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**THE MEASUREMENT AND ECONOMIC VALUATION OF THE HEALTH EFFECTS
OF AIR POLLUTION */**

Summary report of a workshop prepared by Prof. David Pearce (United Kingdom), rapporteur of the
Network of Experts on Benefits and Economic Instruments (NEBEI) in collaboration with the
secretariat

Introduction

1. The workshop on the measurement and economic valuation of the health effects of air pollution sponsored by the United Kingdom Department of the Environment, Transport and Regions, with additional financial support by the Centre for Social and Economic Research on the Global Environment (CSERGE) was held in London, on 19-20 February 2001. The workshop was aimed at establishing the state of the art in the combined areas of epidemiology and economic valuation, with the further goal of assisting with further work under the Convention. A particular feature was the concern to establish firm collaboration between epidemiologists and economists working in these areas. The presentations made at the workshop are available electronically at <http://www.unece.org/env/nebei>.

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2. Experts from Belgium, Croatia, Denmark, Finland, France, Germany, Ireland, Netherlands, Norway, Republic of Moldova, Romania, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States and the European Community participated in the workshop. Experts from the World Health Organization (WHO), as well as from the International Institute for Applied Systems Analysis (IIASA), the International Union of Producers and Distributors of Electrical Energy (UNIPEDE) and the World Conservation Union (IUCN) were also present.

3. This workshop was the first meeting of the newly formed Network of Experts on Benefits and Economic Instruments (NEBEI). The network aims to further develop the economic work formerly carried out by the former Task Force on Economic Aspects and Abatement Strategies and to enable economic considerations to be taken into account in the development and review of protocols to the Convention. NEBEI is to meet only on the occasion of planned workshops and will include not only economists but also representatives from other specialist groups.

4. The second workshop under NEBEI will be on the valuation of the ecosystem benefits from air pollution abatement and will be held in early 2002 in the Netherlands. Future workshops are expected to cover the benefits of reducing air pollution damage to buildings and materials, including cultural monuments, and on economic instruments.

SUMMARY AND CONCLUSIONS

5. In both the United States and Europe, cost-benefit studies of transboundary air pollution control show high ratios of benefit to costs, and health benefits dominate the overall benefits assessment. Perhaps this is actually the case and almost regardless of the severity of the controls, the benefits to be secured from those controls greatly exceed their costs. The reasons for being at least moderately suspicious of this finding are:

(a) That the models used for such analyses usually work with abatement measures based on 'end of pipe' technology, and one would expect marginal abatement costs to be very high for strict controls. To find that marginal benefit-cost ratios are still high in such contexts is potentially surprising;

(b) That health effects are only one category of benefit. Ecosystem benefits tend to be estimated in only conjectural terms due to the absence of research on the economics of ecosystem effects. But in Europe at least the protocols under the Convention are mainly 'driven' by ecosystem concerns. If there was more confidence in valuing those effects, they would probably add dramatically to the benefits and hence inflate the benefit-cost ratios even further;

(c) That particular unit valuations, especially the 'value of a statistical life' in the range of \$3-6 million, boost the health benefits, and there are reasons to question the applicability of these unit values to air pollution impacts.

6. But more recent results of the United States Environmental Protection Agency (US EPA) tend to confirm such high benefit-cost ratios, suggesting that, instead, studies may well be underestimating rather than overestimating health benefits. The US EPA has selected the lower end of the epidemiological studies relating exposure to impact for chronic mortality, omitted health endpoints - such as the links between particulate matter and cardiovascular disease -, and not valued averting behaviour for high-risk groups. It was also suggested that the number of deaths due to acute mortality might be underestimated because studies may only consider the 'net' health impacts of pollution episodes rather than the full effects. Recent studies and meta-analysis have produced dose-response coefficients that are higher than those conventionally adopted in valuation studies, a result of modelling longer time lags for pollution effects and of allowing for 'out of hospital' effects. On the basis of these, and other, considerations, the argument that the epidemiological effects are overstated would not be substantiated. If there is exaggeration of economic impacts, it must be due to the unit values being adopted. Alternatively, the benefit-cost studies are under-rather than over-stating the impacts.

7. Some support for the original concern is given by the provisional finding of a United Kingdom study, which suggests that premature mortality estimates need to be accompanied by some idea of the period of expected life lost. The information yielded by short- and long-term studies varies: those that reveal the number of premature deaths do reveal the life expectancy, and those that reveal the life-expectancy loss do not reveal the number of premature deaths. The study suggests that acute episodes may be reducing life expectancy by only a few days, and the question must arise as to the policy relevance of such impacts. But it has to be noted that this is only one study and for one location (in England), and what is being observed may only be the net rather than the gross mortality effect. An important issue for the research agenda is that a given dataset should be subjected to an agreed set of tests for different time-lag specifications.

8. While much of the epidemiology has been concerned with acute episodes of pollution, there was widespread agreement at the workshop that long-term, 'chronic' exposure is more important. This may suggest that research should no longer focus on acute episodes. The conclusions and recommendations of a WHO working group (meeting in Bilthoven (Netherlands) in November 2000) indicate that the most complete estimates of mortality effects are those based on cohort studies but that studies of mortality due to acute pollution episodes continue to be very valuable. There are good reasons for not neglecting the acute studies. Numbers of premature mortality per year are still a policy-relevant indicator and need to be accompanied by some idea of periods of 'life lost' for those who die. Moreover, in countries where it may still be difficult to

argue that air pollution is relevant at all in policy terms, time-series studies present conclusive evidence of a link. All in all, acute studies continue to be important for policy purposes. There is the intriguing possibility that the results of acute and chronic studies may be showing signs of convergence.

9. Most of the epidemiological evidence available to date is based on United States cohort studies linking chronic exposure of air pollutants to mortality effects. The chronic studies, despite being limited in number, are showing considerable similarity in results in terms of lost lifetime expectancy, perhaps ranging from a few months to about one year. A study of three European countries showed persuasively that these are the orders of magnitude in question.

10. A number of issues are to be considered in the design of cohort studies and there is a need to invest in some new long-term cohort studies that will permit use of sophisticated methods for measuring exposure and also inclusion of all of the factors, which are now believed to be potentially significant confounders.

11. Further original research is vital, but decision-makers frequently require 'rapid results'. The rationality of such expectations is open to question: vast sums are spent on development and infrastructure, and yet the sums spent researching the health and economic impacts of the pollution associated with such developments is tiny. But this bias in decision-making means that there will always be a demand for results, which can be applied across the board without repeating primary studies. This notion has been formalized as 'benefits transfer', whether what is transferred is the dose-response coefficient or the unit value, or both. There are indeed signs that European studies are producing similar coefficients to the United States studies, but great care has to be taken before extending either of these to developing economies or the economies in transition.

12. Epidemiology provides a methodology for analysing the link between pollution and mortality; beginning with life tables, this method can trace a given cohort of individuals exposed to changing life risks. The end result is a matrix that contains the predictions of mortality by age group for any year. The unit monetary values, if those are preferred, can then be superimposed. Such an approach casts doubt on the view that cohort studies may simply be aggregations of acute effects. The exact role played by discounting in such a model remains a little unclear and a matter for further work.

13. One of the more important issues is the relationship between age and willingness to pay to reduce risks. If, after all, air pollution is having the vast majority of its effects on the elderly, what matters is their willingness to pay to reduce risks, not those of someone of median age. Results of recent Canadian and United States studies suggest that willingness to pay does decline with age but not until about 70 years. The age-willingness to pay relationship is certainly not the same as

that imposed on it by approaches which 'derive' values of life years lost (VOLYs) from values of statistical life (VOSLs). There has been a presumption in the literature that the health state of the individual will also affect willingness to pay. In general, the lower the current state of health and/or the lower the expected state of health, the less individuals are expected to be willing to pay to reduce risks. The studies find no support for the view that the current state of health affects willingness to pay. A United Kingdom study suggests, very provisionally, that future states of ill health would substantially reduce willingness to pay (the 'health discount'). The period over which payment is made also affects willingness to pay, a result consistent with the findings in the environmental economics literature.

14. Throughout the workshop, there was an underlying issue: are we looking for values of risk reduction or values for 'life extension'? There is an obvious link between the two even though there are difficulties in determining what those links are quantitatively. What the link is between what the analyst believes the relationship between risk and life expectancy to be, and what the person at risk believes is a further issue. But the focus has shifted from valuing 'mortality' to valuing the life period lost by the premature mortality. Results of work in the United Kingdom suggest some caution here: respondents to a questionnaire revealed a belief that numbers of deaths and the life periods in question both matter. Work in the United States suggest that the value of life expectancy is more likely to pass a 'scope test' than values of risk, i.e. risk valuations prove to be surprisingly insensitive to the scale of risk. Part of the problem appears to be the difficulty of communicating the notion of a change in risk to individuals, but several experiments with alternative risk communication procedures appear to offer some reassuring results.

15. If chronic exposure does matter more than acute exposure - an issue not settled by the workshop - what life period matters most? There is a tendency to 'forget' that infant mortality due to pollution could be important. It might account for around 10% of all pollution-related premature mortality when expressed in life-year terms. Reviewing the epidemiology on long-term morbidity effects, however, shows how much of the available evidence appears inconsistent. A major European follow-up study (ECRHS II) could be useful in providing new evidence. Its major strengths are its size, the diversity of environments being studied and the extent of potential confounders being assessed.

16. Concerning the valuation of morbidity effects, stated-preference questionnaires can be used to value morbidity reduction. A United Kingdom study, part of a much larger pan-European study, provides the first real evidence on how people value certain health end points. The aim of the work was to test whether 'benefits transfer' was justified, a question that could be answered by seeing what, in any subset of the country studies, could predict the stated preference answers in the other countries. The error appears to be around 30-40%, i.e. 'borrowing' a number to apply to another country results in estimates with a 30-40% error attached to them. The context of the

health effect (e.g. what it was caused by) appeared not to matter. Age and health states both affected willingness to pay. It is also possible to use stated-preference techniques that do not rely on an explicit elicitation of willingness to pay by respondents. Rather, willingness to pay is inferred on the basis of answers to questions about choices or ratings. The attraction of this approach is its ability to separate out attributes of various health states in such a way that they can be aggregated to reflect a broad range of respiratory and other conditions.

17. All the economic contributors reminded the workshop that willingness to pay estimates, however derived, are but one part of the total economic value of reducing risk - for example, changes in avertive expenditures also matter, as do costs to the health services.

18. While most studies give higher values for mortality, it may be possible that morbidity effects actually matter more than mortality effects. The importance of morbidity valuation is shown, for instance, in a global assessment of the effects of air pollution. But there are still formidable problems in estimating the morbidity effects. For instance, there are problems of even defining health states, and particularly defining and measuring them so they correspond to the notions needed by economists to make cost-benefit analysis functional. While acknowledging the problems it is justified to continue the use of interim values since the policy process cannot be held up whilst the research is sorted out.

19. A World Bank study of the global impacts of air pollution shows that the effects of local air pollution actually dominate the total costs to the non-industrialised countries. Global warming costs account for less than 20% of the total air pollution damages to those countries. Care has to be taken not to allow global warming measures to absorb budgets that might more effectively be used to solve more immediate concerns in developing countries.

20. Finally, one recurring theme was present in the workshop - the need for continuing cooperation. To some extent it was unsurprising since the workshop was organized to bring epidemiologists and economists together to share their research agendas. The workshop itself was a symbol of that cooperation, with attempts to demarcate professional areas of territory being totally unobservable.

21. The workshop identified the following implications for further work:

- (a) While the Convention is unlikely to finance the required collaborative work, it can and should be one of the main arenas for that work. The Protocols will be reviewed and part of this review should be to check and test their validity in economic terms to derive lessons for future guidance;
- (b) The issues related to the measurement and economic valuation of the health effects

of air pollution need to be kept under continued surveillance by NEBEI and the bodies under the Convention dealing with effects and with abatement strategies. The very latest research should be used for the work to support protocol reviews;

(c) Future research in this area needs to be collaborative. The epidemiology research has to be informed by the needs of the economics research. The economics research must take on board the findings of the epidemiology research and the various uncertainties that remain;

(d) The NEBEI website (www.unece.org/env/nebei) should serve as a point of contact for the group, and all workshop participants were encouraged to submit details of new research projects and links to other relevant web pages which can be posted on the site. This will keep the network running electronically. It has also been suggested that a follow-up meeting should be organised in 2002 to revisit the subject of health valuation in the air pollution context with the same group of participants. This would allow a discussion of the progress that has been made in the intervening time.