Summary for Policymakers

Special Report on Emission Scenarios

A Special Report of Working Group III of the Intergovernmental Panel on Climate Change

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Why new Intergovernmental Panel on Climate Change scenarios?

The Intergovernmental Panel on Climate Change (IPCC) developed long-term emission scenarios in 1990 and 1992. These scenarios have been widely used in the analysis of possible climate change, its impacts, and options to mitigate climate change. In 1995, the IPCC 1992 scenarios were evaluated. The evaluation recommended that significant changes (since 1992) in the understanding of driving forces of emissions and methodologies should be addressed. These changes in understanding relate to, e.g., the carbon intensity of energy supply, the income gap between developed and developing countries, and to sulfur emissions. This led to a decision by the IPCC Plenary in 1996 to develop a new set of scenarios. The new set of scenarios is presented in this report.

What are scenarios and what is their purpose?

Future greenhouse gas (GHG) emissions are the product of very complex dynamic systems, determined by driving forces such as demographic development, socio-economic development, and technological change. Their future evolution is highly uncertain. Scenarios are alternative images of how the future might unfold and are an appropriate tool with which to analyze how driving forces may influence future emission outcomes and to assess the associated uncertainties. They assist in climate change analysis, including climate modeling and the assessment of impacts, adaptation, and mitigation. The possibility that any single emissions path will occur as described in scenarios is highly uncertain.

What are the main characteristics of the new scenarios?

A set of scenarios was developed to represent the range of driving forces and emissions in the scenario literature so as to reflect current understanding and knowledge about underlying uncertainties. They exclude only outlying "surprise" or "disaster" scenarios in the literature. Any scenario necessarily includes subjective elements and is open to various interpretations. Preferences for the scenarios presented here vary among users. No judgment is offered in this report as to the preference for any of the scenarios and they are not assigned probabilities of occurrence, neither must they be interpreted as policy recommendations.

The scenarios are based on an extensive assessment of driving forces and emissions in the scenario literature, alternative modeling approaches, and an "open process"[1] *that solicited wide participation and feedback.* These are all-important elements of the Terms of Reference (see Appendix I).

Four different narrative storylines were developed to describe consistently the relationships between emission driving forces and their evolution and add context for the scenario quantification. Each storyline represents different demographic, social, economic, technological, and environmental developments, which may be viewed positively by some people and negatively by others.

The scenarios cover a wide range of the main demographic, economic, and technological driving forces of GHG and sulfur emissions[2] *and are representative of the literature.* Each scenario represents a specific quantitative interpretation of one of four storylines. All the scenarios based on the same storyline constitute a scenario "family".

As required by the Terms of Reference, the scenarios in this report do not include additional climate initiatives, which means that no scenarios are included that explicitly assume implementation of the United Nations Framework Convention for Climate Change (UNFCCC) or the emissions targets of the Kyoto Protocol. However, GHG emissions are directly affected by non-climate change policies designed for a wide range of other purposes. Furthermore government policies can, to varying degrees, influence the GHG emission drivers such as demographic change, social and economic development, technological change, resource use, and pollution management. This influence is broadly reflected in the storylines and resultant scenarios.

For each storyline several different scenarios were developed using different modeling approaches to examine the range of outcomes arising from a range of models that use similar assumptions about driving forces. Six models were used which are representative of integrated assessment frameworks in the literature. One advantage of a multi-model approach is that the resultant 40 SRES scenarios together encompass the current range of uncertainties of future GHG emissions arising from different characteristics of these models, in addition to the current knowledge of and uncertainties that arise from scenario driving forces such as demographic, social and economic, and broad technological developments that drive the models, as described in the storylines. Thirteen of these 40 scenarios explore variations in energy technology assumptions.

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[1] The open process defined in the Special Report on Emissions Scenarios (SRES) Terms of Reference calls for the use of multiple models, seeking inputs from a wide community as well as making scenario results widely available for comments and review. These objectives were fulfilled by the SRES multi-model approach and the open SRES website.

[2] Included are anthropogenic emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), hydrochlorofluorocarbons (HCFCs), chlorofluorocarbons (CFCs), the aerosol precursor and the chemically active gases sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen oxides (NO_x), and non-methane volatile organic compounds (NMVOCs). Emissions are provided aggregated into four world regions and global totals. In the new scenarios no feedback effect of future climate change on emissions from biosphere and energy has been assumed.

Box SPM-1: The Main Characteristics of the Four SRES Storylines and Scenario Families.

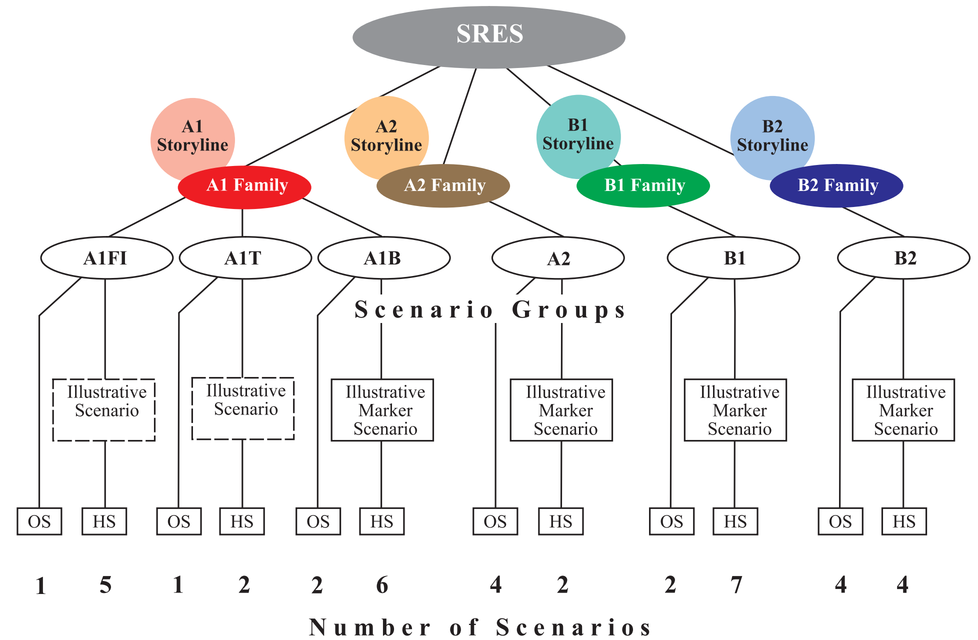

Figure SPM-1: Schematic illustration of SRES scenarios. Four qualitative storylines yield four sets of scenarios called "families": A1, A2, B1, and B2. Altogether 40 SRES scenarios have been developed by six modeling teams. All are equally valid with no assigned probabilities of occurrence. The set of scenarios consists of six scenario groups drawn from the four families: one group each in A2, B1, B2, and three groups within the A1 family, characterizing alternative developments of energy technologies: A1FI (fossil fuel intensive), A1B (balanced), and A1T (predominantly non-fossil fuel). Within each family and group of scenarios, some share "harmonized" assumptions on global population, gross world product, and final energy. These are marked as "HS" for harmonized scenarios. "OS" denotes scenarios that explore uncertainties in driving forces beyond those of the harmonized scenarios. The number of scenarios developed within each category is shown. For each of the six scenario groups an illustrative scenario (which is always harmonized) is provided. Four illustrative marker scenarios, one for each scenario family, were used in draft form in the 1998 SRES open process and are included in revised form in this report. Two additional illustrative scenarios for the groups A1FI and A1T are also provided and complete a set of six that illustrate all scenario groups. All are equally sound.

By 2100 the world will have changed in ways that are difficult to imagine – as difficult as it would have been at the end of the 19th century to imagine the changes of the 100 years since. Each storyline assumes a distinctly different direction for future developments, such that the four storylines differ in increasingly irreversible ways. Together they describe divergent futures that encompass a significant portion of the underlying uncertainties in the main driving forces. They cover a wide range of key "future" characteristics such as demographic change, economic development, and technological change. For this reason, their plausibility or feasibility should not be considered solely on the basis of an extrapolation of *current* economic, technological, and social trends.

- The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B)[3].

[3] Balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies.

- The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines.
- The B1 storyline and scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.
- The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

Within each scenario family two main types of scenarios were developed – those with harmonized assumptions about global population, economic growth, and final energy use and those with alternative quantification of the storyline. Together, 26 scenarios were harmonized by adopting common assumptions on global population and gross domestic product (GDP) development. Thus, the harmonized scenarios in each family are not independent of each other. The remaining 14 scenarios adopted alternative interpretations of the four scenario storylines to explore additional scenario uncertainties beyond differences in methodologic approaches. They are also related to each other within each family, even though they do not share common assumptions about some of the driving forces.

There are six scenario groups that should be considered equally sound that span a wide range of uncertainty, as required by the Terms of Reference. These encompass four combinations of demographic change, social and economic development, and broad technological developments, corresponding to the four families (A1, A2, B1, B2), each with an illustrative "marker" scenario. Two of the scenario groups of the A1 family (A1FI, A1T) explicitly explore alternative energy technology developments, holding the other driving forces constant, each with an illustrative scenario. Rapid growth leads to high capital turnover rates, which means that early small differences among scenarios can lead to a large divergence by 2100. Therefore the A1 family, which has the highest rates of technological change and economic development, was selected to show this effect.

In accordance with a decision of the IPCC Bureau in 1998 to release draft scenarios to climate modelers for their input in the Third Assessment Report, and subsequently to solicit comments during the open process, one marker scenario was chosen from each of four of the scenario groups based on the storylines. The choice of the markers was based on which of the initial quantifications best reflected the storyline, and features of specific models. Marker scenarios are no more or less likely than any other scenarios, but are considered by the SRES writing team as illustrative of a particular storyline. These scenarios have received the closest scrutiny of the entire writing team and via the SRES open process. Scenarios have also been selected to illustrate the other two scenario groups. Hence, this report has an illustrative scenario for each of the six scenario groups.

What are the main driving forces of the GHG emissions in the scenarios?

This Report reinforces our understanding that the main driving forces of future greenhouse gas trajectories will continue to be demographic change, social and economic development, and the rate and direction of technological change. This finding is consistent with the IPCC 1990, 1992 and 1995 scenario reports. Table SPM-1 (see later) summarizes the demographic, social, and economic driving forces across the scenarios in 2020, 2050, and 2100[4]. The intermediate energy result (shown in table SPM 2, see later) and land use results[5] reflect the influences of driving forces.

Recent global population projections are generally lower than those in the IS92 scenarios. Three different population trajectories that correspond to socio-economic developments in the storylines were chosen from recently published projections. The A1 and B1 scenario families are based on the low International Institute for Applied Systems Analysis (IIASA) 1996 projection. They share the lowest trajectory, increasing to 8.7 billion by 2050 and declining toward 7 billion by 2100, which combines low fertility with low mortality. The B2 scenario family is based on the long-term UN Medium 1998 population projection of 10.4 billion by 2100. The A2 scenario family is based on a high population growth scenario of 15 billion by 2100 that assumes a significant decline in fertility for most regions and stabilization at above replacement levels. It falls below the long-term 1998 UN High projection of 18 billion.

[4] Technological change is not quantified in table SPM-1.

[5] Because of the impossibility of including the complex way land use is changing between the various land use types, this information is not in the table.

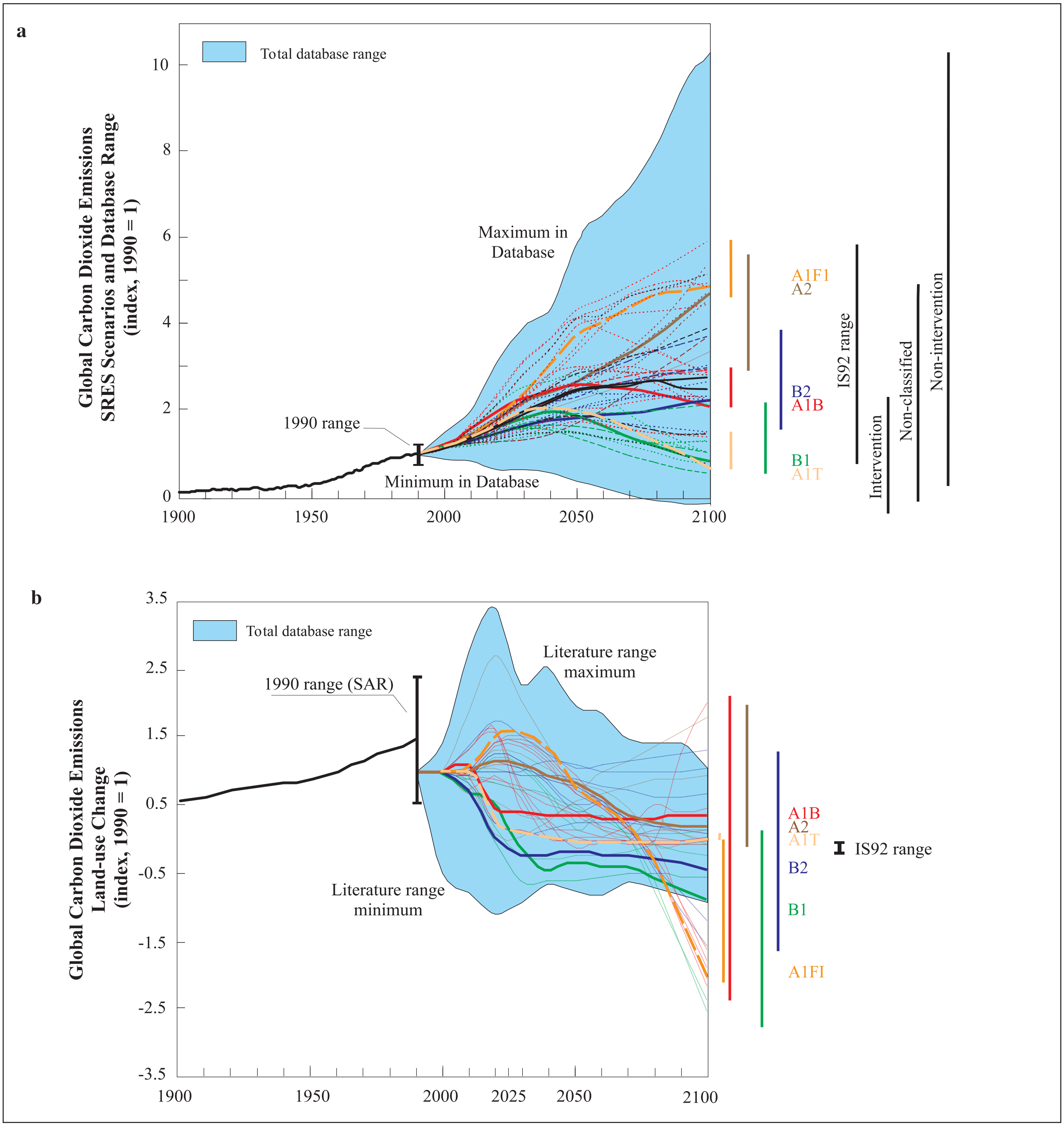

Figure SPM-2: Global CO_2 emissions related to energy and industry (Figure SPM-2a) and land-use changes (Figure SPM-2b) from 1900 to 1990, and for the 40 SRES scenarios from 1990 to 2100, shown as an index (1990 = 1). The dashed time-paths depict individual SRES scenarios and the area shaded in blue the range of scenarios from the literature as documented in the SRES database. The scenarios are classified into six scenario groups drawn from the four scenario families. Six illustrative scenarios are highlighted. The colored vertical bars indicate the range of emissions in 2100. The four black bars on the right of Figure SPM-1a indicate the emission ranges in 2100 for the IS92 scenarios and three ranges of scenarios from the literature, documented in the SRES database. These three ranges indicate those scenarios that include some additional climate initiatives (designated as "intervention" scenarios), those that do not ("non-intervention"), and those that cannot be assigned to either category ("non-classified"). This classification is based on a subjective evaluation of the scenarios in the database and was possible only for energy and industry CO_2 emissions. SAR, Second Assessment Report.

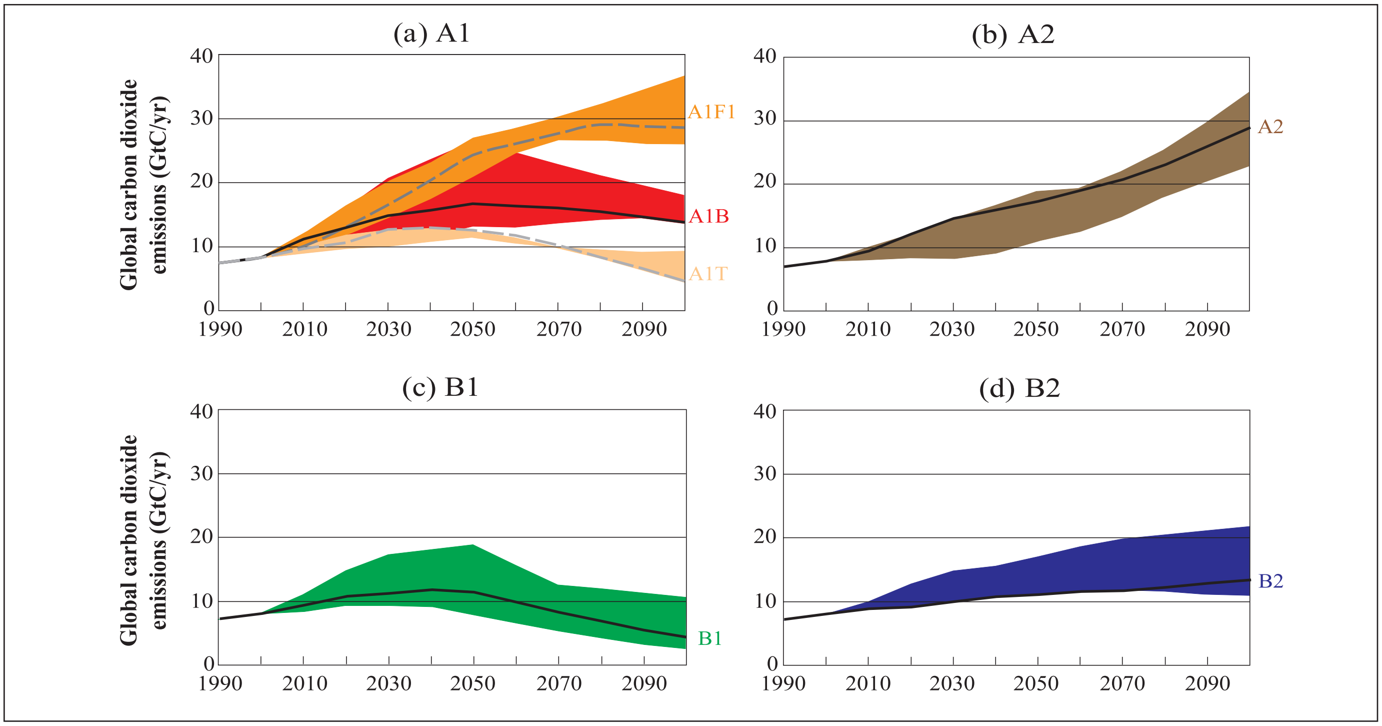

Figure SPM-3: Total global annual CO_2 emissions from all sources (energy, industry, and land-use change) from 1990 to 2100 (in gigatonnes of carbon (GtC/yr) for the families and six scenario groups. The 40 SRES scenarios are presented by the four families (A1, A2, B1, and B2) and six scenario groups: the fossil-intensive A1FI (comprising the high-coal and high-oil-and-gas scenarios), the predominantly non-fossil fuel A1T, the balanced A1B in Figure SPM-3a; A2 in Figure SPM-3b; B1 in Figure SPM-3c, and B2 in Figure SPM-3d. Each colored emission band shows the range of harmonized and non-harmonized scenarios within each group. For each of the six scenario groups an illustrative scenario is provided, including the four illustrative marker scenarios (A1, A2, B1, B2, solid lines) and two illustrative scenarios for A1FI and A1T (dashed lines).

All scenarios describe futures that are generally more affluent than today. The scenarios span a wide range of future levels of economic activity, with gross world product rising to 10 times today's values by 2100 in the lowest to 26-fold in the highest scenarios.

A narrowing of income differences among world regions is assumed in many of the SRES scenarios. Two of the scenario families, A1 and B1, explicitly explore alternative pathways that gradually close existing income gaps in relative terms.

Technology is at least as important a driving force as demographic change and economic development. These driving forces are related. Within the A1 scenario family, scenarios with common demographic and socio-economic driving forces but different assumptions about technology and resource dynamics illustrate the possibility of very divergent paths for developments in the energy system and land-use patterns.

The SRES scenarios cover a wider range of energy structures than the IS92 scenarios. This reflects uncertainties about future fossil resources and technological change. The scenarios cover virtually all the possible directions of change, from high shares of fossil fuels, oil and gas or coal, to high shares of non-fossils.

In most scenarios, global forest area continues to decrease for some decades, primarily because of increasing population and income growth. This current trend is eventually reversed in most scenarios with the greatest eventual increase in forest area by 2100 in the B1 and B2 scenario families, as compared to 1990. Associated changes in agricultural land use are driven principally by changing food demands caused by demographic and dietary shifts. Numerous other social, economic, institutional, and technological factors also affect the relative shares of agricultural lands, forests, and other types of land use. Different analytic methods lead to very different results, indicating that future land use change in the scenarios is very model specific.

All the above driving forces not only influence CO_2 emissions, but also the emissions of other GHGs. The relationships between the driving forces and non-CO_2 GHG emissions are generally more complex and less studied, and the models used for the scenarios less sophisticated. Hence, the uncertainties in the SRES emissions for non-CO_2 greenhouse gases are generally greater than those for energy CO_2[6].

[6] Therefore, the ranges of non-CO_2 GHG emissions provided in the Report may not fully reflect the level of uncertainty compared to CO_2, for example only a single model provided the sole value for halocarbon emissions.

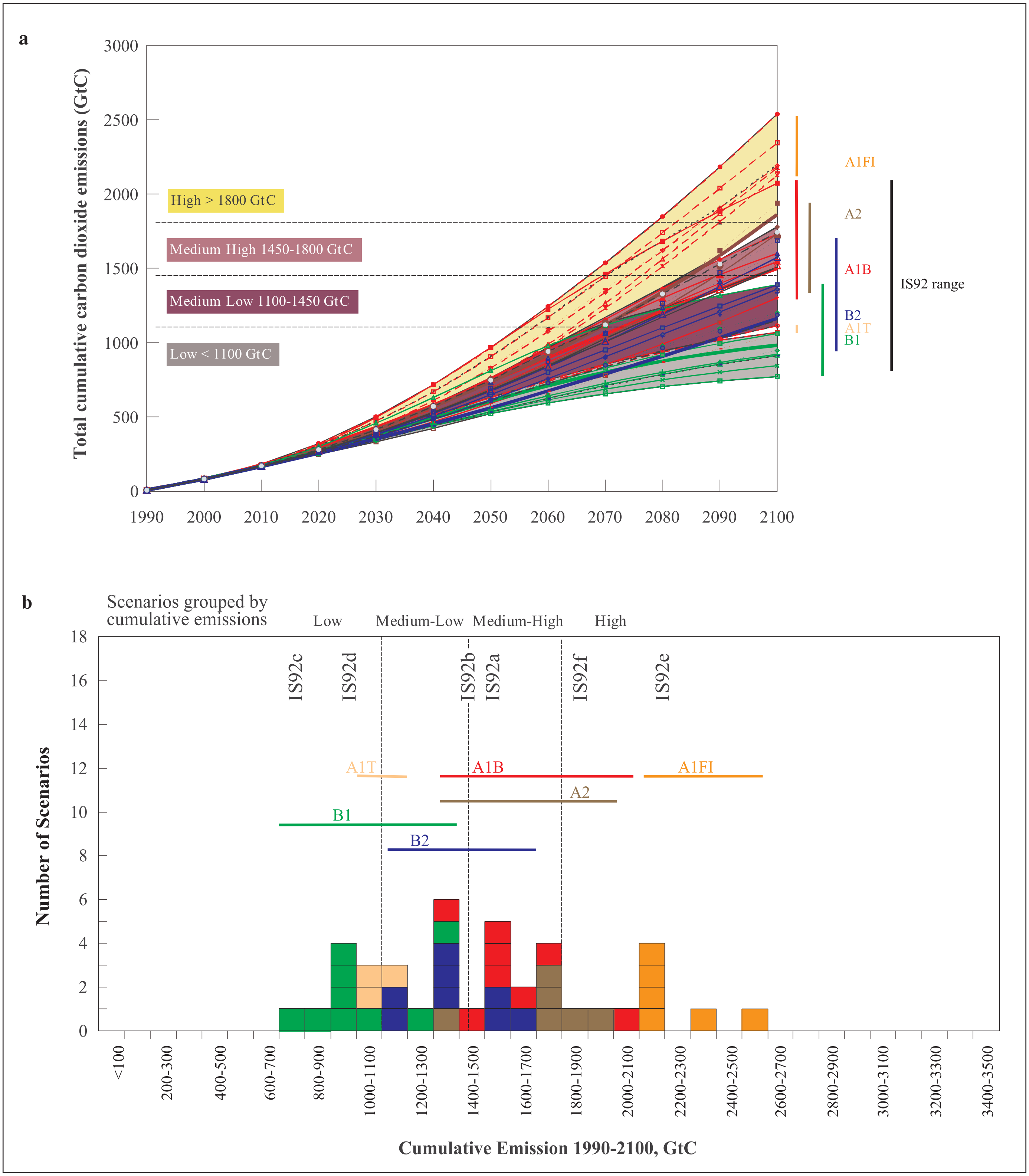

Figure SPM-4: Total global cumulative CO_2 emissions (GtC) from 1990 to 2100 (SPM-4a) and histogram of their distribution by scenario groups (SPM-4b). No probability of occurrence should be inferred from the distribution of SRES scenarios or those in the literature. Both figures show the ranges of cumulative emissions for the 40 SRES scenarios. Scenarios are also grouped into four cumulative emissions categories: low, medium–low, medium–high, and high emissions. Each category contains one illustrative marker scenario plus alternatives that lead to comparable cumulative emissions, although often through different driving forces. This categorization can guide comparisons using either scenarios with different driving forces yet similar emissions, or scenarios with similar driving forces but different emissions. The cumulative emissions of the IS92 scenarios are also shown.

What is the range of GHG emissions in the SRES scenarios and how do they relate to driving forces?

The SRES scenarios cover most of the range of carbon dioxide (CO_2; see Figures SPM-2a and SPM-2b), other GHGs, and sulfur emissions found in the recent literature and SRES scenario database. Their spread is similar to that of the IS92 scenarios for CO_2 emissions from energy and industry as well as total emissions but represents a much wider range for land-use change. The six scenario groups cover wide and overlapping emission ranges. The range of GHG emissions in the scenarios widens over time to capture the long-term uncertainties reflected in the literature for many of the driving forces, and after 2050 widens significantly as a result of different socio-economic developments. Table SPM-2b summarizes the emissions across the scenarios in 2020, 2050, and 2100. Figure SPM-3 shows in greater detail the ranges of total CO_2 emissions for the six scenario groups of scenarios that constitute the four families (the three scenario families A2, B1, and B2, plus three groups within the A1 family A1FI, A1T, and A1B).

Some SRES scenarios show trend reversals, turning points (i.e., initial emission increases followed by decreases), and crossovers (i.e., initially emissions are higher in one scenario, but later emissions are higher in another scenario). Emission trend reversals (see Figures SPM-2 and SPM-3) depart from historical emission increases. In most of these cases, the upward emissions trend due to income growth is more than compensated by productivity improvements combined with a slowly growing or declining population.

In many SRES scenarios CO_2 emissions from loss of forest cover peak after several decades and then gradually decline[7] *(Figure SPM-1b).* This pattern is consistent with scenarios in the literature and can be associated with slowing population growth, followed by a decline in some scenarios, increasing agricultural productivity, and increasing scarcity of forest land. These factors allow for a reversal of the current trend of loss of forest cover in many cases. Emissions decline fastest in the B1 family. Only in the A2 family do net anthropogenic CO_2 emissions from land use change[2] remain positive through 2100. As was the case for energy-related emissions, CO_2 emissions related to land-use change in the A1 family cover the widest range. The diversity across these scenarios is amplified through the high economic growth, increasing the range of alternatives, and through the different modeling approaches and their treatment of technology.

Total cumulative SRES carbon emissions from all sources through 2100 range from approximately 770 GtC to approximately 2540 GtC. According to the IPCC Second Assessment Report (SAR), "any eventual stabilised concentration is governed more by the accumulated anthropogenic CO_2 emissions from now until the time of stabilisation than by the way emissions change over the period." Therefore, the scenarios are also grouped in the report according to their cumulative emissions.[8] (see Figure SPM-4). The SRES scenarios extend the IS92 range toward higher emissions (SRES maximum of 2538 GtC compared to 2140 GtC for IS92), but not toward lower emissions. The lower bound for both scenario sets is approximately 770 GtC.

Total anthropogenic methane (CH_4) and nitrous oxide (N_2O) emissions span a wide range by the end of the 21[st] century (see Figures SPM-5 and SPM-6 derived from Figures 5.5 and 5.7). Emissions of these gases in a number of scenarios begin to decline by 2050. The range of emissions is wider than in the IS92 scenarios due to the multimodel approach, which leads to a better treatment of uncertainties and to a wide range of driving forces. These totals include emissions from land use, energy systems, industry, and waste management.

Methane and nitrous oxide emissions from land use are limited in A1 and B1 families by slower population growth followed by a decline, and increased agricultural productivity. After the initial increases, emissions related to land use peak and decline. In the B2 family, emissions continue to grow, albeit very slowly. In the A2 family, both high population growth and less rapid increases in agricultural productivity result in a continuous rapid growth in those emissions related to land use.

The range of emissions of HFCs in the SRES scenario is generally lower than in earlier IPCC scenarios. Because of new insights about the availability of alternatives to HFCs as replacements for substances controlled by the Montreal Protocol, initially HFC emissions are generally lower than in previous IPCC scenarios. In the A2 and B2 scenario families HFC emissions increase rapidly in the second half of the this century, while in the A2 and B2 scenario families the growth of emissions is significantly slowed down or reversed in that period.

Sulfur emissions in the SRES scenarios are generally below the IS92 range, because of structural changes in the energy system as well as concerns about local and regional air pollution. These reflect sulfur control legislation in Europe, North America, Japan, and (more recently) other parts of Asia and other developing regions. The timing and impact of these changes and controls vary across scenarios and regions[9]. After

[7] In the new scenarios no feedback effect of future climate change on emissions from the biosphere has been assumed.

[8] In this Report, cumulative emissions are calculated by adding annual net anthropogenic emissions in the scenarios over their time horizon. When relating these cumulative emissions to atmospheric concentrations, all natural processes that affect carbon concentrations in the atmosphere have to be taken into account.

[9] Although global emissions of SO_2 for the SRES scenarios are lower than the IS92 scenarios, uncertainty about SO_2 emissions and their effect on sulfate aerosols has increased compared to the IS92 scenarios because of very diverse regional patterns of SO_2 emissions in the scenarios.

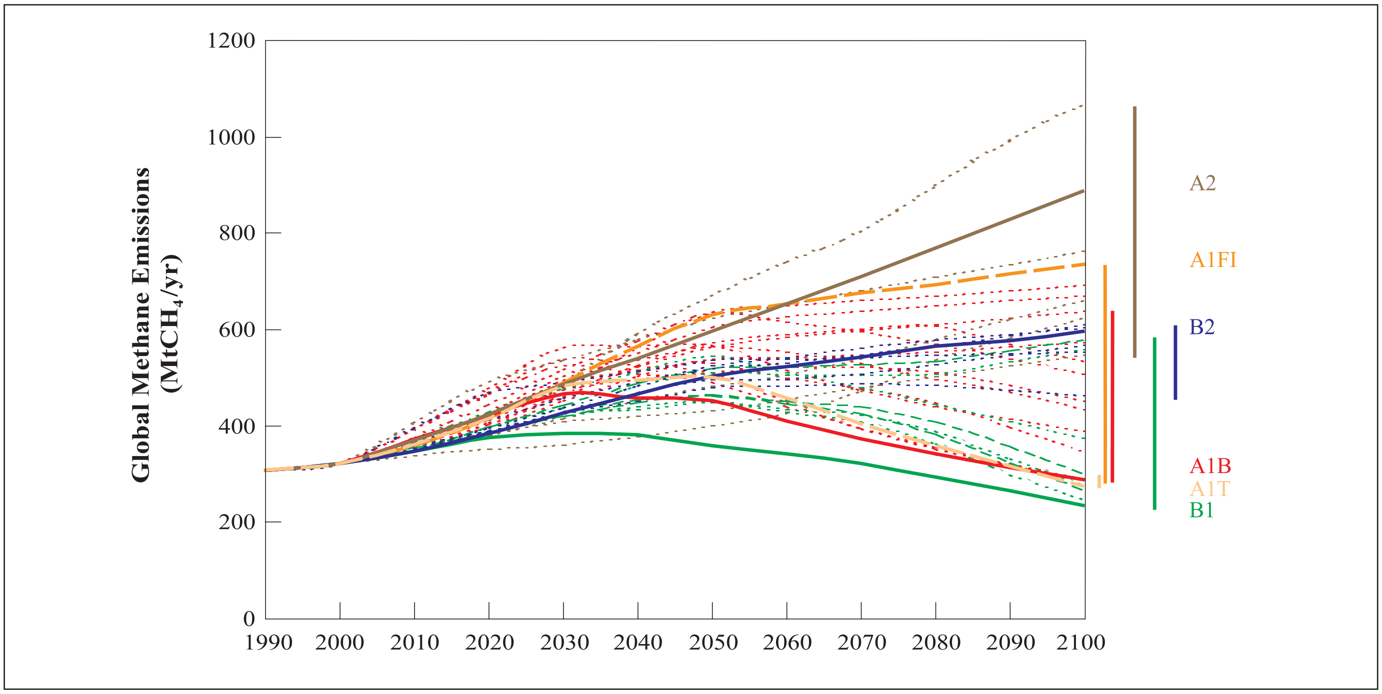

Figure SPM-5: Standardized (to common 1990 and 2000 values) global annual methane emissions for the SRES scenarios (in $MtCH_4$/yr). The range of emissions by 2100 for the six scenario groups is indicated to the right. Illustrative (including marker) scenarios are highlighted.

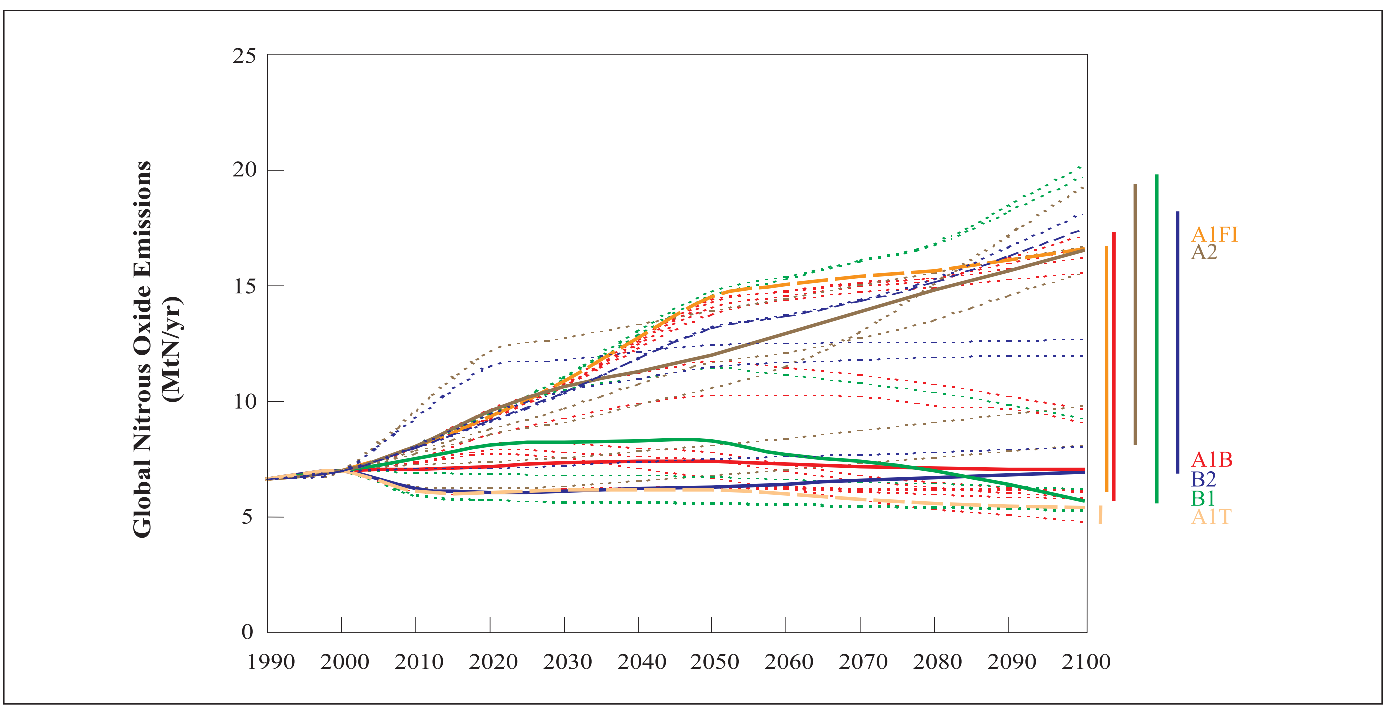

Figure SPM-6: Standardized (to common 1990 and 2000 values) global annual nitrous oxides emissions for the SRES scenarios (in MtN/yr). The range of emissions by 2100 for the six scenario groups is indicated to the right. Illustrative (marker) scenarios are highlighted.

initial increases over the next two to three decades, global sulfur emissions in the SRES scenarios decrease (see Table SPM-1b), consistent with the findings of the 1995 IPCC scenario evaluation and recent peer-reviewed literature.

Similar future GHG emissions can result from very different socio-economic developments, and similar developments of driving forces can result in different future emissions. Uncertainties in the future developments of key emission driving forces create large uncertainties in future emissions, even within the same socio-economic development paths. Therefore, emissions from each scenario family overlap substantially with emissions from other scenario families. The overlap implies that a given level of future emissions can arise from very different combinations of driving forces. Figures SPM-1, SPM-2, and SPM-3 show this for CO_2.

Convergence of regional per capita incomes can lead to either high or low GHG emissions. Tables SPM-1a and SPM-1b indicate that there are scenarios with high per capita incomes in all regions that lead to high CO_2 emissions (e.g., in the high-growth, fossil fuel intensive scenario group A1FI). They also indicate that there are scenarios with high per capita incomes that lead to low emissions (e.g., the A1T scenario group or the B1 scenario family). This suggests that in some cases other driving forces may have a greater influence on GHG emissions than income growth.

How can the SRES scenarios be used?

It is recommended that a range of SRES scenarios with a variety of assumptions regarding driving forces be used in any analysis. Thus more than one family should be used in most analyses. The six scenario groups – the three scenario families A2, B1, and B2, plus three groups within the A1 scenario family, A1B, A1FI, and A1T – and four cumulative emissions categories were developed as the smallest subsets of SRES scenarios that capture the range of uncertainties associated with driving forces and emissions.

The important uncertainties ranging from driving forces to emissions may be different in different applications – for example climate modeling; assessment of impacts, vulnerability, mitigation, and adaptation options; and policy analysis. Climate modelers may want to cover the range reflected by the cumulative emissions categories. To assess the robustness of options in terms of impacts, vulnerability, and adaptation may require scenarios with similar emissions but different socio-economic characteristics, as reflected by the six scenario groups. For mitigation analysis, variation in both emissions and socio-economic characteristics may be necessary. For analysis at the national or regional scale, the most appropriate scenarios may be those that best reflect specific circumstances and perspectives.

There is no single most likely, "central", or "best-guess" scenario, either with respect to SRES scenarios or to the underlying scenario literature. Probabilities or likelihood are not assigned to individual SRES scenarios. None of the SRES scenarios represents an estimate of a central tendency for all driving forces or emissions, such as the mean or median, and none should be interpreted as such. The distribution of the scenarios provides a useful context for understanding the relative position of a scenario but does not represent the likelihood of its occurrence.

The driving forces and emissions of each SRES scenario should be used together. To avoid internal inconsistencies, components of SRES scenarios should not be mixed. For example, the GHG emissions from one scenario and the SO_2 emissions from another scenario, or the population from one and economic development path from another, should not be combined.

While recognizing the inherent uncertainties in long-term projections[10]*, the SRES scenarios may provide policymakers with a long-term context for near-term analysis*. The modeling tools that have been used to develop these scenarios that focus on the century time scale are less suitable for analysis of near term (a decade or less) developments. When analyzing mitigation and adaptation options, the user should be aware that although no additional climate initiatives are included in the SRES scenarios, various changes have been assumed to occur that would require other interventions, such as those leading to reductions in sulfur emissions and significant penetration of new energy technologies.

What future work on emissions scenarios would be useful?

- Establishment of a program for on-going evaluations and comparisons of long-term emission scenarios, including a regularly updated scenario database;
- Capacity building, particularly in developing countries, in the area of modeling tools and emissions scenarios;
- Multiple storyline, multi-model approaches in future scenario analyses;
- New research activities to assess future developments in key GHG driving forces in greater regional, subregional, and sectoral detail which allow for a clearer link between emissions scenarios and mitigation options;
- Improved specification and data for, and integration of, the non-CO_2 GHG and non-energy sectors, such as land use, land-use change and forestry, in models, as well as model inter-comparison to improve scenarios and analyses;
- Integration into models emissions of particulate, hydrogen, or nitrate aerosol precursors, and processes,

[10] Confidence in the quantification of any scenario decreases substantially as the time horizon increases because the basis for the assumptions becomes increasingly speculative. This is why a set of scenarios was developed.

such as feedback of climate change on emissions, that may significantly influence scenario results and analyses;
- Development of additional gridded emissions for scenarios which would facilitate improved regional assessment;
- Assessment of strategies that would address multiple national, regional, or global priorities;
- Development of methods for scientifically sound aggregation of emissions data;
- More detailed information on assumptions, inputs, and the results of the 40 SRES scenarios should be made available at a web site and on a CD-ROM. Regular maintenance of the SRES web site is needed;
- Extension of the SRES web site and production of a CD-ROM to provide, if appropriate, time-dependent geographic distributions of driving forces and emissions, and concentrations of GHGs and sulfate aerosols.
- Development of a classification scheme for classifying scenarios as intervention or non-intervention scenarios.

***Table SPM-1a**: Overview of main primary driving forces in 1990, 2020, 2050, and 2100. Bold numbers show the value for the illustrative scenario and the numbers between brackets show the value for the range[a] across all 40 SRES scenarios in the six scenario groups that constitute the four families. Units are given in the table. Technological change is not quantified in the table.*

Family			**A1**		**A2**	**B1**	**B2**
Scenario group	**1990**	**A1FI**	**A1B**	**A1T**	**A2**	**B1**	**B2**
Population (billion)	5.3						
2020		**7.6** (7.4-7.6)	**7.5** (7.2-7.6)	**7.6** (7.4-7.6)	**8.2** (7.5-8.2)	**7.6** (7.4-7.6)	**7.6** (7.6-7.8)
2050		**8.7**	**8.7** (8.3-8.7)	**8.7**	**11.3** (9.7-11.3)	**8.7** (8.6-8.7)	**9.3** (9.3-9.8)
2100		**7.1** (7.0-7.1)	**7.1** (7.0-7.7)	**7.0**	**15.1** (12.0-15.1)	**7.0** (6.9-7.1)	**10.4** (10.3-10.4)
World GDP (10^{12} 1990US$/yr)	21						
2020		**53** (53-57)	**56** (48-61)	**57** (52-57)	**41** (38-45)	**53** (46-57)	**51** (41-51)
2050		**164** (163-187)	**181** (120-181)	**187** (177-187)	**82** (59-111)	**136** (110-166)	**110** (76-111)
2100		**525** (522-550)	**529** (340-536)	**550** (519-550)	**243** (197-249)	**328** (328-350)	**235** (199-255)
Per capita income ratio: developed countries and economies in transition (Annex-I) to developing countries (Non-Annex-I)	16.1						
2020		**7.5** (6.2-7.5)	**6.4** (5.2-9.2)	**6.2** (5.7-6.4)	**9.4** (9.0-12.3)	**8.4** (5.3-10.7)	**7.7** (7.5-12.1)
2050		**2.8**	**2.8** (2.4-4.0)	**2.8** (2.4-2.8)	**6.6** (5.2-8.2)	**3.6** (2.7-4.9)	**4.0** (3.7-7.5)
2100		**1.5** (1.5-1.6)	**1.6** (1.5-1.7)	**1.6** (1.6-1.7)	**4.2** (2.7-6.3)	**1.8** (1.4-1.9)	**3.0** (2.0-3.6)

[a] For some driving forces, no range is indicated because all scenario runs have adopted exactly the same assumptions.

Table SPM-1b: *Overview of main primary driving forces in 1990, 2020, 2050, and 2100. Bold numbers show the value for the illustrative scenario and the numbers between brackets show the value for the range*[a] *across 26 harmonized SRES scenarios in the six scenario groups that constitute the four families. Units are given in the table. Technological change is not quantified in the table.*

Family			**A1**		**A2**	**B1**	**B2**
Scenario group	**1990**	**A1FI**	**A1B**	**A1T**	**A2**	**B1**	**B2**
Population (billion)	5.3						
2020		**7.6** (7.4-7.6)	**7.4** (7.4-7.6)	**7.6** (7.4-7.6)	**8.2**	**7.6** (7.4-7.6)	**7.6**
2050		**8.7**	**8.7**	**8.7**	**11.3**	**8.7** (8.6-8.7)	**9.3**
2100		**7.1** (7.0-7.1)	**7.1** (7.0-7.1)	**7.0**	**15.1**	**7.0** (6.9-7.1)	**10.4**
World GDP (10^{12} 1990US$/yr)	21						
2020		**53** (53-57)	**56** (52-61)	**57** (56-57)	**41**	**53** (51-57)	**51** (48-51)
2050		**164** (164-187)	**181** (164-181)	**187** (182-187)	**82**	**136** (134-166)	**110** (108-111)
2100		**525** (525-550)	**529** (529-536)	**550** (529-550)	**243**	**328** (328-350)	**235** (232-237)
Per capita income ratio: developed countries and economies in transition (Annex-I) to developing countries (Non-Annex-I)	16.1						
2020		**7.5** (6.2-7.5)	**6.4** (5.2-7.5)	**6.2** (6.2-6.4)	**9**.4 (9.4-9.5)	**8.4** (5.3-8.4)	**7.7** (7.5-8.0)
2050		**2.8**	**2.8** (2.4-2.8)	**2.8**	**6.6**	**3.6** (2.7-3.9)	**4.0** (3.8-4.6)
2100		**1.5** (1.5-1.6)	**1.6** (1.5-1.7)	**1.6**	**4.2**	**1.8** (1.6-1.9)	**3.0** (3.0-3.5)

[a] For some driving forces, no range is indicated because all scenario runs have adopted exactly the same assumptions.

***Table SPM-2a**: Overview of main secondary scenario driving forces in 1990, 2020, 2050, and 2100. Bold numbers show the value for the illustrative scenario and the numbers between brackets show the value for the range across all 40 SRES scenarios in the six scenario groups that constitute the four families. Units are given in the table.*

Family		**A1**			**A2**	**B1**	**B2**
Scenario group	**1990**	**A1FI**	**A1B**	**A1T**	**A2**	**B1**	**B2**
Final energy intensity (10^6J/US$)[a]	16.7						
2020		**9.4** (8.5-9.4)	**9.4** (8.1-12.0)	**8.7** (7.6-8.7)	**12.1** (9.3-12.4)	**8.8** (6.7-11.6)	**8.5** (8.5-11.8)
2050		**6.3** (5.4-6.3)	**5.5** (4.4-7.2)	**4.8** (4.2-4.8)	**9.5** (7.0-9.5)	**4.5** (3.5-6.0)	**6.0** (6.0-8.1)
2100		**3.0** (2.6-3.2)	**3.3** (1.6-3.3)	**2.3** (1.8-2.3)	**5.9** (4.4-7.3)	**1.4** (1.4-2.7)	**4.0** (3.7-4.6)
Primary energy (10^{18} J/yr)[a]	351						
2020		**669** (653-752)	**711** (573-875)	**649** (515-649)	**595** (485-677)	**606** (438-774)	**566** (506-633)
2050		**1431** (1377-1601)	**1347** (968-1611)	**1213** (913-1213)	**971** (679-1059)	**813** (642-1090)	**869** (679-966)
2100		**2073** (1988-2737)	**2226** (1002-2683)	**2021** (1255-2021)	**1717** (1304-2040)	**514** (514-1157)	**1357** (846-1625)
Share of coal in primary energy (%)[a]	24						
2020		**29** (24-42)	**23** (8-28)	**23** (8-23)	**22** (18-34)	**22** (8-27)	**17** (14-31)
2050		**33** (13-56)	**14** (3-42)	**10** (2-13)	**30** (24-47)	**21** (2-37)	**10** (10-49)
2100		**29** (3-48)	**4** (4-41)	**1** (1-3)	**53** (17-53)	**8** (0-22)	**22** (12-53)
Share of zero carbon in primary energy (%)[a]	18						
2020		**15** (10-20)	**16** (9-26)	**21** (15-22)	**8** (8-16)	**21** (7-22)	**18** (7-18)
2050		**19** (16-31)	**36** (21-40)	**43** (39-43)	**18** (14-29)	**30** (18-40)	**30** (15-30)
2100		**31** (30-47)	**65** (27-75)	**85** (64-85)	**28** (26-37)	**52** (33-70)	**49** (22-49)

[a] 1990 values include non-commercial energy consistent with IPCC WGII SAR (Energy Primer) but with SRES accounting conventions. Note that ASF, MiniCAM, and IMAGE scenarios do not consider non-commercial renewable energy. Hence, these scenarios report lower energy use.

Table SPM-2b*: Overview of main secondary scenario driving forces in 1990, 2020, 2050, and 2100. Bold numbers show the value for the illustrative scenario and the numbers between brackets show the value for the range across 26 harmonized SRES scenarios in the six scenario groups that constitute the four families. Units are given in the table.*

Family		**A1**			**A2**	**B1**	**B2**
Scenario group	**1990**	**A1FI**	**A1B**	**A1T**	**A2**	**B1**	**B2**
Final energy intensity (10^6J/US$)[a]	16.7						
2020		**9.4** (8.5-9.4)	**9.4** (8.7-12.0)	**8.7** (7.6-8.7)	**12.1** (11.3-12.1)	**8.8** (6.7-11.6)	**8.5** (8.5-9.1)
2050		**6.3** (5.4-6.3)	**5.5** (5.0-7.2)	**4.8** (4.3-4.8)	**9.5** (9.2-9.5)	**4.5** (3.5-6.0)	**6.0** (6.0-6.6)
2100		**3.0** (3.0-3.2)	**3.3** (2.7-3.3)	**2.3**	**5.9** (5.5-5.9)	**1.4** (1.4-2.1)	**4.0** (3.9-4.1)
Primary energy (10^{18} J/yr)[a]	351						
2020		**669** (657-752)	**711** (589-875)	**649** (611-649)	**595** (595-610)	**606** (451-774)	**566** (519-590)
2050		**1431** (1377-1601)	**1347** (1113-1611)	**1213** (1086-1213)	**971** (971-1014)	**813** (642-1090)	**869** (815-941)
2100		**2073** (2073-2737)	**2226** (1002-2683)	**2021** (1632-2021)	**1717** (1717-1921)	**514** (514-1157)	**1357** (1077-1357)
Share of coal in primary energy (%)[a]	24						
2020		**29** (24-42)	**23** (8-26)	**23** (23-23)	**22** (20-22)	**22** (19-27)	**17** (14-31)
2050		**33** (13-52)	**14** (3-42)	**10** (10-13)	**30** (27-30)	**21** (4-37)	**10** (10-35)
2100		**29** (3-46)	**4** (4-41)	**1** (1-3)	**53** (45-53)	**8** (0-22)	**22** (19-37)
Share of zero carbon in primary energy (%)[a]	18						
2020		**15** (10-20)	**16** (9-26)	**21** (15-21)	**8** (8-16)	**21** (7-22)	**18** (12-18)
2050		**19** (16-31)	**36** (23-40)	**43** (41-43)	**18** (18-29)	**30** (18-40)	**30** (21-30)
2100		**31** (30-47)	**65** (39-75)	**85** (67-85)	**28** (28-37)	**52** (44-70)	**49** (22-49)

[a] 1990 values include non-commercial energy consistent with IPCC WGII SAR (Energy Primer) but with SRES accounting conventions. Note that ASF, MiniCAM, and IMAGE scenarios do not consider non-commercial renewable energy. Hence, these scenarios report lower energy use.

Table SPM-3a*: Overview of GHG, SO_2, and ozone precursor emissions[a] in 1990, 2020, 2050, and 2100, and cumulative carbon dioxide emissions to 2100. Bold numbers show the value for the illustrative scenario and the numbers between brackets show the value for the range across all 40 SRES scenarios in the six scenario groups that constitute the four families. Units are given in the table.*

Family			**A1**		**A2**	**B1**	**B2**
Scenario group	**1990**	**A1FI**	**A1B**	**A1T**	**A2**	**B1**	**B2**
Carbon dioxide, fossil fuels (GtC/yr)	6.0						
2020		**11.2** (10.7-14.3)	**12.1** (8.7-14.7)	**10.0** (8.4-10.0)	**11.0** (7.9-11.3)	**10.0** (7.8-13.2)	**9.0** (8.5-11.5)
2050		**23.1** (20.6-26.8)	**16.0** (12.7-25.7)	**12.3** (10.8-12.3)	**16.5** (10.5-18.2)	**11.7** (8.5-17.5)	**11.2** (11.2-16.4)
2100		**30.3** (27.7-36.8)	**13.1** (12.9-18.4)	**4.3** (4.3-9.1)	**28.9** (17.6-33.4)	**5.2** (3.3-13.2)	**13.8** (9.3-23.1)
Carbon dioxide, land use (GtC/yr)	1.1						
2020		**1.5** (0.3-1.8)	**0.5** (0.3-1.6)	**0.3** (0.3-1.7)	**1.2** (0.1-3.0)	**0.6** (0.0-1.3)	**0.0** (0.0-1.9)
2050		**0.8** (0.0-0.9)	**0.4** (0.0-1.0)	**0.0** (-0.2-0.5)	**0.9** (0.6-0.9)	**-0.4** (-0.7-0.8)	**-0.2** (-0.2-1.2)
2100		**-2.1** (-2.1-0.0)	**0.4** (-2.4-2.2)	**0.0** (0.0-0.1)	**0.2** (-0.1-2.0)	**-1.0** (-2.8-0.1)	**-0.5** (-1.7-1.5)
Cumulative carbon dioxide, fossil fuels (GtC)							
1990-2100		**2128** (2079-2478)	**1437** (1220-1989)	**1038** (989-1051)	**1773** (1303-1860)	**989** (794-1306)	**1160** (1033-1627)
Cumulative carbon dioxide, land use (GtC)							
1990-2100		**61** (31-69)	**62** (31-84)	**31** (31-62)	**89** (49-181)	**-6** (-22-84)	**4** (4-153)
Cumulative carbon dioxide, total (GtC)							
1990-2100		**2189** (2127-2538)	**1499** (1301-2073)	**1068** (1049-1113)	**1862** (1352-1938)	**983** (772-1390)	**1164** (1164-1686)
Sulfur dioxide, (MtS/yr)	70.9						
2020		**87** (60-134)	**100** (62-117)	**60** (60-101)	**100** (66-105)	**75** (52-112)	**61** (48-101)
2050		**81** (64-139)	**64** (47-120)	**40** (40-64)	**105** (78-141)	**69** (29-69)	**56** (42-107)
2100		**40** (27-83)	**28** (26-71)	**20** (20-27)	**60** (60-93)	**25** (11-25)	**48** (33-48)
Methane, ($MtCH_4$/yr)	310						
2020		**416** (415-479)	**421** (400-444)	**415** (415-466)	**424** (354-493)	**377** (377-430)	**384** (384-469)
2050		**630** (511-636)	**452** (452-636)	500(492-500)	**598** (402-671)	**359** (359-546)	**505** (482-536)
2100		**735** (289-735)	**289** (289-640)	**274** (274-291)	**889** (549-1069)	**236** (236-579)	**597** (465-613)

[a] The uncertainties in the SRES emissions for non-CO_2 greenhouse gases are generally greater than those for energy CO_2. Therefore, the ranges of non-CO_2 GHG emissions provided in the Report may not fully reflect the level of uncertainty compared to CO_2, for example only a single model provided the sole value for halocarbon emissions.

Table SPM-3a (continued)

Family		A1			A2	B1	B2
Scenario group	**1990**	**A1FI**	**A1B**	**A1T**	**A2**	**B1**	**B2**
Nitrous Oxide, (MtN/yr)	6.7						
2020		**9.3** (6.1-9.3)	**7.2** (6.1-9.6)	**6.1** (6.1-7.8)	**9.6** (6.3-12.2)	**8.1** (5.8-9.5)	**6.1** (6.1-11.5)
2050		**14.5** (6.3-14.5)	**7.4** (6.3-14.3)	**6.1** (6.1-6.7)	**12.0** (6.8-13.9)	**8.3** (5.6-14.8)	**6.3** (6.3-13.2)
2100		**16.6** (5.9-16.6)	**7.0** (5.8-17.2)	**5.4** (4.8-5.4)	**16.5** (8.1-19.3)	**5.7** (5.3-20.2)	**6.9** (6.9-18.1)
CFC/HFC/HCFC (MtC equiv./yr)[b]	1672						
2020		**337**	**337**	**337**	**292**	**291**	**299**
2050		**566**	**566**	**566**	**312**	**338**	**346**
2100		**614**	**614**	**614**	**753**	**299**	**649**
PFC, (MtC equiv./yr)[b]	32.0						
2020		**42.7**	**42.7**	**42.7**	**50.9**	**31.7**	**54.8**
2050		**88.7**	**88.7**	**88.7**	**92.2**	**42.2**	**106.6**
2100		**115.3**	**115.3**	**115.3**	**178.4**	**44.9**	**121.3**
SF_6, (MtC equiv./yr)[b]	37.7						
2020		**47.8**	**47.8**	**47.8**	**63.5**	**37.4**	**54.7**
2050		**119.2**	**119.2**	**119.2**	**104.0**	**67.9**	**79.2**
2100		**94.6**	**94.6**	**94.6**	**164.6**	**42.6**	**69.0**
CO, (MtCO/yr)	879						
2020		**1204**	**1032**	**1147**	**1075**	**751**	**1022**
		(1123-1552)	(978-1248)	(1147-1160)	(748-1100)	(751-1162)	(632-1077)
2050		**2159**	**1214**	**1770**	**1428**	**471**	**1319**
		(1619-2307)	(949-1925)	(1244-1770)	(642-1585)	(471-1470)	(580-1319)
2100		**2570**	**1663**	**2077**	**2326**	**363**	**2002**
		(2298-3766)	(1080-2532)	(1520-2077)	(776-2646)	(363-1871)	(661-2002)
NMVOC, (Mt/yr)	139						
2020		**192** (178-230)	**222** (157-222)	**190** (188-190)	**179** (166-205)	**140** (140-193)	**180** (152-180)
2050		**322** (256-322)	**279** (158-301)	**241** (206-241)	**225** (161-242)	**116** (116-237)	**217** (147-217)
2100		**420** (167-484)	**194** (133-552)	**128** (114-128)	**342**(169-342)	**87** (58-349)	**170** (130-304)
NO_x, (MtN/yr)	30.9						
2020		**50** (46-51)	**46** (46-66)	**46** (46-49)	**50** (42-50)	**40** (38-59)	**43** (38-52)
2050		**95** (49-95)	**48** (48-100)	**61** (49-61)	**71** (50-82)	**39** (39-72)	**55** (42-66)
2100		**110** (40-151)	**40** (40-77)	**28** (28-40)	**109** (71-110)	**19** (16-35)	**61** (34-77)

[b] In the SPM the emissions of CFC/HFC/HCFC, PFC, and SF6 are presented as carbon-equivalent emissions. This was done by multiplying the emissions by weight of each substance (see Table 5-8) by its global warming potential (GWP; see Table 5-7) and subsequent summation. The results were then converted from CO_2-equivalents (reflected by the GWPs) into carbon-equivalents. Note that the use of GWP is less appropriate for emission profiles that span a very long period. It is used here, in the interest of readability of the SPM in preference to a more detailed breakdown by the 27 substances listed in Table 5-7. The method here is also preferred over the even less desirable option to display weighted numbers for the aggregate categories in this table.

***Table SPM-3b**: Overview of GHG, SO_2, and ozone precursor emissions[a] in 1990, 2020, 2050, and 2100, and cumulative carbon dioxide emissions to 2100. Bold numbers show the value for the illustrative scenario and the numbers between brackets show the value for the range across 26 harmonized SRES scenarios in the six scenario groups that constitute the four families. Units are given in the table.*

Family		**A1**			**A2**	**B1**	**B2**
Scenario group	**1990**	**A1FI**	**A1B**	**A1T**	**A2**	**B1**	**B2**
Carbon dioxide, fossil fuels (GtC/yr)	6.0						
2020		**11.2** (10.7-14.3)	**12.1** (8.7-14.7)	**10.0** (9.8-10.0)	**11.0** (10.3-11.0)	**10.0** (8.2-13.2)	**9.0** (8.8-10.2)
2050		**23.1** (20.6-26.8)	**16.0** (12.7-25.7)	**12.3** (11.4-12.3)	**16.5** (15.1-16.5)	**11.7** (8.5-17.5)	**11.2** (11.2-15.0)
2100		**30.3** (30.3-36.8)	**13.1** (13.1-17.9)	**4.3** (4.3-8.6)	**28.9** (28.2-28.9)	**5.2** (3.3-7.9)	**13.8** (13.8-18.6)
Carbon dioxide, land use (GtC/yr)	1.1						
2020		**1.5** (0.3-1.8)	**0.5** (0.3-1.6)	**0.3** (0.3-1.7)	**1.2** (1.1-1.2)	**0.6** (0.0-1.3)	**0.0** (0.0-1.1)
2050		**0.8** (0.0-0.8)	**0.4** (0.0-1.0)	**0.0** (-0.2-0.0)	**0.9** (0.8-0.9)	**-0.4** (-0.7-0.8)	**-0.2** (-0.2-1.2)
2100		**-2.1** (-2.1-0.0)	**0.4** (-2.0-2.2)	**0.0** (0.0-0.1)	**0.2** (0.0-0.2)	**-1.0** (-2.6-0.1)	**-0.5** (-0.5-1.2)
Cumulative carbon dioxide, fossil fuels (GtC)							
1990-2100		**2128** (2096-2478)	**1437** (1220-1989)	**1038** (1038-1051)	**1773** (1651-1773)	**989** (794-1306)	**1160** (1160-1448)
Cumulative carbon dioxide, land use (GtC)							
1990-2100		**61** (31-61)	**62** (31-84)	**31** (31-62)	**89** (81-89)	**-6** (-22-84)	**4** (4-125)
Cumulative carbon dioxide, total (GtC)							
1990-2100		**2189** (2127-2538)	**1499** (1301-2073)	**1068** (1068-1113)	**1862** (1732-1862)	**983** (772-1390)	**1164** (1164-1573)
Sulfur dioxide, (MtS/yr)	70.9						
2020		**87** (60-134)	**100** (62-117)	**60** (60-101)	**100** (80-100)	**75** (52-112)	**61** (61-78)
2050		**81** (64-139)	**64** (47-64)	**40** (40-64)	**105** (104-105)	**69** (29-69)	**56** (44-56)
2100		**40** (27-83)	**28** (28-47)	**20** (20-27)	**60** (60-69)	**25** (11-25)	**48** (33-48)
Methane, ($MtCH_4$/yr)	310						
2020		**416** (416-479)	**421** (406-444)	**415** (415-466)	**424** (418-424)	**377** (377-430)	**384** (384-391)
2050		**630** (511-630)	**452** (452-636)	**500** (492-500)	**598** (598-671)	**359** (359-546)	**505** (482-505)
2100		**735** (289-735)	**289** (289-535)	**274** (274-291)	**889** (889-1069)	**236** (236-561)	**597** (465-597)

a The uncertainties in the SRES emissions for non-CO_2 greenhouse gases are generally greater than those for energy CO_2. Therefore, the ranges of non-CO_2 GHG emissions provided in the Report may not fully reflect the level of uncertainty compared to CO_2, for example only a single model provided the sole value for halocarbon emissions.

Table SPM-3b (continued)

Family		A1			A2	B1	B2
Scenario group	**1990**	**A1FI**	**A1B**	**A1T**	**A2**	**B1**	**B2**
Nitrous oxide, (MtN/yr)	6.7						
2020		**9.3** (6.1-9.3)	**7.2** (6.1-9.6)	**6.1** (6.1-7.8)	**9.6** (6.3-9.6)	**8.1** (5.8-9.5)	**6.1** (6.1-7.1)
2050		**14.5** (6.3-14.5)	**7.4** (6.3-13.8)	**6.1** (6.1-6.7)	**12.0** (6.8-12.0)	**8.3** (5.6-14.8)	**6.3** (6.3-7.5)
2100		**16.6** (5.9-16.6)	**7.0** (5.8-15.6)	**5.4** (4.8-5.4)	**16.5** (8.1-16.5)	**5.7** (5.3-20.2)	**6.9** (6.9-8.0)
CFC/HFC/HCFC (MtC equiv./y) [b]	1672						
2020		**337**	**337**	**337**	**292**	**291**	**299**
2050		**566**	**566**	**566**	**312**	**338**	**346**
2100		**614**	**614**	**614**	**753**	**299**	**649**
PFC, (MtC equiv./yr) [b]	32.0						
2020		**42.7**	**42.7**	**42.7**	**50.9**	**31.7**	**54.8**
2050		**88.7**	**88.7**	**88.7**	**92.2**	**42.2**	**106.6**
2100		**115.3**	**115.3**	**115.3**	**178.4**	**44.9**	**121.3**
SF_6 , (MtC equiv./yr) [b]	37.7						
2020		**47.8**	**47.8**	**47.8**	**63.5**	**37.4**	**54.7**
2050		**119.2**	**119.2**	**119.2**	**104.0**	**67.9**	**79.2**
2100		**94.6**	**94.6**	**94.6**	**164.6**	**42.6**	**69.0**
CO, (MtCO/yr)	879						
2020		**1204**	**1032**	**1147**	**1075**	**751**	**1022**
		(1123-1552)	(1032-1248)	(1147-1160)	(1075-1100)	(751-1162)	(941-1022)
2050		**2159**	**1214**	**1770**	**1428**	**471**	**1319**
		(1619-2307)	(1214-1925)	(1244-1770)	(1428-1585)	(471-1470)	(1180-1319)
2100		**2570**	**1663**	**2077**	**2326**	**363**	**2002**
		(2298-3766)	(1663-2532)	(1520-2077)	(2325-2646)	(363-1871)	(1487-2002)
NMVOC, (Mt/yr)	139						
2020		**192** (178-230)	**222** (194-222)	**190** (188-190)	**179** (179-204)	**140** (140-193)	**180** (179-180)
2050		**322** (256-322)	**279** (259-301)	**241** (206-241)	**225** (225-242)	**116** (116-237)	**217** (197-217)
2100		**420** (167-484)	**194** (137-552)	**128** (114-128)	**342** (311-342)	**87** (58-349)	**170** (130-170)
NO_x, (MtN/yr)	30.9						
2020		**50** (46-51)	**46** (46-66)	**46** (46-49)	**50** (47-50)	**40** (38-59)	**43** (38-43)
2050		**95** (49-95)	**48** (48-100)	**61** (49-61)	**71** (66-71)	**39** (39-72)	**55** (42-55)
2100		**110** (40-151)	**40** (40-77)	**28** (28-40)	**109** (109-110)	**19** (16-35)	**61** (34-61)

[b] In the SPM the emissions of CFC/HFC/HCFC, PFC, and SF6 are presented as carbon-equivalent emissions. This was done by multiplying the emissions by weight of each substance (see Table 5-8) by its global warming potential (GWP; see Table 5-7) and subsequent summation. The results were then converted from CO_2-equivalents (reflected by the GWPs) into carbon-equivalents. Note that the use of GWP is less appropriate for emission profiles that span a very long period. It is used here, in the interest of readability of the SPM in preference to a more detailed breakdown by the 27 substances listed in Table 5-7. The method here is also preferred over the even less desirable option to display weighted numbers for the aggregate categories in this table.