costs are projected into the future.

The rates  $r_{escalation}$  and  $r_{discount}$  obtain values that are close to each other

$$\begin{aligned} r_{escalation} &\approx r_{growth} \\ r_{discount} &\approx r_{growth} \end{aligned} \tag{8-5}$$

and, thus,  $r_{effective}$  would in principle be zero. As is argued by Rabl (1996), however,  $r_{effective}$  should allow for technological development and should consequently obtain positive values close but not equal to zero.

There is a problem with justifying non-zero discount rates by technical progress. This is because technical progress may affect the effects to occur either by reducing loads (e.g., new developments with respect to abatement techniques) or by providing better means to cope with adverse effects (e.g., medicine, overall better health status). So, rather than discounting the value of effects one should allow for this reduction in impacts to occur in the impact assessment itself. On the other hand, it may indeed be that future generations will have (better) means at hand to tackle problems that are caused by their ancestors. By not accounting for this potential, a misleading allocation of scarce resources may result at present. However, it is rather speculative whether they will in fact have these means available (see below).

While Rabl (1996) argues on the basis of intergenerational equity, Pearce and Moran (2001) point out that discounting is about efficiency and not about equity which should be taken into account by other measures. The question, therefore, arises how to deal with intergenerational equity with respect to intertemporal impacts on human health. Intergenerational equity from an ethical perspective should mean that any individual has equal rights irrespective of when he or she lives (see Hellweg et al. (2003) and the references quoted therein) supporting the perception that there is a “primacy of rights claims over maximizing utility” (Shrader-Frechette, 2000, p. 772). Azar and Sterner (1996) add to this by stating that the “use of a lower discount rate than that observed could be seen as a way of internalizing a market failure” which is caused by the fact that “future generations are not present in the market” (p. 177). Although introducing some elements of conservatism due to scepticism, one may agree not to overly speculate about technological progress which will definitively take place.<sup>22</sup> But whether this will affect the human health status of a person exposed to a substance considered in this work and by when is regarded unpredictable today and, thus, rather uncertain

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<sup>22</sup> Even if one recognizes that, e.g., former ways of living or producing things had been better than present ones.

(termed 'factual problem' by Shrader-Frechette, 2000). As a consequence, it may be argued that the *intergenerational discount rate* be zero. On the other hand, it may be regarded as certain that any individual shows a (positive) pure time preference. It is assumed here that this pure time preference is not subject to change between generations ('proxy consent' of people living today with respect to those living in the future, cf. Shrader-Frechette, 2000). Thus, the *personal discount rate* is positive when disregarding the growth rate of real income which is uncertain due to the potentially very long time scales involved. Combining the two discount rates means that all people that are potentially affected at some time in the nearer or farther future by the release of substances today are assumed to live today, however, showing a time preference that is valid for a person's lifetime. The value of this personal discount rate remains to be defined. It will assume values presumably in the range of the ITP and STP. A value of 3 % is suggested. This approach is termed the *intergenerationally equal, positive personal discounting* scheme.

Hellweg et al. (2003) suggest the use of different discount rates for scenario analyses when dealing with long-term effects. The suggested discount rates can be attributed to different archetypes of people that vary with respect to value systems as proposed by Hofstetter (1998) based on cultural theory. While the hierarchist and the individualist would employ discount rates that are either close to zero or positive, respectively, the egalitarian would even consider to use negative discount rates. When using negative discount rates, however, a waste disposal, for instance, that leads to a slower release of toxics and that, thus, prolongs the emission process would be less favoured than uncontrolled disposal. One such example is to vitrify slags (Hellweg et al., 2003). An uncontrolled disposal can definitively not be intended and accepted by present generations, for their own sake. In line with common practice within the ExternE project series, thus, the valued results, i.e., the external costs, shall be presented for different discount rates (cf. Chapters 10 and 11). There are three sensitivity discounting schemes recommended by the ExternE project series using constant discount rates of 0 %, 1 % and 3 %, respectively (e.g., Friedrich and Bickel, 2001a). The discounting schemes by Rabl (1996) and by Weitzmann (1999) presented above show declining discount rates whose values are about in the range of these sensitivity discount rates. It is, therefore, expected for monetised long-term effects to fall in the range of the ExternE project's sensitivity results also when employing these discounting schemes as well as the *intergenerationally equal, positive personal discounting* scheme introduced above. These shall not be explored further since the external costs according to the upper boundary and lower boundary discount schemes as recommended by the ExternE project series will be given in Chapters 10 and 11.

This section shall be concluded with a note on what may be termed the *environmental protection dilemma* (Rennings, 1997) or *conservationist's dilemma*

(Norgaard and Howarth, 1991). Both high and low discount rates can lead to ecological disadvantages. Lower market discount rates usually lead to an increase in economic activity and investments which in turn will normally bring about for example additional releases of substances into the environment. Higher market discount rates, however, will lead to a lower valuation of future impacts. While the first situation is not desirable for presently living and affected humans or other organisms, the latter is not desirable from an intergenerational equity point of view.

## 8.2 Applied concepts for economic valuation and values used

In order to be able to value impacts due to human activities, economics provide valuation methods that can be grouped into two basic approaches: indirect or behavioural methods and direct or stated preferences methods (Haab and McConnell, 2002). With behavioural methods, individual market behaviour is observed in response to changes for instance in public goods. The preferences may be revealed by different methods such as approaches with respect to travel costs, hedonic pricing and replacement costs (Powell et al., 1997; Rennings, 1997). In the stated preferences approach, researchers directly pose contingent or hypothetical questions to respondents. The most prevalent stated preferences approach is contingent valuation. The valuation is called 'contingent' because people are asked to state their willingness to pay, contingent on a specific hypothetical scenario and description of the environmental service (Mason, 2002). Although initially being looked at as inferior to behavioural methods, contingent valuation has proved to be no less reliable than behavioural methods (Haab and McConnell, 2002).

In principle, direct and indirect methods allow for the derivation of the *willingness to pay* (WTP) for a change in the risk of death for example. A related concept is the *willingness to accept* (WTA). When dividing the WTP by the corresponding change in a mortality risk, the *value of a statistical life* (VOSL or VSL) is obtained. The VOSL has some disadvantages which is why it is recommended to convert it into the *value of a life year lost* (VLYL, European Commission, 1999a; Hunt and Markandya, 2001) that may also just be termed a *value of a life year* (VOLY). Although noting that the empirical evidence on the value of the VLYL is limited (Hunt and Markandya, 2001), it is recommended by the ExternE project series in order to account for the different ages, health states and risk contexts of the affected people (European Commission, 1999a; Hunt and Markandya, 2001). Furthermore, it shall be noted that even though the terminology of the VOSL, VLYL and VOLY seemingly point into this direction it is not a life (year) that is valued but (small) changes in risk of losing a certain time of an average individual's life expectancy.

### 8.2.1 Valuation of human health-related impacts

In section 7.3, the physical impacts and their assessment have been presented. Use is made of the DALY concept (Murray and Lopez, 1996a, 1996b) that combines a morbidity component expressed in Years of Life lived with a Disability (YLDs) with a mortality component (Years of Life Lost, YOLLs). The expression of morbidity effects in terms of mortality measures is appealing from a monetary valuation point of view because it constitutes an easy way of valuing both health effects with the same measure. As discussed in section 7.3, no distinction in terms of monetary valuation will be made between the two DALY components. This is mainly due to the fact that the morbidity indicator constitutes an equivalent measure of years of life lost (e.g., Murray, 1994). Therefore, the same monetary value can be used for mortality and morbidity effects on personal health when following the DALY concept. However, external costs related to morbidity effects are considered to be composed of several aspects which do not only take personal damages into account. These are (European Commission, 1999a; Hunt and Markandya, 2001):

- the value of the time lost because of the illness (opportunity costs),
- the value of the lost utility because of the pain and suffering, and
- the costs of any expenditures (a) on averting and/or mitigating the effects of the illness and (b) due to foregone earnings or absenteeism; these expenditures are also termed *costs of illness* (COIs).

Generally, the components of the morbidity external costs other than the COI are difficult to measure which is why usually only the COI are considered (European Commission, 1999a). In the case of the YLDs, however, one could argue that the pain and suffering-related costs are included in the disability weights used, at least to some extent. Thus, these are considered to be implicitly included in the physical impact indicator. In line with common practice within the ExternE project series, the costs of illness need to be added to each of the non-fatal disease periods. In order to avoid double-counting, an extrapolation from the COI to the Willingness to Pay must not be done (e.g., for cancer-related morbidity, European Commission, 1999a) due to the consideration of the YLDs (cf. Eq. (8-6)).

Only two COI values could be found in ExternE-related project reports which are hypertension due to noise (Hunt, 2001) and cancer-related morbidity (European Commission, 1999a; Table 8-2). In the absence of more information, the COI-related external costs due to the other health effects are not included in the present assessment (cf. Table 8-6).

What needs to be defined still is the monetary value to be assigned to the DALYs associated with the physical impacts as specified in Tables 7-6 and 7-7. In the recently completed, EC-funded NewExt project (Number: ENG1-2000-

**Table 8-2:** Monetary values used for the valuation of the costs of illness (COI) for the endpoints considered in this study

Morbidity effect	COI [€ <sub>2000</sub> per case]	Remarks
High blood pressure <sup>a</sup>	3551 <sup>b</sup>	analogy with noise-related hypertension; hospital and absentee costs of 1830 and 1584 € <sub>1998</sub> /case, respectively considered (Hunt, 2001)
Skin lesions	n/a	
Kidney damage	n/a	
Reduction in water consumption <sup>a</sup>	n/a	
Enzyme (lactate dehydrogenase) affected <sup>a</sup>	n/a	
Cancer-related morbidity	320700 <sup>c</sup>	cancer-related costs of illness of 300000 € <sub>1995</sub> /case without considering pain and suffering-related costs (European Commission, 1999a)

a.Evidence from laboratory tests on rats.

b.Price conversion from basis 1998 to 2000 by factor of 1.04.

c.Price conversion from basis 1995 to 2000 by factor of 1.069.

00129), a value of 50000 €<sub>2000</sub> per chronic YOLL has been determined by means of a contingent valuation survey carried out in France, Italy and the United Kingdom (Markandya et al., 2004). This value is assumed to contain a discount rate of 3 %. The undiscounted value for chronic mortality has been derived to be 75000 €<sub>2000</sub> per chronic YOLL.

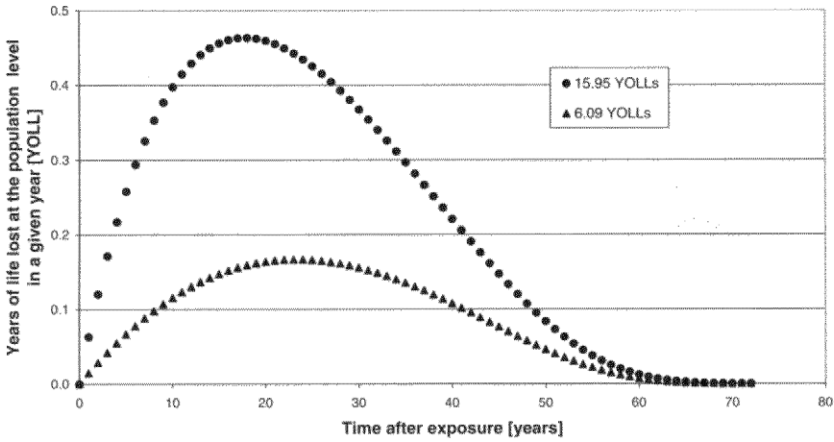
## 8.2.2 Monetary valuation and latency

As was concluded above (cf. section 8.1), two discounting schemes will be employed using 0 and 3 %, respectively. When performing zero discounting, the monetary valuation of the physical impacts is straightforward. The just presented value of 75000 €<sub>2000</sub> per YOLL-equivalent will be taken. As regards the value to be used when discounting at a rate of 3 %, the main question to be answered is:

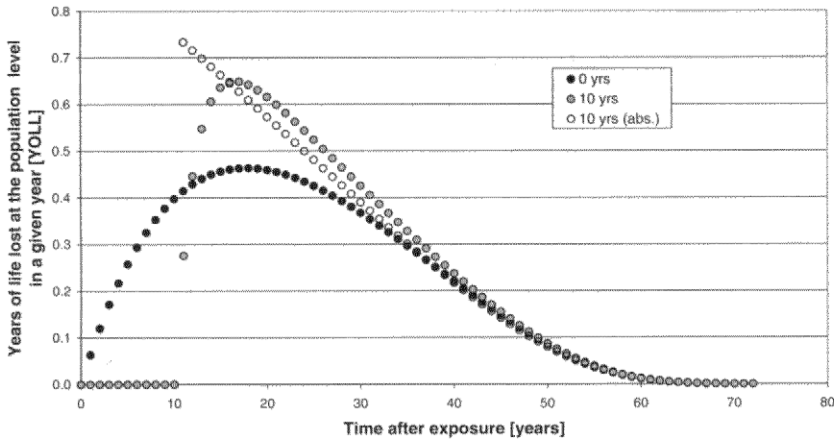
What is the average value of a life year lost in the European population due to the impacts assessed? In order to answer this question, the time structure of when the effects are expected to occur needs to be known. The approach as described by Gressmann and Bickel (1997) is followed which is similar to that by Miller (2001).

The approach compares a reference scenario in which the population develops according to the unmodified mortality probabilities with a scenario in which the survival probabilities are decreased by a certain factor for all age cohorts after an initial minimum latency time. This decreasing factor is adjusted so that the time-integrated sum of the lost life years towards the reference case equals the respective YOLLs given in Table 7-6. Only the cancer-specific YOLLs shall be investigated. This is because the non-cancer impacts are derived from those of an average cancer. Consequently, the same temporal structure of the lost life years is used. Furthermore, the approach only takes survival rates into account without considering the years lived with a disability.

The physical impacts given in Tables 7-6 and 7-7 need to be classified into acute and chronic impacts in order to appropriately apply the 3 % discounting scheme during monetary valuation. None of the impacts considered in these Tables is regarded to constitute a cause for acute mortality despite the assumption of no minimum latency (Searl, 2004). 'Minimum latency' means that no effect occurs at the population level after exposure towards hazardous substances within the specified time. However, one needs to note that the years of life lost for the diseases assessed in this study represent average values at the population level. Similar to the 'no threshold' assumption at the population level, the 'no (minimum) latency' assumption means that there are sensitive individuals that develop a disease immediately after exposure, possibly also due to previous exposure, while other individuals may be affected with a delay only. This is demonstrated in Fig. 8-1 for an integrated sum of years of life lost of 15.95 (circles) and 6.09 (triangles), respectively. If a rather young individual dies in the first year after exposure his/her life years lost show in all subsequent years until he/she would have completed his/her life expectancy. This, however, means that there are new cases of death occurring at least until the peak of each of the curves shown in Fig. 8-1, with variable durations of latency. If minimum latency for instance of 10 years is assumed to occur, the years of life lost are postponed but still quite a few individuals that die do so only with a longer duration of latency (Fig. 8-2, grey circles). If one assumed that the minimum latency time is also the maximum, i.e., the effects only occur in year 11 after the exposure, then an entirely different shape of the temporal distribution of the years of life lost would result (Fig. 8-2, white circles). This could be described as a postponed acute mortality which, however, is rather unrealistic unless the hazard to be assessed is a time bomb for instance set



**Fig. 8-1:** Temporal structure of the distribution of 6.09 and 15.95 years of life lost (YOLL) due to an exposure towards a pollutant at time 0 years without a minimum latency time at the population level



**Fig. 8-2:** Temporal structure of the distribution of 15.95 years of life lost (YOLL) due to an exposure towards a pollutant at time 0 years according to three different assumptions with respect to latency at the population level: no minimum latency, minimum latency of 10 years and absolute latency of 10 years (black, grey and white circles, respectively)

**Table 8-3:** Monetary values per YOLL when discounting at a rate of 3 % according to the approach followed in this study [€<sub>2000</sub> per YOLL]

Type of cancer	YOLL per incidence	Minimum latency time of ...	
		0 years	10 years
Lung	15.95	40845	37009
Skin	6.09	37788	32030
Average	12.5	39563	34627

up in year 0 and that explodes just after completion of year 10. In order to conclude this excursus on latency time, one can state that one needs to be cautious when stating that no latency time is assumed (at the population level).

To what extent does the 'no minimum latency' assumption influence the monetary value to be assigned to the DALYs when discounting at a rate of 3 %? The effect is shown in Table 8-3. Assuming a minimum latency of 10 years would lead to a reduction in the monetary value towards a situation with a minimum latency time of 0 years by between 10 and 15 % when discounting at a rate of 3 %. The values yielded without consideration of latencies suggest to use one value for all cancers investigated due to small discrepancies. The monetary value adopted in the present study for valuing DALYs when discounting at 3 % is 40000 €<sub>2000</sub> per DALY.

### 8.2.3 Impact of employing a different monetary valuation approach for morbidity effects

In section 7.3, the issue of the appropriateness of the disability weights for cancers has been identified. These disability weights are needed to aggregate the years lived with a disability (YLD) with years of life lost (YOLL) into DALYs. It shall be investigated to what extent a different approach would result in changes in the external costs quantified in Chapters 10 and 11. In the present work, the external costs related to one incidence of a disease are calculated according to:

$$\begin{aligned}
 \text{Costs}_{\text{external}} &= \text{Costs}(\text{Mortality}) + \text{Costs}(\text{Morbidity}) \\
 &= \text{Costs}(\text{YOLL}) + \text{Costs}(\text{YLD}) + \text{Costs}(\text{Treatment})
 \end{aligned}
 \tag{8-6}$$

**Table 8-4:** Implications of the pain and suffering-related monetary value for cancers according to the DALY and the ExternE approach for a discount rate of 0 %

Type of cancer	DALY approach				ExternE approach	
	Disability weight [-]	Disability duration [years with a disability per person and cancer case]	YLD per cancer case [years lost-equivalents per person and cancer case] <sup>a</sup>	Monetary value [€ <sub>2000</sub> per non-fatal cancer case] <sup>b</sup>	Pain and suffering- related costs [€ <sub>2000</sub> per non-fatal cancer case]	Resulting theoretical disability weights [-] <sup>c</sup>
Lung	0.146	1.8	0.26	19710	160350	1.19
Skin	0.045	4.2	0.19	14175	160350	0.51
Average	0.809	0.865 <sup>d</sup>	0.70 <sup>d</sup>	52500	160350	2.47

a. Note that the YLD values result when multiplying the disability duration with the disability weight.

b. Yielded by multiplying the YLDs with 75000 €<sub>2000</sub> per YOLL.

c. Yielded by dividing the value of 160350 €<sub>2000</sub> per non-fatal cancer case by the product of the disability duration and the monetary value of 75000 €<sub>2000</sub> per YOLL.

d. See footnote 19 for the derivation of the value.

Within this study, the YOLLs and the YLDs are aggregated into DALYs allowing the use of one monetary value for both health effects, i.e., the monetary value for mortality. According to normal practice within the ExternE project series, in contrast, only the YOLLs are valued with this monetary value while specific values for each end point are to value morbidity-related effects. At present, the value for cancer-specific morbidity effects comprises different aspects. This way of valuing morbidity aggregates treatment costs (referred to as costs of illness, COI) and the willingness to pay (WTP) to avoid pain and suffering. In order to avoid double-counting, the purely pain and suffering-related costs result as:

$$\begin{aligned}
 \text{Costs}(\text{Morbidity}) &= \text{Costs}(\text{Pain} + \text{suffering}) + \text{Costs}(\text{Treatment}) \\
 \Rightarrow \text{Costs}(\text{Pain} + \text{suffering}) &= \text{Costs}(\text{Morbidity}) - \text{Costs}(\text{Treatment})
 \end{aligned}
 \tag{8-7}$$

**Table 8-5:** Impact of choosing the DALY or the ExternE approach with respect to valuing pain and suffering-related monetary valuation when discounting at a rate of 0 %

Type of cancer	DALY approach	ExternE approach	Ratios	
	External costs [€ <sub>2000</sub> per case]	External costs [€ <sub>2000</sub> per case]	$\frac{\text{ExternE}}{\text{DALY}}$	$\frac{\text{DALY}}{\text{ExternE}}$
Lung	1536660	1677300	1.09	0.92
Skin	791625	937800	1.18	0.84
Average	1280700	1415585	1.11	0.90

The presently used value for morbidity amounts to 450000 €<sub>1995</sub> per non-fatal cancer case (p. 257 in European Commission, 1999a). This value corresponds to 481050 € in the year 2000, the base year for valuation in the present study. The treatment costs for a non-fatal cancer case are assumed to be 320700 €<sub>2000</sub> (cf. Table 8-2). The difference of 160350 €<sub>2000</sub> per non-fatal cancer case are the purely pain and suffering-related costs according to Eq. (8-7). These shall be compared to the costs resulting from the morbidity component of the cancer-specific DALYs (Table 8-4). Only the case of discounting at a rate of 0 % is investigated as this is the upper limit scenario for the external costs to be quantified. The difference between the DALY approach and the ExternE approach in terms of valuing the pain and suffering-related effects amounts to a factor between 3 and 11. The theoretically resulting disability weights are also given in Table 8-4. Their purpose is to see which value the disability weights of the respective cancers would need to assume if one wanted to obtain the cancer-unspecific ExternE value when following the DALY approach. Except for the case of skin cancer, these would assume values larger than 1. This is not reasonable according to the underlying philosophy of the disability weights as one cannot lose more time than one possibly expects to have. If one mixed the two approaches on the expense of losing consistency particularly with the assessment of the non-cancer effects, one can see that the 'pure' DALY approach underestimates the external costs per cancer case by up to 16 % (Table 8-5). Or phrased the other way around, the external costs derived in this study might be higher by up to 18 % if one chose to use the ExternE-based valuation approach for the pain and suffering-related costs.

### 8.2.4 Monetary values used

In order to conclude this Chapter on monetary valuation, the monetary values as used in this study are summarized in Table 8-6. Note that the costs of illness (COI) as given in Table 8-2 are current values, i.e., intertemporally valid only when discounting at 0 %. The 3 % discounted values are derived by linear scaling with the quotient of the monetary values per YOLL of 3 % to 0 %, i.e., multiplication by 0.53. This way it is assumed that the costs of illness occurring in the future are distributed over time in the same way as the years of life lost although principally preceding these. Together with the use of one monetary value per YOLL for the 3 % discounting case (see above), this also brings about that the values for these two discounting schemes are different by a constant factor of about 2 for all human health effects considered (comparing the totals in Table 8-6).

Further note that the external costs that result from employing the *intergenerationally equal, positive personal discounting* scheme equal those according to discounting at a rate of 0 % multiplied by this factor. This is due to the fact that the value of an impact only depends on whether an incidence of a disease is assessed to occur and not on when it occurs. In contrast, when constantly discounting at a rate of 3 %, also the time lag between emission and occurrence of a disease contribute to giving a lower value to the respective impact. Thus, the intergenerationally equal, positive personal discounting scheme causes the external costs to be about half of those when 'not discounting'.

**Table 8-6:** Monetary values per incidence of a disease by valuation approach and discount rate as used in the present study [€<sub>2000</sub> per case]

Disease	0 % discounting			3 % discounting		
	WTP	COI	Total	WTP	COI	Total
<b>Cancer</b>						
Lung cancer	1215960	320700	1536660	648512	171040	819552
Skin cancer	470925	320700	791625	251160	171040	422200
Average cancer	960000	320700	1280700	512000	171040	683040
<b>Non-cancer</b>						
Skin lesions	96000	n/a	96000	51200	n/a	51200
Kidney damage	96000	n/a	96000	51200	n/a	51200
Reduction in water consumption	96000	n/a	96000	51200	n/a	51200
Enzyme affected	9600	n/a	9600	5120	n/a	5120
Hypertension	96000	3551	99551	51200	1894	53094