THE GREENHOUSE

A Welfare Assessment and Some Morals

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Contents

List of Tables

Preface

My personal aims with this book are twofold. Firstly, I want to stress the importance of the anthropogenous greenhouse effect and to expose its grave consequences for mankind, many of which are not seen at all by the general public and the rest mostly being underrated, often even by scientists working in this field. With this exposition I will try to contribute my share to counterbalancing the, for the most part, appallingly short-sighted and egocentric political debate about this problem and the questions connected with it, e.g. the carbon-tax. And I want to support all those fighting for much more rigorous measures against the greenhouse effect, for renewable energy and, last not least, for the well-being of the people in poor countries now and in the future. But, surely, whether such measures are right depends on the question if the arguments in this book, or their better substitutes, back the claims to be made here.

Secondly, I want to show that ethics, in particular welfare ethics like utilitarianism, and even more particular welfare ethics incorporating justice like the criterion utilex introduced by me, are able to confront such difficult and far-reaching social, technical and ecological problems like the greenhouse effect, which then translate into problems of social justice. And I want to show that such ethics are able to give, justified in detail, moral recommendations as to what to do with these problems. This means that there is a different, supra-partisan voice, besides the single personal and national voices and the political bargaining and fighting. Up to now no similar, quantitative welfarist assessment of the greenhouse effect and its alternatives has been made, nor are there quantitative welfarist inquiries of other big questions of social justice as one would expect utilitarians and other welfare ethicists to perform. This is a shame because it makes people think that ethics, in particular welfare ethics, is either irrelevant for such questions or at best the background for individual behavior in personal relations but no adviser for the big social issues. Thus, the following study, which tries to assess

the greenhouse effect and its alternatives quantitatively, does pioneer work and has to solve many still open methodological and empirical questions. Therefore, I hope for the reader's forbearance toward many still provisional solutions. And I hope to encourage other ethicists to continue this work and to apply this approach in other fields.

The argument in this book is organized as follows:
(1) First, the specific questions of this study are explained. Specifically, four options with respect to the greenhouse effect, namely business as usual and three more or less radical abatement options, will be evaluated from the point of view of several ethics, the Kantian Categorical Imperative or some sustainability criteria of environmental ethics but first of all from the point of view of two welfare ethics: utilitarianism and utilex.
(2) Then, the methodology of this welfare inquiry is explained: i. In particular the impacts of the greenhouse effect and of the abatement options on human and social life will be estimated according to the data found in the appertaining literature. ii. These impacts then will be evaluated from the personal, individual points of view. For this personal evaluation some sort of rational hedonism is taken as the relevant criterion, i.e. the view that individual desirability is proportional to the subjective well-being of the respective subject. iii. The individual evaluations will then be integrated to various moral evaluations of the options in question.
(3) Chapter 3 contains the inquiry about the social consequences of business as usual and their personal desirability for the individuals. It is subdivided on the basis of the various types of damages - apart from section 3.3 where details of the hedonistic evaluation are explained.
(4) The next chapter contains the analogue to chapter 3 with respect to the abatement options.
(5) The material gathered so far is then used for the moral evaluations of the four options according to utilitarianism, utilex (both without and with temporal discounting), a sustainability criterion of environmental ethics, Kant's Categorical Imperative, and *neminem laedere* (the criterion 'do not harm anybody!'). According to all these criteria, the severest abatement option is found to be the morally best respectively obligatory alternative. The cost-welfare relations of the abatement options are analyzed, too. Again the severest abatement option is found to be the most efficient.
(6) The simple criterion that the morally best option is always morally obligatory is rejected. Then for welfarist ethics the general question arises as to which actions are morally obligatory. A general answer to this question is sketched: a historizing conception of moral obligations. In addition, the problem of what and how moral valuation criteria can be justified is dealt with.

(7) Finally, these general conceptions are applied to the greenhouse effect. It is claimed that we have a moral duty to implement the most stringent, politically feasible norms for greenhouse gas abatement.

As is necessary with a quantitative approach the inquiry contains some mathematical formulas and calculations - but nothing requiring more than school mathematics. And all such technical parts (as well as criticisms of competing theories) are banished into paragraphs in small print which may be skipped without problems for understanding the main parts of the book.

In writing this book I have profited from the help of other people. In particular I wish to thank Dieter Birnbacher, Christoph Fehige, Stefan Guhe, Steven Lukes, Sandro Nannini and Reinhard Suck for very helpful suggestions and discussion and Julia Weiss, Dennis John Newson and Nora Lumer for their invaluable help in all matters of language.

Siena, July 2000
Christoph Lumer

1. Aims of this Study

The anthropogenous greenhouse effect is in danger of becoming the biggest environmental problem of this century with enormous negative consequences for mankind: It threatens to kill hundreds of millions people in this century. Unfortunately, the economic costs for preventing these consequences range from very high to gigantic - at least according to traditional economic assessments. The costs of eliminating the CFCs are in the (US-)billions (= 10^9) of US-dollars per year for some years; the costs of reducing sulphuric acid may be in the tens of billions (Schelling 1992, 3); the costs of preventing the anthropogenous greenhouse effect instead, in the long run, will be higher than (US-)trillion (= 10^{12}) US-dollars per year - always according to these traditional assessments (cf. below). But even such sums can absolutely be paid. This combination of enormous damages and high prevention costs, moreover, is morally explosive because the present generation enjoys the advantages of the causes of the anthropogenous greenhouse effect and eventually would have to pay a considerable part of the cost of its prevention, whereas the disadvantages for the most part are externalized on future generations.

Despite the tremendous seriousness of the anthropogenous greenhouse effect up to now it has not been the object of much attention in environmental ethics. In particular there is no global assessment of the various alternatives in this field from a utilitarian point of view or that of some other welfarist ethic. This in one part is due to the difficult empirical questions, but to another - perhaps even more important - part it is due to the fact that, shamefully, in welfare ethics there is no tradition for assessing even the options (with various advantages and

disadvantages) concerning any other big and difficult problem of social distributive justice - like developmental aid, rationing of medical resources, pensions and intergenerational justice, equity of income etc.[1] Even important parts of the methodology necessary for such studies are lacking, in particular good, ethically acceptable methods of measuring personal desirabilities.

Some first *economic* assessments of the global social and economic consequences and costs of the greenhouse effect, which come closer to what an ethicist needs for evaluating these phenomena, have been published recently (e.g. Fankhauser 1995; Tol 1995; Pearce et al. 1996). In spite of being the best material presently available even these studies, from an empirical point of view, often only rely on informed guesses; e.g. sometimes figures from the US are transferred to the world as a whole. But still more importantly from a moral point of view is that all these studies are cost-benefit analyses, i.e. analyses which try to measure all advantages and disadvantages of the options in monetary terms. Such cost-benefit analyses rely on methods and criteria that are unacceptable for the ethicist.

The main problems of cost-benefit analyses from a welfarist point of view are: 1. Non-monetary welfare-losses are monetized in a very doubtful manner. The value of a life in the First World for example is assessed at 1.5 million US-dollars, whereas in the Third World it is 150,000 US-dollars.[2] Also the differences of purchasing power of money in different parts of the world are usually neglected, so that for example the loss of one unit of arable land is valued quite differently. Taken together this leads to a much greater weighting of damage in the First World compared to the rest of the world, ethically a parochialism.[3] 2. Inversely, the meaning of real monetary losses for the well-being of different persons is ignored completely. This contradicts all welfare-oriented approaches in ethics, which asses e.g. that 1000 dollars for a rich and a poor person will have very different utilities. 3. Cost-benefit analyses tend to be money-fetishistic. They are not very sensitive towards what is really important for well-being and concentrate far too much on monetary losses and on harm that is easily measured in monetary terms. So many categories of damages are ignored, e.g. suffering from hunger-pangs, grief over the loss of loved ones, strain and suffering from emigration. 4. Money has a lot of attributes which welfare does not have - and vice versa. Money can yield interest, it can be easily distributed, it can be changed into goods and services at rather fixed prices, it can be lent etc. Monetizing welfare losses (and gains) means adding these attributes to events in the sphere of welfare and thus may lead to gross distortions of the resulting calculations. Cost-benefit analyses e.g. discount future damages (with an average of 3%/year); this is right for many economic losses but not for real welfare losses. On the contrary, for most ethics discounting welfare losses is an unpermitted preference for the living in place of future generations.[4] 5. The money-metric measure of cost-benefit analyses often measures incommensurable values with different method. Namely a big part of the monetary values expresses real or estimated market prices; another big part, though, expresses willingness to pay and similar things, which is a way

to express personal preferences. But these are different dimensions and scales so that the resulting monetary values of the two methodologies must not be added, it would be equal to adding together apples and pears. Surely, introducing willingness to pay is intended to be a means for accounting for "the" value of things which have no market price and perhaps no market value. The underlying corrective idea, namely that money is not the only valuable thing, is quite right but the consequences derived from it are half-hearted. Things other than money are important because they are preferred or fulfill our desires or contribute to our well-being. But the same holds for money as well. So if one wants to account for non-monetary values too, and this is definitely necessary, the proper and all-embracing scale for doing so would be welfarist in some way. Current cost-benefit analyses instead are an incompatible mixture of monetary and preferentialist assessments.

But could these problems of *current* cost-benefit analysis not be overcome by using improved methods? The third mentioned problem, i.e. the tendency to ignore or underrate non-monetary losses, obviously is not an unsolvable problem for cost-benefit analysis *per se*. And some straightforward attempts to eliminate the first problem (monetizing non-monetary losses) exist too. The Global Commons Institute e.g., explicitly for ethical reasons, recalculated the social costs of greenhouse damages obtained by the IPCC-authors (Pearce et al. 1996; Fankhauser 1995) with, among others, the following modifications: Statistical deaths were equally valued all over the world at 1.5 million US-dollars; and prices were corrected for purchasing power parity (Meyer / Cooper 1995). This obviously lead to much higher damage estimates.[5] But these corrections for the first problem aggravate the fifth problem. As already mentioned the corrections are explicitly made for ethical (and political) reasons (ibid.). Such reasons however have little to do with the monetary value of the objects in question; e.g. they say nothing about what it would cost to pay the benefits of a life insurance or to buy some particular land before it is lost due to the greenhouse effect. The motives for the correction in question, surely, are honorable. But the particular procedure obscures more and more what after all is measured with this kind of "cost-benefit analysis". From an economical point of view, the resulting figures have ceased to reflect market prices (problem 5). And from an ethical point of view, not only problems 2 and 4 (neglect of different impacts of monetary losses on well-being and different attributes of money and welfare) remain unsolved but even the proposed solution to problem 1, to take all statistical human deaths into account universally equally and with the specific sum of 1.5 million dollars, is *ad hoc* and not justified by an ethical criterion. The muddling through between economics and ethics continues as in the studies criticized by the Global Commons Institute.

With respect to the strict differentiation of monetary value and welfare some people think that the units of measurement are not significant; this would mean that the above listed problems could be nonexistent or at least somehow resolvable. A first interpretation of this idea is that the different units, e.g. dollars versus utils, may be converted one into the other. The problem with this type of rejoinder to the above listed criticisms is that monetary value and welfare are not simply different *units* of measurement (like miles and meters) but different *dimensions* or values; different things are measured, apples versus pears. Monetary value in market economies results from supply and demand; welfare however is an aggregation of individual desirabilities. One of the necessary conditions for an attempt to convert monetary value into welfare

should be to dispose of information about who owns the money (because of the diminishing marginal utility of money). But this information is not contained in the monetary value. And for the reverse attempt one should dispose of information about supply and demand of certain goods, which is not contained in the welfarist value. In addition, it is hard to imagine what a conversion of welfare into monetary value should mean if not the monetary value of the goods and services producing such welfare. But these, obviously, are quite different things: the welfare itself (which may be obtained in different ways) and the monetary costs of (the various ways to produce) this welfare. - A second interpretation of the idea that the units of measurement are not significant is to understand cost-benefit analysis as some sort of multi-attribute "welfare" economics or ethics, where the value of market goods is identified with their market value (perhaps corrected for purchasing power parity) and where the value of things from other dimensions is measured differently but, for reasons of simplicity, expressed in monetary units, too. According to this interpretation, cost-benefit analysis would change its aims radically, it would no longer be an economic instrument for measuring market value but an ethical instrument for measuring moral value. This sort of semi-welfarism would not rest on conceptual confusion about values but its way to measure "welfare" now should be compared to the moral criteria and aims of welfare ethics because the aims of this sort of instrument now would be ethical. Even with this interpretation the second mentioned problem (that the individual importance of monetary losses is neglected) remains in any case. Whether the value attributed in the dimensions of non-market goods sufficiently reflected ethical requirements would depend on further specifications of the respective variants of this type of semi-welfarism and on the justifications given for them. (Simply assuming e.g. a universally equal value of 1.5 million US-dollars for each statistical death, firstly would be an unjustified procedure which, secondly, among other problems, neglects how well or badly off persons are in different countries already without the greenhouse effect.) And the better this part of the value criterion complied to ethical requirements the more difficult to answer would be the question why the first half of the criterion is not welfarist, too.

Taking this background into account, this study has three aims:

1. Firstly, the relevant consequences of the unrestricted anthropogenous greenhouse effect, i.e. business as usual (= BAU), and of three alternatives to reduce greenhouse gas emissions to different degrees (= abatement options) will be estimated (ch. 2-4). In the political and scientific worlds these consequences mostly are considerably underrated; and even scientists researching on the social consequences of the greenhouse effect often overlook very important categories of damages. Therefore, this part has some value on its own.
2. Secondly, the social consequences of BAU and the abatement options will be evaluated from the perspective of several moral criteria: utilitarianism, another welfarist criterion called "utilex" and other non-welfarist and much easier applicable moral criteria like sustainability, Kant's Categorical Imperative or '*neminem laedere*' ('do not harm anybody!') (parts of chs. 3-4 and sect. 5.1). Welfare ethics are ethics which define the moral desirability of an option (often solely) in terms

of the personal desirabilities of that option for the affected beings. The easiest way to do this is utilitarianism, which simply adds the individual desirabilities; other welfare ethics use more complex forms of aggregating the individual desirabilities. The disadvantage of welfare ethics is that they eventually (as in the present case) need huge sets of information. But their advantage is that they take into account all sorts of personal advantages and disadvantages and ponder them. Therefore, the bulk of the effort is dedicated to the welfarist assessments. - In addition to the pure moral evaluations, moral efficiency, i.e. the cost-welfare relations, of the abatement options are calculated (sect. 5.2). - Since, as already mentioned, as of today there are no welfarist assessments of the greenhouse effect (or of any other major social issues) this part of the study does pioneer work on a new ground of applied ethics. - Anticipating results of this part, we can already say that, according to all ethical criteria considered here, the severest (of the examined) abatement option, i.e. sustainable reduction, is morally optimum.

3. Finally, considering this result, the question if and how these evaluations translate into moral obligations is discussed: Are we morally obliged to reduce greenhouse gas emissions to a morally efficient or to a sustainable level? To answer this question (ch. 7) a general theory of moral justification and of moral obligation is sketched (ch. 6).

Notes to Chapter 1

1 Some people find these contentions hard to believe. I would like, therefore, to inspect quickly the work of some contemporary theorists whose names may come into mind first when thinking about this question. (The following considerations are absolutely not intended to belittle the works mentioned but are only used to prove my point.) *Broome* (1992) has even written a monograph about the greenhouse effect. In its first chapter information about the natural and social consequences of the anthropogenous greenhouse effect is gathered, whereas in the rest of the book general theoretical problems of welfare ethics are discussed, especially discounting and aggregation. The book never comes to a conclusion as to which alternative is morally best. To reach such a conclusion many premises which would be required are missing: the consequences of alternatives to business as usual and, above all, figures for the personal desirabilities of the persons concerned. *Singer* pleads for giving 10% of one's personal income to the hungry (Singer 1993, 246) but does not calculate the utilitarian moral desirability of this option (as compared to doing nothing). The most critical piece of such an assessment

is missing, namely the determination of the respective personal desirabilities. At first sight this seems to be superfluous though, because with the proposed action the desirability gains of the hungry clearly would outweigh the losses of the people of the First World. But at second sight it is clear that there are many, many more options (giving more; different quotas for different people; distributing the money in different ways) so that a quantitative assessment could be necessary for determining the best of them. Singer does not consider such options seriously because he takes them to be politically utopian. *Ng* (1986; 2001) pleads for an increase in population — but based on a purely theoretical (and I think fallacious) argument and on the ethical principle of maximizing total utility. The really important empirical questions and the problems of hedonistic measurement are not even touched. *Drèze* and *Sen* energetically try to avoid those welfaristic preferential judgements that could be established only by weighing the advantages and disadvantages of several alternatives. They maintain e.g. that in cases of (impending) famines employment programs are better than direct distribution of food but they try to prove this by showing that employment programs are better in *any* respect (or more precisely that all prima facie disadvantages of employment programs actually are not disadvantages at all) (Drèze / Sen 1989, 113-117) so that a quantitative comparison is not necessary. This may even be true in the specific case, in other cases, however, such a dominance of the best alternative does not hold. Comparing the welfare of India and China the same authors found that China does better with respect to mortality, rate of literacy etc. but not with respect to its authoritarian political system so that a simple ranking of these two social systems is not possible; instead of doing this the authors, in a certain sense, propose to combine the advantages of both countries (Drèze / Sen 1998, ch. 4). This may be a wise solution in the case in question but not one feasible in every situation. *Sen*, finally, in pleading for (valuations of) multidimensional vectors of functionings as being the relevant measure of well-being (e.g. Sen 1985, 9-16; 25; 28; 51; 56) abandons the necessary instruments for assessing welfare altogether, namely a one-dimensional, cardinal and intersubjectively comparable measure of well-being. — These are only a very few examples. But they may indicate that some leading welfare theorists are far away from the type of quantitative welfare assessment conducted in the present study.

2 The view of Hohmeyer and Gärtner (1992) which assess the value of each life at 1 million US-dollars is an exception. (Unfortunately, many statements by Hohmeyer and Gärtner are based on obsolete estimations, this is why their study is rarely mentioned here.) On the other hand this uniform assessment is criticized by other economists: this approach is "based entirely on a "moral imperative", the theoretical economic basis of this approach is weak" (Pearce et al. 1996, 196). But this criticism falls back on the authors for the following reasons. In my opinion, the only *purely economic* approach is the human capital approach, which treats an individual as an economic agent capable of producing an output that is valued in monetary terms; a life lost is then the loss of that output, less any consumption that the individual would have made. Pearce et al. criticize this approach because "it tends to produce extremely low values for those with low earnings, clearly discriminating against the already poor" and because it does not take into account the willingness to pay, so that this approach "is not properly founded in economic theory" (ibid.). But the first argument is clearly a moral argument. Pearce et al. themselves

prefer the willingness-to-pay/willingness-to-accept-method, which, admittedly (ibid.), also discriminates against the poor — but not to such an outrageous extent as the human capital approach. And this, I think, is the true reason why Pearce et al. prefer the willingness-to-pay approach: it seems to be a compromise between economic and moral consideration. The alleged "foundation in economic theory" is only a pretext. What counts in an economic context are market prices or estimated market prices; and Pearce et al. in most cases rely on market prices. Willingness to pay is only a bad substitute for this in cases where market prices cannot even be estimated. But the human capital approach provides market prices for what people produce and for what they consume. So, economically there is no need to switch to willingness to pay. — The one real problem is that money is not the only thing which counts; and money is not the right unit for counting these things because it does not count *intrinsic* desirabilities. The other real problem is the interpersonal aggregation of values; simply adding monetary gains and losses is not a well considered solution either. All these are profound ethical questions. And the arguments reported above nicely show how cost-benefit analysis implicitly gives — bad — answers to these questions by making *ad hoc* assumptions and muddling through.

3 Exactly this criticism was raised against the cost-benefit analysis of global warming undertaken in the Contribution of Working Group III to the Second Assessment Report of the IPCC (= Pearce / Cline 1996). The Global Commons Institute e.g. during the process of appoval of the contributions of Working Group III organized a campaign "Defending the 'value of life'" against this particular chapter of the report. This campaign, among others, lead to a very critical comment in the "Summary for Policymakers". (In the reports of the IPCC the "Summaries for Policymakers" — as opposed to the single chapters, which are signed by the respective authors — are intergovernmentally negotiated texts drawing generally accepted conclusions from the single chapters.) The "Summary" e.g. relativized in the following way: Assuming an equally high, namely as in developed countries, value of statistical lives in different countries and correcting for purchasing power parity of different currencies would lead to damage estimates several times larger than those estimated according to the usual methods of cost-benefit analysis (IPCC 1996d, 10).

4 General criticisms of cost-benefit analysis can be found e.g. in: Adams 1993; Kelman 1981; Leist 1996a; MacLean 1994. A good philosophical critique of discounting is: Cowen / Parfit 1992.

5 Another modification relevant in the present context is that the Global Commons Institute included some damage categories neglected by Fankhauser, in particular deaths by malaria and malnutrition. All these modifications lead to world-wide damage costs 42 times as high as those calculated by Fankhauser. (Meyer / Cooper 1995.)

2. Methodology of the Welfare Inquiry in this Study

2.1. The Steps of the Inquiry

The following welfare assessment of the options with respect to the greenhouse effect proceeds in three large steps:
1. On the basis of information published in the cost-benefit analyses, which can be corrected and completed if necessary, first the health, economic and the social effects of four alternatives are determined: a_1: business as usual; a_2: stabilization of greenhouse gas emissions; a_3: strong (25%) CO_2-reduction; and a_4: sustainable (60%) CO_2-reduction. For further calculation it is assumed that these effects are known with certainty. As a matter of fact some of these findings are, of course, very speculative but they are each best estimates allowing upward and downward deviations according to today's knowledge. And the, sometimes ridiculously exact, figures are only the middle in a range. Then, at best, the expected value for single items will meet the best estimations; in this case the expected moral desirability may be identical with the desirability obtained by my simplistic calculations. (At the present state of information a more subtle calculation, including appraisal of risk, is hardly possible or not worth the effort.[1]) I will regard the effect of each alternative for periods of 25 years, roughly corresponding to one generation: 2000-2025, 2025-2050 and 2050-2075. With BAU temperature rises will persist longer, but the effects after 2075 can be largely compensated by new decisions which will

have to be taken by 2025. In addition, estimates regarding social effects after 2075 are rather scarce. Therefore, later consequences in the following assessment will be ignored.
2. Then, as a second step (which in the presentation is interwoven with the first step), these damages are evaluated from a personal point of view. This step presupposes some sort of rational hedonism, that changes in individual desirabilities or prudentially conceived utilities are proportional to changes in well-being, i.e. the state of the subject's feelings. (For some more details about the desirability function of rational hedonism cf. below, sect. 3.3.) This is not the place to defend such a hedonistic theory of individual desirability in detail - I have done it elsewhere (cf. Lumer 2000, ch. 4-6; Lumer 1998); but some hints of a justification are given below, in sect. 2.2. (This section can be skipped entirely without problems for understanding the rest of this inquiry.) But even according to a purely preferentialist view of individual utilities (which takes the uncriticized preferences of people as the basis of utility calculation), hedonic changes of life normally will be the major component of utility; and the other, non-hedonic components are difficult to find out. Rational hedonism equates changes in personal desirabilities by an event with the changes in the person's well-being provoked by this event. Therefore, the second step of this inquiry, i.e. the personal evaluation of the consequences of BAU and the abatement options, is nearly identical with finding out the influences of the "visible" social consequences of the greenhouse effect (like illness, loss of relatives, migration, unemployment, property loss, absolute or relative poverty) on subjective well-being. These influences are estimated, relying on psychological findings about the effects of various life events on the level and distribution of subjective well-being.
3. Finally, the information about the hedonic changes, which are equated with individual desirabilities, are used for moral aggregations of desirabilities, that is for welfarist assessments of the considered options. The assessments are made according to the criteria of hedonistic utilitarianism, utilex, and some variants of these systems which discount consequences in the distant future. Cost-benefit analyses monetize damages for well-being and welfare; the aim of the present analysis is to welfarize, among others, monetary damages. In addition to these purely welfarist assessments, cost-welfare analyses for the three abatement options are undertaken providing ratios of social economic net costs for the OECD to the utilitarian and utilex welfare net gains.

Unfortunately, not only are the data concerning the socio-economic impacts of the greenhouse effect very insecure but the presently available information about the influence of impacts of this sort on

subjective well-being is even worse and very scattered - in particular because cardinal measurement of well-being is required. I have gathered the material I could find from the psychological literature and processed it for the current purposes. Unfortunately, in some cases of probably less important effects, due to a lack of information and to arrive at a complete welfare assessment, I had to guess the necessary well-being figures. But this procedure is probably rather innocuous for the final result because the most important classes of damages are not determined in this way and because the two most important classes, namely death and economic loss, already cause at least about 80% of the utility losses of all alternatives. So the resulting preference orders are rather stable with respect to plausibly limited alterations in the assumptions made about some specific influences on well-being.

Anyway, a further aim of my executing a *complete* calculation, if necessary with only guessed figures, is to show vividly what further information is missing and should be urgently collected. Such information would not only be necessary for a welfare assessment of the greenhouse effect but in many other fields of applied ethics as well (e.g. in all cases of distributing resources). Empirical collection of such data requires a lot of person years of psychological investigation but it is not more difficult than what is done in much of the usual psychological empirical research. Rather, the lack of such data (at least in part) is due to lack of - in particular philosophical - demand. Therefore, by executing a complete welfare assessment in spite of all these deficiencies I hope to give at least some stimulation for further research in this field. In any case, the following assessments are only some first tentative steps and should not be taken as the final results of ethical inquiry.

2.2. A Very Short Defense of Rational Hedonism [2]

Strong rational hedonism is the view that precisely a person's feelings have intrinsic desirability for that person, i.e. desirability for its own sake, independently of any consequences. "*Feeling*" as used here means, bodily feelings (like pleasurable sensations and pain), emotions (like joy, satisfaction, anger and grief) and moods (like elation and depression). Pleasant feelings have positive intrinsic desirabilities, unpleasant feelings have negative intrinsic desirabilities. And their amount of intrinsic desirability is equal to the integral of their intensity over time. The *(personal) intrinsic desirability of a life* is equal to the sum of the intrinsic desirabilities of all the feelings experienced in it.

And the *total personal desirabilities* of things other than feelings, e.g. the single impacts of the greenhouse effect, are equal to the amount in which they influence the intrinsic desirability of the person's life. These definitions of 'desirability' do not rely on the person's opinion about e.g. the integral of the intensity of that feeling or about the influence of certain events on his feelings. Instead, they rely on the objective facts, that is if these things are really so. Hence objective knowledge about such facts is required to establish hedonist desirabilities.

Hedonism here will be defended by the prudentialist desirability theory (cf. below). This theory only roughly leads to (pure) hedonism as just explained. More precisely it leads to a *corrected hedonism*. According to this theory, in order to account for such things as experience machines (à la Nozick), i.e. that a person lives her whole life in a machine which provides all kind of pleasant feelings, positive experiences relying on manipulation have to be discounted in different degrees (cf. Lumer 2000, sect. 5.4; Lumer 1996). But this peculiarity of corrected hedonism is not relevant in the context of assessing effects of global warming.

Rational hedonism is only a *criterion* for personal desirabilities, which then may be justified in different ways. The justification to be sketched here is taken from the *prudentialist desirability theory* (Lumer 2000, ch. 4-6; Lumer 1998). It relies on three main adequacy conditions or normative axioms.

1. Motivational preferentialism: Desirability theories rely on various sources like motivational desires or preferences, or the valuations implicit in our emotions, or objective values. The prudentialist desirability theory is motivationally preferentialistic. That means it relies on motivational desires, i.e. the desires - in the technical sense - underlying our decisions: something is positively or negatively evaluated to a certain degree with motivational consequences; these desires can, but need not, be accompanied by emotions of craving or abhorring. This motivational preferentialism is the practical component of the prudentialist desirability function. The first reason for this is internalistic, namely that a desirability theory is to be used by a subject as a tool for decision-making and that it can be used as such only if the subject has motivational reasons for following the recommendations of that theory, which, therefore, in turn must already be arranged according to such possible motivational reasons on the part of the subject. Or in other words, desirability theories not relying on motivational desires are practically impotent: they cannot affect the subject's decision unless they hiddenly rely on motivational desires. Such practical impotence holds for objective value theories or theories relying on those evaluations which are implicit only in our emotions but are not part of our motivation. Another reason for motivational preferentialism is that it respects the subject's autonomy: the decisions

about what is important for the subject rely on the *subject's* preferences. (This argument is more general and also sustains other forms of subjectivism.) - Rational hedonism usually is taken to be in opposition to preferentialism. This must not be so and does not hold for the prudentialist desirability theory for the following reasons. Rational hedonism is a theory about the *content* of the desirability function; preferentialism instead is a theory about the s*ources* of the desirability function. Therefore, there is no contradiction in justifying rational hedonism preferentialistically.

2. Prudentialism: Motivational preferences always rely on and contain biologically fixed inclinations. But in addition to that most of our motivational preferences are cognitively formed, linking such inclinations with the subject's beliefs. The really basic inclinations are hard to criticize; they are simply biological facts - though they can develop by confrontation with new information (cf. below). However information used in developing complex preferences may be false or falsely applied. Prudentialism then requires that the information used in calculating desirabilities be true. Therefore, very often there is a difference between the desired and the desirable, namely if the desire relies on false or falsely applied information. Thus, prudentialist desirability theories cannot rely on all the subject's - uncriticized - preferences but only on selected preferences which are stable with respect to cognitive criticism, i.e. resistant to further (true) information. There are two methods of implementing this idea: 1. *Full information approaches* of rationality require the preferences used for defining desirability to be formed while the subject has all the relevant information. 2. *Stability approaches* require the preferences to remain stable when the subject is confronted with new (true) information. The differences between these two accounts will be discussed below. - Prudentialism is the epistemically rational component of the prudentialist desirability theory. It is intended to guarantee something like desirabilities resulting from wisdom. In addition this kind of prudentialism guarantees that the resulting desirabilities express what the subject in a certain sense really wants, namely if not misguided or irritated by false information.

The main alternative to prudentialist accounts is the decision theoretic utility theory. This theory is criticized, legitimately as I think, by many philosophers because they do not regard it rational enough. In particular they criticize the use of unfiltered preferences.

The use of unfiltered preferences in classical *subjective expected utility theory*, e.g. in the von Neumann / Morgentern version, entails several problems: 1. The axioms of these theories, which must be fulfilled for the utility of the preferred objects to be defined, are violated by literaly everybody. Many more

or less systematic violations of such axioms have been found (cf. e.g. Kahneman / Tversky 1979; Kahneman / Tversky 1984; Camerer 1995).[3] Nor does the utility theory give any advice as to how we can and should arrive at consistent preferences. Therefore, in many cases the subjective utility of an object is not defined. One reason for the violations is that even if the axioms of the classical utility theory were accepted by the subjects as requirements of rationality, it would mean asking too much of the same subjects to always comply with them. Preferences are not natural or even inborn, they have to be formed in the particular moment relying on very many informational inputs. And this informational process can go astray. 2. The whole strategy of the classical subjective expected utility theory is paradoxical for the following reasons. Subjective expected utility originally was thought of as a part of the theory of rational decision. The theory of rational decision should give recommendations as to how a subject should decide. On the one hand, this presupposes that people do not always decide rationally, so that the advices of rationality theory would be helpful to them. On the other hand, the axioms of the utility theory, which must be fulfilled for 'utility' to be defined, already presuppose complete rationality of preferences. So we have a dilemma here. Either people already obey the rules of the rational decision theory, in particular the axioms of the utility theory (which is not the case); so then this theory is not a, counselling, theory of rational utility and decision. Or people factually often violate these rules (which is the case); then utilities, the most central ingredient of the theory, are not defined in many cases. The underlying problem is that the usual subjective expected utility theory does not differentiate between basic preferences, which cannot be criticized and which shall be used for defining utilities, and non-basic utilities (cf. Lumer 1998a). 3. The first two criticisms were immanent; the next one is emanent. The axioms of the subjective utility theory are much to weak (perhaps in part even false) to define rational utilities. Even if the preferences of a subject are coherent (in the sense of complying with the axioms) they may rely on false information. Surely, one cannot rationally decide on the basis of information one simply does not have. But this does not mean that 'desirability' must be defined relative to the subject's information. It seems clear that during decision making people try to estimate the *real* desirability of the alternatives at hand, i.e. they implicitly use a stronger concept of desirability with much stronger information requirements; and they will revise their preferences when they believe they have better information. The utility of the subjective expected utility theory then does not express this ideal that people are seeking.

Another instrument for measuring utilities, currently used in health economics, is *quality adjusted life years* or *QALYs*.[4] QALYs are to measure utilities of life situations in a way that is much closer to that of rational hedonism: The value of a subjectively *felt health state* is measured by - again unfiltered - preferences for that verbally described *type* of state (which is equal to the quality of life) and multiplied by its duration. The value for complete health is 1 and for death 0. The total desirability of *other* (states and) *events* (like having a heart attack), i.e. states and events different from subjectively felt health states, then is (or should be) equal to the difference between the value of the health states following this state or event and the normal value multiplied by its duration. (Or more exactly: The total desirability should be equal to the difference between the two respective integrals of the quality of life. I wrote "*should* be equal" because this part of the QALY-framework usually is not made explicit.) - The QALY approach differs from hedonistically measuring social well-being for large groups in the following way. The hedonist (at many

different moments) would ask people having experienced an event (or state) of the specific type how they feel right now and would take the difference between the mean of their answers and the normal mean of well-being as an approximation of the mean total desirability of events (or states) of the specific type. (Or more exactly: The mean total desirability is equal to the difference between the two socially mean integrals of well-being, of the well-being with and without the event.) The QALY-researcher instead in a first step asks people about their preferences concerning a limited set of subjectively felt health states (and their possible combinations), which shall constitute the complete spectrum of such states, e.g.: "What would you prefer, to depend on a wheel chair, not being able to speak and the rest being normal or ...?" From the answers to these questions the (real) personal cardinal quality of life of the specific type of situation is calculated for all subjects as well as the social mean. For determining the total desirability of other types of events (like suffering from a specific disease), in a second step the (mean) influence of these events on the subjectively felt health states should be found out empirically, so that the (mean) difference in (the integral of the) quality of life with respect to the (mean) normal course can be calculated. This difference then is regarded as an approximation of the total desirability looked for. Usually, though, the information about the influence of the various diseases on the felt health states is taken from medical wisdom, and complete health (with a quality of life of 1) often is regarded as the normal course.

QALYs are problematic in several respects and therefore not used here: 1. Currently QALYs are available only for health states but not for other conditions such as unemployment, the situation of migrants and the like. 2. The QALY-approach rests on an uncritical stipulation of the intrinsically relevant, leading to conceptually confused values of the quality of life. The two-step procedure of the QALY-approach would make sense if the states valued in the first step and being the value basis for the other objects had been exactly the intrinsically relevant states. So establishing the respective list of fundamental health states comes up to determining what is intrinsically relevant. Most health states investigated with the QALY method however (e.g. being able to move around, being able to communicate) have no intrinsic desirability, and their total desirability depends on the accompanying circumstances. This leads to confusions and quantitative distortions. 2.1. If subjects are asked to rate the desirability of such health states they will rate their total desirability. But this changes over time, depending on the changing circumstances the person is surrounded by and the plans (s)he may have. So if subjects are asked to rate one specific health state it is not clear what they should rate and what they are actually rating. (It would be a clear task to let people rate the *total* desirability of specified *single events* or the *intrinsic* desirability of any *event of a certain type*, which then, in combination with empirical information, may be used to calculate the total desirability of other events leading to this type of event. But to let people rate their *total* desirability of any *event of a certain type* is nonsensical. The hedonistic method instead takes the second route: it tries to find out how certain *single events* change the integral of well-being, where well-being is something intrinsically relevant.) 2.2. Because the total desirability of complete health (the quality of which is defined as being equal to 1), depending on the different life situations and plans, is different for different people (and for the same people at different times) there is no interpersonal comparability of the measured qualities of life. (Hedonism instead gives the same desirability to each person's highest possible happiness.) 3. QALYs are measured by uncritically taking over the persons' preferences for such states,

even of persons who are not in that state. So the third objection advanced against the subjective expected utility theory applies here as well: The preferences of the people asked are often irrational or far from being well informed, e.g. most people have insufficient or false beliefs about the effects of such health states on their well-being or they put too much weight on irrelevant factors. Therefore, uncritical preferences often do not reflect the real value of the preferred objects. the persons' subjective well-being), equate this happiness with the intrinsic desirability of that part of their life and then take the difference of this intrinsic desirability to the usual intrinsic desirability as the total desirability of such states. The mean of the total desirabilities may then be equated with the expected desirability for other people eventually being in such states. In this way desirabilities are calculated relying completely on objective empirical information (about the influence of the states in question on subjective well-being) and the hedonistic approach of equating well-being with intrinsic desirability, which is justified in a different way (cf. below).) (According to the hedonistic approach instead all the information about the influence of the objects in question on the intrisically relevant (i.e. well-being) is taken from empirical research (asking people who have experienced an event of the specific type for their well-being), whereas establishing intrinsic desirabilities is undertaken in a different way (cf. below).) 4. Most methods for measuring the felt quality of life have additional problems. Cardinal measurement by probability weighting for example is influenced by the subject's risk aversion, whereas time weighting is problematic because different durations of the same health state very often have different impacts e.g. on subjective well-being. 5. The way of ascertaining the total desirability of other objects (different from felt health states) from the quality of life pertinent to the various felt health states comprises some - though not insurmountable - difficulties, too. 5.1. According to the QALY-approach, the relevance of these other objects is always procured /filtered /must be expressed by their influence in the dimension of felt health states. This should be no problem if the respective list of possible health states contains everything which might be intrinsically relevant - from a (corrected) hedonist point of view this would be the well-being (and its generation); the rest then mayy be ignored. If these intrinsically relevant things are not comprised, which is the case in several QALY-models, the calculated total desirability necessarily must be incomplete. 5.2. After determining the quality of life pertinent to the various health states the, possibly very long acting, influence of the object in question on these health states must be measured empirically. This task usually is underrated, *ad hoc* assumptions are used and the respective empirical research is concentrated far too much on physical health variables, thus tending to be health-fetishistic and to ignore the long-term influences on well-being.

3. Reconstructivism: The information requirement of prudentialism should be fulfilled in a particular way. The process of decision making has to be scrutinized in a very detailed manner with the aim of finding out what basic, biologically fixed, inclinations we have and how and what information is used to arrive at a decision. In particular we must find out how (true) information changes the way or criterion of decision. After this empirical step 'desirability' should be defined according to the following conditions: 1. From the biologically basic inclinations we take those that are stable with respect to confrontation

with further information as the basis of definition (stability approach of prudentiality). 2. From the various ways to arrive from basic inclinations at decisions that way is taken as defining 'desirability' (on the basis of inclinations) which in cases of the most thriftiest decisions may be used and would be stable with respect to confrontation with further information. 3. The way to a decision always encompasses empirical assumptions; the empirical information which, according to the desirability definition, must be used for establishing desirabilities has to be true. - The upshot of this reconstructivism is that the definition of 'desirability' prescribes in detail on what inclinational basis which cognitive operations have to be executed for calculating the desirability. So even a third person can calculate the personal desirabilities of another person following these instructions. Some advantages of this reconstructivism are: It gives clear instructions on how to calculate desirabilities; i.e. it fulfills an advisory function. It fulfills the prudentialist idea of stability with respect to further information to a maximum. It can be used by third persons in cases of paternalistic decisions or bigger social studies where not all the people affected can be queried.

The main alternative to reconstructivism (which here includes the stability approach) is the *full-information approach of desirability*:[5] According to this approach the subject is treated as a black box which is filled up with all relevant information and then spits out the right decision and the rational preference order. In a certain sense there is no possibility of surpassing the degree of rationality inherent in the resulting preferences: if these preferences are based on *all* relevant information what can be added to make them more rational? But the problem with this desirability definition is that it asks too much and gives too little: 1. The definition never or only in rare cases makes it possible to find out the desirability of an object because the condition of full information is literally never or at least hardly ever fulfilled. This generates a dilemma. Either the decisions meant in the definition are factual decisions, i.e. decisions which really must take place; then the desirability of most, perhaps of all, objects is not even defined. Or the decisions are hypothetical (or factual) decisions; then the desirability of all objects may be defined but we will not know what they are because the full information approach does not give us the means to find out how a person with full information would decide on a particular object. 2. The full information approach does not give any support or suggestions to the subjects how they should decide. It just recommends procuring all the relevant information. But if the subject then asks, 'but which information is relevant?', the theory answers in a scarcely helpful way: 'It is the information which would alter or influence your decision.' If the subject then specifies, 'but I wanted to know which information rationally *should* influence my deliberation and in what way', the theory does not give any answer. How to decide rationally, surely, is a relevant information; it is exactly this information which the rational decision theory or desirability theory should provide; however, the full information approach does not do this. 3. Full information approaches lead to problems with decisions about actions which have to do with the acquisition of information: Actions aimed at providing information or suspense, according to

this approach, must always have a low desirability because a fully informed subject already possesses the crucial information. But this does not hold for the actual subjects. 4. Full information approaches lead to problems where taste matters. Taste refinement, besides other things, comes about by gathering information about and making experiences with the objects of taste. Fully informed subjects, therefore, will always have a very refined taste, and the - hypothetical - decisions with full information will be made from this perspective. But the resulting preferences - e.g. for eating oysters or listening to twelve-tone music - may be disgusting for the subject with his current taste.

How do the three adequacy conditions of the prudentialist desirability theory, i.e. motivational preferentialism, prudentialism and reconstructivism, lead to rational hedonism? About this question, too, I can only give some sketchy hints (for more details cf.: Lumer 2000, chs. 4-5). According to reconstructivism and motivational preferentialism, the decisional process has to be scrutinized empirically. One main result about the structure of decision-making is that the basic inclinations are originally intrinsic desires. "Intrinsic" means that these desires are desires about final ends, i.e. for things desired for themselves and not for their consequences. And "originally" roughly means that these desires are not only intrinsic because the subject has forgotten that in the first place these desires were not intrinsic. The way from intrinsic desires to total desires and motivational preferences is to find out how an option changes the intrinsic desirability of one's life, i.e. the way already described in the definition of 'total desirability' at the beginning of this section.

The crucial question then is: Which things are originally desired intrinsically and to what extent? Or what is the originally intrinsic desirability function?[6] One clear type of originally intrinsic desires are hedonist desires with the desirability function explained above.[7] Another type of originally intrinsic (motivational) desires are those desires caused by our emotions and which can be called "emotionally induced desires": Emotions of every type seem to cause originally intrinsic desires of a certain type appertaining to this emotion. E.g. rage induces the desire to destroy or impair the object of rage; pity induces the desire to improve the object's miserable state; joy induces the desire for others to share this joy. But these emotionally induced desires are completely dependent on the emotion in the sense that they grow and fade with the underlying emotion. This means these desires are not stable over time, or the desirability function relying on these desires is not coherent in time. In the state of emotion a certain object is desired to a certain positive degree; later its intrinsic desirability is reduced to zero. This is the reason why acts committed in the heat of passion, which rely on such emotionally induced desires, are regarded as irrational. And in the prudentialist desirability theory they are excluded

as a basis of intrinsic desirability because of their instability over time. Further originally intrinsic desires have not been found. So the hedonist desires alone define the intrinsic desirability function of the prudentialist desirability theory.

Notes to Chapter 2

1 An example for densities of probabilities (and not only best estimates) and their relation to mean and median probability is given in: Hourcade 1996, 337. But this kind of precision is an exception in the literature.

2 This section can be skipped without problems for understanding the rest of this inquiry.

3 In the last 25 years many non-linear "utility" theories which use much weaker axioms than those of von Neumann / Morgenstern have been developed. But these theories do not claim to measure any sort of *rational* utility, instead they are intended to explain and forecast factual behaviour.

4 "QALY" is not an expression for the product of duration and just any measure of quality of life (which would include well-being in the above defined sense) but for such products with rather specific measures of quality of life developed in health economics. — Theory: e.g. Broome 1993; Kind / Gudex / Godfrey 1990; Kind / Rosser / Williams 1982; Nord 1992.

5 E.g.: Brandt 1979, part 1; Griffin 1986; Sumner 1996.

6 For the following cf. also: Lumer 1997b.

7 The hedonist desirability function at first has the simple form that the amount of desirability of a feeling is proportional to its integral of intensity over time. But this *simple hedonist desirability function* is not stable with respect to confrontation with further information. Specifically when people are confronted with thought experiments of the experience machine kind (i.e. the information that such things as experience machines might be possible) or with real options of manipulating their feelings, after some reflection, they change their hedonist desirability function step by step in the direction of the *corrected version of hedonism* explained above.

3. Alternative a_1: Business as Usual

3.1. General Features of a_1

For business as usual the Intergovernmental Panel on Climate Change (= IPCC) estimates that the concentration of greenhouse gases, the most prominent of which being CO_2, will double compared to preindustrial levels (= $2xCO_2$) by 2050-2060. This will raise the mean global temperature by about 2.5°C (ranges: 1.5-4.5°C for equilibrium $2xCO_2$ and 1.0-3.5°C for transient warming), but with strong regional differences. For mid-continental areas the actual warming may be about twice the global mean estimate (IPCC 1996a). The sea level will rise, with some delay, by about 50 cm by the year 2100 (Pearce et al. 1996, 189). - Most studies about the social and economic impacts of the greenhouse effect estimate the consequences for the year when $2xCO_2$ will be reached; this may be the case at the beginning or in the middle of the third period (2050-2075). I follow this practice. In addition I generalize the results for this specific year taking them as the mean for the whole period, which might be a good approximation. For the second period (2025-2050) the effects could be supposed to be half as strong as in the third; because of inertia of climate, however, these effects are roughly equal in all considered alternatives, that is why they are ignored here. - The following list attempts to include all major types of possible positive and negative consequences of a_1 for human well-being. Three main categories of effects are distinguished: 1. Rather direct changes in well-being, 2. real economic changes resulting in indirect changes in

well-being, 3. other indirectly caused changes in well-being. This list will be dealt with in more detail below:

Table 3.1

Damages and improvements resulting from the greenhouse effect:

1. *Direct (or approximately direct) changes in well-being:*
   - *1.1. Casualties, decreased life span or their prevention:* due to:
     - *1.1.1. Catastrophes:* floods, high-waters, tropical cyclones, extratropical storms, droughts (famines), other bad harvests, epidemics.
     - *1.1.2. Migration:* strains of migration.
     - *1.1.3. Social conflicts:* ecologic wars, conflicts due to immigration.
     - *1.1.4. Worsened conditions of life:* poverty (increase of food prices),[1] (universal) shortage of water, infectious diseases, air pollution, hot spells; positive: prevention of cold spells.
   - *1.2. Injuries, diseases, deformations, physical pain:* in analogy to 1.1.1-1.1.4.
   - *1.3. Psychic suffering:* in analogy to 1.1.1-1.1.4.
2. *Real economic ("market"), monetary changes, causing indirect changes in well-being:*
   - *2.1. Changes in productivity of the primary economic sector:*
     - *2.1.1. Agriculture:* changes in growth, aridisation.
     - *2.1.2. Forestry:* deforestation.
     - *2.1.3. Fishery:* loss of coastal fishing-grounds.
     - *2.1.4. Energy production:* decrease of hydro-energy.
   - *2.2. Changes in productivity in other economic sectors:*
     - *2.2.1. Water supply:* shortage of usable water.
     - *2.2.2. Leisure and tourist industry:* loss of beaches, shortening of skiing seasons.
     - *2.2.3. Transportation, construction.*
   - *2.3. Property losses:*
     - *2.3.1. Dryland losses:* by inundation of low coastal land, aridisation.
     - *2.3.2. Wetland losses.*
     - *2.3.3. Damages due to extreme events:* hurricanes, droughts, nontropical storms, high waters, hot and cold spells, other catastrophes.
     - *2.3.4. Damages to buildings.*
     - *2.3.5. Forest loss:* dying of forests.
     - *2.3.6. Increased costs of living:* increase of food prices.
     - *2.3.7. (Property) damages by air pollution.*
   - *2.4. Costs of measurements of prevention and compensation:*

2.4.1. Coastal protection: construction of dams.
2.4.2. Energy demand: less heating, more space cooling.
2.5. Economic effects of damages to eco-systems:
2.5.1. Species loss: pharmaceutical value.
2.6. Economic losses through casualties, disease and migration:
2.6.1. Deaths: loss of human capital.
2.6.2. Disease: days of illness.
2.6.3. Loss of human capital due to emigration.
2.6.4. Immigration: costs for integrating immigrants.
3. Other consequences causing indirect changes in well-being:
3.1. Damages to eco-systems and natural spaces: recreational value, existence value.
3.1.1. Wetland losses.
3.1.2. Forest losses.
3.1.3. Species loss.
3.1.4. Other damages to eco-systems: coral reefs, protected ecotopes.
3.1.5. Loss of natural spaces: islands, coasts, lakes.
3.1.6. Decimation of animals.
3.2. Political and social stability: dictatorships, restrictions in liberty rights.
3.3. Damages to cultural goods.

Unfortunately, I have not found any basis for estimating the extent of some of these possible impacts; therefore, I shall not discuss them in detail. Some of these uncertain impacts could be rather irrelevant: decrease of hydro-energy (2.1.4), damage to buildings e.g. due to decreased ground-water level (2.3.4), losses for the tourist industry (2.2.2), transportation and construction (2.2.3), damage to cultural assets, e.g. destruction of historic buildings by storms or decreased ground-water levels (3.3). But the other uncertain impacts may well be important: ecological wars (e.g. for water resources, cf. 1.1.3), deaths and suffering from diseases other than malaria (part of 1.1.4; 1.2.4), dryland losses through aridisation (cf. 2.3.1), loss of human capital by death (2.6.1) and by emigration (2.6.3), dictatorships and restrictions in liberty rights arising from social conflicts (3.2).

3.2. Direct Losses in Well-Being: 1. Casualties

1.1.1. Casualties due to natural disasters: The most important category of damage is the dead. There are several ways people may be

killed by $2xCO_2$. *Floods and storms:* A rise in the global mean temperature of 2.5°C will lead to turbulence in the global weather. There will be more tropical cyclones and a rise in their destructive power, affecting not only inland areas but also leading to major inundations of coastal areas - which has often been the case in Bangladesh. (E.g. in April 1991 a cyclone caused a six-meter-high storm surge which penetrated far inland and killed 200,000 people (Myers 1993, 753; Der Spiegel 1991, no. 19, p. 181; no. 20, pp. 197-207)). Monsoons will be more abundant causing more river floodings like in China in August 1998. From 1989 to 1992 worldwide 42,000 people died annually from extreme weather events (Pearce et al. 1996, 202). Fankhauser assumes an increase in damages due to extreme weather events of 42% (Fankhauser 1995, 53). This would result in 17,640 additional casualties per year or 441,000 in the 25 years of the third period. - *Famines:* Global warming will have positive effects on agriculture in some parts of the world, and negative in others, in particular in areas at low latitude, where most of the developing countries are situated. The net effect for the whole world will probably be negative,[2] whereas the population will increase to about 10 billion people (Myers 1993, 757; Pearce et al. 1996, 190; Fankhauser 1995, 35). In this already strained situation droughts and other events could drastically aggravate the situation. Myers (1993, 757) quotes estimates by Daily / Ehrlich that three times in ten years there may be a shortfall of 10% in global crop yields, which will lead to huge catastrophes in developing countries because international aid will be available to a much lesser extent than today. Though their estimate that this will lead to 50-400 million casualties each time seems to be exaggerated, a tenth of their lower bound, i.e. 5 million casualties three times in ten years, might be a reasonable figure, resulting in 37.5 million deaths from famines in 25 years.

1.1.2. Casualties of migration: Floods, loss of coastal land, famines, aridisation will force many people to leave their homelands. Myers (1993, 757) estimates that $2xCO_2$ will lead to 150 million additional environmental refugees with a large part of them emigrating. Corrected for some errors [3] Myers' estimates amount to 104.6 million additional refugees caused by $2xCO_2$ spread over the 25 years of the third period.The psychic hardship caused by emigration is considerable, it will be treated below. What has to be considered here are casualties brought about by migration. And according to many experiences in the recent past, migration, in particular of poor people, costs a high death toll, namely by: exertions of migration (exhaustion, malnourishment during migration, disease, death from exposure to cold or thirst etc.), departure in disorder (children and old people getting lost in the

crowds, people are stampeded to death or hit by cars ...), bad means of transport (sinking of ships with refugees), danger in being smuggled across the border (being left helpless or being killed for greediness etc.), killing by border guards of immigration countries, robberies etc. I consider that a figure of 1% of all environmental refugees to be killed in the course of their migration is a rather conservative estimate. We must reckon then with 1,046,000 additional people being killed during migration.

1.1.4. Deaths from deteriorated conditions of living: Poverty and famine: The already mentioned decline in the food supply will involve increases in world food prices, according to some estimates, in the order of 40% or more (Pearce et al. 1996, 190). This in turn will raise the number of people at risk of dying from hunger from a baseline of presently 640 million by about 10%, i.e. 64 million (ibid.; Fankhauser 1995, 36). Today 14 million children under 5 years of age die from deficiency diseases and infections resulting from them every year (Singer 1993, 218). If we add perhaps half as many older children and adults dying from hunger, an increase of 10% of the people at risk of dying from hunger would mean: annually 2.1 million additional people actually dying from absolute poverty induced by $2xCO_2$ or 52.5 million people in the 25 years of the third period. - *Infectious diseases:* The conditions for several diseases will be "improved" by global warming: malaria, cholera, bacterial dysentery, amoebiasis and diseases transmitted by hookworms. I have found global estimates only for malaria. Malaria is restricted to areas where daily temperatures are above 16°C throughout the year. By benchmark warming the boundary of the area where this condition holds will extend some 400 km to both sides of the equator, exposing an extra 200 million people to the risk of malaria (Hohmeyer / Gärtner 1992, 38). Hohmeyer and Gärtner estimate that this will result in 10 million additional malaria infections per year and that 50,000 of these infected people will die (ibid.). That is 1.25 million additional deaths from malaria in the 25 years of the third period. - *Hot spells:* Although global warming will reduce the number of people dying from cold it will increase the number of hot spells, which leads to an increase of heat-related deaths from coronary disease and stroke. Unfortunately, the net effect will be negative. Fankhauser (1995, 46), relying on Kalkstein's calculations for the US, estimates an increase of 27 deaths/million annually and therefore assumes in the countries that do not belong to the OECD (=NOECD) an increase by 114,804 casualties (the ex-SU contributing 7,722) and within the OECD an increase by 22,923 casualties per year due to the warmer climate. These figures seem to be plausible for the OECD, but too high for the ex-SU and too low for the rest of the NOECD-countries, where there

are only few possibilities of space cooling. Correcting these implausibilities, i.e. assuming a zero-increase for the ex-SU and for the rest of the NOECD an increase which is twice as high as assumed by Fankhauser, the result is: 237,087 additional deaths/year (NOECD: 214,164 deaths/year; OECD: 22,923 deaths/year) from heat-related diseases or 5,927,175 deaths in the 25 years of the third period.

Discussion of indirectly, economically caused damages (which fall into category 2) will reveal a further 59,000 casualties due to pauperization by economic ruin. Summing up all these figures there will be about 100 million additional deaths in 2050-2075 by option a_1.

Table 3.2

a_1: 2050-2075: additional deaths during 25 years by $2xCO_2$:	
floods and storms	441,000
famines due to crop failures (droughts)	37,500,000
migrants during migration	1,046,000
absolute poverty, malnutrition due to increased prices	52,500,000
malaria	1,250,000
hot spells	5,927,175
absolute poverty due to economic ruin	59,197
sum	98,723,372

3.3. Insertion: Methods of Hedonistically Measuring Personal Gains and Losses

How do death and other kinds of damages have to be valued from a personal point of view, in particular hedonistically? *(Strong) rational hedonism* above (in sect. 2.2) was defined as the view that exactly a person's feelings have intrinsic desirability for that person, i.e. desirability for its own sake, independently of any consequences. With "*feeling*" thereby bodily feelings, emotions and moods are meant. Pleasant feelings have positive intrinsic desirabilities, unpleasant feelings have negative intrinsic desirabilities. And their amount of intrinsic desirability is equal to the integral of their intensity over time. The intensity of positive and negative feelings at a certain time plus the (positive respectively negative) sign for pleasant respectively unpleasant feelings here is called the person's "*well-being*" at that time. So the intrinsic personal desirability of a certain section of a life is equal to the integral of well-being for that section. The *total personal*

desirabilities of other things than feelings are equal to the amount they change the intrinsic desirability of this person's life. (The *total desirability of a feeling* is equal to the sum of its intrinsic desirability and the amount of its influence on the intrinsic desirability of the rest of the respective person's life.) So total desirabilities are calculated relying on the intrinsic desirabilities and the empirical knowledge about causation of hedonic events (feelings).

Losing one's life by force, injuries etc. means losing possible positive life events, i.e., from a hedonistic point of view: losing all sorts of possible pleasures and pains. And the loss due to death is equal to the integral of the expected well-being during the lost time. So, for calculating the individual desirability loss due to death we must know the expected mean of the person's well-being and the time in which this well-being would occur and then multiply these two figures. Assuming that premature death would strike the members of the mentioned groups according to a symmetric pattern of age (e.g. killing more children and elderly people and fewer people of an intermediate age) the mean time lost by one death would be equal to the half of the life expectancy of that group. The life expectancies taken as a basis for the following calculations are 76.31, 65.01 and 62.92 years for the OECD, the world and the NOECD respectively (my own calculations from: UNO 1997, 93-100); so one mean person in these countries would lose about 38.16, 32.51 and 31.46 years respectively.

For certain ethics, which treat gains and losses for differently situated people differently, in particular ethics which, like utilex, give more weight to gains and losses of people badly off, the information about desirability losses does not suffice: the individual desirability of the originally expected life must be known as well. This holds because these ethics can value directly only whole lives; the moral desirability of a single event can be calculated only indirectly by comparing the moral desirability of the life with this event with the moral desirability of the life without this event. (This derives from the fact that the moral desirability function above individual desirabilities is not linear. Applying the moral desirability function simply to the individual desirability of the event in question, therefore, usually leads to a different result compared to calculating the difference between the moral desirabilities of the life with respectively without the event. For utilitarianism instead these two ways of calculating moral losses make no difference because the utilitarian moral desirability function is linear, i.e. the moral desirability is proportional to the individual's utility.) Therefore, in the following collections of data for every type of damage always 1. length and 2. average well-being of the originally

expected life have to be estimated as well as 3. the individual reduction in well-being and 4. its duration and, of course, 5. the number of people affected (cf. tables 3.5, 4.4-4.6). (The reduction inflicted by death is a reduction to a zero level of well-being during the lost years.) The individual desirabilities of the undamaged and (by simple subtraction of the loss) of the damaged or shortened life can be calculated from this information. (Then the moral desirability function is applied to these individual desirabilities, and finally the difference of the two moral desirabilities is calculated.)

Data about life expectancy are easily available. Quite the contrary holds true for data concerning individual means of medium or long term well-being because the data needed should fulfill the following conditions: 1. Over a long period 2. the subjective well-being, i.e. the subject's present hedonic state, in particular his good or bad mood (and not his life satisfaction or subjective valuation of other things), 3. is measured on a cardinal level; 4. this has to be done for a sufficiently large sample of the group involved so that the social distribution of the individual average or long term levels of well-being can be calculated. The social distribution and not only the social mean is needed because again for some non-utilitarian ethics this makes a difference: If moral desirability is not proportional to individual desirability the moral desirability of two lives with a mean well-being of e.g. 0.1 and 0.3 respectively may be different from (in fact smaller than) the moral desirability of two lives with a mean well-being of 0.2 each.

The best data I have found, which come closest to these conditions, are those of Wessman et al. (Wessman et al. 1960), who collected means, minima and maxima of daily moods of 21 subjects during 42 days. In the following all levels of well-being are normalized in the interval [-1;1] with 1 being the most pleasurable state within reach under optimum conditions, -1 being the contrary and 0 being a neutral state of zero intensity of all feelings. I call the units of levels of well-being normalized in this interval "*well-being intensities*" or "*wi*" for short. Via some plausible assumptions the data of Wessman et al. then can be interpreted like this: the social distribution of the medium-term means of well-being is a normal distribution with a grand mean of μ=0.142wi and a standard deviation of σ=0.109wi. This means that 50% of the people have a medium-term mean level of well-being above 0.142wi and 50% below 0.142wi; 68.27% have a medium-term mean level which lies in the interval $[\mu-\sigma;\mu+\sigma]$, i.e. in our case [0.033wi;0.251wi]; and 95,45% have a medium-term mean level out of the interval $[\mu-2\sigma;\mu+2\sigma]$, i.e. in our case [-0.076wi;0.360wi]; only 7.36% have a medium-term mean level above 0.3wi.

The grand mean and the standard deviation have been calculated from the data reported by Wessman et al. in this way: Wessman et al. asked 25 students to record their best, worst and average mood of the day on a scale with mood descriptions every night for six weeks. Subsequently these were numbered from 1 to 10 with 5 being the highest negative mood and 6 being the lowest positive mood, so that 5.5 corresponded to neutrality. The descriptions of the moods were chosen so that there would be approximately equal subjective gradations between units, and the ends of the scale would be so extreme that few subjects would experience them and only on rare occasions (Wessman et al. 1960, 118). Because of this scale construction I have interpreted the rating values as representing cardinal values. The individual means of the daily ratings of "average mood for the day" over the entire period varied from 5.43 to 7.37 with 6.14 being the mean and the medium of the means; only one subject had an average mean below 5.5 (Wessman et al. 1960, 120). Translating these figures from the interval [1;10] by positive-linear transformation in the interval [-1;1] minimum and maximum of the average moods are -0.016wi and 0.416wi respectively; and the grand mean and medium is 0.142wi. Because the single values of the distribution we are looking for already consist of (medium-term) means of (daily) means (so that it is rather improbable that they contain exotic runaways) and because the mean is equal to the social medium this distribution probably is a normal distribution. Unfortunately, Wessman et al. do not report the standard deviation. Therefore, I have estimated the standard deviation this way: The reported data are from 21 subjects (N=21). Therefore, the probability of finding more extreme individual means than the two obtained (-0.016wi and 0.416wi) roughly could be 1/2N = 1/42 in both cases. The standard deviation of the normal distribution then can be calculated in such a way that the integral of this distribution from -1wi to -0.016wi equals 1/42 or that the integral from 0.416wi to 1wi equals 1/42. The standard deviations obtained with this sort of calculation are 0.080wi and 0.138wi respectively; the mean of these figures, i.e. 0.109wi, then has been taken as the actual standard deviation.

These data imply that 9.63% of the population has a medium-term mean level of well-being below zero. This makes it probable that the variance of the long-term (in particular the lifelong) mean level of well-being - which we are interested in - is smaller than the variance of the medium-term mean just calculated because otherwise it would be rational for at least 9.63% of the population to commit suicide, which is far too much. Simply taking the variance of the medium-term mean as an approximation of the long-term mean's variance would lead to strange results; so we cannot simply ignore this error. (E.g. for 9.63% of the population to be killed by the consequences of the greenhouse effect would be *good*; this would hold for even higher percentages in groups worse off than the mean, thus reversing the effects one has hoped to obtain by welfare ethics containing justice components.) Therefore, in the following the variance of the medium-term mean is used as an approximation of the lifelong variance only in combination with a *discontinuance hypothesis* for correcting such errors. This hypothesis states that there are no lifelong mean levels of well-being below zero because people who risk arriving at this level due to an

expected mean decline of their well-being below zero during the rest of their life would commit suicide; furthermore the virtual percentages of lifelong mean levels of well-being below zero are taken as percentages of lifelong mean levels of zero. The discontinuance hypothesis seems to be plausible (independently of the present context); the only remaining problem is that it has to correct a virtual distribution of well-being which is only a rough approximation of the distribution of the lifelong means of well-being.

The distribution of lifelong means of well-being obtained so far is an *ordinary* distribution for normal circumstances, which can be taken as the baseline for eventual reductions.[4] Common hardships of every type other than death lead to a more or less dramatic reduction of the ordinary mean for some time, in extreme cases for the whole life. It is assumed that the variance is not affected by such hardships, i.e. all members of that group suffer the same *diminution* of well-being (they are not reduced e.g. to a certain absolute level of well-being). This is not quite the truth but a reasonable approximation. Diminutions of well-being in some group from an original distribution of well-being with the mean $\mu=x$ (and the variance $\sigma=0.109wi$) to a distribution with the mean $\mu=y$ ($\sigma=0.109wi$) here simply are called "*reductions of well-being from x to y*" or "*reductions of well-being by x-y*".

The hardships, apart from death, that are the most important in the following calculations quantitatively are poverty and income losses. The best data I could get about well-being in these types of life situations are the representative surveys by Campbell (1981) in the USA which relate subjective well-being to family income. Translating his results in the framework established so far leads to the following means of well-being: the social means of the individual means, i.e. the grand means, of well-being of the highest, second, third and lowest income quartile were 0.1655wi, 0.1494wi, 0.1352wi and 0.1145wi respectively. Another important grand mean of well-being which can be calculated from Campbell's results is that of the unemployed; it is 0.0643wi. According to Campbell, well-being of the unemployed is nearly independent of their income (Campbell 1981, 122) and is not due to low income or financial problems (ibid. 120). Rather their very low level of well-being originates from the feeling of having been deceived by life, leading a particularly hard life and not being able to control their lives (ibid. 121 f.). This feeling may be similar to the experience someone has when e.g. losing all his property because of natural disasters. Therefore, the grand mean of well-being of 0.0643wi in the following will also be used for estimating the impact of events of this type on well-being.

In national surveys undertaken in 1957, 1971, 1972, 1976 and 1978 with at least 2164 participants each (Campbell 1981, 241) Campbell asked people, among other things, for their family income and: "Taking all things together, how would you say things are these days - would you say you're very happy, pretty happy, or not too happy these days?" (ibid.). Cumulating the results of all five surveys the percentages were the following (cf. table 3.3):

Table 3.3

Subjective well-being related to income:

family income	ratings in %			
	very happy	pretty	not too	sum
highest quartile	37.77	57.77	4.47	100.01
second quartile	32.28	61.48	6.24	100.00
third quartile	27.77	62.40	9.83	100.00
lowest quartile	21.80	61.26	16.95	100.01
mean	29.91	60.73	9.37	100.01

(Own calculations on the basis of: Campbell 1981, 241)

Taking the means of the last line of table 3.3 as a basis the quantitative interpretation of the expressions "very happy", "pretty happy" and "not too happy" with respect to the interval [-1; 1] can be calculated so that the percentages of the last line are equal to three adjacent integrals of the ordinary distribution of well-being (with μ=0.142wi and σ=0.109wi). According to this method, the three expressions can be attributed to the following intervals of well-being: very happy = [0.1995wi; 1wi]; pretty happy = [-0.002wi; 0.1995wi]; not too happy = [-1wi; -0.002wi]. (So "not too happy" roughly means "unhappy", i.e. having a well-being below zero; "very happy" means having a well-being above 0.2wi; and "pretty happy" covers the well-being in between. "Feeling pretty good" in the rating scale of Wessman et al. (1960, 118) corresponds to [0wi; 0.2wi] too; so we have a good confirmation of the quantitative interpretation obtained with the method just described.) The quantitative interpretations of the three expressions "very happy", "pretty happy" and "not too happy" finally are used to calculate the grand means of well-being of the four income groups: The variance is taken to be equal to that of the ordinary distribution (i.e. σ=0.109wi); the (grand) mean then is chosen so that the integrals from -1wi to -0.002wi, from -0.002wi to 0.1995wi and from 0.1995wi to 1wi are equal (or nearest, minimizing the sum of the three differences) to the percentages in the four middle lines of table 3.3. (The highest sum of the errors was 0.054 for the lowest quartile.)[5]

For calculating the grand mean of well-being of the unemployed a similar method was used: Campbell reports the portion of the unemployed who in his 1971 and 1978 surveys considered themselves as "very happy", namely 12% and 10% respectively (Campbell 1981, 120). Calculating the means according to the number of people interviewed leads to 10.74% very happy unemployed people. Again interpreting "very happy" as well-being above 0.1995wi and retaining the variation σ=0,109wi the grand mean now can be calculated on the basis of the condition that the integral from 0.1995wi to 1wi of the function looked for has to be 0.1074. The result is μ=0.0643wi.

The results of these methodological considerations now have to be applied to the valuation of casualties calculated in the last section. Floods, storms and hot spells with fatal effects may take place in OECD as NOECD countries alike so that a population with the world mean life expectancy (65.01 years) is afflicted (cf. table 3.5). The other causes of casualties (i.e. famines due to crop failures, migration, absolute poverty, malaria) are present nearly exclusively in NOECD countries so that the NOECD mean life expectancy (of 62.92 years) has to be applied here. Additional casualties due to absolute poverty will afflict only people who are already very poor and therefore have a long-term mean level of well-being at least as low as that of the lowest income quartile (i.e. μ=0.1145wi). All the other casualties caused by the greenhouse effect instead may occur in all social groups, i.e. in a population with the ordinary distribution of well-being (with μ=0.1420wi).

3.4. Direct Losses in Well-Being: 2. Injuries, Diseases, Directly Caused Psychic Suffering

1.2.1-4. Injuries and diseases: In all above mentioned events leading to deaths additional injury or illness of other people is quite likely. (This is quite clear for malaria, as the numbers of deaths from malaria are derived from the number of infected persons.) There are hardly any figures in the literature regarding this category of damage. Prevailing data, however, give clues for informed guesses. *Reductions in physical well-being through catastrophes, migration and heat-related diseases:* The amount of injuries and illnesses due to flood and storm catastrophes, acute famines, exertions of migration and heat stress can be guessed by the number of deaths. Death is regarded here as the tip of an iceberg. That is to say in all these catastrophes death occurs from relatively short extreme stressful events so that one group of the victims does not survive; others manage to survive badly injured or ill. According to this iceberg-hypothesis, physical injuries correlate roughly with the number of deaths, only higher. For each death I presume ten people to be severely physically injured with diminished well-being matching an average of ten days (=0.027 years) of reduction of well-being from the level of the ordinary distribution (with μ=0.1420wi) to the level of the distribution where 0 is the mean (cf. table 3.5 [6]). - *Malaria:* Symptoms of malaria are fever, chills, headache, myalgia, splenomegaly, anaemia. The disease occurs in attacks of different regular intervals, each lasting one day. Febrile attacks occur every second day in malaria tertiana, every third in malaria quartana,

irregularly in malaria tropica. Untreated, attacks will continue for weeks. The most dangerous form is malaria tropica, where the symptoms depend on which organs are involved. (Cerebral malaria can lead to paralysis, delirium, coma, death; pulmonal malaria to haemoptysis, gastrointestinal malaria can finally result in renal failure, etc.) (Petersdorf et al. 1983, 1190.) These are the qualitative descriptions. But what is the effect on the amount of well-being? On feverish days the level of well-being might be reduced from the level of the ordinary distribution (μ=0.1420wi) again to 0wi or slightly more, while it could be hardly reduced on other days, so that this may be ignored. Taking "several weeks" to average six weeks, which can be reduced by treatment to four weeks and taking three days as mean length of one cycle, this leads to an average of 28/3 days (or 0.026 years) of reduction of the ordinary well-being by 0.1420wi per malaria infection. This holds for 9,950,000 additional non-lethal cases of malaria per year (Hohmeyer / Gärtner 1992, 38), i.e. 248.75 million cases in 25 years (cf. table 3.5). - *Air pollution:* Rise in temperature leads to increased emissions of HC, NO_x and SO_x and to an increase in the ozone concentration, which in turn may lead to health problems and damage to physical objects e.g. via corrosion. Fankhauser (1995, 48) estimates that $2xCO_2$, by air pollution, leads to monetized damages of about 15 bn. US-dollars/year, the bigger part of which being damage to human health. In a somewhat speculative way these monetary damages may be 'rewelfarized';[7] the results of this calculation are 477 million cases of 0.013 years reduction from the ordinary level to 0wi due to air pollution induced by the greenhouse effect.

1.2.4. Absolute poverty and hunger: Malnutrition caused by absolute poverty has various terrible impacts on human well-being, even if it doesn't lead to death. Many of these people constantly suffer from hunger-pangs; others suffer from deficiency diseases and infections which could be avoided by better nourishment, e.g. goitre, or vitamin A deficiency induced blindness. Malnutrition in infants inhibits their psychic and physical development (Singer 1993, 218-220). The effects on the subjective well-being are hard to estimate, in particular because subjective well-being is usually investigated only in richer countries (cf. fn. 4); therefore, I have only estimated the levels of well-being. The group afflicted by this further deterioration of the conditions of life are the poor people of the NOECD countries with a starting position of 62.92 years life expectancy and a distribution of well-being with 0.1145wi being the mean. The most terrible effect seem to be hunger-pangs. They do not reduce well-being to a grand mean of 0wi permanently but perhaps to a level half as high as that of the unemployed, who have a grand mean of 0.0643wi (see above), i.e.

0.03wi (the reduction then amounts to 0.0845wi). This could be true for all the 25 years of the third period and 10% of the additional 64 million people suffering from malnutrition. Deficiency diseases may affect another 40% of the 64 million people (= 25.6 million people) leading to a permanent but not that dramatic decrease so that the reduced grand mean may be a bit higher than that of the unemployed, perhaps 0.08wi (so that the reduction amounts to 0.0345wi).

1.3.1. Psychic suffering through catastrophes: Psychic suffering from the effects of $2xCO_2$ is practically ignored in the literature. So the following considerations will be very tentative. - *Sorrow for and psychic losses due to deaths:* For everybody dying from catastrophes like floods, storms and famines there will be, on the average, several (I assume 10) partners, relatives and friends mourning for the lost person (altogether 379.41 million people with an originally ordinary distribution of well-being). Of course, the victim would have died anyway some day in the future; but the mourning will be more intense around someone who is killed in the middle of his life than if he dies naturally at a ripe old age having finished his life-projects. This additional sorrow may be equal to 60 days (= 0.164 years) of a 0.035wi reduction in well-being (which is approximately equal to the difference in well-being between the richer and the poorer half of the population). In addition to that, the bereaved suffer from a greater loss due to the unnatural death of dear ones who have greatly contributed to their well-being and cannot be easily replaced because of their shared history. Naturally, this is strongest for persons who have lost their children, parents, or partner. Per deceased I assume two such persons (altogether 76 million) whose well-being is reduced again by 0.035wi but over two years. This second group is a subset of the first group. Therefore, we have to split up the first group into two groups: one group (let us say the close friends) which is afflicted only once; the other group (children, parents, partners) which is afflicted twice. For the second group the losses have to be added. It is important to be exact in this respect because in welfare ethics with a nonlinear moral valuation of individual desirabilities it makes a moral difference if two persons are afflicted or if one person is afflicted twice by the same loss.

1.3.2. Misery of migrants: Refugees usually suffer from their fate for a very long time: Not only do they lose most of their property, often they also lose their relatives, their home country, their familiar cultural and linguistic surroundings to move into a rather hostile environment, where it is difficult to find work and housing and to work their way upwards. Under these premisses the level of well-being of the 103.6 million surviving migrants (with an originally ordinary distribution of

well-being) will supposedly be reduced in the long run - stronger at the beginning, decreasing slowly. More precisely, in the first thirty days (= 0.082 years) there may be a 0.1000wi decrease, in the rest of the first year a 0.0777wi decrease (which is equal to the reduction suffered by unemployed) and for further 10 years a 0.0340wi decrease in well-being. To these losses for 10% of the refugees (i.e. ten times as many as were supposed to die during migration) we have to add the losses by injuries and diseases according to the iceberg-hypothesis (i.e. a reduction by 0.1420wi for 0.027 years). So we have to split up the group of the 103.6 million surviving migrants in 10.45 million with this additional loss and 93.09 million without it.

1.3.3. Psychic suffering through worsened social climate: Huge numbers of immigrants may cause social problems in the countries of immigration. Fear of immigrants, rougher domestic climate, increased crime rates, fear of wars etc. could lead to a measurable decrease of well-being for some people (e.g. not feeling safe in their homes or fears for the future). These problems are dealt with individually in very different ways; many of the poorest will hardly be affected by it. Counting one half of the population to be objectively unaffected by such problems and one half of the other half not reacting, this results in one quarter of the world population (1.5 billion) with impairment of well-being - even if only to a lesser extent. This small extent might consist of a 0.0170wi decrease in well-being (which is equal to the difference in well-being between two adjacent income quartiles) for half an hour per week. (This amounts to 0.112 years (= 25·(0.5/(16·7))) during 25 years if we take into account that all the well-being assumptions refer only to the 16 waking hours of the day.)

1.3.4. Psychic suffering by worsened conditions of life: For many people increased food prices and water shortages will lead to noticeable reductions in well-being. This category of damages will be dealt with together with similar discomforts due to economic losses (category 2).

3.5. Economic Losses and Their Influence on Well-Being

3.5.1. Economic Losses

Real economic damages through $2xCO_2$ are the major concern of cost-benefit analyses. Therefore, a huge wealth of literature, though only few global studies, exist on this topic. But as will be shown below, from a welfarist point of view these losses are not that important when compared with the losses already mentioned (about 5% of all damages).

For that reason I shall devote much less space to this topic and mostly rely on calculations by Fankhauser (1995), eventually correcting his estimates. - The final results of these corrected estimates are given in table 3.4, columns 2 and 5. The total loss is 165 bn US-dollars/year for the whole world, 61 bn for NOECD countries and 105 bn US-dollars for the OECD.

Table 3.4

a_1: 2050-2075: Economic damages per year through 2xCO_2 in billion US-dollars$_{1990}$ in the year 2050 and the socialized portions of these costs:

1	2	3	4	5	6	7
Cause or sphere of damage	NOECD			OECD		
	total costs BD	soc. fract. %	soc. costs BD	total costs BD	soc. fract. %	soc. costs BD
agriculture	16.011	0	0.000	23.130	90	20.817
deforestation	1.932	0	0.000	7.204	90	6.484
estuarine fishing	1.298	0	0.000	5.006	90	4.505
water supply	11.900	0	0.000	34.849	0	0.000
coastal dryland losses	10.621	0	0.000	8.084	90	7.276
wetland losses	7.346	0	0.000	8.466	90	7.619
natural disasters	0.300	0	0.000	1.100	90	0.990
air pollution	1.752	0	0.000	5.949	0	0.000
coastal protection	1.037	100	1.037	0.994	100	0.994
loss of species	3.000	100	3.000	4.000	100	4.000
diseases and injuries	2.331	0	0.000	2.619	90	2.357
integration of immigrants	3.453	100	3.453	3.103	100	3.103
sum	60.981	12.3	7.490	104.504	55.6	58.145

2.1.1. Agriculture: In some areas of the world the effect of benchmark warming on agricultural productivity is even positive, but much more often it is negative. Reductions in crop yields result from heat stress, reduced soil humidity, increases in pests and diseases (Pearce et al. 1996, 189 f.). The effect of C-fertilization will be minimal (ibid.). Fankhauser estimates losses of about 39 billion US-dollars per year for the whole world (Fankhauser 1995, 36). This estimate is adopted in table 3.5.

2.1.2. Forestry: Relying on Sedjo and Solomon, Fankhauser estimates that forests in boreal and temperate zones will be reduced by 9.6% and that tropical forests will extend by 5.2% from benchmark warming (Fankhauser 1995, 36; Fankhauser's estimates are also adopted by Pearce et al. 1996, 204). But an extension of tropical forests seems to be rather unrealistic: Where would the necessary space come from, in particular if one thinks of the deforestation already taking place? Correcting this there will be losses of 1,268,020 km^2 of

forests in the NOECD and 901,000 km^2 in the OECD. Fankhauser capitalizes these losses with 2000, 400 and 200 US-dollars/km^2 in high-, medium and low income countries respectively (Fankhauser 1995, 37; Pearce et al. follow him: 1996, 192). If these figures are applied to the forest losses mentioned above the monetary losses would be 0.483 bn US-dollars/year in the NOECD and 1.801 US-dollars/year in the OECD. But Fankhauser admits that his calculations hold only for equilibrium damages, whereas transition damages may be much higher (Fankhauser 1995, 37). Therefore I have multiplied the last figures by 4; the result can be found in table 3.4.

2.1.3. Fishing: Fankhauser reports estimates that rising sea levels may reduce estuarine catches by 8% thus leading to losses of 4.326 mill. t in the NOECD and 2.503 mill. t in the OECD (Fankhauser 1995, 38 f.; Pearce et al. 1996, 204). Taking 300 US-dollars/t in the NOECD and 2000 US-dollars/t in the OECD as the price of raw fish this would imply losses of 1.3 bn US-dollars/year in the NOECD and 5 bn US-dollars in the OECD.

2.2.1. Water supply: In high latitude regions water run-off is projected to increase due to increased precipitation, whereas lower latitudes could experience decreased run-off due to the combined effects of increased evapotranspiration and decreased precipitation. The current arid and semi-arid regions, in particular, could experience the largest decreases in run-off. (Pearce et al. 1996, 193.) Fankhauser assumes a worldwide reduction by 7% for the current annual water withdrawal, multiplies the obtained absolute losses with current prices and thus calculates economic losses of 11.9 bn US-dollars/year for the NOECD and 35 bn US-dollars/year for the OECD. Being rather simplistic, because it does not account for increasing prices and secondary damages, this calculation still is the best estimate I could find.

2.3.1. Dryland losses: Fankhauser assumes that all densely populated coastal zones will be protected against the rising sea. According to this assumption, e.g. in China no land will be lost because all coastal zones are densely populated (in the sense of the definition); on the other side the northern coast of the former SU will remain almost entirely unprotected. Then measuring the length of sparsely populated, low-lying coastlines and taking 0.46 km^2/km as the average loss Fankhauser estimates that in the NOECD about 100,000 km^2 and in the OECD about 40,000 km^2 will be lost to the rising sea. (Fankhauser 1995, 30.) But the assumptions of this calculation seem to be too optimistic. Firstly, NOECD-countries often are too poor to be able to pay the assumed measures of protection; secondly, most of the biggest low lying deltas, which are very difficult to protect, are in the developing world. Therefore, in the NOECD, except the former SU, at least double the losses seem to be realistic, i.e. about 176,000 km^2. A monetarization of these losses which follows Fankhauser's [8] leads to losses of about 10.6 bn US-dollars/year for the NOECD and 8 bn US-dollars/year for the OECD. Note: these figures do not contain economic losses from aridisation. But a big part of the latter losses is already contained in the agricultural damages.

2.3.2. Wetland losses: Wetland losses are the higher the better a coast is protected against the sea (Fankhauser 1995, 31). The services and benefits deriving from coastal wetlands are manifold and comprise among others: commercial fishing, recreation, furs, flood protection, salinity balance, life support for migratory birds and fish, landscape value (ibid. 32). Fankhauser

assumes a loss of 33% of all coastal wetlands by the rising sea and capitalizes these losses (e.g. with 5 million US-dollars/km^2 for the OECD and a rent of 10%) and thus calculates monetized losses of about 14.7 billion US-dollars for the NOECD and 16.9 billion US-dollars for the OECD (Fankhauser 1995, 32). But both estimates seem to be too high for our purposes: The reasons for this are that monetarization contains many non-economic losses, which will make up a much bigger portion in the OECD; and that for the NOECD we had already assumed higher dryland-losses so that the lost area of wetland may be smaller than Fankhauser assumes. In accounting for these deviations, in both cases I assume losses only half as high as Fankhauser.

2.3.3. Economic damages from natural disasters: The causes for an increase in natural disasters by $2xCO_2$ have been explained above. Tol estimates such additional economic damages at 0.3 bn US-dollars/year in the NOECD and at 1.1 bn in the OECD (Tol 1995, 369).[9] - Forest losses are already included in the changes in forest productivity (2.1.2). The analogue holds for the rise of food prices (cf. 2.1.1). But the problem with this category of damages is that losses in consumer surplus are, to a great extent, gains in producer surplus because the decrease in the food supply leads to higher food prices, which are only partly due to more expensive ways of production. Therefore, even an economically neutral result may imply big welfare losses.

2.3.7. Air pollution: Estimates of monetized damages due to increased air pollution above had been split into health and economic damages (cf. footnote 7). The remaining economic damages are: 1.8 bn US-dollars/year in the NOECD, and 5.9 bn US-dollars/year in the OECD.

2.4.1. Coastal protection: For estimating the total expenses for the protection against a 50 cm rise in the sea level Fankhauser multiplies the figures calculated by Delft-Hydraulics for a 1 m rise by $0.5^{1.28}$=0.41; the resulting 103.73 billion US-dollars for the NOECD and 99.41 billion US-dollarss for the OECD then are distributed over 110 (1990-2100) years and discounted. (Fankhauser 1995, 28-30.) In the present calculation discounting will only be considered below; and part of the 110 years has already gone by. Therefore, for determining the mean annual protection costs the total costs assumed by Fankhauser are simply divided by 100, obtaining about 1 bn US-dollars/year for the NOECD and the OECD each.

2.4.2. Energy demand: In US studies of climate costs increased energy demand due to augmented space cooling is always a big item (Fankhauser (1995, 40): 20.5 bn US-dollars/year for the whole world). And savings in winter heating do not get enough attention. The first is partly due to an incorrect generalization about the American way of life. So European estimates are completely different. Pearce et al. (1996, 194) quote a British study which calculates 32 bn ECU/year net *gains* from a 3°C increase in mean temperature - but only for the European community. So, the assumptions in the literature are rather contradictory. Perhaps the net-effect is 0 for the whole world. Therefore, this item is ignored in the present estimate of economic losses.

2.5.1. Species loss: 1/10000 to 1/1000 plants may have pharmaceutical value which, for the US, is estimated to be at least 300 mill. US-dollars/year and species. Pearce et al. estimate that the number of 60.000 plants expected to become extinct in the USA in the following 50 years may be increased by 10%,

thus obtaining annual losses of 1-18 bn US-dollars/year for the USA alone. (Pearce et al. 1996, 200 f.) Unfortunately, I have not found suitable figures for the whole world;[10] therefore, I venture a rough estimation of the magnitude for the world. Extrapolating the estimates for the USA by population, the losses for the OECD may be four times as high as those for the USA alone, and for the NOECD 20 times as high. But the latter figure must be multiplied by 15%, accounting for the smaller purchasing-power parity of the NOECD. Conservatively taking the lower limit of the individual loss (i.e. 1 billion dollars for the USA) as the real value, the damages would be 3 bn US-dollars/year in the NOECD and 4 bn US-dollars/year in the OECD.

2.6.2. Economic losses due to disease and injuries: The above estimates of losses due to diseases and injuries (summarized in table 3.5) imply that at least 24.867 million years of severe illness in which people cannot work will be lost. This figure can be used as a basis for calculating at least the lower limit of the economic loss through disease and injuries. However, this calculation does not include the costs of medical treatment, but only the economic losses because of lost working days. The calculation is based on the following additional assumptions. Each year of a reduction to 0wi by disease and injuries (group 1.2 (plus 1.3.c1) of table 3.5) counts for one year of disease. Half of the population does work in an economic sense. The all embracing mean gross salary (including taxes, social security etc.) may be 36,500 US-dollars/year in the OECD and 15% of this sum (i.e. 5475 US-dollars/year) in the NOECD. 95% of the injuries and diseases due to floods, storms and malaria could occur in the NOECD. The potential for heat-related diseases is proportional to population; but the possibilities for protection are better in the OECD. Therefore, 90% of the heat-related diseases may occur in the NOECD. Diseases from air pollution follow emissions; so 50% of these diseases will occur in the NOECD. Finally, famines as well as diseases and injuries due to migration are a problem of the NOECD-countries alone. According to all these assumptions the annual economic damage due to lost working days is 2.3 bn US-dollars/year in the NOECD and 2.6 bn US-dollars/year in the OECD.

2.6.4. Costs for integrating immigrants: Immigrants will not find jobs immediately and often must be supported for some time by the country of immigration. Fankhauser estimates the costs per immigrant at between 4.500 US-dollars for the USA and 72 US-dollars for poor countries (Fankhauser 1995, 51). Taking the present distribution of refugees between countries of immigration as a basis for their future distribution, he estimates that the NOECD has to pay about 2.3 bn US-dollars/year and the OECD 2.0 bn US-dollars/year for the integration of additional immigrants due to $2xCO_2$ (ibid. 50). But Fankhauser assumes (in a not well-founded manner) a slightly lower number of total refugees, namely 2.734 mill. immigrants/year, than was assumed here: 103.6 million surviving immigrants distributed over 25 years, i.e. 4.142 million additional immigrants/year. Therefore, Fankhauser's final figures of the costs of immigration here are multiplied by the relation of the two estimated numbers of immigrants (which is 1.515). The costs for integrating immigrants then are: 3.453 bn dollars/year for the NOECD and 3.103 bn dollars/year for the OECD.

3.5.2. Welfarizing Individually Borne Economic Losses

In order to get an idea of the importance of economic losses for well-being, firstly, the economic losses of the NOECD should be corrected for purchasing-power parity (= 17%). The economic losses of the NOECD then increase to 359 billion US-dollars/year. The next step is to correct for population. According to the current population distribution, the total individualized economic losses through $2xCO_2$ would be: 72 US-dollars (corrected for purchasing-power parity)/inhabitant and year in the NOECD and 105 US-dollars/inhabitant and year in the OECD. Thirdly, for to obtain an impression of the significance for family income these figures should then be multiplied by the number of family members. For the OECD such losses are not that important, but for people in NOECD-countries the resulting losses often will be considerable.

However, the individualization of economic losses just intimated is conceptually wrong because the simple sums of economic losses say nothing about their distribution; and for a welfarist approach this distribution is essential. In particular, the most influential determinant of this distribution is if originally big individual losses will be socialized later on, e.g. via insurance or national aid programs, which is to be expected much more frequently in the OECD than in the NOECD, or if, finally they even have to be borne by the individual. The same initial loss could thus lead to a negligible final loss for the individual or to economic ruin. And the influences on well-being from the same initial loss may thus vary from leaving people nearly unaffected to plunging them into absolute poverty.[11] Ignoring such facts, surely, is one of the main inadequacies of cost-benefit analysis. - Unfortunately, I have not found any estimates regarding the *distribution* of economic losses and their impacts on individual well-being. Therefore, I can only make a very rough guess as to that distribution and its consequences. In a first step I try to welfarize those economic losses which have to be borne even in the end by the affected individuals; the second step deals with welfarizing socialized economic losses.

So who does bear the economic losses in the end? 1. Economic costs of coastal protection, loss of species and integration of immigrants here are assumed to be socialized completely all over the world (i.e. in OECD countries as well as in NOECD countries). They are payed for by tax revenues or diminish social income in general (cf. columns 3 and 6 of table 3.4). 2. Economic losses due to reduced water supply and air pollution (in particular corrosion) instead are assumed to be borne completely by the individuals. 3. Economic losses in agriculture (esp. due to aridisation), due to deforestation, reduced estuarine fishing,

coastal dryland and wetland losses, natural catastrophes, diseases and injuries in the NOECD countries are assumed to be borne completely by the individuals, whereas the same types of losses in OECD countries will be socialized for the most part (90%) by national help programs or insurance. According to all these assumptions, in the NOECD countries 53.491 billion dollars of economic losses annually have to be borne by the individuals and only 7.49 billion dollars are socialized, whereas in the OECD countries 46.359 dollars annually of economic losses are born by the individuals and 58.145 billion dollars are socialized.

But even this modal split still does not tell us anything about how much different individuals lose. I can only speculate about this. Let us consider *individually borne damages in NOECD countries* first: *1. Economic ruin:* Non-socialized economic losses in form of aridisation of arable land, inundation of costal dryland, reduced catches in estuarine fishing, property losses due to natural disasters, diseases and injuries (via costs of treatment, losses of income, losses of job or profession due to disease or disablement) and half of the losses from deforestation, which altogether amount to 31.5 billion dollars annually or 788 billion dollars in 25 years, may lead to economic ruin for 1% of the population (= 50 million people with an individual loss of 15,764 dollars/person). These people will have to look for new sources of income, which eventually will be less rich. *1.1. Migrants:* The major part of this group, namely all of those who have lost coastal dryland and most (perhaps 3/4) of those who have lost arable land because of aridisation will emigrate from their native homes because simply there is no land left for them to live respectively because due to aridisation the whole region has lost the basis for living. If we take the portion of this group as being equal to the portion of the economic damages leading to migration this holds for 35.9 million people. This group has already been considered in the group of the migrants. The rest of the people who are economically ruined (i.e. 14.1 million people) has to be split up in three groups. *1.2. Absolutely poor:* One group will fall into absolute poverty. This portion of the economically ruined non-migrants may be equal to the ratio of the quantity of the absolute poor to the number of people living in NOECD countries (i.e. 640 mill./5 bn = 12.8%), resulting in an additional 1.8 million absolutely poor people. The fate of these people will be equal to that of the absolute poor considered in the above categories 1.1.4 and 1.3.4 (cf. p. 25, 35) but with two differences. Firstly, the initial well-being of the economically ruined is ordinary (= 0.1420wi) and not yet reduced. Secondly, these people have most probably lost their original economic existence forever, reducing the greenhouse effect will not bring it back. So if these people lose their economic basis with long-term consequences

these long-term consequences will last for the rest of their lives,[12] i.e. in the mean for half the life expectancy of these people. (These two differences hold for OECD countries, too.) If we respect these two differences but otherwise take over the assumptions for categories 1.1.4 and 1.3.4 the results are: 3.28% of the 1.8 million people (= 59,200 persons) will starve or die from deficiency disease etc.; 10% (= 180,000 persons) will suffer from permanent hunger-pangs for the rest of their lives; 40% (= 722,000 persons) will suffer from serious deficiency diseases; and the well-being of the remaining 46.28% (= 843,000 persons) may be reduced "only" to the level of the lowest income quartile (from 0.1420wi by 0.0275wi). *1.3. Relatively poor:* The first half (i.e. 6.1 million persons) of the remaining people will find new jobs but poorly paid jobs so that they will be reduced to relative poverty with a mean well-being at best as high as that of the lowest income quartile during the rest of their lives - except from an additional transitory reduction to the level of unemployed (i.e. by 0.0777wi) for six months. *1.4. Return to ordinary well-being:* The other half (i.e. again 6.1 million people) may find sufficiently good new jobs for returning to a well-being as before and so may suffer only from transitory reductions in well-being (because of having lost their property and personal belongings, initial insecurity of prospects etc.) perhaps of that of an unemployed (i.e. by 0.0777wi) for 3 months and for 0.017wi (equal to the difference between the lowest income-quartiles) for another 9 months. *2. Inconveniences of daily life:* Rising food prices, increase in water prices or reduced availability (which have been postponed from the discussion about category 1.3.4), loss of firewood and other freely available resources due to (the second half of the) losses of forests, losses of wetlands and mangroves, etc. for the poorest part (20% or 1 billion persons) of the population (with an initial well-being of 0.1145wi) may lead to noticeable sacrifices and increased discomforts. These discomforts may worsen well-being by 0.0170wi (i.e. the difference in mean well-being between the two lowest income-quartiles) for in the mean 30 minutes of 16 hours of the waking part of the day or e.g. the duration of a then frugal meal, which in 25 years amount to 0.781 years. *3. Small economic damages:* The other 79% of the population are assumed to be able to bear the remaining economic losses (due to reduced water supply, air pollution leading to corrosion and perhaps small portions of the damages already dealt with) and increased food and water prices without reductions in well-being worth mentioning.

Individually borne damages in OECD countries: 1. Economic ruin: Non-socialized economic damages due to aridisation, deforestation, reduced catches in estuarine fishing, inundation of coastal dryland,

property losses due to natural disasters, diseases and injuries amount to 118 billion dollars during 25 years. These losses may be spread over 0.05% of the population or 500,000 people (with mean economic losses of 235,700 dollars/person), who will be ruined economically with effects partially similar to but much less dramatic than those in NOECD countries: Absolute poverty and real emigration will occur only to a negligible degree. *1.1. Social degradation:* The first half (i.e. 250,000) of these people even in the long run will get jobs and social positions only considerably worse than before, thereby being reduced in well-being by an amount equal to a degradation by one income quartile (= 0.0170wi) for the rest of their life. In addition these people will suffer from transitory reductions perhaps equal to those of somebody unemployed (i.e. by 0.0777wi) for three months. *1.2. Return to ordinary well-being:* The other half may suffer from the same transitory reductions (by 0.0777wi during three months) plus some further transitory reductions (by 0.0170wi during nine months) but then return to ordinary well-being because they will have found sufficiently good new sources of income which allow this return. *2. Mourning for lost property:* A group nine times as big as the first group will be compensated for their property losses. Nonetheless a part of these people, perhaps one half (= 2,25 million people) may mourn for lost personal belongings, homes, professions and similar things, which may reduce well-being transiently by 0.0777wi for three months and by 0.0170wi for another nine months. *3. Small economic damages:* Economic damages like reduced and more expensive water supply, wetland losses and air pollution with corrosion effects are assumed to be borne individually. But their individual impact will be hardly noticeable and, therefore, is neglected here in the calculation of damages.

3.5.3. Welfarizing Social Economic Costs

Only parts of the economic losses due to $2xCO_2$ are directly borne by individuals, the other parts are social economic costs, e.g. expenses directly made by public authorities (such as publicly paid coastal protection), losses of public property (such as losses of public forests) or socialized individual costs (such as public aid for victims of catastrophes). The social economic costs for NOECD and OECD countries are calculated in columns 4 and 7 of table 3.4. They amount to about 7.5 billion US-dollars$_{1990}$ annually in the NOECD and 58 billion US-dollars$_{1990}$ annually in the OECD during the third period.

Welfarizing these costs is rather difficult. It would require information about what would have been done with this money; and

this depends largely on the political aims of the respective public authorities and the necessities and urgencies felt by them - which is hard to predict 50 or more years in advance. In the worst case the money would be used for *reducing* human welfare e.g. by war. A more appropriate worst case may be that this money is spent without effects for social welfare, such as for raising the income of already prosperous people. The best case from a welfarist point of view may be spending the saved money for programmes prolonging life expectancy or efficiently raising the income of non prosperous people. The prospects of prolonging life expectancy again are hard to predict, so I will consider only investment in mass income. The actual expenditure of the saved money is then taken to be half way between the two extremes, expenditure neutral to welfare and pure welfare policy; i.e. the possible welfare produced by a pure welfare policy will be halved. This, probably, is a rather optimistic estimate - matching the conservative approach of this study because it handicaps the abatement options in the following way. The social economic costs due to BAU may be valued rather highly by this half-way hypothesis; but the same will hold for the abatement options, where this type of damage is much, much more important.

In OECD-countries the biggest potential for increasing welfare by raising incomes would be to lift people from below the poverty line (which in the USA 1990 was approximately equal to the 87.5th income percentile, i.e. the median of the lowest income quartile and 3707 $dollars_{1990}$/year·person (cf. calculation below)) to a level only "near to poverty" (which is defined as lying between the poverty level and twice the poverty level). Mean expenditures for this would be equal to the mean poverty line, i.e. 3707 $dollars_{1990}$/year·person; the gain would be an increase in well-being from a grand mean of at most 0.1145wi [13] by 0.0163wi (cf. the calculation in the next paragraph in small print). Inversely, social economic losses due to business as usual would prevent such an increase, and therefore must be considered as a reduction in well-being from a grand mean of 0.1308wi by 0.0163wi for 25 years. According to these assumptions, this would hold for about 7.8 million people (= (0.5·58.145 bn dollars)/(3707 dollars/person)).

Similar calculations may hold for NOECD countries. But one main difference is that in NOECD countries there are many absolutely poor people and many more relatively poor people than in OECD countries. Unfortunately, I have no good data about these people. Therefore, I assume that the available money in the best case would be spent for people with a grand mean of well-being of 0.1000wi and that the gradient of the well-being function (over income) for this value is 1.5

times as high as for 0.1145wi so that an increase by 0.0163wi may be achieved with just 2471 dollars annually. The other main difference is the greater purchasing power, which implies that the 2471 dollars decrease to 420 dollars. Assuming again that a more realistic scenario would lie in between this best case and a worst case with a zero increase of welfare the 7.5 billion US-dollars of annual social economic costs will lead to a reduction of well-being from 0.1163 by 0.0163 over 25 years for 8.9 million people (= (0.5·7.49 bn dollars)/(420.07 dollars/person)).

A rough well-being function over individual income has been computed as follows.[14] Statistical data about the percentages of different income categories (e.g. up to 4,999 dollars/year: 5.2%; 5,000-9,999 dollars/year: 9.7%) in 1990 in the USA (Statistical Abstract US 1992, 446) imply the income of certain income positions, where "*income position*" shall mean the income percentile counted beginning from the lowest income (e.g. the income of position 5.2 is 4,999 dollars/year, of position 14.9 it is 9,999 dollars/year). From this, by linear interpolation, the income of optional income positions can be calculated approximately, in particular the income of income positions for which we know (cf. above, sect. 3.3) (taking the medium well-being being approximately equal to the mean) the grand mean of well-being: position 12.5: 8762 dollars/year; position 37.5: 22400 dollars/year; position 62.5: 38942 dollars/year; position 87.5: 70301 dollars/year. - All these data (as well as the official definitions of poverty line) refer to *household* income - and not to individual income, the data for which are needed here. And the mean size of households varies strongly with income (the main tendency is that richer households are bigger on the average). So the mean household sizes of the interesting income positions have been calculated (from statistics giving the percentages of the various household sizes in the income categories (Statistical Abstract US 1992, 446) and taking again the medium of these categories being equal to the mean and then interpolating), which results in 1.943, 2.429, 2.839 respectively 3.174 persons/household for the four positions. Finally, the previously obtained family incomes were divided by these sizes with the following results: position 12.5 (with a grand mean of well-being of 0.1145wi): mean individual income of 4510 dollars/year; position 37.5 (with a grand mean of well-being of 0.1352wi): mean individual income 9222 dollars/year; position 62.5 (with a grand mean of well-being of 0.1494wi): mean individual income 13717 dollars/year; position 87.5 (with a grand mean of well-being of 0.1655wi): mean individual income 22149 dollars/year. These anchor values then can be used for interpolating the well-being of further mean individual incomes.

The mean poverty line was computed this way: On the basis of the definitions of the poverty line for different household sizes (Statistical Abstract USA 1992, 427) and data about the household sizes of various income categories (Statistical Abstract US 1992, 446), by interpolation, the number of households below the poverty line can be calculated as well as their mean size (which is 2.610 persons). Interpolating the definitions of poverty line for this mean household size leads to a family poverty line of 9674 dollars/year, which then has been divided by household size, resulting in a mean individual poverty line of 3707 dollars_{1990}/year.

3.5.4. Sparing Parts of the Welfarization: Principles of Cost-Welfare Analysis

Admittedly, the welfarization of social economic costs in sect. 3.5.3 is rather crude. This is not a problem so far because in BAU the social economic costs make up only a trifling part of the welfare damages (a bit more than 1%); this is different with the abatement options. In sustainable reduction (a_4) they make up the lion's share of all damages so that inexact welfarization of these costs could make a difference. An alternative way of accounting for social economic costs is *cost-welfare analysis* (which is different from cost-benefit analysis with its complete monetarization): from the point of view of a given decider for several of his options the relations of (real economic) net costs (for this decider) to the net welfare gains (or losses), expressed in utilities or other moral values, caused by this decider are calculated and compared. "Net costs" means costs minus benefits, "net welfare gains" means welfare gains minus welfare losses. So the real *economic costs for this decider* do not have to be welfarized; the cost-welfare ratios then say how profitable some measure is from a *welfarist* point of view, i.e. from the perspective that this decider has the aim of creating much welfare and perhaps wants to maximize welfare. The community of OECD-countries (i.e. states, and not individuals) here is treated as the decider because these countries have the key position for bringing about substantial greenhouse gas abatement. For our case the formula for the cost-welfare relation is:

F1: cost-welfare relation of a_i =

$$\frac{\text{social costs of } a_i \text{ for the OECD - social costs of BAU for the OECD}}{\text{welfare losses by BAU - welfare losses by } a_i}$$

The options a_i are the three abatement options (a_2, a_3, a_4) and several other possibilities of spending public money. The costs are real economic costs for the decider. This means that only *real public economic costs and gains* for the *OECD* will be left in monetary terms, whereas *non-socialized* economic costs (running up in the OECD or in the NOECD) and socialized economic costs for NOECD-countries have to be welfarized (translated into moral desirability) as before. The social economic costs of BAU (a_1) prevented by an abatement option a_i count as benefits of a_i (cf. the subtrahend of the numerator). The utilities or desirabilities gained or lost are the moral desirabilities of the options. The welfare gains of abatement option a_i are the prevented welfare losses due to BAU (cf. the minuend of the denominator). The welfare losses of a_i are the hardships etc. imposed on the people by greenhouse gas reduction, e.g. unemployment (cf. the subtrahend of the

denominator). The social economic costs for the OECD due to BAU calculated in table 3.4, i.e. the 25·58 billion dollars, will be the subtrahend of the numerator in the cost-benefit analyses; and the other welfare costs of a_1, the estimate of which is still in course, will be the minuend of the denominator.

The advantages of cost-utility analysis are, firstly, that the social economic costs for the OECD are not be welfarized so that some arbitrariness can be prevented and, secondly, that the efficiency of the abatement options can be compared not only between each other but with the efficiency of other alternatives as well, such as investing in health care programmes or developmental aid. In the following, both types of studies, complete welfare analysis and cost-welfare analysis, are undertaken. All losses which have to be treated differently in these types of studies, i.e. social economic costs for the OECD translated into welfare losses in the one case and left unchanged in the other, will be marked by "■".

3.6. Other Damages and Integration of Reductions in Well-Being

3.1. Damages to ecosystems and natural spaces: Erosion and flooding of beaches, death of coral reefs, dying forests, desertification of savannahs have consequences not only for tourism, agriculture, forestry, but also for human beings in general: for example by reducing possibilities of recreation and experience. But well-being should only slightly be influenced by that, as people looking for recreation and experiences of nature will turn to alternative possibilities, and damage for the expelled inhabitants of such natural spaces have already been taken into account. Therefore, the main remaining type of losses in well-being caused by the destruction of ecosystems probably are losses in what economists call existence value, i.e. losses due to sadness because of a conscious loss, and not losses in use value. Losses in existence value may stem from lost ecosystems at great distances from the subject; and for each subject a quite different set of ecosystems may be important. I have not found any reliable calculation of these damages. Therefore, I will try a very rough estimate. Most people (perhaps 75%), children, very poor people struggling for survival, have other sorrows or interests and do not care about losses of ecosystems. The minority who does care (= 1.5 billion people) may think of these losses now and then, let's say 20 minutes per month (= 0.017 years during 25 years), and will be a little sad so that their well-being is

reduced during this time by 0.017 (equal to the mean decrease in well-being due to degradation by one income quartile).

All welfare losses due to business as usual are summarized in table 3.5. As already anounced, welfarizations of economic losses of the decider, i.e. the community of OECD countries, are marked with "■". They will be considered only in the pure welfare calculation. In the cost-welfare analysis instead of these welfarizations the original monetary losses of the decider have to be taken into account, which for BAU amount to 1454 billion dollars (= 25·58.145 bn dollars) in the third period.

Table 3.5

a_1: 2050-2075: Reductions of well-being (in wi) for specified periods from specified initial levels due to various causes:

1 cause	2 init. position LE³ years³	3³ WB³ in wi³	4 reduction durat.³ years³	5³ WB³ in wi³	6 persons in 1000
1.1. direct casualties:					
a floods, storms	65.01	0.1420	32.505	v0.1420	441
b famines due to crop failures	62.92	0.1420	31.460	v0.1420	37500
c migrants during migration	62.92	0.1420	31.460	v0.1420	1046
d absolute poverty, malnutr.	62.92	0.1145	31.460	v0.1145	52500
e malaria	62.92	0.1420	31.460	v0.1420	1250
f hot spells	65.01	0.1420	32.505	v0.1420	5927
1.2. direct physical suffering:					
a nat. disasters: injuries etc.	65.01	0.1420	0.027	0.1420	4410
b famines: diseases, suffering	62.92	0.1420	0.027	0.1420	375000
c malaria	62.92	0.1420	0.026	0.1420	248750
d air pollution: diseases	65.01	0.1420	0.013	0.1420	447179
e hot spells: diseases	65.01	0.1420	0.027	0.1420	59272
f chronic hunger pangs	62.92	0.1145	25.000	0.0845	6400
g deficiency diseases, pain	62.92	0.1145	25.000	0.0345	25600
1.3. direct psychic suffering:					
a greater grief for deaths	65.01	0.1420	0.164	0.0350	303528
b1 greater grief for deaths	65.01	0.1420	0.164	0.0350	75882
b2 psych. gaps due to deaths		+	2.000	0.0350	
c1 migration: diseases, injuries	62.92	0.1420	0.027	0.1420	10460
c2 misery of migrants		+	0.082	0.1000	
c3		+	0.918	0.0777	
c4		+	10.000	0.0340	
d1 misery of migrants	62.92	0.1420	0.082	0.1000	93090
d2		+	0.918	0.0777	
d3		+	10.000	0.0340	
e worse social climate	65.01	0.1420	0.112	0.0170	1500000
2. reductions in well-being by economic losses:					
a NOECD ec. ruin, starving	62.92	0.1420	31.460	v0.1420	59

b NOECD ec. ruin, hunger pa.	62.92	0.1420	31.460	0.1120	180
c NOECD ec. ruin, defic. disease	62.92	0.1420	31.460	0.0620	722
d NOECD ec. ruin, other paup.	62.92	0.1420	31.460	0.0275	843
e1 NOECD ec. ruin, return to	62.92	0.1420	0.250	0.0777	6148
e2 original level		+	0.750	0.0170	
f1 NOECD ec. ruin, social	62.92	0.1420	0.500	0.0777	6148
f2 degradation		+	30.960	0.0275	
g NOECD harder daily life	62.92	0.1145	0.781	0.0170	1000000
h1 OECD ec. ruin, return to	76.31	0.1420	0.250	0.0777	250
h2 original level		+	0.750	0.0170	
i1 OECD ec. ruin, social	76.31	0.1420	0.250	0.0777	250
i2 degradation		+	37.904	0.0170	
j1 OECD ec. ruin, reimbursem.	76.31	0.1420	0.250	0.0777	2250
j2		+	0.750	0.0170	
k NOECD social monet. losses	62.92	0.1163	25.000	0.0163	8915
l ■OECD social monet. losses	■76.31	0.1308	25.000	0.0163	7843
3. other influences on well-being:					
a grief about ecological losses	65.01	0.1420	0.017	0.0170	1500000

Social economic costs for the OECD countries in billion US-dollars$_{1990}$*:* a_1*:*	undisc. BD	discounted BD
2050-2075: uncontrolled greenhouse effect	1,454	213

Explanations: Column 1 describes the cause of reductions in well-being. If several losses with certainty hit the same persons these losses are grouped together and are differentiated by numbers behind the letter for that group. - *Columns 2 and 3* represent the initial position of the group: its life expectancy in years and its long-term grand mean of well-being in wi. - *Columns 4 and 5* represent the reductions in well-being: its duration in years and the amount of reduction in wi. In most cases these reductions are assumed to be equal for the whole group. But a "v" indicates that the specified reduction is a mean reduction, and the individual reduction is equal to the original level: all members of that group by death are reduced to the level zero. - *Column 6* represents the size of the group in 1000 persons. - "■" indicates welfare losses which are welfarizations of the economic losses of the decider listed in the annex of the table (which in the cost-welfare analysis have to be treated differently).

Notes to Chapter 3

1 "Poverty by worsened conditions of life" (in groups 1.1.4, 1.2.4 and 1.3.4) is meant in the sense that consumer prices, in particular of food, increase so that the same earnings will provide less commodities. Group 2 instead covers monetary losses, in particular income losses which in certain cases may lead to poverty, too; but in this case the monetary loss is the cause of poverty. Subsuming the first type of poverty in the first group and the second type in the second group may appear a bit sophistic. But the two types are clearly different; so there is at least no double counting.

2 Some scientists hope for a fertilization effect of CO_2. But according to others, this is an illusional hope: CO_2 will not do alone; in addition water, fertilizer, trace elements and energy are needed — which makes a big difference between laboratory experiments and open-field conditions (Pearce et al. 1996, 189 f.; Newton / Dillingham 1994, 184).

3 In the cases of Bangladesh and Egypt, Myers counts all the refugees from *relative sea level* rise and does not subtract that portion which is due to subsidence; and he excludes nearly completely defense measures like diking, which at least in the cases of Alexandria and the Chinese Coast seems to be unrealistic.

4 Eventual regional differences here are disregarded due to lack of data. — Indeed, Inglehart (1997) reports representative investigations even in very poor countries. But, apart from a rather crude analysis of the data, his results cannot be used here because that question of his coming nearest to what would be needed for our concern is: "Taking all things together, would you say you are very / quite / not very / not at all happy?" (ibid. 395). This question already aims at a rather cognitive appraisal of the subjective state or even the personal life situation (if "happy" is taken to mean "satisfied") and not at the current mood and feelings.

5 Some researchers have doubted that increasing income (as such) could improve human happiness. Easterlin (1974) e.g., after re-analyzing some other studies, maintained that there is a strong correlation between income and well-being within nations (in particular in the USA) but no correlation between GNP/person and mean national well-being of different countries. He explained this alledged finding with a relativity hypothesis, saying that (intra-national) differences in well-being stem from comparing one's income with the income of the national environment. — As has been shown in several studies since, Easterlin's explosive finding of a non-correlation is simply false. There is a grossly concave function of national mean well-being (measured with a 10-step scale comparison with the best and worst life respectively one can imagine as the two extremes) over the GNP/person (cf. e.g. Veenhoven 1984, 145-150, in particular 149). And it seems quite clear that income must have a nonrelativistic influence on well-being as far as the satisfaction of bio-psychic minimal needs is concerned (ibid. 400).

6 Diseases of the migrants exceptionally are represented together with their psychic sufferings (as 1.3.e1) and not in group 1.2.

7 Fankhauser's estimates of the damages from NO_x and SO_2 are: NOECD: 3.504 bn dollars/year; OECD: 11.898 bn dollars/year (Fankhauser 1995, 49). He does not differentiate between damages for health and for wealth. I simply assume that these categories are of equal weight. In addition, Fankhauser uses a monetarization in the relation of 10/2/1 for countries with high, medium and low income, respectively. The mean relation OECD / NOECD is 5/0.98 so that the remaining monetized health-damages of the NOECD-countries should be multiplied by this fraction for getting fair monetarizations of their health damages, resulting in 8.939 bn dollars/year for the NOECD and 5.949 bn dollars/year for the OECD. Fankhauser monetizes one lost life with 1.5 million US-dollars (in countries with high income) so that the losses amount to 9,925 death equivalents per year or 248,133 death equivalents in 25 years, which during 25 years amount to 6.203 million lost

years. These lost years may be interpreted as being lost by days of illness. Assuming that diseases due to air pollution last only half as long as the other diseases considered so far, i.e. 0.013 years, the 6.203 million lost years spread over 477 million cases.

8 The value of the lost land is taken to be 2 million US-dollars/km^2, 0.5 million and 1 million US-dollars for the OECD, the former SU, and the world as a whole, respectively. A rent of 10% is assumed. (Fankhauser 1995, 30 f.)

9 Fankhauser's guess is 124 million US-dollars for the NOECD and 506 for the OECD (Fankhauser 1995, 54). But he includes only cyclones.

10 Fankhauser estimates 40 bn US-dollars/year losses from ecosystem damages for the whole world (Fankhauser 1995, 201). But the basis of this figure is more than obscure, and it includes non-economic losses, too. Therefore, it is not suited for the present purposes.

11 This difference is important for utilitarianism too, because utilitarianism in the end counts utilities and not money, with different distribution of monetary losses leading to completely different disutilities.

12 If for example a farmer loses his land to the rising sea and even if the sea recedes to its former position the farmer would have to move back to his land, recultivate it, and rebuild or at least renovate his house etc., for which he probably will not have the money — if he has not succeeded economically in the meantime. But in the latter case the farmer probably will not have suffered from long-term economic degradation anyway.

13 0.1145wi is the grand mean of the people *on* the poverty line (taking the medium of the lowest quartile as being equal to the mean) and therefore is too high. But, unfortunately, I have not found anchor values for poorer people so that to obtain more appropriate values we would have to *extra*polate from the values calculated up to now. But such an extrapolation would be completely unfounded. Therefore, as a sufficient approximation the mean of the lowest quartile has been taken as the initial position of the poor.

14 Surely, economists have developed many theories about the utility function of income. But these, usually, are established via the methods of subjective expected utility theory, which has been criticized above (sect. 2.2). But even for an approach which is rather near to the methods used here, namely that of van Praag (e.g. Praag 1971), holds the third criticism mentioned above, that unfiltered preferences are used which by no means are always rational. In particular van Praag establishes the utility function on the basis of answers to the question if the subject would call a particular income for themselves as "very bad, bad, insufficient, sufficient, good or very good". These six levels then were interpreted as cardinal valuations from 0 to 1. Apart from the problem of an inadequate translation of the rating values into cardinal values, the answers given often will correspond to social conventions but not reflect the real importance of the income in question for one's life. People mostly do not have good information about such impacts: for example they tend to overrate the importance of big income rises whereas empirical studies confirm that for average people they may not change well-being very much (cf. e.g. Brickman et al. 1978; Grom 1987, 87-92).

4. Alternatives a_2-a_4: Abatement Options

4.1. Characterizing the Alternatives

As with business as usual, I have analyzed three alternatives:
a_2, *stabilization*, i.e. freezing emissions of greenhouse gases at the 1990 level,,
a_3, *strong CO_2-reduction*, i.e. reduction of emissions by 25% (until 2015) compared to the level of 1990, and
a_4, *sustainable CO_2-reduction*, i.e. reduction of emissions by 60% (until 2035) compared to the level of 1990.

4.2. Monetary Abatement Costs

The core of all counter measures against the anthropogenous greenhouse effect is the reduction of CO_2-emissions. This aim is attainable e.g. by high taxes on CO_2-emissions (= carbon tax or C-tax), which would create incentives for a more economic use of energy and for the technological development of alternative sources of energy. In the short run at least this will lead to increases in prices and probably to some unemployment in energy-intensive industries. Some of these negative effects, in particular unemployment, can be reduced considerably if the revenue of the C-tax is used in an economically positive manner, namely for reducing labour tax, costs for social

security, and personal income tax, thus reducing producer wages and creating new jobs (Hourcade et al. 1996, 309; Mabey et al. 1997, 403). And further reductions of costs are attainable by an economically efficient abatement, which means reducing emissions first where it is cheapest. This may be obtained by allocating emissions through tradeable emission permits. Such measures for efficiency are presupposed in the following calculation of economic costs.

Among economists there are extensive discussions about the economic costs of such reductions. Above all there are two fundamentally different methods: top-down-models versus bottom-up-models. Top-down-models strongly generalize prevailing experiences of effectiveness, utilization, and energy costs and presuppose an economically efficient utilization of sources of energy already in the present. Bottom-up-models are much more orientated towards technological possibilities and potentials of saving, but they neglect the effects on economy as a whole and end up with far too optimistic estimations about the costs for scenarios of reduction. As a precaution I used the pessimistic top-down-models as a guide-line, and averaged and extrapolated the results of whole series of such models.

Hourcade et al. (1996, 335) list a collection of global CO_2 abatement cost modelling studies. These studies inquire GWP (= gross world product) impacts for very different reduction aims. To get comparable data I have treated the results as if they were obtained according to the following formula:

F2: $c_{ann} = -1 + (1+f)^{100g}$,

where c_{ann} are the annual abatement costs in fractions of GWP, f are the fractional abatement costs, i.e. the costs (in fractions of GWP) of reducing CO_2-emissions for 1 further percent with respect to an assumed baseline (i.e. business as usual), and g is the reduction target in fractions of the assumed baseline. The reduction target g with respect to the baseline (BAU) can be translated into a reduction target r with respect to the starting year (normally 1990) according to the following formula:

F3: $g = 1 - (1-r)/(1+e)^t$,

where t is the relative target year, i.e. the difference between the target year and the starting year (for the target year being 2050 t would be 60), and e is the assumed annual increase in CO_2 emissions taking place under baseline conditions. (Assuming e.g. an annual increase in CO_2-emissions under baseline of 1.5% a reduction aim of 25% with respect to 1990 in 2050 translates into an abatement target of $1-(1-0.25)/1.015^{60} = 69\%$ with respect to baseline.)

The interesting variables of the various models then are e, the annual increase in CO_2-emissions assumed for BAU, and f, the fractional abatement costs. Reckoning back from the various results reported in Hourcade et al. to these variables, according to the formulas just given, the mean value of all models for e is 1.42% (range 0.92-2.18%) and the mean value for f is 0.0383%GWP/% of reduction (range 0.0045-0.0862%). Inserting these values in the above formulas, abatement costs for any reduction target can be calculated and have been calculated for the targets of the alternatives a_2 to a_4.

For NOECD with BAU increases in GNP of 2% annually from 5373 billion dollars in 1990 are assumed, for OECD increases of 1% annually from 13877 billion dollars in 1990 are assumed. For calculating the cumulated reduction costs the following reduction paths of options a_3 and a_4 may be reasonable: a_3: stabilization until 2005, afterwards for ten years reduction of emissions by 2.5%/year, then freezing this level; a_4: stabilization until 2005, subsequently for 20 years reduction of emissions by 2.5%/year, for the following ten years reduction by 1%/year, then freezing this level. In cost-welfare analysis the annual costs have to be discounted (because the costs may be paid by today's investments which will bear interest until the year of payment). The discount rate used here is 3%/year (0.97); and discounting begins in 2000. The resulting formula for calculating e.g. the cumulated discounted costs in billion US-dollars$_{1990}$ for NOECD by a_4 from 2005 to 2025 is:

F4: $$\sum_{t=15}^{35} [0.97^{(t-10)} \cdot 5373 \cdot 1.02^{t} \cdot (-1+1.000383^{100 \cdot (1-(1-(t-15)\cdot 0.025)/1.0142^{t})})].$$

According to these averaged and extrapolated assumptions, *cumulated* abatement costs amount to the sums shown in table 4.1. Altogether stabilization (a_2) in the three periods considered without discounting will cost about 57 (US) trillion (= 10^{12}) US-dollars$_{1990}$ and with discounting still 15 trillion dollars; the figures for the 25% reduction (a_3) are 69 trillion dollars and 18 trillion dollars

Table 4.1

a_2-a_4: 2000-2075: Cumulated economic costs for OECD, NOECD and the world due to CO_2-reductions, undiscounted and discounted (with 3%/year) in billion US-dollars$_{1990}$:

1	2	3	4	5	6	7
option & period	NOECD	OECD	world	NOECD disc.	OECD disc.	world disc.
a_2: 2000-2025:	2371	4768	7139	1506	3075	4581
2025-2050:	6739	10680	17419	2054	3307	5361
2050-2075:	14430	17940	32370	2076	2622	4698
sum a_2	23540	33388	56928	5636	9004	14640
a_3: 2000-2025:	3318	6634	9952	2066	4186	6252
2025-2050:	8476	13470	21946	2606	4208	6814
2050-2075:	16430	20460	36890	2374	3003	5377
sum a_3	28224	40564	68788	7046	11397	18443
a_4: 2000-2025:	3665	7288	10953	2244	4522	6766
2025-2050:	10783	17170	27953	3333	5389	8722
2050-2075:	19250	24000	43250	2794	3539	6333
sum a_4	33698	48458	82156	8371	13450	21821

Table 4.2

a_1-a_4: Annual GNP-losses by CO_2 abatement in the year 2050:

1	2	3	4	5	6	7
option	loss of GWP in BD	loss of GWP in %	GNP NOECD ·1990	GNP OECD ·1990	GNP NOECD in BD	GNP OECD in BD
a_1: BAU	0	0.00	3.2810	1.8167	17629	25210
a_2: stabilization	946	2.21	3.2085	1.7766	17239	24654
a_3: 25% reduction	1127	2.63	3.1947	1.7689	17165	24547
a_4: 60% reduction	1379	3.22	3.1754	1.7582	17061	24399

Explanations: Because this table only deals with abatement costs the figures, in particular for BAU, only represent theoretical baselines from which the losses due to $2xCO_2$ still have to be subtracted. - "*BD*" means: billion US-dollars$_{1990}$. - *Columns 2 and 3* represent worldwide abatement costs in comparison to BAU, absolute in billion US-dollars$_{1990}$ and relative. - *Columns 4 and 5* represent how much higher GNP (of NOECD and OECD) will be in 2050 than in 1990. - *Columns 6 and 7* show the absolute GNPs (of NOECD and OECD) in 2050 in billion US-dollars$_{1990}$.

(discounted), respectively; and for the 60% reduction (a_4) they are 82 trillion dollars and 22 trillion dollars (discounted), respectively. What is clearly to be seen is that much sharper abatement options (a_3 and a_4) do not cost that much more than stabilization (a_3), which might lead to a higher efficiency of the stricter options. *Annual* costs of the considered options in 2050 are shown in table 4.2. For the strictest option, i.e. sustainable reduction (a_4), costs for the whole world amount to 1379 billion US-dollars/year, and for a_3 and a_2 to 1127 and 946 billion dollars respectively. At first sight these figures look really frightening; but we have to examine them more closely.

The morally crucial question is how these costs should be distributed. This question of the allocation of payments is completely independent of the problem of allocation of emissions (cf. Kverndokk 1995, 130-132):[1] The problem of allocating emissions usually is thought to be optimally resolved by introducing tradeable emission permits. (If reduction of emission in our own country is more expensive than the global mean then we will buy emission rights for the price of the global mean from other countries where reduction of emission is cheaper,; and both countries will gain.) The problem of allocating payments then can be reformulated as the question of the initial distribution of emission permits in each emission period. Giving one country only relatively few emission permits leads to making this

country pay more for the abatement. Knowing the various abatement costs, an initial distribution of emission permits can be arranged exactly in such a way that abatement costs are distributed according to a desired pattern. Various distributions of emission permits have been discussed. The two extremes are the grandfather principle, that emission rights are distributed proportionally to current emissions, and the principle 'no harm to developing countries', that developing countries should pay nothing for CO_2-reduction.[2] The grandfather principle obviously discriminates against developing countries from several points of view. They get much fewer rights per person, which contradicts egalitarian considerations; they need many more rights for their further development, which is important for a welfarist conception of justice; and they have contributed only little if anything at all [3] to the high concentration of greenhouse gases, which is important for a liberal polluter-pays principle.[4] Independently of such moral considerations, developing countries and even countries with economies in transition simply will not participate in global abatement agreements if they have to carry a heavy burden regarding it as unfair. Whatsoever, from a welfarist point of view the best distribution is that the OECD-countries pay the abatement costs completely because they will have the smallest utility loss from this. And for the strategy of the present comparison this assumption seems to be adequate too for the following reasons. If then severe abatement options are obligatory for people in the OECD even under this worst case condition (worst case for the OECD) this would be a stronger argument for such an obligation. If the OECD pays for all, abatement costs will be 3.75% of its GNP for a_2 (stabilization), 4.47% of its GNP for a_3 (25% reduction), and 5.47% of its GNP for a_4 (60% reduction) annually in 2050 (cf. table 4.3).

Table 4.3

a_1-a_4: Annual GNP-losses by CO_2 abatement in the year 2050 if OECD pays for all:

1	2	3	4	5	6	7
option	GWP in BD	GNP NOECD in BD	GNP OECD in BD	GNP OECD ·1990	GNP loss OECD in %	GNP loss OECD in BD
a_1: BAU	42839	17629	25210	1.8167	0.00	0
a_2: stabilization	41893	17629	24264	1.7485	3.75	946
a_3: 25% reduction	41712	17629	24083	1.7355	4.47	1127
a_4: 60% reduction	41460	17629	23831	1.7173	5.47	1379

Explanations: "*BD*" means: billion US-dollars$_{1990}$. - *Column 5* shows the relation of OECD GNP in 2050 to OECD GNP in 1990. - *Columns 6 and 7* list

GNP losses relative to BAU. The figures of column 7 must be identical with those of column 2 of table 4.2 because OECD pays for all.

So, in the worst case, namely taking a 60% reduction, the OECD pays 5.5% of its GNP, i.e. 1379 billion dollars (25210-23831 billion dollars) for reducing greenhouse gases - due to directly taking over costs of NOECD-countries, higher expenses for energy per unit and reduced growth. These figures look gigantic. But (as shown in column 5 of table 4.3) that does not imply anyone being poorer than today. On the contrary, the GNP will be 71% above that of 1990. It just means that the economic growth that otherwise would be reached in 2050 will only be reached in 2056.

Nonetheless the money would be there and could be spent for increasing well-being.[5] In the following cost-welfare analysis all these costs will be treated as social economic costs of the decider OECD.[6] (They count as monetary gross costs of the relevant options (minuend of the numerator in formula F1); cf. below.) In a pure welfare analysis, on the other hand, these losses have to be welfarized. But this can easily be done following the assumptions of section 3.5.3, i.e. treating the losses as money that otherwise, in the best case, could have been spent for lifting people from below the poverty line to an income level near poverty, namely raising people from a grand mean of well-being of 0.1145wi by 0.0163wi with 3707 dollars/year·person. Because we are now dealing with losses distributed over 75 years we must decide for how long single individuals will profit from this possibility. Again 25 years are assumed here, as a mean between aid lasting for half the lifetime of these persons and a much shorter duration, which is politically desired for not making people depend too much on public assistance. A further difference to welfarizing damages from the greenhouse effect is that the costs due to abatement and the number of possible beneficiaries are so high (higher than 125 million) that even people from the second lowest income octile could have profited from the lost public assistance. The original level of well-being of these people is assumed to be in the middle of the grand means of the two lowest income quartiles (i.e. 0.1249wi) (cf. sect. 3.3 and fn. 13 in ch. 3). The gradient of the well-being melioration is taken to be unchanged (i.e. 3707 dollars/0.0163wi). According to these guidelines, the most extreme welfare loss, i.e. by sustainable reduction (a_4) in the third period, would amount to 125 million reductions over 25 years from 0.1308wi by 0.0163wi and further 108 million reductions over 25 years from 0.1412wi by 0.0163wi (cf. complete lists in tables 4.4-4.6).

4.3. Non-Monetary Abatement Costs

In the last section (4.2) only monetary abatement costs have been considered. But there are some non-monetary reductions of well-being due to abatement as well. As already intimated, the people of the OECD people will not directly feel the economic losses during the third period. (That the economic growth otherwise reached in 2050 will only be reached in 2056 is merely a calculated loss.) Probably, the main loss of well-being felt by OECD-inhabitants during the third period will be their upset about the high contributions to the Second and Third World, many people will be angry and complain about it. At most half of the politically thinking (50%) adults and adolescents (altogether 200 million people) might be upset about that for half an hour per month (= 0.026 years during 25 years) and thereby reduce their well-being from the ordinary level by a small value (perhaps equal to the mean difference in well-being between two adjacent income quartiles: 0.0170wi) in all three periods. I assume these costs to mount up in all three periods and to be equal for the three abatement options considered here.

Economic losses in 50 years will not be felt; but what will be felt intensely are decreases in well-being due to difficulties of adaptation of economy and people in the first period. People working in energy-intensive industries will lose their jobs, however, later on they will find new jobs at lower pay, when the revenue from the C-tax is used for the reduction of labour-taxes, social security costs etc. Consumers must get used to considerably increased energy-prices etc. The monetary costs (like lower pay and higher prices) among these losses have already been dealt with, though in the form of welfarized social economic losses. But unemployment leads to reductions in well-being independently of the monetary losses (Campbell 1981, 120-122; cf. above, sect. 3.3). Therefore these losses have to be estimated separately. In the worst case, i.e. due to sustainable reduction, 300 million people in the OECD are assumed to be unemployed during the first period in the mean for 1 year each, which leads to reductions of well-being from 0.1420wi by 0.0777wi.

a_2: stabilization: Restructuring the economy to stabilization may cause, during the 25 years of the first period, 10% of the OECD population (= 100 million people) to be unemployed for 1/2 year on the mean. Their well-being during this time will be reduced from 0.1420wi by 0.0777wi (cf. above, sect. 3.3) (These figures are inserted in table 4.4). Though economic losses (in comparison to BAU) will continue after the first period, the process of restructuring the economy for all three abatement options is assumed to be

completed during the first period. Therefore, in the second and third period no unemployment due to greenhouse gas abatement will occur.
a_3: 25%-reduction: With a 25%-reduction of CO_2-emissions the problems for national economies in the OECD will be much bigger in the following respects. The importance of creating new jobs and of re-investing revenue from the C-tax decreases with increasing abatement costs; national economy is approaching full employment, and the marginal productivity of new jobs decreases (Mabey et al. 1997, 406). Many more people will be ruined economically or intermittently unemployed, some of them repeatedly. Perhaps twice as many people (200 million) as with stabilization may be affected and their mean time of unemployment (perhaps distributed over several periods) may be a bit longer, namely 9 months.
a_4: 60%-reduction: A reduction of greenhouse gas emissions by 60% with respect to 1990 is possible but only by a very radical change of technologies: exploiting atomic, solar and wind-energy for electricity production and creating non-fossil fuels like hydrogen and using them for vehicle traffic, heating mainly with solar energy, and especially radically more efficiency in energy utilization, and similar actions. As shown with passive-energy-houses, low-energy-cars and other examples (cf. e.g. Weizsäcker / Lovins / Lovins 1996) this aim of economization can definitely be reached - but only at very high costs. Because of a lack of more information I simply assume, again very pessimistically, that perhaps 300 million people may be affected with a mean time of unemployment of 1 year.

4.4. Costs Due to a Moderated Greenhouse Effect

The use of alternatives a_2, a_3 and a_4, of course, lies in slowing-down the greenhouse effect. Complete prevention of projected damages due to the greenhouse effect in the third period, however, necessitates a reduction of emissions by 50-70% (Mabey et al. 1997, 380), hence alternative a_4, which for this reason has been called "sustainable reduction". Unfortunately, again there are no precise estimates of the successes of reducing damages by given abatement options. But a good guess may be that stabilization (a_2) halves the damages of $2xCO_2$ and that the 25% reduction (a_3) quarters the damages of $2xCO_2$.

4.5. Integration of Damages

The various estimates of damages by a_2, a_3 and a_4 are summed up in tables 4.4-4.6.

Table 4.4

a_2: 2000-2075: Integration of damages due to greenhouse gas stabilization: Reductions of well-being (in wi) for specified periods from specified initial levels by various causes:

1 cause	2 init. position LE³ years³	3³ WB³ in wi³	4 reduction durat.³ years³	5³ WB³ in wi³	6 persons in 1000
a_2: 2000-2025:					
a ■OECD missed publ. assist.	■76.31	0.1308	25.000	0.0163	38516
b political upset	76.31	0.1420	0.026	0.0170	200000
c unemployment	76.31	0.1420	0.500	0.0777	100000
a_2: 2025-2050:					
d ■OECD missed publ. assist.	■76.31	0.1308	25.000	0.0163	93979
e political upset	76.31	0.1420	0.026	0.0170	200000
a_2: 2050-2075:					
f ■OECD missed publ. assist.	■76.31	0.1308	25.000	0.0163	125000
g ■OECD missed publ. assist.	■76.31	0.1412	25.000	0.0163	49643
h political upset	76.31	0.1420	0.026	0.0170	200000
i halved greenhouse effect:	cf. table 3.5				

Social economic costs for the OECD countries in billion US-dollars$_{1990}$:

a_2:	undisc. BD	discounted BD
2000-2025: abatement costs	7,139	4,581
2025-2050: abatement costs	17,419	5,361
2050-2075: abatement costs	32,370	4,698
halved greenhouse effect	727	107
sum	57,655	14,747

For *explanations* see Table 3.5.

Table 4.5

a_3: 2000-2075: Integration of damages due to strong (25%) greenhouse gas reduction: Reductions of well-being (in wi) for specified periods from specified initial levels by various causes:

1 cause	2 init. position LE³ years³	3³ WB³ in wi³	4 reduction durat.³ years³	5³ WB³ in wi³	6 persons in 1000
a_3: 2000-2025:					
a ■OECD missed publ. assist.	■76.31	0.1308	25.000	0.0163	53693
b political upset	76.31	0.1420	0.026	0.0170	200000
c unemployment	76.31	0.1420	0.750	0.0777	200000
a_3: 2025-2050:					
d ■OECD missed publ. assist.	■76.31	0.1308	25.000	0.0163	118403
e political upset	76.31	0.1420	0.026	0.0170	200000

a_3: 2050-2075:					
f ■OECD missed publ. assist.	■76.31	0.1308	25.000	0.0163	125000
g ■OECD missed publ. assist.	■76.31	0.1412	25.000	0.0163	74029
h political upset	76.31	0.1420	0.026	0.0170	200000
i quartered greenhouse effect:	cf. table 3.5				

Social economic costs for the OECD countries in billion US-dollars$_{1990}$:

a_3:	undisc. BD	discounted BD
2000-2025: abatement costs	9,952	6,252
2025-2050: abatement costs	21,946	6,814
2050-2075: abatement costs	36,890	5,377
quartered greenhouse effect	364	53
sum	69,152	18,496

Table 4.6

a_4: 2000-2075: Integration of damages due to sustainable (60%) greenhouse gas reduction: Reductions of well-being (in wi) for specified periods from specified initial levels by various causes:

1	2	3³	4	5³	6
cause	init. position ³		reduction ³		persons
	LE³ years³	WB³ in wi³	durat.³ years³	WB³ in wi³	in 1000
a_4: 2000-2025:					
a ■OECD missed publ. assist.	■76.31	0.1308	25.000	0.0163	59094
b political upset	76.31	0.1420	0.026	0.0170	200000
c unemployment	76.31	0.1420	1.000	0.0777	300000
a_4: 2025-2050:					
d ■OECD missed publ. assist.	■76.31	0.1308	25.000	0.0163	125000
e ■OECD missed publ. assist.	■76.31	0.1412	25.000	0.0163	25812
f political upset	76.31	0.1420	0.026	0.0170	200000
a_4: 2050-2075:					
g ■OECD missed publ. assist.	■76.31	0.1308	25.000	0.0163	125000
h ■OECD missed publ. assist.	■76.31	0.1412	25.000	0.0163	108342
i political upset	76.31	0.1420	0.026	0.0170	200000

Social economic costs for the OECD countries in billion US-dollars$_{1990}$:

a_4:	undisc. BD	discounted BD
2000-2025: abatement costs	10,953	6,766
2025-2050: abatement costs	27,953	8,722
2050-2075: abatement costs	43,250	6,333
sum	82,156	21,821

There are no damages due to the anthropogenous greenhouse effect.

Notes to Chapter 4

1 This *a priori* consideration has been confirmed by economic modelling: the distribution of emission rights does not affect global abatement costs significantly (Hourcade et al. 1996, 339).

2 Hourcade et al. (1996, 340-343) have calculated the effects of several permit allocation principles, including costs of emission reductions and net wealth transfers from sales of emission rights. See also: Kverndokk 1995, 133.

3 Many of them have contributed nothing if one assumes an upper limit for sustainable emissions up to which emissions can be absorbed sufficiently by plants and oceans so that the global concentration of greenhouse gases remains stable.

4 For an overview of such discussions see: Banuri et al. 1996, 91-112.

5 Some people may argue that even today in the OECD too much money is spent on rubbish. Therefore, braking economic growth would only confine further expenditures on rubbish, and some eventually real reductions in well-being could easily be compensated by politically redirecting expenditures for rubbish to sensible goods. — The latter idea in principle is right but it holds for all the other options as well so that the monetary differences still have to be considered. When (theoretical) economic losses have to be welfarized it does not count what *could* be done at worst (or at best) with the lost money but what *probably would* be done with it. And that in the OECD much money is spent on rubbish does not exclude that there are still lots of possibilities for spending money to increase welfare. That all the additionaly disposable money would be spent on rubbish seems to be a too pessimistic prognosis. The method adopted above (sect. 3.5.3), i.e. assuming a development half-way between the pessimistic and the optimistic scenario, seems to be much more realistic.

6 This is not completely correct because a part of them are borne by the individuals of the OECD countries. But this part is not that big, and could be reduced to zero if the states would decide to assume these costs (which, surely, would only be a redistribution of losses in well-being), and hardly can be individuated because our method of calculation does not give any hint about the particular sources of these damages. Therefore, the procedure adopted here seems to be a good pragmatic solution. The error of this procedure is not as big as may appear at first glance: the damages, of course, are not ignored they are only welfarized in a false way leading, perhaps, to some minor faults in the numerical values of the welfare calculation.

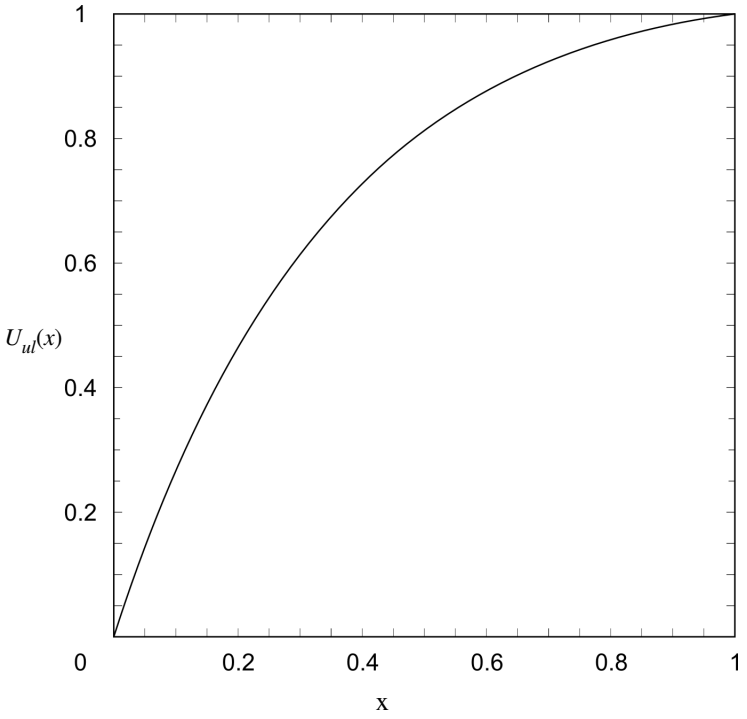
5. The Moral Point(s) of View

5.1. Moral Evaluation of the Alternatives

The above assumptions are highly speculative in part; but some ethical systems require such assumptions for the moral evaluation of a situation - if, as is the case with the greenhouse effect, the various advantages and disadvantages of the alternatives in question are so tangled that there is no alternative which clearly dominates the others. The gain of the work done so far is, of course, that prescriptions of single ethics can be easily calculated from these assumptions. First I will calculate the hedonistic-*utilitarian* value of the options and then the value according to the welfare-ethics utilex, developed by the author (Lumer 2000, ch. 7; Lumer 1997a).

Utilex is similar to utilitarianism: it aggregates personal desirabilities or utilities and these personal desirabilities themselves are conceived hedonistically, i.e. as integrals of subjective well-being. But instead of simply summing up personal utilities of all sentient beings or persons for obtaining the moral value of an alternative, as is done by utilitarianism, utilex first weights the personal utilities morally, before summing up. These moral weights of personal desirabilities are arranged in such a way that higher personal desirability always has a higher moral value, but the increments of the weights decrease with increasing well-being (cf. the graph of the utilex weighting function in figure 5.1). (The weighting function increases strictly and is concave.) As a consequence, improvements in well-being for unhappy people are treated as being morally much more important than improvements

Figure 5.1: The moral weighting function of utilex:



Explanation: x represents the personal desirability of a person's life measured in life-utils, i.e. a normalized way of measuring (cf. below), according to which e.g. a life 80 years long with a (extremely high) mean well-being of 0.3308wi has a personal desirability of 1 life-util. $U_{ul}(x)$ is the moral value of *x* according to utilex.

of the same degree for people already well off.[1] Two examples may explain this. If by medical treatment an additional year with a mean well-being of 0.1420wi can be given to two persons who otherwise would die at 40 and 80 years of age respectively (during which they had the same mean well-being of 0.1420wi) the additional year for the younger person would be valuated 88% higher than that of the older. Or if two people with the same life expectancy of 76 years but (apart from one particular year) different mean well-being, namely 0.1145wi and 0.1655wi (i.e. the mean of the lowest and of the highest income quartile), during one particular year would suffer from a reduction to a

mean well-being of 0.0643wi (e.g. by unemployment) but which could be prevented by some measure which to both would secure a mean well-being of 0.1420wi during this year, this possible melioration for the first person would be valued 53% higher than that for the second person. - Utilex is a synthesis of utilitarianism and leximin [2] (which has lead to the name "utilex"). Like utilitarianism it considers improvements in well-being of all people and not, like leximin (or maximin), only improvements for the people worst off; in this respect utilex is economically efficient, allowing expenses for improvements even for people already well off if these improvements are easily attainable. But like leximin it gives much more weight to improvements for unhappy people, though not indefinitely more weight, as leximin does; in this respect utilex is fair and equitable, trying to compensate for natural disadvantages.

The general idea of Utilex of giving a more or less though not indefinitely high priority to people worse off, which Parfit has called the "priority view" (Parfit, 1997, 213), seems to be shared by many people, though in philosophy only exceptionally it has been clearly formulated and it never has been substantiated with strong reasons.[3] The novelty of Utilex consists in giving a clear justification for this idea and in developing a precise quantitative criterion which can be applied in welfare ethics. Utilex justifies this criterion on the basis of our sympathetic desires and the specific qualities of our sympathy.

The weighting function of utilex is:
$U_{ul}(x) := (19/18)\cdot(1\text{-}19^{-x})$, with x being the (normalized, cf. below) personal desirability of a life.[4]
Some values of this function are:

x:	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
$U_{ul}(x)$:	0.000	0.269	0.470	0.619	0.730	0.813	0.875	0.921	0.955	0.981	1.000

Utilex is designed for people who want to optimize their impersonal sympathetic feelings, i.e. maximize the integral of their (negative (= pity) and positive) sympathy for such people with whom they do not have a particular personal relationship. If people always did the, according to utilex, best action (under certain idealizing conditions) they would optimize their unpersonal sympathy. The priority for people worse off in the resulting utilex weighting function is due to the fact that our negative sympathy (= pity) is stronger than our positive sympathy. (The exact utilex criterion relies on a specific empirical sympathy function over the feelings of other people (how strong is our sympathy resulting from confrontation with different levels of momentary well-being of other people?) and assumptions about the long-term frequency density of such feelings for people with different mean levels of well-being. The weighting function then results from integrating over the product of these two curves for different long-term mean values of well-being. (Cf. Lumer 2000, ch. 7; Lumer 1997a.) In addition to this practical justification of utilex, it has been shown that the utilex criterion expresses the moral intuition of some people (Lumer 2000, 616-625; Lumer 1997a, sect. 1).

But utilex originally was only developed for the moral evaluation of lives which are different with respect to their mean well-being but not to length. Therefore, utilex's range of application has been extended to what is needed here in the following way: 1. Lives with the same personal desirability also have the same utilex desirability. This holds e.g. for a life 40 years long with a mean well-being of 0.2000wi and a life 80 years long with a mean well-being of 0.1000wi because these lives have the same (hedonistic) personal desirability, which is equal to the integral of well-being over time. 2. Then the above mentioned utilex weighting function may be applied to whatever personal desirabilities of lives provided that these desirabilities are normalized for the specific aims of utilex. Because personal desirabilities have a natural zero point (a life which lasts zero years or a life with a mean well-being of zero) which should have an utilex desirability of zero, too, only the positive constant for converting natural personal desirabilities into normalized ones has to be fixed. This has been done intuitionistically, i.e. following intuitive moral judgments of subjects. Subjects were asked to answer the following question: "One person 40 years old and another one 80 years old both with the same and ordinary mean level of well-being are suffering from a malignant disease from which they both will die after one week if they are not operated immediately. With the operation the death of the 40 year old person can be postponed by 8 (= y; variants: y = 4, 1) years during which (s)he will have an ordinary well-being but after that (s)he will die irrevocably. Similar things hold for the 80 year old person; death of this person can be postponed by x years. Unfortunately, only one person can be operated. For what value of x are you morally indifferent between the two possible operations?" Answers of those subjects who seemed to use criteria completely different from utilex ($x \leq y$ or $x = \infty$) were excluded from further consideration because a variable in the framework of *utilex* was looked for; if some people adhere to rival moral criteria their intuitions will be represented by these criteria and must not be represented (in a distorted form) by utilex. The medium of the remaining answers, namely $x=2y$, was taken as *the* utilex answer, from which the properties of the normalized desirability function can be calculated (for the method of calculation cf. the next footnote): A life of 80 years with a mean well-being of 0.3308wi (and all the personal equivalents like 90 years with a mean level of well-being of 0.2941wi etc.) has the normalized personal desirability 1 (and the utilex desirability of 1, too).

One important technical difference of utilex with respect to utilitarianism is that utilex weightings apply only to personal desirabilities of whole *lives*. Thus, for morally evaluating a single event or action the expected personal desirabilities of the whole life with and without this event must be estimated; the difference of the two utilex desirabilities of these lives then is the utilex desirability of the event.

For facilitating the further calculations and comparisons some measuring units have to be introduced. The personal desirability of one year with a well-being of 1wi is called "*1 util*" or "*1u*". (So 100 years with a mean well being of 0.142wi have a personal desirability of 14.2u.) Utilex evaluations are applied to personal desirabilities only if measured in a certain normalized measure. The normalized personal desirability which has the utilex value 1 is called "*1 life-util*" or "*1 lu*". 1 lu := 26.464828u (or 1u = 0.037786 lu).[5] (Apart from very extreme cases the range of personal desirabilities of a whole life is [0 lu;1 lu].)

For comparison with QALYs (which are used in health economy and medical ethics, cf. the explanation in sect. 2.2) a further unit is useful: *1 qaly-util*, or *1qu* for short, is defined as the personal desirability of one year with an ordinary well-being, i.e. 0.1420wi; so 1qu := 0.142u. Because utilitarianism simply sums up personal desirabilities the just mentioned units for personal desirabilities can also be used to express utilitarian desirabilities. The analogue does not hold for utilex; for utilex additional units of *moral* desirabilities have to be introduced. *1 life-lexi*, or *1 ll* for short, is defined as the utilex desirability of a life with the personal desirability of 1lu; other values of utilex desirabilities of whole lives are defined as the result of applying the above introduced utilex weighting function ($U_{ul}(x)$) to the personal desirability of this life measured in life-utils. *1 qaly-lexi*, or *1ql*, finally, is defined as: 1ql := 0.005925 ll; this value was chosen so that if utilex desirabilities are expressed in ql the addition of one further year with an ordinary well-being (of 0.1420wi) to a life with the world mean life expectancy of 65 years and an ordinary well-being would have the moral desirability of 1ql. But please note: utilex desirabilities can be determined directly for whole lives only; and because utilex desirabilities are not proportional to personal desirabilities the addition of one year with a mean well-being of 0.1420wi to a life of 65 years (with a mean well-being of 0.1420wi) has a different moral desirability than the addition of such a year to a life with different length or different mean well-being. (Or taken differently: The utilex desirability of a life of 65 years with a mean well-being of 0.1420wi, i.e. of a life with a personal desirability of 65qu, is 114.35ql and *not* 65ql, because younger years count more.)

Thus we have the following units:
1. Utils:
1 u := 1year·1wi (= 0.037786 lu = 7.042qu).
1 lu := 26.464828u (= 186.365319qu; U_{ul}(1 lu) = 1 ll).
1 qu := 0.142u (= 0.00536561 lu).
2. Lexis:
1 ll := U_{ul}(1 lu) (= 168.774733ql).
1 ql := 0.005925 ll (= U_{ul}(66qu) - U_{ul}(65qu)).

With all these assumptions the moral desirabilities (according to utilitarianism and to utilex) of the four options with respect to the greenhouse effect can be calculated as done in tables 5.1-5.8.

The mean utilitarian and utilex desirabilities of the undamaged lives (columns 2 of tables 5.1-5.8) have been calculated as follows: The social well-being distribution, i.e. the probability density *PDW* of a certain personal mean value of well-being *w* (measured in wi), assumed in section 3.3 was:

$$PDW(w) = \frac{1}{\sigma \cdot \sqrt{2\pi}} e^{-\frac{(w-\mu)^2}{2\sigma^2}}$$

with Σ=0.109 and μ being the social mean of well-being of the respective group (specified in columns 3 of tables 3.5 and 4.4-4.6). The discontinuance hypothesis (cf. sect. 3.3) was not incorporated in this formula but in the formulas for the moral desirabilities. So the formula for the utilitarian desirability changed to:

$U_{ut}(x) = x \cdot \Phi(x)$, with $\Phi(x)$ being the function: $\Phi(x)=1$ for $x=0$, $\Phi(x)=0$ for $x<0$.

And the formula for the utilex desirability changed to:

$U_{ul}(x) = (19/18) \cdot (1-19^{-x \cdot \Phi(x)})$.

The mean moral desirability of the lives of a given group then is equal to:

$$\int_{-1}^{1} [PDW(w) \cdot U(c \cdot m \cdot w)] dw,$$

with U being U_{ut} or U_{ul}, c (=0.037786) being the constant for transforming utils in life-utils, and m being the mean life expectancy of this group in years (i.e. the values of columns 2 of tables 3.5 and 4.4-4.6). For calculating the total moral desirability of the lives of the whole group the results obtained by this formula simply has to be multiplied by the quantity of that group.

The formula for calculating the mean moral desirabilities of the damaged lives (columns 3 of tables 5.1-5.8) is:

$$\int_{-1}^{1} [PDW(w) \cdot U(c \cdot ((m-t) \cdot w + t(w-r)))] dw,$$

with t being the time of reduced well-being and r being the amount of reduction in wi.

The resulting formula for calculating e.g. the mean utilex desirability of lives of 65.01 years length and with a grand mean of well-being of 0.1420wi (cf. e.g. rows *a* in tables 3.5 and 5.5) is:

$$\text{Ø}U_{ul}(65.01y;0.1420wi) = \int_{-1}^{1} \frac{1}{0.109 \cdot \sqrt{2\pi}} \cdot e^{\frac{-(w-0.142)^2}{2 \cdot 0.109^2}} \cdot \frac{19}{18} \cdot (1-19^{-(0.037786 \cdot [65.01 \cdot w]) \cdot \text{▯} (0.037786 \cdot [65.01 \cdot w])}) dw$$

$$= 0.360934$$

Explanations for tables 5.1-5.8: Columns 1 list the abbreviations of the types of damages as they were introduced in tables 3.5 and 4.4-4.6. - *Columns 2* list the *mean* utilitarian respectively utilex desirabilities of the undamaged lives (initial position) of the persons whom the respective type of damage befalls, i.e. of the lives people would have expected in a fictitious world without the artificial greenhouse effect and without the abatement exertions. The units are millionths of life-utils respectively life-lexis. These mean desirabilities have been calculated considering that the well-being information of columns 3 in the tables 3.5 and 4.4-4.6 are only the means of the social well-being distribution. - *Columns 3* give the *mean* moral desirabilities of the damaged lives, calculated according to the assumptions in columns 2-5 in tables 3.5 and 4.4-4.6, again in millionths of life-utils respectively life-lexis. - *Columns 4* are the differences of

columns 2 and 3, i.e. they represent the mean moral desirabilities of the respective damages (again in millionths of life-utils respectively life-lexis). - *Columns 5* report the numbers (taken from columns 6 of tables 3.5 and 4.4-4.6) of people affected (in 1000 persons). - *Columns 6* contain the products of columns 4 and 5 and thus represent the (negative) moral desirabilities of the total damage (of the respective damage category) in life-utils respectively life-lexis. - *Columns 7*, finally, give the percentages of the respective damage class from the overall damage by the respective option. - "■" again indicates welfare losses which are welfarizations of the economic losses of the decider (which in the cost-welfare analysis have to be treated differently).

Table 5.1

a_1: utilitarian evaluation of welfare losses from BAU (2050-2075):

1	2	3	4	5	6	7
type of damage	$ØU_{ut}$ init. position in µlu	$ØU_{ut}$ damaged life in µlu	$ØU_{ut}$ damage in µlu	persons in 1000	total damage in lu	portion of all damages in %
1.1a floods, storms	360934	180467	180467	441	79586	0.403
1.1b famines	349330	174665	174665	37500	6549938	33.186
1.1c migrants dur. migration	349330	174665	174665	1046	182700	0.926
1.1d absolute poverty	291817	145909	145908	52500	7660170	38.811
1.1e malaria	349330	174665	174665	1250	218331	1.106
1.1f hot spells	360934	180467	180467	5927	1069627	5.419
(subtotal direct casualties				*98664*	*15760352*	*79.851)*
1.2a nat. disasters	360934	360805	129	4410	569	0.003
1.2b famines, suffering	349330	349202	128	375000	48000	0.243
1.2c malaria	349330	349206	124	248750	30845	0.156
1.2d air pollution	360934	360872	62	447179	27725	0.140
1.2e hot spells	360934	360805	129	59272	7646	0.039
1.2f chron. hunger pangs	291817	226900	64917	6400	415469	2.105
1.2g deficiency diseases	291817	264725	27092	25600	693555	3.514
(subtotal direct phys. suffering					*1223809*	*6.200)*
1.3a stronger grief	360934	360741	193	303528	58581	0.297
1.3b stronger grief & psy. gaps	360934	358394	2540	75882	192740	0.977
1.3c migration & diseases	349330	335135	14195	10460	148480	0.752
1.3d misery of migrants	349330	335263	14067	93090	1309497	6.635
1.3e worse social climate	360934	360870	64	1500000	96000	0.486
(subtotal direct psych. suffering					*1805298*	*9.147)*
2a NOECD ec. ruin, starving	349330	174665	174665	59	10305	0.052
2b NOECD ec. ruin, hunger pa.	349330	233257	116073	180	20893	0.106
2c NOECD ec. ruin, def. diseas.	349330	285039	64291	722	46418	0.235
2d NOECD ec. ruin, pauperiz.	349330	320322	29008	843	24454	0.124
2e NOECD ec. r., return or. lev.	349330	348251	1079	6148	6634	0.034
2f NOECD ec. ruin, soc. degr.	349330	319480	29850	6148	183518	0.930
2g NOECD harder daily life	291817	291400	417	1000000	417000	2.113
2h OECD ec. ru., return or. lev.	423671	422592	1079	250	270	0.001
2i OECD ec. ruin, soc. degrad.	423671	401414	22257	250	2223	0.011
2j OECD ec. ruin, reimbursem.	423671	422592	1079	2250	2428	0.012
2k NOECD social ec. losses	295477	282612	12865	8915	114691	0.581
2l ■OECD social ec. losses	394704	381444	13260	7843	■103998	0.527
(subtotal damages via economic losses					*932832*	*4.726)*

3a grief about ecological losses	360934	360924	10	1500000	15000	0.076
sum without welf. of soc. ec. losses					19633293	99.473
■sum welfarized soc. ec. losses					■103998	0.527
ΣΣ					19737291	100.000

Table 5.2

a_2: utilitarian evaluation of welfare losses from stabilization:

1	2	3	4	5	6	7
a_2: 2000-2025:						
a ■OECD missed publ. assist.	394704	381444	13260	38516	■510722	3.622
b political upset	423671	423656	15	200000	3000	0.021
c unemployment	423671	422368	1303	100000	130300	0.924
a_2: 2025-2050:						
d ■OECD missed publ. assist.	394704	381444	13260	93979	■1246162	8.838
e political upset	423671	423656	15	200000	3000	0.021
a_2: 2050-2075:						
f ■OECD missed publ. assist.	394704	381444	13260	125000	■1657500	11.756
g ■OECD missed publ. assist.	421588	407946	13642	49643	■677230	4.803
h political upset	423671	423656	15	200000	3000	0.021
i1 halved greenh. ef. without welf. of soc. ec. loss					9816647	69.624
i2 ■halved greenh. ef. welf. soc. ec. loss					■51999	0.369
sum without welf. of soc. ec. losses					9955947	70.612
■sum welf. of soc. ec. losses					4143613	29.388
ΣΣ					14099559	99.999

Table 5.3

a_3: utilitarian evaluation of welfare losses from strong reduction:

1	2	3	4	5	6	7
a_3: 2000-2025:						
a ■OECD missed publ. assist.	394704	381444	13260	53693	■711969	6.923
b political upset	423671	423656	15	200000	3000	0.029
c unemployment	423671	421717	1954	200000	390800	3.800
a_3: 2025-2050:						
d ■OECD missed publ. assist.	394704	381444	13260	118403	■1570024	15.267
e political upset	423671	423656	15	200000	3000	0.029
a_3: 2050-2075:						
f ■OECD missed publ. assist.	394704	381444	13260	125000	■1657500	16.118
g ■OECD missed publ. assist.	421588	407946	13642	74029	■1009904	9.821
h political upset	423671	423656	15	200000	3000	0.029
i1 quart. greenh. ef. without welf. of soc. ec. loss					4908323	47.730
i2 ■quart. greenh. ef. welf. soc. ec. loss					■26000	0.253
sum without welf. of soc. ec. losses					5308123	51.618
■sum welf. of soc. ec. losses					■4975396	48.382
ΣΣ					10283519	99.999

Table 5.4

a_4: utilitarian evaluation of welfare losses from sustainable reduction:

1	2	3	4	5	6	7
a_4: 2000-2025:						
a ■OECD missed publ. assist.	394704	381444	13260	59094	■783586	11.662
b political upset	423671	423656	15	200000	3000	0.045
c unemployment	423671	421066	2605	300000	781500	11.631
a_4: 2025-2050:						
d ■OECD missed publ. assist.	394704	381444	13260	125000	■1657500	24.668
e ■OECD missed publ. assist.	421588	407946	13642	25812	■352127	5.241
f political upset	423671	423656	15	200000	3000	0.045
a_4: 2050-2075:						
g ■OECD missed publ. assist.	394704	381444	13260	125000	■1657500	24.668
h ■OECD missed publ. assist.	421588	407946	13642	108342	■1478002	21.997
i political upset	423671	423656	15	200000	3000	0.045
sum without welf. of soc. ec. losses					790500	11.765
■sum welf. of soc. ec. losses					■5928715	88.235
ΣΣ					6719215	100.002

Table 5.5

a_1: utilex evaluation of welfare losses from BAU (2050-2075):

1	2	3	4	5	6	7
type of damage	$ØU_{ul}$init. position	$ØU_{ul}$da-maged life	$ØU_{ul}$da-mage	persons	total damage	portion of all damages
	in µll	in µll	in µll	in 1000	in ll	in %
1.1a floods, storms	594690	395324	199366	441	87920	0.371
1.1b famines	585260	386512	198748	37500	7453050	31.482
1.1c migrants dur.migration	585260	386512	198748	1046	207890	0.878
1.1d absolute poverty	512207	331704	180503	52500	9476408	40.028
1.1e malaria	585260	386512	198748	1250	248435	1.049
1.1f hot spells	594690	395324	199366	5927	1181642	4.991
(subtotal direct casualties				*98664*	*18655346*	*78.799)*
1.2a nat. disasters	594690	594544	146	4410	644	0.003
1.2b famines, suffering	585260	585110	150	375000	56250	0.238
1.2c malaria	585260	585116	144	248750	35820	0.151
1.2d air pollution	594690	594620	70	447179	31303	0.132
1.2e hot spells	594690	594544	146	59272	8654	0.037
1.2f chron. hunger pangs	512207	419856	92351	6400	591046	2.497
1.2g deficiency diseases	512207	474706	37501	25600	960026	4.055
(subtotal direct phys. suffering					*1683742*	*7.113)*
1.3a stronger grief	594690	594472	218	303528	66169	0.279
1.3b stronger grief & psy. gaps	594690	591796	2894	75882	219603	0.928
1.3c migration & diseases	585260	568312	16948	10460	177276	0.749
1.3d misery of migrants	585260	568469	16791	93090	1563074	6.602
1.3e worse social climate	594690	594618	72	1500000	108000	0.456
(subtotal direct psych. suffering					*2134122*	*9.014)*
2a NOECD ec. ruin, starving	585260	386512	198748	59	11726	0.050
2b NOECD ec. ruin, hunger pa.	585260	434063	151197	180	27215	0.115
2c NOECD ec. ruin, def. diseas.	585260	502668	82592	722	59631	0.252

2d NOECD ec. ruin, pauperiz.	585260	548884	36376	843	30665	0.130
2e NOECD ec. r., return or. lev.	585260	584000	1260	6148	7746	0.033
2f NOECD ec. ruin, soc. degr.	585260	547776	37484	6148	230452	0.973
2g NOECD harder daily life	512207	511667	540	1000000	540000	2.281
2h OECD ec. ru., return or. lev.	639979	638915	1064	250	266	0.001
2i OECD ec. ruin, soc. degrad.	639979	616575	23404	250	5851	0.025
2j OECD ec. ruin, reimbursem.	639979	638915	1064	2250	938	0.004
2k NOECD social ec. losses	517095	499639	17456	8915	155620	0.657
2l ■OECD social ec. losses	609619	595016	14603	7843	■114531	0.484
(subtotal damages via economic losses					*1184642*	*5.005)*
3a grief about ecological losses	594690	594679	11	1500000	16500	0.070
sum without welf. of soc. ec. losses					23559821	99.516
■sum welfarized soc. ec. losses					■114531	0.484
ΣΣ					23674352	100.001

Table 5.6

a_2: utilex evaluation of welfare losses from stabilization:

1	2	3	4	5	6	7
a_2: 2000-2025:						
a ■OECD missed publ. assist.	609619	595016	14603	38516	■562449	3.426
b political upset	639979	639964	15	200000	3000	0.018
c unemployment	639979	638694	1285	100000	128500	0.783
a_2: 2025-2050:						
d ■OECD missed publ. assist.	609619	595016	14603	93979	■1372375	8.358
e political upset	639979	639964	15	200000	3000	0.018
a_2: 2050-2075:						
f ■OECD missed publ. assist.	609619	595016	14603	125000	■1825375	11.117
g ■OECD missed publ. assist.	637844	624054	13790	49643	■684577	4.169
h political upset	639979	639964	15	200000	3000	0.018
i1 halved greenh. ef. without welf. of soc. ec. loss					11779910	71.744
i2 ■halved greenh. ef. welf. soc. ec. loss					■57266	0.349
sum without welf. of soc. ec. losses					11917410	72.581
■sum welf. of soc. ec. losses					■4502042	27.419
ΣΣ					16419452	100.000

Table 5.7

a_3: utilex evaluation of welfare losses from strong reduction:

1	2	3	4	5	6	7
a_3: 2000-2025:						
a ■OECD missed publ. assist.	609619	595016	14603	53693	■784079	6.717
b political upset	639979	639964	15	200000	3000	0.026
c unemployment	639979	638049	1930	200000	386000	3.307
a_3: 2025-2050:						
d ■OECD missed publ. assist.	609619	595016	14603	118403	■1729039	14.812
e political upset	639979	639964	15	200000	3000	0.026
a_3: 2050-2075:						
f ■OECD missed publ. assist.	609619	595016	14603	125000	■1825375	15.638
g ■OECD missed publ. assist.	637844	624054	13790	74029	■1020860	8.746

h political upset	639979	639964	15	200000	3000	0.026
i1 quart. greenh. ef. without welf. of soc. ec. loss					5889955	50.458
i2 ■quart. greenh. ef. welf. soc. ec. loss					■28633	0.245
sum without welf. of soc. ec. losses					6284955	53.842
■sum welf. of soc. ec. losses					■5387986	46.158
ΣΣ					11672941	100.001

Table 5.8

a_4: utilex evaluation of welfare losses from sustainable reduction:

1	2	3	4	5	6	7
a_4: 2000-2025:						
a ■OECD missed publ. assist.	609619	595016	14603	59094	■862950	12.077
b political upset	639979	639964	15	200000	3000	0.042
c unemployment	639979	637403	2576	300000	772800	10.815
a_4: 2025-2050:						
d ■OECD missed publ. assist.	609619	595016	14603	125000	■1825375	25.546
e ■OECD missed publ. assist.	637844	624054	13790	25812	■355947	4.981
f political upset	639979	639964	15	200000	3000	0.042
a_4: 2050-2075:						
g ■OECD missed publ. assist.	609619	595016	14603	125000	■1825375	25.546
h ■OECD missed publ. assist.	637844	624054	13790	108342	■1494036	20.909
i political upset	639979	639964	15	200000	3000	0.042
sum without welf. of soc. ec. losses					781800	10.941
■sum welf. of soc. ec. losses					■6363683	89.059
ΣΣ					7145483	100.000

According to these calculations, the resulting total utilitarian desirability losses (i.e. the differences with respect to a fictitious ordinary distribution of well-being) are as follows: $\Delta U_{ut}(a_1)$ = 19,737,291 lu; $\Delta U_{ut}(a_2)$ = 14,099,559 lu; $\Delta U_{ut}(a_3)$ = 10,283,519 lu; $\Delta U_{ut}(a_4)$ = 6,719,215 lu. The resulting utilex desirability losses are: $\Delta U_{ul}(a_1)$ = 23,674,352 ll; $\Delta U_{ul}(a_2)$ = 16,419,452 ll; $\Delta U_{ul}(a_3)$ = 11,672,941 ll; $\Delta U_{ul}(a_4)$ = 7,145,483 ll. This means that for utilitarianism and for utilex sustainable reduction of CO_2 (a_4) by a wide margin is the best option, followed by strong reduction (a_3), stabilization (a_2) and business as usual (a_1); the preference order for utilitarianism and utilex is: $a_4 > a_3 > a_2 > a_1$. (Note that in tables 5.1-5.8 *damages* are counted, i.e. the higher the figures (in columns 6 (and 4)) the *worse* is the respective option.) These preference orders are rather stable with respect to possible alterations of the assumptions because the distances in desirabilities are rather high. The worst alternative (a_1) produces 193.75% respectively 231.32% more losses than the best alternative (a_4), according to utilitarianism respectively utilex. And the desirability differences between preferentially adjacent alternatives are rather equal for both types of evaluations. For utilitarianism as well as

for utilex directly caused deaths (group 1) make up the lion's share of all damages from BAU: 79.85% and 78.80% respectively; welfare losses caused by economic damages (group 2) make up 4.73%, respectively 5.01%. For the reduction options this is different: The extreme is a_4 where welfarized economic losses for utilitarianism respectively utilex make up 88.24% respectively 89.06% of all damages.

Analyzing the peculiarities of utilex against utilitarianism cannot be done by simply comparing the different evaluations of the various damages (i.e. comparing the values of columns 4 (and 6) of tables 5.1-5.4 with those of tables 5.5-5.8) because already the absolute figures of utilex are *always* higher. 1. A first useful way of analysis instead is to compare the percentages of the various types of damages with respect to the total damage (cf. columns 7 of the tables). At first glance a very astonishing result of this comparison is that direct casualties in the utilex calculation are valued lower (78.799% of all damages), though only very slightly, than in the utilitarian calculus (79.851%) - which is exactly the contrary of what one would have expected from an ethical criterion favouring the people worst off (and surely the people killed by the greenhouse effect are those worst off in our context (cf. columns 3 of tables 5.1 and 5.5)). The explanation is that death reduces all the people to a welfare level of zero (exactly), whereas nonlethal damages always reduce a part of the respective group temporarily to a level *below* zero. (Remember that the levels of well-being specified in column 3 of table 3.5 are *means* of a social distribution; the part of this distribution below 0wi is cut off via the discontinuance hypothesis. If those originally only slightly above 0wi due to greenhouse damages are temporarily reduced to a well-being below 0wi these negative parts of the well-being integral will not be cut off by the discontinuance hypothesis as long as the total life balance is still positive.) And in utilex such relatively bigger losses are weighted higher. So utilex in the end behaves as it should: considering unhappiness more.

2. Another and more exact way of comparing utilex to utilitarianism is to choose one outstanding type of damage, e.g. the morally biggest, to calculate the relation of the mean moral desirability (according to both, utilitarianism and utilex) of the other types of damages to the mean moral desirability of the outstanding damage and to compare which moral criterion gives more weight to this type of damage; the latter can be done by dividing the percentage obtained for utilex by the percentage obtained for utilitarianism. The most important damage considered here according to utilitarianism as well as according to utilex are casualties in a worldwide average group (i.e. with 65 years life expectancy and a mean well-being of 0.1420wi, cf. lines 1.1a and 1.1f of tables 3.5, 5.1 and 5.5). A first big difference between utilitarianism and utilex is that death by bringing people from poverty to absolute poverty (cf. line 1.1d of tables 3.5, 5.1 and 5.5) for utilitarianism in the mean has 80.85% desirability of the maximum damage, whereas for utilex it has 90.54% desirability of the maximum damage, so that utilex gives 12.00% more weight (in the sense just explained) to this type of damage. This means that utilex, as opposed to utilitarianism, does not take the death of a person with an already bad life prospect much more lightly. Other damages which by utilex in the mean are

valued much higher than by utilitarianism are the following - only the most extreme cases are listed:

- chronic hunger pangs (lines 1.2f of tables 3.5, 5.1, 5.5): 28.77% more weight;
- deficiency diseases etc. by aggravated poverty (lines 1.2g): 25.30%more weight;
- missed public assistance / social economic losses in NOECD countries (lines 2k): 22.82% more weight;
- economic ruin in the NOECD leading to absolute poverty with hunger pangs (lines 2b): 17.91% more weight;
- harder daily life (lines 2g): 17.32% more weight;
- economic ruin in the NOECD leading to absolute poverty with deficiency diseases (lines 2c): 16.29% more weight; etc.

On the other hand utilex in the mean gives less weight to several other types of damages than utilitarianism does. The most extreme cases are:

- half year unemployment in the OECD (lines c of tables 4.4, 5.2 and 5.6): 10.73% less weight;
- economic ruin in the OECD with reimbursement (lines 2j of tables 3.5, 5.1, 5.5): 10.70% less weight;
- nine months unemployment in the OECD (lines c of tables 4.5, 5.3 and 5.7): 10.58% less weight;
- one year unemployment in the OECD (lines c of tables 4.6, 5.4, 5.8): 10.49% less weight;
- political upset (lines b, e, h of tables 4.4, 5.2, 5.6 etc.): 9.64% less weight;
- missed public assistance in the OECD for people above the poverty line (e.g. lines g of tables 4.4, 5.2, 5.6): 8.49% less weight.

The main reason for these differences between utilitarianism and utilex is that utilex gives more weight to the damages besetting people with a comparatively low initial position - in our case in particular, to losses for poor people of the NOECD countries, i.e. people with a comparatively low life expectancy and low well-being, compared to average people of the OECD countries. A much smaller contribution to these differences stems from the fact that utilex as compared to utilitarianism gives proportionally more weight to bigger damages than to smaller damages. And this is exactly what one expects from a moral criterion like utilex.These peculiarities explain why the difference in moral desirability losses between the worst (a_1) and the best (a_4) of our alternatives is bigger for utilex (231.32% worse) than for utilitarianism (193.75% worse); utilex makes the difference 10.10% greater: Most of the bigger damages of a_1 (BAU) beset people in NOECD countries, in particular poor people, i.e. people with a comparatively low life expectancy and low well-being and consequently low personal desirability of life; all damages from a_4 (sustainable reduction) instead beset people in the OECD countries with a higher life expectancy (though to a large part slightly less than ordinary well-being (0.1308wi)) and thus a higher desirability of life.

But the differences between utilitarianism and utilex, at least at first glance, are not overwhelming. Among the types of damages considered here, the damages which in the mean are weighted maximally stronger by utilex than by utilitarianism (i.e. chronic hunger pangs due to absolute poverty (line 1.2f of tables 3.5, 5.1, 5.5): 28.77% more weight) are weighted only 44.25% higher than the damages which in the mean are weighted maximally lower by utilex than by utilitarianism (i.e. half a year of unemployment (line c of tables 4.4, 5.2, 5.6): 10.73% less weight).[6] In short, utilex and utilitarianism differ only maximally by 44.25% in their mean weighting of different types of damages.

But firstly, this holds only for the *means* of the damage groups; the extremes of these groups are treated much more differently by the two moral criteria. And secondly, the maximal weighting difference of 44.25% results only from the group of damages considered here: As already reported, the main contribution to the differences between utilitarianism and utilex in weighting damages stems from the fact that utilex gives more weight to damages besetting people with an already low initial position. But the means of the best and the worst initial positions considered here (the mean of the OECD countries with a mean life expectancy of 76.31 years and a mean well-being of 0.1420wi, i.e. 10.8360u = 0.4094 lu = 76.31qu, versus the poor of the NOECD countries with a mean life expectancy of 62.92 years and a mean well-being of 0.1145wi, i.e. 7.2043u = 0.2722 lu = 50.73qu) differ "only" by 50.41% in their personal desirabilities. And, obviously, this may be quite different with other social problems, e.g. when comparing the moral desirability of programs intended to rescue children from starvation with the moral desirability of lowering property taxes in OECD countries.

According to the classical interpretation of utilitarianism, because a_4 is the morally best option we have the moral obligation to reduce greenhouse gas emissions to a sustainable level (i.e. to do a_4). But according to some recent interpretations and according to utilex, the moral optimum does not directly imply a moral obligation. I will return to this question in chapters 6 and 7.

The preference order $a_4 > a_3 > a_2 > a_1$ is not changed if the values of future events are discounted by 3%/year, taking the year 2000 as the year of decision; this holds for discounting on a utilitarian as well as on an utilex basis. But due to the fact that the damages from the anthropogenous greenhouse effect make a big difference only in the third period, whereas the damages by abatement mainly occur in the first period, the desirability difference between the worst and the best option is diminished as follows. The discounted damages due to the worst option (a_1) according to utilitarianism and utilex are 35.03% and 52.83% respectively worse than those due to the best option (a_4). However, one may be surprised that nonetheless sustainable reduction still is the best and BAU the worst option. But as shown in table 5.9, welfare losses due to the full anthropogenous greenhouse effect in the third period, even if discounted, are still much more important than the highest (discounted) abatement costs in the first period, i.e. those of sustainable reduction, for both utilitarianism (2,901,382 lu / 1,055,322 lu = 2.749) and utilex (3,480,130 ll / 1,102,879 ll = 3.155).

Even very different ethical criteria result in preferring or demanding sustainable CO_2-reduction (a_4). An (intermediately strong) criterion of *sustainability*, which is accepted by many environmental ethicists

Table 5.9

a_1-a_4: welfare losses according to utilitarianism and utilex differentiated for periods, undiscounted and discounted by 3%/year:

1 option & period	2 undisc. utili- tarian losses in lu	3 disc. utili- tarian losses in lu	4 undisc. utilex losses in ll	5 disc. utilex losses in ll
a_1: BAU				
2000-2025	0	0	0	0
2025-2050	0	0	0	0
2050-2075	19,737,291	2,901,382	23,674,352	3,480,130
sum a_1	19,737,291	2,901,382	23,674,352	3,480,130
a_2: stabilization				
2000-2025	644,022	433,427	693,949	467,028
2025-2050	1,249,162	392,237	1,375,375	431,868
2050-2075	12,206,376	1,794,337	14,350,128	2,109,469
sum a_2	14,099,559	2,620,001	16,419,452	3,008,364
a_3: strong reduction				
2000-2025	1,105,769	744,183	1,173,079	789,482
2025-2050	1,573,024	493,929	1,732,039	543,860
2050-2075	7,604,726	1,117,895	8,767,823	1,288,870
sum a_3	10,283,519	2,356,007	11,672,941	2,622,212
a_4: sustainable reduction				
2000-2025	1,568,086	1,055,322	1,638,750	1,102,879
2025-2050	2,012,627	631,965	2,184,322	685,877
2050-2075	3,138,502	461,360	3,322,411	488,394
sum a_4	6,719,215	2,148,647	7,145,483	2,277,150

Explanation: Because timing of the damages here consisted only in grouping them into periods of 25 years all the damages of one period were discounted with the discount factor of the middle year of the respective periods (i.e. 2013, 2038 and 2063). 2000 was taken as the year of decision. So the discount factors used here were: $(1\text{-}0.03)^{13} = 0.673$, $(1\text{-}0.03)^{38} = 0.314$, and $(1\text{-}0.03)^{63} = 0.147$ for the third, second, and third period.

(e.g. Barry (1983, 17; 20; 24), Birnbacher (1988, 218-221), Höffe (1993, 186-188), Kavka (1978), Koller (1995, 134), Leist (1996, 436)), demands from all generations that they leave as many resources to the following generation as they have found themselves; substitution of existing resources is permitted, though only by resources with the same commodity value (and not just by things with equal utility). According to this criterion, in particular we have to leave an equal amount of resources of arable and inhabitable ground - if we do not provide for substitutes, which is hardly possible to the required extent in the case of lost ground etc. Thus, this criterion also demands sustainable CO_2-

reduction: a_4. - In spite of all the unclearness of Kantian moral criteria, presumably already from the Categorical Imperative in the narrow sense (GMS, BA 17; 52; 81) it follows that I cannot will that other people, specifically that our ancestors of three generations ago, had emitted CO_2 in a similarly excessive manner leading today to the consequences of the greenhouse effect described in a_1, a_2 and a_3. Thus, in our situation with the four options, sustainable CO_2-reduction would be our duty. - Also according to the (partial) criterion '*neminem laedere*', 'do not harm anybody!', as supported by Schopenhauer and contemporaries like Lenzen and Leist (Schopenhauer 1840, 177; 199; 251; Lenzen 1999, 16-23; Leist 1996b, 64 f.; 76) sustainable CO_2-reduction would be demanded of the First World, as with the alternatives a_1 to a_3 the present generation of the First and Second World [7] impair mainly the generation after the next in all coastal and arid areas.

The unanimity of these very different moral criteria in their judgement of the greenhouse effect derives from two characteristics common to all the alternatives leading to the greenhouse effect: 1. the very unfavourable cost-welfare-ratio and 2. the externalization of costs from the profiteers to *other* persons. The first is relevant for ethics aggregating utilities like utilitarianism and utilex, the latter for ethics thinking in terms of rights and causation of harm. The unanimity of all these ethics is frightening for the inhabitants of the First World considering the burden they will have to carry by meeting the accepted moral duties.

5.2. Cost-Welfare Analysis of the Abatement Options

As announced above, to prevent the welfarization of social economic costs (of OECD countries) and to be able to compare the greenhouse gas abatement with completely different measures, cost-welfare analyses of the abatement options will now be undertaken, according to formula F1 (cf. above, sect. 3.5.4). The moral desirabilities have been calculated as in the last subsection in tables 5.1-5.8 but without the welfarizations of social economic costs indicated by "■". (In addition the desirabilities have been converted from life-utils and life-lexis to qaly-utils and qaly-lexis respectively.) The figures of the social economic costs (of OECD countries) themselves were taken from the annex of table 3.5 (for a_1) and from the annexes of tables 4.4-4.6 (for a_2-a_4). The results of these calculations are documented in table 5.10. The first two lines represent cost-welfare relations for undiscounted costs and undiscounted utilitarian and utilex desirabilities. The two

lines in the middle describe cost-welfare relations for costs discounted by 3%/year and undiscounted moral desirabilities. The last two lines, finally, represent cost-welfare relations based on discounted costs (by 3%/year) and discounted (by 3%/year) moral desirabilities. The amounts in lines 5 and 6 are much higher than in the first two lines because the moral yields (prevented damages due to the greenhouse effect) will turn up only late, whereas moral damages (unemployment) will appear early. The calculations in the first two lines are conceptually wrong and are given here only for information. They are wrong because future costs cannot be treated like present costs since they can be paid with money invested currently which will bear interest until the day of payment. Whether the two lines in the middle or the last two lines represent the right cost-welfare relations depends on the question if temporal universalism is right or not (which will be discussed below). - In any of the six considered ways of calculating the cost-welfare relation the moral preference order is: $a_4 > a_3 > a_2$. That means that sustainable reduction (among the abatement options) is the most efficient alternative.

Table 5.10

Cost-welfare relations of the abatement options a_2, a_3, a_4 according to different criteria (costs are always given in US-dollars$_{1990}$):

criterion	*unit*	a_2	a_3	a_4
simple utilitarianism, undisc. costs	Doll/qu	31,162	25,358	22,981
simple utilex, undisc. costs	Doll/ql	28,602	23,220	20,992
simple utilitarianism, costs 3% disc.	Doll/qu	8,059	6,848	6,153
simple utilex, costs 3% disc.	Doll/ql	7,397	6,271	5,621
utilitarianism 3% disc., costs 3% disc.	Doll/qu	57,684	51,683	49,197
utilex 3% disc., costs 3% disc.	Doll/ql	52,453	46,407	43,550

Cost-welfare relations make it possible to compare the abatement options to completely different possibilities of spending, in this case public, money. In health economics cost-welfare relations on the basis of QALYs (quality adjusted life years) are calculated. The methods used for measuring the quality of life differ very much from each other and are, in part, highly problematic (cf. the discussion in sect. 2.2). But the basic idea of QALYs is to measure something similar as is done by qaly-utils; therefore information about QALYs and about qaly-utils may be roughly comparable. QALYs are comparable to qaly-*lexis* only under the condition that the examined melioration of health state prolongs the life of a 65 year old person with ordinary well-being (or personal equivalents of such a life); this may often be the case approximately, but very often it is not. Now in health economy,

measures which cost up to 20,000 $dollars_{[1982]}$/QALY (= 27,023 $dollars_{1990}$/QALY [8]) are held to be efficient in any case; measures costing more than 100,000 $dollars_{[1982]}$/QALY (= 135,117 $dollars_{1990}$/QALY) are considered to tend to be questionable from an economic point of view as compared to other measures, but are not to be to rejected in any case (Kaplan / Bush 1982, 74). Cost-utility relations of some medical measures are listed in table 5.11. The

Table 5.11

Cost-welfare relations of some measures (prices in in US-dollars$_{1990}$):

measure	*cost/welfare utilitarian*	*cost/welfare utilex*
rhesus prophylaxis after delivery	< 0 D/QALY [a]	
rhesus prophylaxis before delivery	1,597 D/QALY [a]	
left coronary artery bypass surgery	5,498 D/QALY [a]	[b]
newborn intensive care, 1000-1499 g	5,891 D/QALY [a]	
treatment of mild hypertension (diastolic 95-104 mm Hg) in males above 40	25,002 D/QALY [a]	[b]
newborn intensive care, 500-999 g	41,626 D/QALY [a]	
coronary artery bypass surgery for single vessel disease in intermediate angina pectoris	47,517 D/QALY [a]	[b]
tuberculin test program in schools	57,203 D/QALY [a]	
inpatient hemodialysis	70,686 D/QALY [a]	[b]
allowance against starvation [c]	470 D/qu	237 D/ql [d]
social assistance in NOECD countries [e]	3,659 D/qu	2,627 D/ql [f]
social assistance in the USA (raising income of people slightly below poverty line)	32,324 D/qu	30,988 D/ql [g]

Explanations: a) These data are based on: Torrance / Zipursky (1984, 278). Torrance and Zipursky have gathered prices from the literature, mainly from the period up to ten years before publication of their paper, and have converted these prices into prices of 1983. Here the latter prices have been converted into 1990 prices, according to the consumer price index (Statistical Abstract US 1998, 487). - *b)* Utilex cost-welfare relations can be equated with the utilitarian ones if the measures serve for prolonging a life of 65 years with ordinary well-being. - *c)* "Allowance against starvation" shall mean that for the period of the allowance people are rescued from starvation but without opening a long-term perspective for survival for them. Aid in case of disasters which helps over short-term life threatening bottle-necks of different kinds is much more efficient. - *d)* For calculating the utilex desirability a life expectancy of 31.25 years and an original mean well-being of 0.1000wi were assumed. - *e)* Differences to the USA derive from lower original well-being and greater purchasing power. - *f)* For calculating the utilex desirability a life expectancy of 62.5 years and an original well-being of 0.1000wi were assumed. - *g)* A life expectancy of 75 years and an original well-being of 0.1145wi were assumed.

welfarizations of the social economic costs undertaken above contain the material for some further estimated cost-welfare relations, which are listed in the lower part of table 5.11.

At least sustainable reduction is clearly efficient according to the criteria of health economics if the welfare gains are not discounted (even if the costs are not discounted). After discounting welfare gains the efficiency of a_4 (49,197 dollars/qu for utilitarianism and 43,550 dollars/ql for utilex) declines to the level of rather expensive though far from inefficient medical measures. Efficiency of the abatement options is even quite good as compared to that of social assistance in OECD countries. But the efficiency of developmental aid to NOECD countries may still be much higher. The consequences of this comparison will be discussed below.

Notes to Chapter 5

1 According to utilitarianism too, melioration for people worse off often is preferred to melioration (of the same size) for people better off — but for *economic* reasons, i.e. because the latter melioration is more expensive, so with the same money one could help more people worse off. Surely, utilex would generate the same preference in such a case. But this is not meant by "giving more moral weight to melioration for people worse off". Rather, utilex would prefer the melioration for a person worse off to a melioration (of the same degree) for a person better off even if the two meliorations cost the same and even if the melioration for the person (much) worse off costs (moderately) more because this melioration is treated as being morally better. This cannot happen in utilitarianism because the two meliorations are treated as being equally desirable from a moral point of view. The same can be explained in a more technical way: What utilitarians are insisting on is that the personal utility function of money and some other goods is concave, i.e. the gradient of the desirability or well-being curve decreases as income increases. (This above, in sects. 3.3 and 3.5.3, has been empirically confirmed by the fact that mean well-being statistically increases underproportionally with increasing income.) In this case the x-axis represents monetary income and the y-axis personal utilities, which in utilitarianism are taken to be identical with moral desirabilities. This concave personal desirability function, surely, is also important for utilex. But in utilex there exists another concave function: the moral weighting function for personal desirabilities. In this case the x-axis represents *personal desirabilities*, and the y-axis represents *moral desirabilities*. For utilitarianism such a moral weighting function would be the identity function ($U_{ut}(x) = x$, where x is a personal desirability) instead, which means that it is superfluous.

2 *Maximin* is a moral criterion according to which the following holds: of two options that one is the morally better with which the person worst off is better off than the person worst off with the alternative; if the persons worst off with the respective options are equally badly off maximin is indifferent with respect to the two options. *Leximin* is a more sophisticated criterion: the beginning of the evaluation equals maximin but in the described case that the

persons worst off are equally badly off it continues the comparison with considering the persons second worst off. If one alternative is better for these persons then it is morally better. And the comparison continues with the persons third worst off if even the second worst off are equally badly off etc.

3 An informal exposition of the idea of this criterion can be found in: Nagel 1991, ch. 7. Parfit lists some further adherents (Parfit 1997, 213) and seems to subscribe to it himself. Gaertner (1992; 1995) in several experiments with samples up to 300 persons has observed empirically that in intuitive judgements about distributive morality the priority view is often applied.

4 Harsanyi and Broome criticize the application of such nonlinear weighting functions to personal desirabilities saying that the resulting value does not make sense because it distinguishes between desirability and how much this desirability should count (Harsanyi 1975; Broome 1989, 246). This perhaps may be true if the result of such application should reflect *equality* considerations — which was the target of Broomes critique (ibid. 248). But it is false if the weighting function shall reflect *priority*. In this case the result of applying the weighting function is the moral value of the person's well-being.

5 This value has been calculated according to the answers given by the subjects during the interviews above (comparison of life prolongation of persons of 40 respectively 80 years of age). Because of the moral indifference of subjects between the two alternatives the following equation holds:
$U_{ul}(c \cdot ((80+x)\text{years} \cdot 0.142\text{wi})) - U_{ul}(c \cdot (80\text{years} \cdot 0.142\text{wi})) =$
$U_{ul}(c \cdot ((40+y)\text{years} \cdot 0.142\text{wi})) - U_{ul}(c \cdot (40\text{years} \cdot 0.142\text{wi}))$,
with x being the subjects' answers to the question (e.g. x=16), y being the life prolongation of the 40 year old person mentioned in the question (e.g. y=8), and c being a constant translating utils in life-utils (years multiplied by mean well-being in wi are identical to utils). c is the interesting value which can be calculated by solving this equation for c. The result is: c=0.037786, which then was used to define life-utils with respect to utils.

6 128.77/89.27 = 1.4425. This value does not change if we take another damage as the reference point for calculating the weight given to a particular type of damage. (The reference damage here was the greatest damage.) Whereas taking another reference damage would change the other values reported above.

7 "Altogether in 1993 the OECD countries accounted for about 50.5% of global fossil carbon emissions, with about half of this being from the U.S. The former USSR and Eastern European countries accounted for 17% [...], and the developing countries contributed just under a third of gross fossil carbon emissions." (Banuri et al. 1996, 95.) If the OECD, the former SU and Eastern European countries had per capita emissions only at the level of the developing countries global emissions would be roughly on a just still sustainable level. However, this is only the present situation; projections say that greenhouse gas emissions of developing countries, in particular China, will increase drastically in the periods under consideration.

8 Corrections for consumer prices were done according to: Statistical Abstract US 1998, 487.

6. From Moral Valuation to Moral Obligation - 1. The Conception of a Historical Morality

6.1. Problems of Conventional Ethics and of Rigorous Moral Postulates

All the conventional ethics considered above (utilitarianism, ethics of (intermediately strong) sustainable development, Kantian ethics, *neminem laedere*) demand sustainable CO_2-reduction. Do we have this obligation?

Even if ethicists would postulate such an obligation this would not have remarkable consequences. A first excuse for denying an obligation to sustainable reduction is that the forecasts are too insecure, that until now nothing has been proved. But even if nothing has been proved the sketched scenarios are probable; and obligations follow from probable consequences too. A second excuse is that in the abatement scenarios a collective subject is presumed; individually one cannot do anything. But of course individuals can contribute their share to greenhouse gas reduction, as home-owners, as drivers and road users, as consumers and as political subjects.

But even after accepting the just given replies resistance against an (hypothetic) obligation to a_4 will remain because for several reasons it is seen as an unreasonable exaction: 1. The requirements resulting from

this obligation are rather high. 2. Hardly anyone else would keep to this obligation, thus one would be isolated with all accompanying insecurities and with no one for support. 3. Instead of finding appreciation one would rather be suspected of being a moralist, fundamentalist, or eco-nut. 4. It would be frustrating to see that alone or together with a small minority of like-minded people only little can be done against the greenhouse effect; their own efforts would only have a marginal effect. 5. It would be outrageous to see hardly anyone else doing his duty but everybody taking profit from the positive achievements. 6. Maybe the declaration of such an obligation would even have a contra-intuitive effect, in that it would deter people only ready for lesser engagement.

Behind the just mentioned difficulties I see the following basic problems of traditional ethics:

1. Binding force of norms: What does it mean, when ethicists state: 'Doing *A* is morally obligatory'? This statement usually implies doing *A* to be in some way impersonally binding. The easiest conception of this binding force is that it stems from sanctions, from internal sanctions like conscience or from external ones, be they formal, i.e. legal sanctions, or informal ones, with a range from frowning up to lynch law. This kind of commitment is missing at least in the severest ethical demands regarding the greenhouse effect, i.e. a_4. And again, without this binding force there is not sufficient pressure to follow the severe norms, and that is one of the reasons why they have not been followed yet. For those obeying the norm, it has the (unjust and at least annoying) consequence of doing the moral work for all the others.

2. Coordination of obligations: Many proposals of norms in ethical literature do not name a clear subject for the proposed norms, but they refer to, for example, a whole generation as carrier of the alleged obligations and only name a general *aim*, like conservation of resources, but not *actions*. An economically effective limitation of the anthropogenous greenhouse effect is only possible with *coordinated* individual and collective actions (by organizations, firms, nations, communities of nations). And for such complex coordination very detailed, partly highly technical, and above all legally valid standards are necessary. Without this coordination and embedding, in a well-directed social practice, lump-sum ethical norms remain only appellative: individuals do not know what to do, and negligible efficiency and lack of perspective of their actions are discouraging.

3. Overtaxing: motivation, moral ideals versus moral obligations and the limits of morality: Most ethics, at least occasionally, seem to ask too much of the subjects motivationally. Moral norms can only be justified considering such motivational limitations. This consideration is lacking

in most ethics. The most prominent form of overstraining is the utilitarian (and of some other welfare ethics as well) obligation to always do the morally best action. The permanent obligation for morally optimal action would ask too much of people, motivationally. A theoretical solution of this problem is to differentiate between moral ideals (or morally optimal options) and moral obligation; what is morally best must by no means be a moral duty. Maybe sustainable CO_2-reduction is a moral ideal, but no moral obligation.[1] - I think another form of overstrain by utilitarianism (and other demanding welfare ethics) is what is discussed as the problem of the limits of morality (Rawls 1971, 26-30; Scheffler 1994; Kagan 1989).[2] Often this problem is taken as an evidence that before any obligation to moral optimizing there must be protective rights. But this is already a suggestion for a concrete solution. I think this problem can be reduced to the motivational problem just mentioned and then there may be different solutions for it: The difference between the problem of demanding optimality and the limitation problem seems to be that the first speaks of active limits, i.e. the limits of our obligations to do something, whereas the second speaks of passive limits, i.e. the limits of other people's rights to invade our rights and to impose disadvantages on us. But the passive limitation problem can be approximated to the active limitation problem, and then it will turn out as a problem of motivation as well: According to the duty to moral optimizing, not only *other* agents are obliged to harm the person in question for raising public welfare; strictly speaking even this person is obliged to endure the intervention and to help execute it; and he is obliged to support a system that requires all this from him.

4. The sense of universalism: Modern ethics mostly are universalistic - and this, surely, is historical progress insofar as universalism tends to support efforts for peace. But ethical universalism may be getting problematic not only because of an increasing tendency to move away from purely negative, prohibitive to positive ethics with positive obligations for aid, but also for the ever increasing (possible) spatial (among others including the Third World) and temporal (e.g. via the greenhouse effect affecting generations in the distant future) reach of our actions as well as the increasing sensibility for the ontological dimension of universality (that we have to respect (certain) animals as well). Such empirically produced extensions of the implications of moral universality are not or are hardly calculable, at least not without good empirical knowledge, and they may be unbearable. Considering this, unlimited universalistic moral obligations cannot be justified *a priori*, independently of the empirical constellations (as nowadays is mostly assumed, from discourse ethics to utilitarianism). This holds

because the world might be so bad that unlimited universality in combination with strong positive obligations as well as in combination with "weak" prohibitive ethics (like *neminem laedere*) would lead to unbearable obligations. For example the world could be full of paupers whose survival would depend on our permanent and massive aid (in a certain way the world actually is like this); or our own survival could depend on killing (e.g. eating) other humans. But if universalism does not hold absolutely, how can it be justified and what is its sense? And how can universalism eventually be restricted legitimately?

5. Motivational justification of criteria of morality: In ethics there are many rivalling criteria of morality together with their efforts and claims for justification. For making such a criterion of morality acceptable in a *practically relevant* way, i.e. making someone regard it in his decision of actions as his own moral criterion (which has certain influences on his actions without therefore always doing the morally best), there must be *motivating* reasons for him to do so. These motivating reasons, then, are also the first reasons for following the norms. Most ethics are not justified in this motivating way, hence lacking these first reasons for following the norms.

I will tackle these problems now in reverse order.

6.2. Motivational Justification of Moral Desirability Functions - Sympathy and Its Range

I cannot present in detail here how I think a justification of morals has to be made (but cf.: Lumer 1999b; Lumer 1994). But the core of a justification of morals is to find i. motives ii. which are resistant to information and iii. independent from socially or individually accepted norms, iv. which motivate to something similar as moral actions and v. which interpersonally are quite similar. From such motives then moral standards of valuation can be constructed subject to the condition that following these standards will maximize the realization of the aims inherent in these motives. Sympathy is the most prominent motive satisfying all the mentioned conditions (Lumer 1999a; Lumer 2002). From the two forms of sympathy, sharing in joy and feeling pity (i.e. positive and negative sympathy), pity is the stronger motive. Therefore, if one develops moral valuation standards on the basis of sympathy in the way sketched above this leads to a stronger weighting of ameliorations for people worse off than for people already well off, i.e. it leads exactly to the criterion utilex explained above (Lumer 1997a; Lumer 2000, ch. 7).

But to be more precise, several ways have to be distinguished as to how sympathy can motivate moral actions, which have different implications for the universality of morals (cf. Lumer 1999a):

1. Acting from sympathy: desires induced by sympathy: Sympathy, to begin with, is only an emotion: We are pleased because another person is well or even happy; we are distressed, sad, dismayed because (s)he is in a bad way. Such sympathy secondly has motivational *effects*. Namely, like all emotions sympathy changes our intrinsic desires, induces new intrinsic desires; positive sympathy induces the desire that the situation of the other person should be consolidated or enhanced, negative sympathy induces the desire that the situation should be ameliorated. Such desires induced by sympathy are not temporally stable however - exactly because they depend on our current sympathy. And because of this they are not apt as a basis for rational planning and for a rational ethics.

2. Acting for optimizing sympathy: the motive of sympathy expectancy: Secondly, one can optimize sympathy hedonistically. Pity after all is an unpleasant emotion, positive sympathy (with people well off) is a pleasant one. And one consequence of our general hedonist motivation is that we desire to optimize this kind of emotion, i.e. maximize the sum of the integrals of positive and negative sympathy over time. We can fulfill this desire by contributing to the amelioration of other people's situation. This *motive of sympathy expectancy* is stable over time and it is suitable for founding morals. - Sympathy always arises from the fact that we are confronted, in a broad sense, with the fate of another person. According to the way of this confrontation (i.e. the genesis of sympathy), several subtypes of the motive of sympathy expectancy can be distinguished.

2.1. Sympathy expectancy from causal confrontation: "*Causal confrontation*" with the well-being of an object of sympathy shall mean that there is a causal chain from this well-being to the sympathy. For example the subject directly experiences how well the other person is, or the subject is told by other persons about this, or the subject comes across circumstantial evidence allowing him to draw conclusions about the well-being, or the subject learns about it from the media, or the subject remembers one of these types of confrontations (and imagines it vividly). Sympathy from causal confrontation can refer to contemporaries and to people of the past; but in the latter case it is practically irrelevant because we cannot change the fate of these people. But it cannot refer to future people. Therefore, sympathy expectancy from causal confrontation alone does not lead to an intuitively acceptable moral criterion.

2.2. Sympathy expectancy from confrontation by inference: "*Confrontation by inference*" here shall mean a confrontation without a causal chain from the well-being of the object to the subject's sympathy but a confrontation where the fate of the object is inferred in some other way and then imagined more or less vividly. For example the subject learns of the object's fate via generalizing background reports or forecasts, or vividly imagines this fate with the help of such reports, or images this fate independently of such external occasion, such as when considering the outcomes of his own actions. We may be confronted by inference with the fate of beings of all times. Though confrontation by inference with the fate of people of the past again is practically irrelevant; and, what is more important, the frequency of confrontation with the well-being of other beings will decrease with the temporal (and spatial) distance from the subject, and perhaps does so exponentially. So if the justification of morals is based on sympathy expectancy from confrontation by inference ideally the moral criterion utilex with temporal discounting results. Thus perhaps any following generation (with a presumed duration of 25 years) in this way may receive half as much moral consideration as the preceding generation. This corresponds to an annual discounting of about 3% (exactly: 2.73%), i.e. it is roughly equal to the usual discount rate. The fate of all future generations together then gets the same weight as the fate of the present generation (since $0.5+0.25+0.125+0.0625+... \approx 1$).
2.3. Sympathy expectancy from action-induced confrontation by inference: Hitherto I have found only one very particular way of confrontation with the well-being of others which leads to a temporally universal sympathy: action induced confrontation by inference. After our decisions (and after their execution) we often reconsider them and in doing so we eventually imagine how other people may be affected by them. *Sympathy expectancy from action-induced confrontation by inference* then is the motive to optimize the sympathy resulting from this reconsideration. Now, ideally, the amount of confrontation with the fate of a stranger affected by our actions is proportional to the subjectively expected degree of how much our action concerns the object. The amount of empathy in this case directly depends only on the qualities of the *action* (how much it will concern other people) and not additionally (but only indirectly) on the historical or regional position of the subject. Exactly this leads to the universality of the value function based on this type of sympathy. - This motive is quite specific. But the emerging of the type of sympathy appertaining to it resembles the procedure of an ideal observer assumed by many ethics.

Now which type of sympathy should a moral criterion be based on? Already above, desires induced by sympathy have been rejected as a

base because of their temporal instability. And the isolated sympathy expectancy from causal confrontation has been rejected as well because the resulting moral criterion would be intuitively unacceptable. But even in combination (i.e. summing up the desirabilities) with sympathy expectancy from confrontation by inference, sympathy expectancy by causal confrontation leads to intuitively unacceptable results. Namely this combination, i.e. the total sympathy expectancy, leads to a moral criterion which could be named "*utilex with generational discounting*": the fate of the present generation is weighted with the factor 1, that of the following generation much lower, e.g. with the factor 0.2, and the fate of the further generations is weighted with a factor half as high as that of the preceding generations (i.e. for the third generation the weight 0.1 applies, for the fourth generation the weight 0.05 applies etc.). (The rationale behind this criterion is this. It is taken to apply to the politically responsible people who may die in about 25 years. Because sympathy from causal confrontation stops at this date and only sympathy from confrontation by inference remains, there will be a sharp decline in sympathy expectancy with respect to effects occurring afterwards. These effects are only the objects of the - much weaker - sympathy from confrontation by inference which decreases exponentially.) The fate of all future generations together in this case has only 40% weight of the fate of the present generation. Applying this type of discounting to the above utilex assessments of the greenhouse gas options leads to the following preference order: utilex with generational discounting: $a_1 > a_3 > a_2 > a_4$. (Utilitarianism with generational discounting even leads to an exact reversal of the preferences obtained so far: $a_1 > a_2 > a_3 > a_4$.)[3] So it is the first criterion with which sustainable reduction is not optimum; and the preference order is essentially more hostile to the environment than the official political programs, which presently (at least roughly) aim at stabilization (a_2) or something a bit more incisive. This means that with respect to intergenerational justice a big portion of humans is clearly more universalistic than utilex (or utilitarianism) with generational discounting. Therefore, this criterion and its motivational foundation should be morally refuted. Thus only sympathy expectancy from confrontation by inference and (a smaller section of it) from action-induced confrontation by inference seem to be suited as motives for basing morals. Utilex with simple discounting or utilex without discounting would result from these motives.

6.3. Sense and Range of the Universality of Morals

Two fundamental types of universality can be distinguished in ethics. "*Universality of subjects*" here shall mean that all moral subjects have the same moral; or more precisely: For all moral subjects exactly one moral holds (or is justified) in such a way that (within certain boundaries) the same objects for them always have the same moral desirability.[4] The opposite of universality of subjects is relativism. "*Universality of beneficiaries*" on the other hand shall mean that all potential beneficiaries of a moral are treated equally. More precisely: if the same states of affair are fulfilled for two beneficiaries and these states of affair satisfy certain conditions then these states of affair have the same moral desirability.[5] The most important forms of non-universality of beneficiaries are moral egoism and parochialism. - Universality of subjects and universality of beneficiaries are analytically independent. There may be morals giving the same rights to all humans or all living creatures (universality of beneficiaries) but which are not rationally acceptable to all subjects (no universality of subjects); this for example may hold for some sort of Christian or Islamic morals. And conversely it is analytically possible that some morals are universal with respect to subjects but not with respect to beneficiaries; according to these morals, e.g. the life of slaves could have less desirability than that of the freemen, but this would have to be rationally acceptable for the freemen as well as for the slaves. Empirically though the latter combination is impossible; this means universality of subjects empirically implies universality of beneficiaries, but the converse does not hold.

I think the sense of a certain form of moral universality, namely of universality of subjects, derives from the *prudentially consensualistic* sense of that morals which are binding by social sanctions. The sense of socially binding morals is to provide an intersubjectively uniform and binding value system (desirability function) and on this basis to regulate cooperation and conflicts between individuals, in particular to regulate cooperation dedicated to fulfilling sympathetic inclinations. Or more generally: the sense is to cooperatively create - according to this value system - a better world.[6] Some implications of this determination are: the socially binding morals necessarily are a collective project of the addressees of those morals; and the moral value system and the moral norms must be acceptable for all moral addressees or result from something which is homogenously desirable for them.

Sympathy with strangers to certain limits and under idealizing assumptions at least in principle is a motive universal with respect to

subjects (and with respect to beneficiaries): different persons in the same situations display if not the same, roughly proportionate sympathy. Therefore, sympathy in principle is suited for a rational justification of morals. Sympathy expectancy from confrontation by inference though is only (half-way) universal with respect to subjects if the probabilities to be confronted with the fate of the same object of sympathy are equal for any subject. But as already discussed above this - even with idealizations - holds only for members of the same generation and society. So sympathy expectancy from confrontation by inference leads to temporal and spatial discounting. This limitation does not, in principle, contradict the prudentially consensualistic aim of morals: one has only to assume that the society, the "universe", in which the peacemaking and cooperation securing effect shall be reached is correspondingly restricted. In a time of globalization, however, this is a somewhat antiquated and not very ambitious though not unacceptable ideal. And in the case of evaluating the greenhouse options it would lead at least to different moral assessments (if not perhaps different preference orders) of these options already in the OECD, because each of the single countries of the OECD have different interests and different neighbours whose fate counts more to them than that of distant countries. (This consequence could be prevented by incorporating only temporal but not spatial discounting in one's moral. But from the point of view of a motivational justification of morals this step would be unfounded: there is no motive which discounts in this way, that is temporally but not spatially.)

The problem of limiting the universality of subjects does not emerge with sympathy expectancy from confrontation by action-induced inference. A justification on this basis leads to a real universalism of subjects, in particular to simple, undiscounted utilex. However, this moral criterion, precisely because of its universality, seems to have the disadvantage of asking too much of the subjects and of providing only a very weak motive for moral action.

6.4. Bindingness and Limits of Morals - Social Implementation and Historization of Morals

The first three problems - commitment of norms, coordination of obligations and exaction - can be discussed here together. The approach for solving these problems is a conception of the social bindingness of moral norms which then leads to a historization of morals:[7] *Norms in*

the broad sense are only patterns of (typical) behaviour. *Norms in the strict sense* are the (at a certain time) binding norms, i.e. legally, socially or individually binding norms. *Socially binding norms* are ways of acting that are largely followed generally and the following of which is protected by sanctions, thus creating their binding force (Lumer 1990). *Moral norms in the strict sense* then are those socially binding norms - in particular also (legally) valid standards - that can be justified by relying on a criterion of moral desirability. With this conception the problems of binding force and coordination and to a certain degree also that of motivation can be solved. The sanctions belonging to socially binding norms are at least *one* important motive for following these norms and thus are binding. And at least legally valid standards can resolve the problem of coordination.

Social bindingness of norms does not come on its own but it has to be implemented. The social implementation of moral norms is a historic process in the course of which moral standards of socially binding norms are raised in the long term. Or, to put it differently: it is the aim of this process of implementation to morally improve the set of binding norms. One task of applied ethics in this process is to evaluate new actually or possibly binding norms with the help of the criterion of moral desirability as to whether they are a moral improvement or not. The *criterion which should lead applied ethics* then is: Social bindingness of norm x presently can be implemented and it is morally better than the social bindingness of all alternative norms presently implementable. According to this conception, there would then be three kinds of moral obligation: 1. the *formal moral duty*, to follow morally advanced legal standards; 2. the *informal moral duty*, to follow morally advanced non-legal social norms; and 3. the *imperfect moral duty*, to help keeping up already binding morally good norms and socially implementing not yet binding morally better norms by following these norms, making propaganda for them, exerting sanctions for their violation etc.

This conception in particular resolves the problem of moral overtaxing: Moral obligations are mainly (apart from imperfect moral duties) established by socially binding moral norms. These obligations in each case are a historical compromise between morally exacting ideals and amoral particular interests running counter to these ideals. This compromise in particular fixes the amount of moral engagement which can be put through in each case and which - as a cause of this - is accepted by the subjects as being reasonable. One side of this compromise is that the ideal is not reached (which however has the positive effect of not overtaxing anybody); the other side is that norms

now can be enforced and in particular that there is enough motivation to fulfill one's duties: social bindingness creates the motive to avoid sanctions and, above all, it creates a certain reciprocity, namely that the moral subjects obliged to do their duties have the right to get the same moral benefits as the moral beneficiaries if the subjects themselves are in the same situation as the beneficiaries. The amount of the morally obligatory engagement will always be lower than the possible maximum, i.e. the complete devotion to moral tasks, because moral motivation is only a part of the total motivation. But social bindingness at the same time provides the prerequisites for a continuous approach to that ideal: Social bindingness and the just mentioned reciprocity constitute a certain stable level of peaceful exchange of give and take of moral contributions, which then is the base for an unilateral, and in the beginning not "rewarding", extension of one's active contributions supported by imperfect moral duties only. And these extensions in turn, finally, may lead to a higher level of consolidated (socially binding) morals.

Passive limitation results from this conception of social bindingness in the following way: the extent of one's morally obligatory contribution is fixed by the moral norms in the strict sense, including things one has to endure (like in many western societies deductions from one's wages for various reasons, in particular for income taxes). Therefore, it is not allowed to increase *other persons'* contributions by individual interventions beyond the obligatory extent (except for cases of fulfilling one's imperfect moral duty). (The doctors in the famous organ donation example are supposed to do exactly this.) *Collective* raising of moral contributions by initiating more rigid norms instead must obviously be permitted. If somebody wants to augment his *own* moral contribution beyond the obligatory extent (in particular by authorizing operations which (s)he himself has to endure) this is not only morally permitted but also a particularly meritorious supererogatory action.[8]

6.4.1. Applying the Solution of the Overtaxing Problem: Efficiency of Moral Action versus Temporal Discounting

The reduction of moral obligations by temporal (and occasionally also spatial) discounting is often proposed as a solution to the problem of overtaxing. This solution is practicable in principle but in the case of the greenhouse effect it does not lead to a reduction of moral obligations. (Remember that even with simple discounting by 3%/year utilitarianism and utilex lead to the preference order: $a_4 > a_3 > a_2 > a_1$.) However, discounting is not the only possible solution to the overtaxing

problem and intuitively is not a morally satisfying one. For example going very far into the future it might be the case that, due to temporal discounting, the deaths of many in the future must be accepted for a tiny advantage in the present. For many people this is intuitively unacceptable. In addition, if they had the alternative of preventing a big catastrophe in the distant future instead of preventing a small catastrophe in the near future (after their death) most people would choose the former option (Cowen / Parfit 1992, 149). But above all, this solution is nonsensical. If we find that the personal expenditures for certain moral actions are too high this, after all, does not change the moral desirability of these actions (and of their omissions); e.g. death due to consequences of the greenhouse effect does not get any better because of the high costs of its prevention. If the aim is to prevent overtaxing we should adopt *this aim* as a principle (ibid.). For our case this means: limitation of moral obligations should be effected from the side of expenditures, for example by establishing certain upper limits for our contribution in certain situations. And the remaining commitment should follow maxims of moral efficiency: the contribution dedicated to morality should be assigned to those cases where intervention is most urgently required and most efficient, or more precisely, where cost-welfare relations are lowest. (Cost-welfare relations with utilex desirabilities consider both urgency of need as well as efficiency; whereas cost-welfare relations with utilitarian desirabilities consider efficiency only. This is a disadvantage of utilitarianism.) But the welfare calculations themselves should not be distorted. If future damages are big (measured in utilex desirabilities) and costs for preventing them are small then they should be prevented.

These considerations reject only the most prominent justification for temporal discounting, they do not imply that temporal discounting is false; it may be the right method for moral evaluation for other reasons. In the previous two sections (6.2, 6.3) whether the total sympathy expectancy from confrontation by inference or only sympathy expectancy from action-induced confrontation by inference shall be the bases of morals and consequently whether utilex with discounting or simple utilex is the right moral criterion remained open. Simple utilex had a clear advantage in a globalizing society, however and keeps up this advantage now that the problem of overtaxation has been shown to be resolvable for both criteria. But this advantage does not imply that utilex with discounting is clearly false. (The justification for adhering to utilex with discounting would be to base morals on a stronger but - in its consequences - more parochialist type of sympathy and to identify oneself with a more restricted society, so that the fate of extraneous

beings is considered as being less important.) So there is no definite decision between these two moral criteria.

Notes to Chapter 6

1 For some utilitarians this problem is a reason for refraining from the assumption of a direct duty to do the morally best action. Peter Singer sticks to the duty to do the morally best with the restriction that only that moral the propagation of which leads to the best results, should be propagated (Singer 1993, 245 f.). However, this difference between a presently valid (in which sense?) and a publicly propagated moral is odd; it would lead to the condemnation of people for offending against a moral that cannot even be publicly propagated. Birnbacher avoids this problem. According to his conception, that way of acting is obligatory, the actual social validity of which is [would be?] nearest to the optimum (Birnbacher 1988, 16-20; 147; 199). Unfortunately this criterion is not clear.

2 The paradigm for the problem of the limits of morality is this: A stranger without relatives and friends comes into a hospital with a minor ailment. Five patients urgently need different new organs, the first a heart, the second a liver etc. without which they would die in the next weeks. The stranger, as the doctors find out, is the ideal donor for all these five other patients (and not much time to live has been left for himself). (Cf. Hare 1981, 132 (sect. 8.2.).) — At least at first glance act utilitarianism in this situation seems to command that the doctors should take the organs from the stranger.

3 The discounted desirabilities of the four alternatives are:

Generationally discounted moral desirabilities of options a_1-a_4:

criterion	*unit*	a_1	a_2	a_3	a_4
utilitarianism gen. disc.	lu	1,973,729	2,114,492	2,180,847	2,284,462
utilex gen. disc.	ll	2,367,435	2,404,037	2,396,269	2,407,855

For utilex the alternatives now have nearly the same desirabilities; the worst option only causes 1.7% more damage than the best one. So the preference order now no longer is stable against changes in assumptions.

4 Formalization: $U_{mor}p,s$:= the (justified) moral desirability of the state of affair p for the subject s; C shall be a limiting condition.
Universality of subjects then is: $\forall s_i,s_j,p\ (Cp \rightarrow U_{mor}p,s_i = U_{mor}p,s_j)$.

5 Formalization: C and D again are limiting conditions; $A[x]$ is a predicate in the logical sense, i.e. a formula with a free variable.
Universality of beneficiaries then is:
$\forall b_i,b_j,A\ (Cb_i \,\&\, Cb_j \,\&\, D(A) \rightarrow U_{mor}(A[b_i]),s = U_{mor}(A[b_j]),s)$.

6 Justifying this determination of the sense of socially binding morals here would lead too far, but cf.: Lumer 1999b, sect. 3.

7 A more detailed exposition and discussion of the historical conception of morals sketched in the following is given in: Lumer 1999b, sect. 5-6.

8 If the stranger in the organ donation example sacrifices his life for the benefit of the five patients this is morally better than if he does not. And only intersubjectively aggregating moral desirability functions are a basis for appreciating such a deed as morally particularly meritorious. But such a sacrifice is not reasonable, therefore it is not obligatory and forcing it is forbidden.

7. From Moral Valuation to Moral Obligation - 2. Application to the Greenhouse Effect

7.1. The Problem of Possibly Better Alternatives

In the foregoing chapters we calculated the moral desirabilities of BAU and three abatement options as well as the cost-welfare relations of the latter three. But according to the sketched solution of the overtaxing problem, in order to determine the direction of the further moral development and our duties with respect to the greenhouse effect it would be necessary to compare the cost-welfare relations of the abatement options with the cost-welfare relations in other fields of possible moral dedication, e.g. developmental aid, social programs in the OECD countries or medical programs for prolonging life. And the very high costs of sustainable CO_2-reduction are an incentive to double-check if this alternative really is the most efficient. But apart from the very superficial estimates (in section 5.2, table 5.11) of some social measures, I have not calculated the cost-welfare relations of other measures. It would require as equally intense analyses of other social problems as those carried out here for the greenhouse effect. Therefore, the following considerations contain only some general assessments of some groups of alternatives. - Economists suggest two main types of alternatives to the options considered so far: 1. alternative treatments of

the greenhouse effect and 2. engagement in fields other than the greenhouse effect.

1. Alternative treatment of the greenhouse effect: Instead of the expensive greenhouse gas reduction more measures of mitigation and / or of compensation could be financed (Beckerman 1991). *One* of the reasons for the massive damages caused by BAU is that in this scenario the Third World is largely left to itself, so that measures for mitigation which would be a matter of course in the First World, like increased coastal protection in densely populated areas, would be left partly untaken there. If, as presumed in alternative a_4 with the principle 'rich countries pay for all', the First World would sympathize more with the developing countries, it could also pay for such inexpensive mitigation measures, putting up with a somewhat increased anthropogenous greenhouse effect due to higher CO_2-emission than in sustainable reduction (a_4), and thereby lowering total costs. Apart from coastal protection, organized and paid relocation and measures against aridisation and dying of forests would also be possible. The range of these measures is rather limited, however (e.g. deaths by floods and storms make up "only" 0.40% (utilitarian calculation) respectively 0.37% (utilex calculation) of all damages by BAU (cf. tables 5.1 and 5.5), part of them occurring in the OECD). So with a more exact calculation which includes further options, an alternative between strong (a_3) and sustainable reduction (a_4) might be optimal and most efficient, but presumably no alternative with a reduction lower than 25% would be optimal. On the other hand the presumption of very high costs for stronger reductions of greenhouse emissions was based on the very pessimistic top-down-models. Maybe the truth lies in between the presumptions of top-down-models and bottom-up-models which estimate alternative energies to be more favourable.[1] The results of this would be that the morally best alternative would be closer to sustainable reduction again and much money would have to be invested into research on alternative energies. Beyond that it is quite certain in the long run that fossil energies must be replaced by alternative energy-carriers because of limited stocks. This may additionally make sustainable reduction a cheaper alternative in very long-term calculations.

2. Engagement in other fields than the greenhouse effect:
2.1. Medical treatment and social assistance in OECD countries: The cost-welfare relations for sustainable reduction are 6153 dollars/qu according to simple utilitarianism and 5621 dollars/ql according to simple utilex (both with discounted costs). This is less than the cost-welfare relations for social assistance in OECD countries (32,324 dollars/qu respectively 30,988 dollars/ql) and for many types of medical

treatment (cf. table 5.11); and those types of medical treatment which are more efficient than sustainable reduction in the OECD for the most part are undertaken anyway. (And if they are not this probably is due to some economic inefficiency of the respective medical system and not to moral considerations.) So from the point of view of really universalist welfarism (whether utilitarian or utilex) sustainable reduction of greenhouse gases has a clear precedence over an increase of investments in these sectors. This picture may change however if non-universalist welfarism is taken as the basis of moral assessment. In this case the cost-welfare relations for sustainable reduction increase to 49197 dollars/qu according to utilitarianism with 3% discounting and 43550 dollars/ql according to utilex with the same discounting (both with additionally discounted costs). For the comparison with hitherto not implemented poorly efficient medical measures this may make no difference. But sustainable reduction now is less efficient than investing in social assistance in the OECD. From a certain parochialist point of view it then may be better to give priority to improving the fate of the poor of one's own country over greenhouse gas reduction.

2.2. Developmental aid: The costs of eliminating the CFCs will be in the billions of US-dollars per year for some years; the costs of reducing sulphuric acid may be in the tens of billions (Schelling 1992, 3). In relation to that the costs for reducing greenhouse gas emissions are gigantic. According to the above calculations, in 2050 they will be 1379 bn US-dollars/per year or 5.47% of GNP in the OECD (if the OECD pays for all) for sustainable reduction (1127 bn US-dollars/year or 4.47% of OECD-GNP for strong reduction, and 946 bn US-dollars/year or 3.75% of OECD-GNP for stabilization; cf. table 4.3). The official recommendation of the UN to the rich countries (which was confirmed in Agenda 21, ratified at the Earth Summit of Rio 1992) is to spend 0.7% of their GNP on developmental aid. But most OECD countries are far from this aim; e.g. the USA only spend 0.19% of their GNP on developmental aid - a big part of that being military aid (Launer 1992, 212 (according to World Bank 1990)). In view of that Schelling assumes that if the largest portion of the money needed for the abatement of greenhouse gases were spent on the development of the developing countries this would be much better for these countries (Schelling 1992, 7). Weakening this statement somewhat, in that not the largest, but a good part of the money should be spent on the development, this statement is also probably true from a welfarist point of view; not having calculated the value of such alternatives, however, I can only surmise this. My crude calculation of the efficiency of social assistance in NOECD countries, however, supports this view. The cost-welfare relations for these were 3,659 dollars/qu and 2,627 dollars/ql

respectively (cf. table 5.11) or roughly a bit more (60% for utilitarianism) respectively a bit less (47% for utilex) than half of the cost-welfare relations of sustainable reduction (a_4) - with the undiscounted desirabilities. And good developmental aid, which helps to develop and is not only a continuous allowance, hopefully has still lower cost-welfare relations. - A further reason for surmising that developmental aid has a better cost-welfare relation than sustainable reduction is that a large part of the worst consequences of BAU will only be caused by the synergism of poverty and the greenhouse effect, e.g. death due to increased costs of food (which make up 39% (for utilitarianism) and 40% (for utilex) of all damages caused by BAU (cf. tables 5.1 and 5.5)). So developmental aid could even mitigate some negative consequences of the greenhouse effect, thus reducing its own cost-welfare relation.

So what proposal for the further development of morals should be made by the historizing conception of our moral duties? Which new moral norms should be introduced? To answer this question, according to the criterion for applied ethics that among the presently implementable norms the morally best should be implemented (cf. above sect. 5.4), apart from moral efficiency, another condition has to be considered: which norms can be socially implemented at present? But with respect to this question it is rather clear that there is no fixed amount of moral contribution with free availability as to where to invest it - as a welfarist approach would like it. In our societies the moral willingness to pay depends on the object of investment. And a discussion as just begun, which takes further alternatives into account besides the greenhouse options will dissolve the unanimity of the different ethics as reached above in the valuation of a_1 to a_4: 1. According to deontological and liberal ethics, a switch of dedication of money intended for protection against the damages due to greenhouse effect towards other fields in which bigger increases of welfare can be reached, is not allowed because, according to these ethics, we have the (absolute) duty to prevent harming other people via greenhouse damages, whereas helping other people e.g. via developmental aid may only be a supererogatory act. A rigorous position of this kind, not allowing any trade-off between expensive prevention of small damages and cheap help with big effects even in the most extreme cases, is at least out of touch with reality. But milder (and not theoretically elaborated) versions seem to be rather influential in public morals. 2. In applied ethics there is always the basic conflict between global and sectoral justice: Is it possible to achieve justice only in certain sectors such as, in this case, distribution of the resource 'capacity of absorption for CO_2' (cf. Elster 1992; Kverndokk 1995, 134)? Welfarist approaches

in ethics tend to take up a global perspective here, which is much more flexible and allows for compensation in whatever other sectors. On the other hand, taking up a global perspective, which leads to the inclusion of sectors like world poverty, distribution of other resources, the value of wildlife etc., subjectively increases the dimension of the problems and thus may discourage people from doing anything at all. So, at second sight, even from a welfarist point of view, largely respecting traditional sectors of duties and justice presently seems be the more successful option. This would include insisting on the principle that future generations may not be damaged by our greenhouse gas emissions or must be fairly compensated for that damage; such a principle would still allow for much flexibility.

7.2. Moral Duties with Respect to the Greenhouse Effect

What conclusions can be drawn from all these considerations regarding our duties with respect to the greenhouse effect? As insinuated in the last section even for welfarist ethics it would currently be wise to respect traditional sectors of duties and justice, i.e. in our case the sector of environmental damages provoked by the greenhouse effect. The following considerations therefore will be restricted to this sector. We should not forget, however, that the still unrestricted search for more efficient alternatives has revealed another very important field of urgent moral engagement: developmental aid and international help in the fight against absolute poverty should drastically be intensified as well.

With respect to the discussed options concerning the greenhouse effect all ethics considered led to the order of preference: $a_4 > a_3 > a_2 > a_1$. Discussion of more differentiated options which include more measures of mitigation or compensation in the meantime revealed that there may be even better options between strong (a_3) and sustainable reduction (a_4). But actually we are still far from even realizing stabilization (a_2). Thus, according to the historicizing conception of morals, present moral duties with respect to the greenhouse effect consist of pushing moral development in the direction of reducing greenhouse gas emissions as far as politically feasible. If some greater moral progress in this direction has been achieved then which reduction aim is the best and which measures of mitigation and compensation should be taken may be decided more in detail.

Thus, in particular at the moment we have the *formal moral duty*, to abide by currently valid national legal standards for CO_2-reduction:

insulation regulations concerning heat or concerning cleaner or more efficient combustion by heating systems or motors, etc. Governments and the executive also have the formal moral duty to see to it that accepted international obligations regarding CO_2-reduction are translated into laws and corresponding actions. Apart from that there is the *informal moral duty*, to minimize CO_2-emissions as far as possible without larger subjective costs, by using less-polluting means of transportation, changing heating to non-fossil energy or similar actions. Finally, for any individual there is the *imperfect moral duty*, to help to bring about more rigid informal norms, e.g. by talking to others about their high CO_2-emissions, and to engage politically for a tightening up of valid legal standards for CO_2-reduction, e.g. for a high CO_2-tax. Executives in particular have the imperfect moral duty to fight for much stronger reduction goals internationally and to introduce such stronger standards first on the national level. And the legislators have the imperfect moral duty to heighten the legal standards for greenhouse gas abatement as much as is politically feasible.

Notes to Chapter 7

1 1. Many bottom-up studies state that the costs of CO_2 stabilization in the OECD in the next decades can be neglected (Hourcade et al. 1996, 301; 309); for the U.S.A. e.g. for 2025-2030 several studies calculate reductions of >61-82% (median 72%) below the level of the base year 1990 to result in zero net costs (ibid. 310 f.). There are several reasons why this calculation is too optimistic (cf. ibid. 309 f.); but top down-models on the other hand ignore many reduction possibilities. 2. All economic models of prognosis for greenhouse gas reduction, including top-down models, necessarily use rather speculative assumptions about technological development, especially about backstop technologies, e.g. that a non-carbon base liquid fuel will be developed costing 100 US-dollars/barrel crude oil equivalent (Energy Modeling Forum cited by: Hourcade et al. 1996, 305). Also in this point bottom-up-studies are much more optimistic than top-down-studies. For example the Stockholm Environment Institute / Greenpeace 1993 in their "fossil-free energy future" scenario (where in the year 2100 79% of all energy is solar or wind energy) assumes that up to 2030 a breakthrough in solar photovoltaic electricity production costs will take place along with a breakthrough in advanced storage facilities (SEI 1993). The truth of such assumptions is hard to judge.

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Index

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