

SRESRSPS

10 June 2003

Economics, Emissions Scenarios and the Work of the IPCC

Ian Castles and David Henderson

ABSTRACT

This article restates and extends our critique of the economic and statistical work of the Intergovernmental Panel on Climate Change (IPCC), including in particular the Special Report on Emissions Scenarios (SRES). We respond to the article in the previous issue of *Energy and Environment*, in which 15 authors associated with the SRES argued against the case we had made there. We give reasons for rejecting their view that market exchange rates (MERs) should be used in deriving cross-country measures of economic growth, and note that in its handling of this and related issues they and others involved in the IPCC process are not professionally representative. We show how the mistaken use of MER-based comparisons, together with questionable assumptions about ‘closing the gap’ between rich countries and poor, have imparted an upward bias to projections of economic growth in developing countries, and hence to projections of total world emissions. We list actions that could be taken now, in the context of the IPCC’s Fourth Assessment Review which is about to be launched, to set the economic and statistical aspects of the Review on a sounder basis. We argue that it is high time for ministries of economics and finance to inform themselves about the IPCC process and to become involved in it.

1 Introduction

This paper has two related concerns. First, we respond to the article in the previous issue of *Energy and Environment* by fifteen authors connected with the Special Report on Emissions Scenarios (SRES) prepared for the Intergovernmental Panel on Climate Change (IPCC). (For brevity, we refer to these authors simply as ‘the Team’. Their article was itself a response to what we had written in the same issue). We set out below what we now see as the main heads of disagreement between us and them (while also noting some common ground), and consider the implications of these differences both for the possible growth of emissions and for the future conduct of work on this subject under IPCC auspices.

In commenting on the SRES and the Team's response, we do not try to cover all aspects. Here as in our previous article, we refer specifically to only a limited number of the 40 scenarios that are presented in the Report. In this connection, the Team reproach us (p. 196) with 'selective (biased) treatment'. But the scenarios that we deal with are those that are relevant to our theme. Our object was not, and is not, to write a review article on the SRES, but to bring out what we see as some basic weaknesses in its procedures and results. Our chief concern is therefore with the scenarios in which these weaknesses are most apparent, and have led to results and inferences that are open to question. In particular, we focus on the scenarios of the B1 family that yield the lowest cumulative emissions totals; and among these we single out for attention the B1 IMAGE scenario, which is the 'marker' scenario for the family.

Again as in our previous article, we do not confine our argument to the methods and results of the SRES and the groups directly involved with it. Our second concern is with the economic and statistical work of the IPCC generally, within which the task of preparing emissions projections is one element only, albeit an important one. Hence the present article is not so much a rejoinder to the Team as a restatement and extension of our critique of the treatment of economics and economic statistics in the IPCC process, as revealed not only in the SRES, and now additionally in the response of the Team, but also in other IPCC-related documents. As before, our critique leads on to suggestions for improving the process as a whole.

In what follows, Sections 2 and 3 belong together. In Section 2 we review, in the light of the Team's response to us, the main single difference between us and them – namely, the choice of exchange rates when international comparisons are in question and the arguments that bear on that choice. In that context, we refer also to other instances within the IPCC process where the authors or agencies concerned have fallen into the same errors as the Team. We offer further evidence that, despite the large numbers of persons and organisations that form part of it, the present IPCC milieu, in so far as issues of economics and economic statistics are concerned, is not professionally representative. In Section 3 we turn briefly from the general to the particular, by commenting on specific aspects of the treatment of exchange rate issues in the SRES.

In Sections 4 and 5 we review, more fully than before and again in the light of the Team's response, the basis and implications of the SRES projections of GDP and GDP per head. In Section 4 we restate our reasons for thinking that the assumptions and procedures adopted, for some scenarios at any rate, impart an upward bias to the projections for developing regions, and hence to the corresponding projections of world GDP. In arguing the case, we go beyond the issue of which exchange rates are appropriate: we question the working assumptions which underlie the scenarios we focus on, and which reflect ideas and perceptions held not just within the scenario groups but in the IPCC milieu more broadly. We note that these SRES projections for developing countries in the first half of this century are out of line with some others that have been recently made in the same context, as well as being high by historical standards. We then consider, in Section 5, whether this upward bias in projections of world GDP implies a corresponding bias in the projections of emissions: here we contest two different arguments that are given by the Team, at different points in their article, for holding that this connection need not hold good. We conclude, as before, that even the SRES scenarios which show the lowest cumulative emissions over this century do not in fact represent reasonable lower limits. These projections do not, as is claimed for them, encompass the full range of uncertainties about the future.

Following this reformulated critique of the procedures and results of the SRES, and of related thinking in IPCC circles, we sketch out the moral to be drawn, not just for the work on emissions projections but for the IPCC process more generally. After a brief Section 6 on the uses of history in assessing future developments, we present in Section 7 some positive proposals. These relate to action that could be taken now, in the context of the IPCC's Fourth Assessment Review which is about to be launched, to set the economic and statistical aspects of the Review on a sounder basis. Here we emphasise the need for greater awareness, and closer participation, on the part of the central economic departments of state. Afterwards, in an Annex, we comment briefly on some questions of conduct and procedures that the Team have raised in their article.

2 The choice of exchange rates for international comparisons: general issues

The disagreements between us and the Team are both analytical and statistical: the two are interrelated. We begin with some remarks under the first heading. These relate to the relevance and uses of purchasing power parity (PPP) measures, as distinct from market exchange rates (MER), in economic aggregations and comparisons that extend across countries.

Allowing for price changes and differences

The Team draw a distinction between two purposes of international comparisons. One is to make '(static) comparisons of economic welfare (income and consumption) across different countries' (p. 191): for this purpose, they view PPP-based figures as a better measure, and express agreement with us on the point. The second purpose, in relation to which they 'sharply disagree' with us, is the measurement of economic growth, for which they maintain that the MER basis is 'the preferred measure'.

We believe that this distinction between 'growth' and 'static welfare' is invalid; that MER valuations, since they do not measure cross-country differences in output for any given period, should not enter into a 'preferred measure' of changes in output over time for groups of countries or the world as a whole; and that our position on these issues reflects a widely-held professional view.

To begin with, the rationale for making PPP-based comparisons, just as for the construction of price index numbers within a single country, is to separate out price effects from quantity (or 'real') effects in comparing the values taken by economic variables. The need for such a separation arises in many contexts: it is by no means confined to, although it includes, items that enter into national income accounts. In relation to those items, it applies equally to data that refer to different periods (when *intertemporal* comparisons are in question) and to those that refer to different regions or countries (when the comparisons are *interspatial*). Just as it is not legitimate, whenever 'real' comparisons are in question, to compare national accounts items for different years for a single country at current prices, without taking into account estimated price *changes* between the periods concerned, so it is inadmissible to compare these items across countries at nominal exchange rates only, without allowing for estimated price *differences*. The cases are parallel. Valuation at current

prices does not yield a measure of quantity changes over time, and valuation at market exchange rates does not measure the relative economic size – the relative quantities produced or consumed - of different countries in a given period.

It follows directly that, in measuring the growth of output in a number of countries grouped together, or across the world as a whole, the appropriate country weights – the measures of comparative real size of these different economies in some agreed base period - are PPP-based values. In constructing such a measure of growth, we are weighting quantity relatives; the weights to be used are comparative outputs; and these can only be stated in terms of PPPs, since market exchange rate valuations do not yield measures of relative quantities (outputs). Just as with intertemporal comparisons, there is of course room for debate as to which set of prices should be chosen for valuing quantities, and rival PPP measures are to be found. But this does not alter the fact that, contrary to what the Team maintain, a meaningful index of regional or world GDP growth cannot be defined with reference to quantities that are valued across frontiers at market exchange rates. It is their recognition of this fact, which is given formal expression in the 1993 System of National Accounts (SNA), that has led the leading international agencies, with the full support of national statistical agencies, to change to PPP-based valuations.¹

Such a switch brings with it substantial changes in the estimated relative size of different economies. Thus for the year 2000, in the revised weighting system for that year adopted by the International Monetary Fund (IMF), the share of world GDP accounted for by the developing countries, at 37.2 percent, was over twice as high as it would have been if MER weights had been used. Again, the GDP of Japan for that year appears as some four and one-half times that of China if the translation is made at MERs, while on the PPP basis Chinese GDP exceeds that of Japan by well over 50 per cent, and it is China, rather than Japan, that ranks after the US as the second largest economy in the world.²

¹ PPP weights are likewise appropriate for cross-country measures of aggregate price changes over time across a group of countries.

² This set of weights is described in the May 2002 issue of the Fund's *World Economic Outlook*, pp. 189-96. The Fund listing of developing countries is not identical with that to be found in the SRES, since it excludes Hong Kong China, South Korea, Singapore, Taiwan and Israel.

In taking the view that MER-based values are ‘the preferred measure’ for the growth of output, the Team are at variance with current international thinking and practice. The main justification that they offer for using MER values in cross-country comparisons, rather than relying on PPP-based data, is that virtually all model-based scenario work has been done on that basis. In fact, this is not true of some of the leading work of this kind published during the past decade. Among the PPP-based studies which have incorporated projections of global and regional population, GDP, energy use and carbon dioxide emissions for 30 or more years into the future have been *Energy for Tomorrow's World*, an analysis of three scenarios (plus a higher growth variant of the middle one) which was published in 1993 by the World Energy Council (WEC); the projections elaborated with the POLES energy model (funded in part by the Commission of the European Union, DG XII), which were published in 1999 and analysed in a series of papers in a special issue of the *International Journal of Global Energy Issues*; and a series of studies by the International Energy Agency (IEA), which have been published in the 1998, 2000 and 2002 editions of the Agency's *World Energy Outlook*.

More broadly, our arguments for PPP-based comparisons and aggregates are in line with those of other professionals who are working on issues and problems relating to the process of economic growth. Thus the editors of a recent volume entitled *International and Interarea Comparisons of Income, Output and Prices* note that the UN International Comparisons Programme (ICP), which is the prime source of PPP estimates, has now been running for over 30 years; that ‘measures derived from it are increasingly used in economic research in place of the distorted values derived from translating from exchange rates’; and that ‘Almost the entire recent literature on the determinants of economic growth that covers large numbers of countries is dependent on these [PPP-based] data’.³ Again, the World Bank, in commenting on the ICP a few years ago to the UN Statistical Commission, took the view that ‘there is unanimous agreement among researchers and theoreticians [that] proper comparisons [across countries] can only be made once values have been adjusted to eliminate differences in price levels using purchasing power parities’.

³ Heston and Lipsey (1999). The quotations are from pages 2 and 1 respectively. It is worth noting that, at a representative conference held some 25 years ago on international comparisons of energy

In making the case for PPP-based estimates of comparative output and the growth of GDP over time, we are not arguing against the use of MERs as such and for all purposes. What we object to is the practice, which the SRES has followed, of making cross-country comparisons and aggregations of national accounts data without allowing for differences in prices, and then using the results as a basis for projections of aggregate GDP. This practice has been followed in all the SRES scenarios, including those of the MESSAGE group in which PPP-based values have also been brought in and which we refer to below.

In separating price effects from quantity effects in national accounts data, there is no valid distinction to be made between output and real income (or ‘welfare’, if one wants to use that term), nor for viewing the one as ‘dynamic’ and the other as ‘static’. Both are equivalent measures, and both can be compared either at a given time or over a period. It is true that historically a distinction has been made in economic theory between the ‘growth’ and ‘welfare’ aspects of national accounting aggregates. But this distinction has nothing to do with a supposed difference between ‘static’ and ‘dynamic’ aspects. The point concerns the two different aspects of real national income or product. For any given country and period, this concept can be defined and viewed in terms of either total goods and services produced (value added) or total final expenditures net of imports of goods and services; and a succession of authors, starting with a classic 1940 article by J. R. Hicks, have presented a contrast between the former aspect, as a measure (or indicator) of output or productive capacity, and the latter, as a measure (or indicator) of real consumption or economic welfare.⁴ But for the purposes of applied economic work, including projections of future real GDP, such a distinction need not (and perhaps cannot) be usefully introduced. In dealing with actual historical data, we are working within the framework of national accounts conventions, so that the two totals are constrained to be equal. Whether real GDP is expressed in terms of final expenditures or in terms of value added, the same economy-wide aggregate is in question: the two totals, defined to be the same

consumption, ‘Almost all were agreed on the importance of converting GDP... to a comparable unit using purchasing power parity rates rather than exchange rates...’ (Resources for the Future (1978)).

⁴ Among the authors who drew on Hicks’s article were Milton Gilbert and Irving Kravis, in Chapter VI of their pioneering 1954 study of purchasing power parities in what were to become the OECD countries.

although each has its own components, emerge from the matrix of transactions in goods and services for any given period.⁵ This equivalence holds good both for comparisons across time and those between countries: in both cases, one can think and work equally in terms of output-related or expenditure-related changes or differences. It is true that most PPP comparisons so far have been made in terms of final expenditures, rather than value added, and that this expenditures approach is often seen as the starting point for an analysis of changes or differences in economic welfare. But the main reason for focusing on expenditures rather than outputs has been the greater availability and accessibility of data; and in any case – and this is the key point - the choice of one concept rather than the other does not affect the relationship of identity between the two.

To sum up: the idea that different valuations of outputs and real incomes are appropriate for ‘growth’ as distinct from ‘welfare’ has no basis, while MER valuations across countries, since they do not measure quantity differences, have no place in international comparisons of output or real expenditure, nor in constructing measures of the growth of output or real expenditure that extend across national boundaries.

An unrepresentative milieu

The arguments that we have made above about national accounts comparisons and measurements are familiar to economists and economic statisticians, and some readers may find them trite. Yet they seem to have gone unrecognised or disregarded by the 53 authors, four review editors, 89 expert reviewers and numerous though uncounted government officials who were involved in the preparation of the SRES. Sheer numbers have not sufficed to make these participants professionally representative.

Further evidence of non-representativeness, specific but telling, is that in the SRES the concept of gross national product (GNP) is misdefined.⁶ Such an elementary error

⁵ Of course, valuation may be at factor cost or at market prices; but the choice does not affect the identity relationship.

⁶ On p. 115, in a box conveying basic information, it is stated that the GNP of an economy ‘equals GDP plus the net balance of international payments to and from that economy’. The correct definition is of course GDP plus net factor income from abroad. It may be added that, following the recommendation made in the SNA, the term gross national income (GNI) is now generally used, rather than GNP.

would not have escaped wider professional scrutiny. Again, it is striking that the SNA, which has been a standard work of reference across the world since its publication in 1993, is not listed in any of the extensive bibliographies that are to be found in the SRES.

Within the IPCC process, it is not only the scenario-builders that are out of touch with widely accepted thinking and practice in this area. We noted in our previous article (p. 162) that the report of the IPCC's Working Group III cites incorrect MER-based statements about the international distribution of income – statements of a kind which the agency that was responsible for them, the United Nations Development Programme, has agreed to discontinue since they involve 'material error'. This mistake passed uncorrected by the many peer reviewers involved with the chapter in question. A further conspicuous example of the same error is to be seen in a recent flagship publication of the United Nations Environment Programme (UNEP), which is one of the two parent agencies of the IPCC. This document, *Global Environment Outlook 3*, likewise quotes misleading UNDP data, and in our view it goes even further than the passage from the WG III Report in presenting (pp 35-6 in particular) a distorted picture of the international distribution of income and the ways in which it has changed in recent years.⁷

A misuse of MER-based data is also to be seen in some of the official submissions to the UN Framework Convention for Climate Change (UNFCCC) by its member governments. Although the Team are mistaken in thinking that 'All government reports to the UNFCCC ... give their respective GDP in terms of MER' (p. 191), it is true that many developing countries and a few Annex I countries report their GDP converted in this way. For example, the Australian government has quoted estimates of the country's GDP at different dates, converted into \$US at MER rates, which convey a misleading impression of changes over time. This practice serves no useful purpose, and is not consistent with the thinking that enters into the SNA.

⁷ The UNEP acknowledges the assistance of 40 'GEO-3 Collaborating Centres' in the production of this volume. Among them are two of the six organisations that developed groups of scenarios for the SRES - the National Institute for Public Health and the Environment (RIVM) in the Netherlands, which developed the IMAGE group, and the Japanese National Institute for Environmental Studies (NIES), which developed the AIM group. RIVM, which is the longest serving GEO collaborating centre, used its IMAGE global change model to develop for UNEP a series of scenarios for the 30-year outlook chapter of GEO 3.

These latter instances give point to our argument that the issue of non-representativeness goes wider than scenario-building: it relates to the whole IPCC process including the part played by member governments. It may be unfair to criticise the SRES authors and reviewers for being in tune with the thinking of those in Working Group III of the IPCC who appointed them and gave them terms of reference, WG III itself for being in tune with the IPCC which created it, or the IPCC for being in tune with the representatives of member governments who direct its activities. But this does not mean that criticisms are unwarranted, since *the fault lies with the process as a whole*. In relation to economic and statistical issues, the work of the IPCC, in both its official and unofficial aspects, is not professionally sound.

3 The choice of exchange rates: SRES procedures

Although the Team express agreement with us that cross-country comparisons of real income at a given time should be based on PPP valuations, it is not clear what significance can be attached to their saying this. Thus they do not disown the misleading MER-based comparison between living standards in Bangladesh and Switzerland that is quoted in the SRES (p. 197), nor the statement (on the same page) that in 1990 real income per head in the OECD group of countries was almost 40 times higher than in the Asia region, even though on a PPP basis, taking Maddison's estimates for that year, this ratio would be less than 9 to 1. In the Report, the differences in GDP per head between countries in 1990 that emerge from a MER-based comparison are wrongly taken (p. 197) as indicative of 'present disparities'. In Figure 3-13 on p. 125 of the report, cross-country comparisons of the energy intensity of GDP are made on the basis of GDPs that are expressed in 1990 US dollars at MERs, so that the energy intensities of the poorer regions are overstated.⁸

The Team make the point (p. 190) that 'one of the six models is parameterized equally for PPP so that all four economic development paths for the four scenario families are reported in SRES both in terms of PPP and MER': they reproach us for not having

⁸ On the opposite page, by contrast, a diagram showing comparative metals intensity of GDP uses PPP data. The fact that 'income per capita' is differently defined in the two diagrams is not mentioned. In calculating and reporting energy intensities in relation to GDP (MER), the SRES is out of step with the practice followed in leading publications of the World Bank (2002a), the UNDP (2002) and the IEA (2002a).

acknowledged this. It is true that the MESSAGE scenarios, prepared by the International Institute of Advanced Systems Analysis (IIASA), all show what are described as PPP-based figures for GDP, alongside those that are identified as MER-based. However, it is not explained how these PPP-based series are derived, nor is it clear what economic meaning can be given to them. What *is* clear is that they do not, as is claimed for them, represent changes in GDP for any of the four regions that are distinguished or for the world as a whole.

This can be seen by asking how such a series representing GDP for groups of countries, if authentic, would compare with the corresponding set of MER-based estimates. Both series are designed to measure changes in output (though the MER basis gives misleading results), and any difference between them can only arise from the use of different weighting systems. These differences in turn chiefly result from differences in GDP per head across countries: generally speaking, a switch from MER to PPP gives poorer countries higher weights in relation to richer ones. Hence it is when poor and rich countries are brought together in a single grouping, and in particular when growth is estimated (or projected) for the world as a whole, that the divergence between MER-based and PPP-based measures of output growth will be greatest. For groups of countries with broadly similar levels of GDP per head, whether rich or poor, the two measures will diverge much less: they may well be close, though they will virtually never be identical.⁹

The so-called PPP-based GDP figures in the MESSAGE scenarios do not exhibit these properties. The proportionate changes shown in this series for the 'OECD 90' group of countries are identical with those for the MER-based series, which they would not be if they were genuine measures of GDP; for the developing regions, the divergences between the two series are impossibly great; and for the world as a whole the divergences are intermediate, presumably because they reflect some kind of averaging across regions, even though such averaging could have no place in a

⁹ Within countries, the distinction is seldom made, so that MER- and PPP-based measures of growth are treated as identical. However, as is noted in Heston and Lipsey (1999), the possibility exists for regional price differences to be taken into account in PPP-based estimates of GDP growth for a single country. These would differ from the standard estimates, though in most countries probably not by much.

genuine PPP series where as just noted the divergences would be greatest for the world as a whole, as distinct from groups of like countries within it.

Looking at specific figures makes it clear that, whatever the MESSAGE PPP series may reflect, it is not an alternative measure of the growth of GDP. Over the period 2000-30, for example, the GDP of the 'ASIA' region is shown in the B1 MESSAGE scenario as increasing in MER terms by a factor of 5.6, whereas for the PPP series the figure is 3. Such a gap could not possibly have arisen from differences in weighting which are the only true source of divergence between the two measures of GDP growth. The MESSAGE GDP series expressed in PPP terms is not such a measure – it is mislabelled.

4 Projecting the GDP of the developing countries

One might ask how and why the use of cross-country MER comparisons, even if acknowledged to be mistaken, should have a bearing on emissions projections. After all, the emissions figures themselves for the base year are what they are, unaffected by the choice of exchange rates. Starting from these figures, emissions projections can be made by projecting (1) the growth of world GDP, (2) the energy intensity of world GDP, and (3) the emissions intensity of world energy consumption. Why and in what way does the choice between MER-based and PPP-based international comparisons come into this?

Assuming the closure of an overstated gap

The answer, as noted on p. 169 of our previous article, is that the choice has been made relevant as a direct result of two interrelated features of the SRES scenarios, which together lead directly to projections of GDP growth for the developing countries that are biased upward. First is a working assumption that the gap in terms of GDP per head in 1990, as between Annex I countries and the rest of the world (the developing regions), will be progressively and largely narrowed. Second is the mistaken presumption that this initial 1990 gap is to be defined with reference to GDP figures expressed in terms of MERs. Some scenarios, in particular the A1 and B1 families, set ambitious targets for closing the initial 1990 gap, while for all scenarios

the gap itself is greatly overstated because it is defined with reference to cross-region MER-based comparisons for that year.¹⁰

In our previous article (p. 169) we gave a few figures to show how these twin scenario features combined to inflate projections of GDP in the developing regions over the period 1990-2100. Before presenting some further illustrative numbers, relating to the present century, a word is in order on the assumptions made in the SRES about 'closing the gap' in GDP per head between rich countries and poor.

Questionable 'storylines'

The idea that poor countries may achieve higher rates of growth in income per head than rich ones is familiar, plausible, and well attested in economic history: no one could reasonably object to constructing scenarios of the future which incorporate a trend towards convergence. In the SRES, however, the main stated basis for building in convergence is neither theory nor past experience but a judgement, or presumption, about what is equitable and fair: such a presumption has been written into scenario storylines. Thus it is said of the B1 storyline (p. 5 of the SRES) that 'the emphasis is on solutions to economic, social and environmental sustainability, including improved equity', while the B2 scenario family 'is also oriented toward environmental protection and social equity'. We would make three passing comments on this approach.

First, such language is hard to reconcile with the statement made in the SRES (pp. 177-9) that as between storylines 'no judgments have been made by the SRES team as to their desirability'. Can one be neutral as between scenarios that are 'oriented towards equity' and those that are not? When we are told (p. 181) that 'the central elements of the B1 future are a high level of environmental and social consciousness combined with a more globally coherent approach to a more sustainable development', does this not suggest a measure of superiority to scenarios that incorporate lower levels of consciousness and a less globally coherent approach?

¹⁰ It is true, as noted by the Team pp. 193-4) that PPP-based estimates of the gap in 1990 are available from the MESSAGE scenarios; but these were not made the basis for the SRES projections of GDP per

Second, it is taken for granted in the SRES, as also in the Report of WG III, that substantial differences in GDP per head across countries constitute ‘inequities’: inequalities as such are viewed as unjust. This is, to put it mildly, a questionable presumption.

Third, it is a dubious procedure to project a specific sequence of future outcomes and events, not on the basis of argument and evidence, but on the grounds that the world would be a better place if it occurred. Because we question some of the SRES projections of growth in developing regions, the Team charge us (p. 201) with having made ‘an attempt to socially construct’ the range of future possibilities. If one wishes to attach this dubious label, their own ways of thinking, which admittedly are those of other leading participants in the IPCC process, appear more suited to it.

Since it is obvious that convergence has to be viewed as a serious possibility, even though not for the reasons chiefly emphasised in the SRES, we do not argue that scenarios which embody it are at fault. The error of the SRES procedures, as distinct from the dubious assumptions that enter into the storylines, is that they provide for substantially closing a gap the size of which is greatly overstated. Hence the built-in tendency to overstate the growth of developing regions, to which we now turn.

Effects on GDP projections: a further illustration

In our previous article, we made the point that within the B1 IMAGE scenario the GDP of the developing regions is projected to increase by a factor of 65 between 1990 and 2100. The effect of this, given projected GDP per head in Annex I countries, is to reduce the ratio of GDP per head in those countries to that in the developing regions from 16.7, which is the (MER-based) figure taken for 1990, to a postulated ratio for 2100 of 1.8. But the figure of 16.7, since it is derived from MER values, is misleading. A more accurate PPP-based ratio for that year would be 6.2; and on this basis, the increase in GDP required to reduce the gap to the postulated figure of 1.8 in 2100 would be 24.5, rather than 65.

head and GDP in developing regions. They are in effect memorandum items, while as noted above the figures for later years that correspond to them are not in fact measures of changes in real GDP.

By way of further illustration, still taking the B1 IMAGE scenario¹¹, we consider the present century, thus taking the year 2000 as a starting point; and we estimate by how much the projected increase in world GDP over the period 2000-2100 shown in this scenario would have been affected by taking as a point of departure a PPP-based figure for the gap in GDP per head between Annex I countries and the developing regions, rather than the MER-based ratio which appears in the scenario. In B1 IMAGE, this latter ratio is 13.67, while a PPP-based alternative, derived from data presented in a forthcoming volume by Angus Maddison, can be put at 5.23.

In round terms, the B1 IMAGE scenario projects the GDP of Annex I countries for 2100 as 4.8 times that for 2000. For the developing regions the corresponding multiple is over 39, and for the world as a whole it is 12.3. If we rework the figures taking the PPP-based gap for 2000 as a point of departure, the increase for the Annex I countries is of course unaffected; but the multiple for the developing regions becomes 15 instead of 39, and as a result the increase in GDP for the world as a whole is only ninefold, instead of over 12-fold. *Hence the prima facie effect of taking a PPP-based gap as a point of departure at the beginning of this century is to reduce prospective world GDP in 2100 in this scenario by over one-quarter.* A similar proportionate reduction is arrived at if one makes the same kind of calculation for 2050 rather than 2100. Of course, it could be argued that if a PPP-based figure had been taken for the initial gap in GDP per head other features of the scenario might have been changed; but it seems clear that a significantly lower total for world GDP would still have resulted.

Do the GDP projections for the developing regions appear reasonable?

Admittedly, what has just been said is not the full story. Although the arguments just made cast doubt on the way in which the projections of GDP for the developing regions were arrived at in the B1 scenario family (and the same applies to the A1 family), they do not suffice to establish that these projections are unreasonably or improbably high. Some light can be thrown on this issue by comparing SRES growth

¹¹ We considered switching from the B1 IMAGE scenario to another member of the B1 family, since along with its other IMAGE brethren it contains an obvious error which escaped the peer reviewers. Alone among their fellows, the IMAGE scenarios give lower population figures for the 'OECD 90' group of countries, evidently because Turkey was excluded from it. However, this deviant property

projections with those of other recent scenarios and with past economic performance in developing countries. In this connection, it is the projections that relate to the earlier decades of this century that are in question, since it is over this period that the SRES scenarios show especially rapid rates of growth for developing regions.¹²

Comparative scenario projections for the period 2000-30 are set out in the table below. This shows the increases projected over these three decades for the real GDP and GDP per head of developing countries, and the corresponding annual average percentage rates of growth, in 12 different scenarios. Seven of these are to be found in the SRES, while the rest are from three outside sources – the IEA and POLES scenarios already mentioned above, together with three scenarios that are contained in a recent study jointly undertaken by IIASA and the World Energy Council (WEC). The SRES list comprises all the four marker scenarios and the two ‘illustrative’ scenarios that appear in the Report, together with the B1T MESSAGE scenario which we include because it yields the lowest figure for cumulative emissions over the whole period from 1990 to 2100.

does not significantly affect our illustrative calculations, and we stayed with B1 IMAGE because of its marker status.

¹² ¹² It is worth noting that this ‘front-loading’ of GDP growth in the first half of the century, with slower growth in the second half, yields a higher total for cumulative emissions by 2100 than if the projected growth rate had been much the same over the century as a whole

PROJECTED GROWTH OF DEVELOPING REGIONS, 2000- 30

(selected scenarios, SRES and others)

Scenario Source	Scenario	2030 as a multiple of 2000		Average annual growth rates	
		GDP per head	GDP	GDP per head	GDP
SRES	A1T MESSAGE	6.23	8.74	6.29	7.55
SRES	A1B AIM	6.07	8.51	6.17	7.39
SRES	A1FI MINICAM	4.80	6.69	5.37	6.54
SRES	B1T MESSAGE	4.26	5.98	4.92	6.14
SRES	B1 IMAGE	3.94	5.51	4.68	5.86
SRES	B2 MESSAGE	3.32	4.85	4.08	5.41
IIASA / WEC	Case A	2.45	3.68	3.04	4.44
POLES	Reference	2.34	3.51	2.87	4.27
SRES	A2 ASF	2.12	3.34	2.53	4.11
IEA	Reference	2.31	3.29	2.83	4.04
IIASA / WEC	Case C	2.16	3.24	2.59	4.00
IIASA / WEC	Case B	1.84	2.77	2.06	3.46

Sources: IPCC (2000), Nakicenovic *et al* (1998), Criqui and Kouvaritakis (2000), IEA (2002).

Note: Ten of the twelve listed scenarios are MER-based. The exceptions are the IEA and POLES scenarios.

It will be seen that six of the seven SRES scenarios yield greater increases in GDP and GDP per head than any of the five 'outsiders'. As compared with the IEA 'Reference' projection, the A1T MESSAGE scenario puts the total GDP of developing countries at two-and-a-half times higher. Of the two low-emissions SRES scenarios shown in the table, the B1 IMAGE scenario gives a figure nearly 70 per cent higher than the IEA 'Reference' projection, while for the B1T MESSAGE scenario the figure is over 80 per cent.

As to comparisons with the past, the Team maintain (p. 198) that 'the values are squarely within the historical experience'. For GDP per head, the growth rates shown above for the four marker scenarios range from 2.53 to 6.17 per cent per annum, with the B1 IMAGE scenario, which we are especially concerned with, showing a figure of

4.68 per cent. These projected rates compare with a (Maddison-derived) figure of 2.76 per cent for the same regions for the 30-year period from 1970 to 2000. We agree with the Team that it would be wrong to rule out of consideration the possibility of substantially better economic performance for developing countries than in the past, and that the notably – and unexpectedly - high growth rates recorded for particular developing countries during the past half-century are evidence of what is possible. But the SRES projections, including those that yield the lowest projections for cumulative emissions, have extended to the developing world as a whole the growth rates in output per head which have up to now have been achieved only by the most successful among them.

Last under this heading, a word is due about the implications of these SRES projections for individual countries. In our earlier article we criticised the MER-based projections of GDP for individual countries which had been published on the web site of the IPCC's Data Dissemination Centre (DDC) at Columbia University. The Team object strongly to this critique, saying that it is ‘a deplorable misinformation’ to attribute to SRES ‘these preliminary attempts to downscale global scenarios to local levels’ (p. 201-02, 210). They acknowledge that the ‘strong words [we] use to describe the absurd nature of scenarios for some individual countries are to an extent warranted’, but point out that "these country-related scenarios are not part of SRES" (p. 210).

It is true that the SRES does not report projections of GDP and population for individual countries: all of the scenario tabulations are given at the level of four world regions only. But these tabulations represent the sum totals of the individual countries that comprise the regions, and it is not clear that the results of a SRES-approved downscaling procedure would be free from apparent absurdities such as appear in the figures that we quoted from the DDC, which were themselves arrived at under the guidance of an IPCC expert group. Such improbable results are especially likely to form part of the A1 storyline, which describes a future in which average global incomes increase nearly 20-fold and ‘current distinctions between “poor” and “rich” countries eventually dissolve’ (p. 179).

5 Emissions and economic growth

Our main single criticism of the SRES is not that it projects rates of growth for GDP in the developing regions which are impossibly high. It is that the Report's assumptions and procedures have resulted in projected rates which have an upward bias and which do not, as is claimed for them, yield lower limits for projected GDP: they do not span the reasonable range of uncertainties. From this we draw corresponding conclusions for projected emissions: we infer that even the scenarios that show the lowest cumulative emissions over the present century do not represent lower limits.

This inference is questioned by the Team on what appear to be two distinct and independent grounds: first, that the emissions projections would be substantially unaffected if PPP-based valuations were taken as a point of departure, and second, that they would be affected, but not in the way and to the extent that we suggest.

The former argument is put on p. 194, where it is said that the difference between MER-based and PPP-based valuations and projections of GDP 'does not have a substantive effect on the results such as the emissions paths'. This statement is made in the context of the series in the MESSAGE scenarios which purport to show the course of real GDP over the period 1990-2100 in PPP values. Since as we noted above the series does not represent GDP at all, it is true but beside the point that it has no bearing on emissions paths. Our argument is that (1) other things being equal, emissions growth and GDP growth are positively related, and (2) the GDP growth for developing regions shown in the SRES scenarios, since it is based on closing an overstated MER-based gap between richer and poorer countries, is greater than it would have been if a lower and more accurate estimate of the initial gap, based on PPP valuations, had been taken as a point of departure. Hence a 'substantive effect' on emissions paths cannot by any means be ruled out, and is to be expected in this particular case because of the orders of magnitude involved.

A second argument is made in pp. 207-9. Here the Team maintain that we are wrong 'both theoretically and practically' (p. 208) to presume that lower growth rates of GDP would result in lower growth rates of emissions. The reason for this is that 'income and technology variables ... are highly interdependent': rates of growth of

GDP are closely linked with rates of technological advance, which in turn will affect the energy-intensity of output growth and the emissions-intensity of energy consumption. Because of that interdependence,

‘The result of lowering GDP growth assumptions in the developing countries in the more optimistic scenario families A1 and B1 **would therefore not change anything** in the projected emission range of the SRES scenarios. If anything, emissions would tend to move in the direction of the slow growth, slower technology scenario family A2, i.e., be *higher* rather than lower...’ (p. 209; the italicised word is in the original, while the bold type is our addition).

We agree that growth rates and technological advances are closely interdependent, and accept the criticism of the Team (in their footnote on p. 208) that we ought to have stated explicitly in our own critique that this interdependence is fully recognised in the SRES and given expression in the modelling work that underlies it. But we find the conclusion quoted above both strange and mistaken.

It is of course true that, as between different scenarios, the same levels of GDP, and similar rates of increase in GDP, can be associated with quite different levels or growth rates of emissions. It is also true that, even within a given scenario, in so far as a lower rate of economic growth results in a lower rate of technological advance this latter effect may lead to a higher emissions intensity of output. But within each scenario, the effect of higher output *in itself* on prospective energy consumption, and hence prospective emissions, must be to increase them: the partial derivative of emissions with respect to output is positive, since it is the output - the real GDP and real final expenditure - that gives rise to the emissions. Within each scenario, it seems to us to make no sense to say either that a lower assumed level or rate of growth of GDP ‘would not change anything’ with respect to the level or rate of growth of emissions, or that its negative effect would be more than offset by technological changes that it would *of itself* engender.

In support of this generally accepted position, we can quote the SRES itself. Consider the following quotations:

‘... growth in productivity and intensity improvement growth have historically been outpaced by economic output growth. Hence, materials and energy use has risen in absolute terms’ (p. 124)

‘... if governments support the development of rapid-growth sectors, the tendency may be to promote long-term economic growth, increase household income and consumption, and hence increase GHG emissions’ (p. 156)

‘... as currently constituted many national systems for innovation could tend to increase emissions by stimulating economic growth’ (p. 156).

In these excerpts, as elsewhere, the SRES takes for granted the positive relationship between output growth and emissions growth.¹³ Since we take the same view of the relationship, we do not accept the argument, now surprisingly made by the Team, that we are mistaken in holding that, other things being equal, lower projected rates of economic growth in developing regions would be associated with lower prospective emissions growth. We stand by our contention that by imparting an upward bias to GDP projections some SRES scenarios, including those in the B1 family which yield the lowest totals for cumulative emissions, have imparted a similar bias to emissions projections.

6 Viewing the past and the future

The Team attribute to us the view that ‘the future can be determined by simply looking at the past’ (p. 200). Of course, this is not at all what we are saying. Our position was, and remains, that in the IPCC’s programme of work on economic issues there should be more emphasis on the presentation and analysis of evidence relating to the past, and a conscious attempt to enlist the participation of economic historians and historically-minded economists.

This neglect of the historical dimension in the IPCC process is one aspect of a wider problem. At any rate in relation to the economic aspect of its work programme, past and prospective, the IPCC has not drawn on a broadly representative range of professional views and interests. This seems to have been the result of a decision, made soon after the process was set in motion, to focus the economic work predominantly on long-term projections derived from model-based scenarios. Up to a point, such a focus was and is understandable. Emissions projections have been made a point of departure for the analysis of possible long-term climate changes; and in reviewing and commissioning work on these projections, and on the economic factors

which bear on them, it was natural for the IPCC to turn to the published work on possible long-term developments which had characteristically taken the form of model-based scenarios. But it was and remains a mistake to give the model-based scenario approach such near-exclusive emphasis, on no better grounds than that this approach was characteristic of the peer-reviewed literature on long-term economic projections. We believe that the peers in question are not fully representative; and we think that the response of the Team to our previous article has provided further evidence to this effect.

Given that the economic and statistical side of the IPCC's programme of work needs to be strengthened, the question arises of how this might be done. We turn now to consider the kinds of actions that could be usefully taken, in relation to the next stage of the programme, by the IPCC and its member governments.

7 What is to be done?

Our arguments have implications for the conduct of the IPCC's Fourth Assessment Review (AR4), which is due to be launched in November at a meeting of the IPCC Panel. The Panel is scheduled to approve then an outline for the Review as a whole, and in doing so, to discuss and approve proposals that will have been drawn up, through two 'scoping meetings' one of which has already taken place, for the contributions to be made by its three Working Groups which will continue to function as before. The planned year of publication for AR4 is 2007.

Broadly, and not surprisingly now that the whole elaborate set of procedures is in place, well understood and generally accepted, this Fourth Review can be expected to follow the pattern of its predecessor. Many of the same organisations and individuals will be involved, and the end-product, on present indications, will take much the same form. It is our contention that this 'business as usual scenario' should now be questioned in some respects, and that, on the economic side at any rate, new elements should be brought into the process. Our suggestion has a particular aspect – namely, the emissions projections – and a general aspect which relates to the economic dimension of the IPCC's work.

¹³ So too, not surprisingly, does Working Group III of the IPCC, as for instance where it refers in its

Emissions and scenarios

In the arrangements for launching AR4, as outlined on the IPCC web-site, there is no reference to the scenarios. As we understand the situation, it has been agreed that the SRES constitutes an adequate point of departure for AR4, as for the Third Review before it. IPCC circles do indeed envisage a new large-scale scenario exercise, designed to produce in due course, probably over the period 2005-8, a successor report to the SRES. But this new report could not be completed in time for its results to serve as a basis for AR4, and meanwhile the SRES is to serve.

For the reasons that we have outlined in this article and its predecessor, we do not think that the SRES should be taken as the accepted point of departure for this coming Fourth Review. IPCC member governments should now consider, the sooner the better, the question of how to derive for use in AR4 a more acceptable set of emissions projections. Such an official review could well explore the possibility of modifying and improving the present SRES scenarios, but its terms of reference should go wider than this. Its main tasks should be four:

- to consider the case for developing alternative or additional emissions projections as a basis for AR4, whether within the SRES framework or outside it – for example, a B1-style scenario with lower projected growth rates for developing regions
- to establish a procedure by which such an alternative basis for projections could be given timely shape, if the case for it appears to be well established
- to review the SRES procedures for measuring the cross-country growth of output, with a view to adopting the concepts and methods recommended in the System of National Accounts
- looking further ahead, to make recommendations as to the future conduct of work on emissions projections, including the continued use of model-based scenario exercises but not excluding the possibility of other ways of working.

Under the last heading in particular, a sketch of a possible agenda for a meeting to explore the issues is given on p.176 of our previous article.

Report (p. 96) to ‘the underlying pressures imposed by the growth of consumption and population’.

The purpose of this suggested procedure is not to rule out, or even discourage, the continued use and further development of the kind of model-based scenario work that entered into the SRES. Its purpose is to identify and remedy the weaknesses and questionable elements which – as we continue to believe - are to be seen in the working assumptions and results of the SRES, and to open up the possibility of recognising, and developing, alternatives to the model-based scenario approach which could be pursued alongside it.

Economic issues in general

At the same time, arrangements should now be made to ensure that a broader range of professional expertise and viewpoints is represented, not just in relation to emissions projections, but also in the economic work of the IPCC more generally and in the preparation of key documents such as the Summaries for Policymakers. In particular, we have argued that among the academic participants there should be a greater representation of economic historians and historically-minded economists, while on the official side there should be a significant involvement of national statistical offices and the central economic departments of state.

Whether such a broadening of participation takes effect, or is even seriously considered as a possibility, depends on member governments; and within governments, it chiefly depends on whether and to what extent the central economic departments – treasuries, ministries of finance or economics, and agencies such as the US Council of Economic Advisers – show themselves ready and determined to participate. That they have so far held aloof, and left the handling of economic issues in the IPCC process to others, is to us surprising as well as unfortunate. The article in *The Economist* (15 February 2003) that commented on our critique noted that, in relation to issues of climate change policy, ‘vast sums are at stake’. Yet *the questionable treatment of economic issues in the SRES and the IPCC’s Third Assessment Review, which as independent outsiders we have drawn attention to in this and our previous article, seems not to have been noticed by a single official in a single finance or economics ministry in a single country.*

One result of making the economic and statistical work of the IPCC more professionally representative would be to give more prominence within it to PPP-

based series in measuring and projecting the economic growth of different regions and the world as a whole. But greater reliance on these series carries with it a need to ensure that the underlying statistical base is adequate. This in turn requires the continuation and further development of work on international price differences, in particular through the UN International Comparisons Project. Right now the Project is in need of more effective support from governments; and ministries of economics and finance, most of which have so far taken little or no interest in it, should now be ready to play a part in ensuring this support.

Whether and how far the central economic departments of state now become more involved in the IPCC process is largely a matter for each government to decide for itself. But it is worth noting the possibility that the issues could be reviewed across governments, as also across ministries and departments, within the Organisation for Economic Cooperation and Development (OECD). One of the OECD's assets, which could with advantage be better recognised and exploited, is that it is the only international agency where the central economic departments are able to review, and to commission Secretariat work on, the whole range of economic policy questions, 'macro' and 'micro'. A useful start would be for the kinds of issues that we have raised here to be brought on to the agenda of the OECD's Economic Policy Committee and its Working Party No 1. Since as noted in our previous article (p. 176) other departments, including those most closely involved in the IPCC process, also meet at the OECD and have their own Secretariat back-up there, the further possibility exists of setting up jointly-sponsored discussions and reviews under OECD auspices. More speculatively, there could also be scope, since the OECD's procedures are highly flexible and no question of decisions or negotiations need be involved, for the Organisation to convene special meetings and discussions in which non-member countries would be full participants.

Whatever the mechanisms that governments may decide on, the main objective that we propose is clear. It is to review and strengthen the economic dimension of the IPCC process, and to do so in a timely way, before the arrangements for AR4 have been finally decided.

Annex: Protocol and Procedures

In their response to our critique, the SRES Team have raised some issues of conduct and procedure that we would like to comment on. We begin with a few specific clarifying points, and then go on to consider a broader procedural aspect.

Clarification

In their opening footnote, the Team refer to ‘the extremely short journal time table’ for the preparation of their article. This however was due to the fact that, when the editor, at our request, invited the Chairman of the IPCC, Dr Pachauri, to arrange for a response to our critique which she would publish, he made the condition that this response should appear in the same issue of the journal as the critique.

The Team state in their second footnote (p.189) that Castles ‘is a member of the Lavoisier group’ in Australia, and that in this context he made a ‘misleading’ statement at the IPCC meeting in Amsterdam. Neither of these assertions is correct.

It is not correct to say (p. 189) that we ‘summarized [our] views’ in the article that appeared on 18 February in *The Economist*: the journal itself decided to prepare and publish the article in question. With our permission, they also posted our documents on their website.

Contrary to the impression conveyed by the Team (p.189, and in their closing paragraph on p. 210), we have not made ‘accusations of “non-response”’ on the part of the IPCC, nor have we suggested that, before accepting the editor’s invitation to respond to us, the SRES authors, or the IPCC itself, ought to have acted differently. We noted in the preface to our article (p.160) that in mid-December, when the invitation came to attend the meeting in Amsterdam in early January, ‘the IPCC had at that stage made no formal substantive response’ to the points we had raised; but this was simply a statement of fact, with no element of accusation or reproach.

In our respective presentations in Amsterdam, both of us formally thanked the IPCC and the organisers of the meeting for inviting us to participate and speak: these expressions of thanks are reproduced *verbatim* on pages 170 and 174 of our previous article, and we stand by them. Not surprisingly, however, the opportunity thus given

to us to make short presentations at the meeting, and the constructive discussions held alongside its formal proceedings, neither resolved the main differences nor exhausted the subject – as indeed is clear from the present article. That was why we decided to take our arguments further, by writing the two notes that make up Document 3 of our previous article, and to extend the debate, by giving a wider circulation to the whole set of documents. We do not see these actions as being (p. 189) ‘outside the normal spirit of dialogue’. They marked the second stage in a debate which, thanks to our participation in Amsterdam, had just been opened.

The conduct of public debate

There is still a question as to how such debates are best conducted. The IPCC process understandably places strong emphasis on peer-reviewed published research; and what we have written, both in this article and its predecessor, does not fall under that heading. As noted in the preface to our original article, the various texts it contains were prepared ‘at short notice, in response to immediate opportunities and concerns’. When we gave them wider circulation, we did not have in mind publication in a journal, and the editor’s invitation to publish them in *Energy and Environment* came as a pleasant surprise.

In deciding to make the texts public, after the Amsterdam meeting, timeliness was a consideration for us. We were conscious that the full IPCC Panel was due to meet in the third week of February, and we hoped that the issues we raised, once publicly aired, would find a place on the Panel’s agenda. This in fact happened, and we think it was a useful result.

Of course, there is a trade-off here. More deliberate preparation on our part, with more time allowed for comments and peer review, would have enabled us to put our collection of documents into better shape. In their response to us, the SRES Team have made points that we would like to have taken into account. But the various improvements we could have made would not have affected our argument fundamentally, or brought us into line with the views and approach of the Team. On some matters, such as the meaning and rationale of PPP adjustments, it now appears that the disagreement was wider than we had thought. In any case, and as the present

article makes clear, our main critique of the SRES, and of the IPCC process more broadly, still stands.

In our view, public debate on issues of policy cannot reasonably be confined, or even largely confined, to writings that have been accepted for publication in peer-reviewed journals and peer-reviewed summaries of such writings. One reason why this is so is the sheer lapse of time that is normally involved, between the emergence of an idea that deserves attention and its appearance in peer-reviewed print. Another consideration, which we have pointed to in our articles, is that any given circle of peer reviewers may be less inclusive, and more restricted in its knowledge, assumptions and beliefs, than its members realise – or, perhaps, are willing to admit. More fundamentally, it is an oversimplification to think of the task of policy-makers as being to translate the findings of ‘the research community’ into actual measures and programmes.

References

Commission of the European Communities (Eurostat), International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations and World Bank, 1993: *System of National Accounts 1993*, United Nations Statistical Division, New York.

Commission of the European Union, 1999: *European Union Energy Outlook to 2020: The Shared Analysis Project*, DG XII, November.

Criqui, P. and Kouvaritakis, N., 2000: 'World energy projections to 2030'. *International Journal of Global Energy Issues*, 14: 1-4: 116-36.

Dunkerley, Joy, ed. (1978). *International Comparisons of Energy Consumption*, Resources for the Future, Washington, D.C.

Gilbert, M. and Kravis, I., 1954: *An International Comparison of National Products and the Purchasing Power of Currencies*, Paris, Organisation for European Economic Cooperation.

Heston, A. and Lipsey, R. E., 1999: *International and Interarea Comparisons of Income, Output and Prices*, Chicago, Chicago University Press.

Hicks, J. R., 1940: 'The Valuation of the Social Income', *Economica*, Vol. VII, No. 2, reprinted in *Wealth and Welfare*, Volume 1 of the author's *Collected Essays in Economic Theory*, Oxford, Blackwell, 1981.

International Energy Agency (IEA), 1998: *World Energy Outlook 1998*. OECD/IEA, Paris

International Energy Agency (IEA), 2000: *World Energy Outlook 2000*. OECD/IEA, Paris

International Energy Agency (IEA), 2002a: *World Energy Outlook 2002*. OECD/IEA, Paris.

International Energy Agency (IEA), 2002b: *CO2 Emissions from Fossil Fuel Combustion 1971-2000*, 2002 Edition, IEA, Paris.

International Energy Agency (IEA), 2002e: *Energy Prices and Taxes*, 2nd. quarter, IEA Paris.

International Monetary Fund (IMF), 2002, *World Economic Outlook*, Washington, D. C.

Jefferson, M., 2000: 'Long-term energy scenarios: the approach of the World Energy Council'. *International Journal of Global Energy Issues*, 13: 1-3: 277-84.

Maddison, A., 2001: *The World Economy: A Millennial Perspective*. OECD Development Centre, Paris.

Nakicenovic, N., Grubler, A., and McDonald, A (eds), 1998: *Global Energy Perspectives*, Cambridge University Press.

United Nations Development Programme, 2002: *Human Development Report 2002*, Oxford University Press, New York.

United Nations Environment Programme, 2002: *Global Environment Outlook 3: Past, present and future perspectives*. Earthscan Publications, London.

United Nations Framework Convention on Climate Change (UNFCCC), 1999: 'UNFCCC Reporting Guidelines on National Communications', agreed at COP 5, Bonn, Document FCCC/CP/1999/7.

United Nations Statistical Commission, 2001: 'United Nations Development Programme Human Development Report: Report of the Friends of the Chair of the Statistical Commission', item 6(e) of the provisional agenda of the thirty-second session of the Statistical Commission, 6-9 March, New York, available at <<http://www.un.org/Depts/unsd/statcom/sc2001.htm>>

World Bank, 2003b: *World Development Indicators*. World Bank, Washington, D.C.

World Energy Council (WEC), 1993: *Energy for Tomorrow's World*, Kogan Page, St. Martin's Press, London.