Proposal
for air pollution and climate change scenarios for the SoEOR2005 report

(DRAFT)

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1. INTRODUCTION

1.1 OBJECTIVE OF THIS NOTE

EEA considers that the themes air pollution and climate change are the first priority for EEA's scenarios for the 2005 State of the Environment and Outlook report. The aim is to develop these as similar as possible and in close collaboration with the CAFE baseline scenarios, the EU Greenhouse Gas (GHG) Monitoring Mechanism, especially as far as the period 2010/2020 is concerned, and existing EU-wide scenarios for the period after 2020. The EEA requested the ETC/ACC to ensure consistency with the societal and socio-economic scenarios that are defined by the EEA (in close collaboration with the European Commission and member countries). In this respect, EEA will follow as much as possible the information provided by the CAFE baselines.
The scope of this note is to propose the principles and assumptions for scenario development for the areas air pollution and climate change. For generating scenarios it is vital to first define the key questions to be addressed by the scenarios.

We have selected the following:
Short term (up to 2010):

- What is the progress at the EU level in meeting the agreed emission targets in 2010 (Kyoto protocol and NECD)?

Medium term (2010-2020/2030)[1]:

- What could be GHG emissions for the EU (and associated driving forces), other industrialized and developing countries, in the medium term (2020-2030), from different equity and burden sharing perspectives and consistent with the EU long-term goal?
- What are the co-benefits of climate policies by 2020 for air pollution in terms of reduced emissions and reduced costs?
- What is the state of the environment in 2020 assuming full implementation of current policies and 2010 targets[2]?
- What are the uncertainties in 2020 in key policy areas (climate change, transport, energy, agriculture) and socio-economic developments and how will this affect the state of the environment?

Long term (up to 2050 and 2100):

- What will be impact of climate change in Europe in the long run (2050/2100) and how would these impacts be reduced if GHG concentrations would be stabilized at different levels (including the EU long-term goal)?
- What are the co-benefits of climate policies by 2050 for air pollution in terms of reduced emissions and reduced costs?

1.2 OVERVIEW OF INTEGRATED ASSESSMENT FRAMEWORK.

The ETC/ACC has developed an integrated assessment (IA) framework to enable the evaluation of different scenarios. We refer to Eerens, Amann and Van Minnen (2002) for details about the framework. In summary, the framework consists of a combination of existing models in a way that connections between the models have been ensured and data exchange needs are harmonized. The objective of the framework is to:

- Analyze the full causality chain (from economic activities and emissions to impacts) in order to evaluate the (cost-) effectiveness of different policies in the field of climate and air pollution.
- Analyze co-benefits of environmental policies by integrating different environmental themes (i.e. climate change, air pollution, particulate matter, ozone[3]).

[1] The period 2020-2030 is sometimes already considered as long-term prospects, the period 2050/2100 could then be characterised as very long term.
[2] See annex III for a full list of indicators

Despite the basic idea of using existing models, certain aspects had to be added/changed in order to reach the mentioned objectives. New data sources, for example, had to be added into the framework in order to develop more accurately future trends projections in non-CO2 GHG emissions (see Bates and Klimont, 2002).

An aspect of the framework is the development and use of indicators (see appendix 3). Indicators have become indispensable to policy makers since they are useful to communicate information, including the evaluation of progress in agreed policy targets (so-called distance to target) and the provision of early warning signals. In order to accomplish these needs, a list of indicators has been developed, using different criteria (e.g. do they communicate meaningful political messages, are they comparable between countries, are they scientifically sound, can they be modelled?). The number of indicators is considerable, since many parameters that contribute to one of the environmental issues (i.e. climate change, air pollution) are useful to present as indicators but are difficult to combine. In addition the aim is to evaluate the full causality chain.

One critical issue in the definition of an appropriate indicator is the time horizon of the assessment. In the framework of the ETC/ACC four time horizons have been defined (see also chapter 3). The first one is covering the past trend, secondly comes 2010. 2010 is important in order to appraise the progress of defined policies (i.e. assess distance to target) as 2010 is often a target year of current policies (Kyoto Protocol, formally 2008-2012, NEC, CLRTAP Gothenburg Protocol). Indicators will be related to economic activities, i.e. socio-economic driving forces, and emissions. Impact indicators will be less relevant up to 2010, since politically agreed (emission) targets are fixed and based on, or linked to 'thresholds' of impacts, which were already assessed at the time when the targets had been discussed and agreed. Thirdly, various scenarios up to 2020 will be defined. State (e.g. concentrations of GHG and air pollutants) and impact (e.g. exceedances of critical loads) indicators will be used in the evaluation of these scenarios in combination with the socio-economic driving forces. Politically agreed environmental targets do not yet exist for the year 2020. In fact the air pollution and climate change scenarios being developed for SoEOR2005 could help the ongoing policy making processes in the analysis of possible future (2020) environmental targets (see below), either defined as emission or as quality targets. Innovative in the ETC/ACC framework is the inclusion of indicators for the interaction between air pollution and climate (change). For example, the climate change effect on the percentage exceedance of critical loads (e.g. total nitrogen) will be included. But also the co-benefits of climate change policies for air pollution will be analysed, in terms of reduced air pollutant emissions and reduced costs. Finally, the long (2020-2030) and very long-term perspective (up to 2100) is needed to evaluate the effectiveness of current and future policies in terms of reduced impacts. This is especially the case for the climate field, since the response of the climate system is slow. State and impact indicators are especially included for this purpose. In addition an analysis will be performed of the possible GHG emissions level and associated socio-economic activities for the EU in the long term (2020-2030), from different equity and burden sharing perspectives and consistent with the EU long-term climate change goal.

1.3 CAFE BASELINE SCENARIO AND SOEOR2005.

The Clean Air For Europe (CAFE) programme organized by the European Commission (DG Environment) is preparing a thematic strategy to reduce air pollution. The thematic strategy should be published in 2005. Recognizing the fact that the SoEOR2005 report and the CAFE programme both need to develop scenarios for evaluating the socio-economic and sectoral implications of different environmental targets, EU and EEA agreed to work as closely as possible together in developing scenarios for CAFE and for SoEOR2005.

In mid 2002 some of the institutions that are a member of the ETC/ACC (i.e. IIASA and NTUA) were awarded the contract for constructing a baseline scenario for CAFE, with a requirement to work closely with ETC/ACC.

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[3] The focus for ozone will include tropospheric and stratospheric ozone

RAINS, the main model for the integrated assessment and scenario work in CAFE, will:

- Quantify the effects of present emission reduction legislation on future air quality,
- Assess the scope, costs and benefits of additional emission control measures and, if appropriate,
- Identify cost-effective packages of additional emission control measures to meet air quality objectives

The RAINS model needs for the construction of the baseline scenario(s):

- Exogenously supplied projections/scenarios of emission generating activities (energy, transport, agricultural activities, industrial production, etc.),
- Emission characteristics of the various sources (emission factors, efficiencies and costs of emission control measures, the penetration of measures in the EU and Candidate Countries)

For energy (demand and supply) scenarios it has been agreed within CAFE to use the PRIMES model and an associated model for Candidate Countries (ACE). The PRIMES energy baseline scenario has been developed in 2002 and will be published early 2003.

The Commission recognized that the available models to construct the required transport scenarios for EU and candidate countries were not meeting its demands for CAFE. A separate Call for Tender was therefore issued in mid 2002 for improving the TREMOVE model that earlier had already been selected as the main model for transport emission projections. In October 2002 the contract was awarded to a consortium led by KU Leuven. The SCENES model, also agreed for use in CAFE, will provide the transport demand scenarios required by TREMOVE.

The Commission's DG Agriculture agreed to provide the required agricultural scenarios for CAFE, which could be based on or linked to the CAPRI model. For the agricultural sector ETC/ACC has prepared an internal note (September 2002) in which options to construct agricultural scenarios were presented. It concluded that beside the main model (CAPRI) supported by the Commission some additional information, especially for the new candidate countries and the period after 2010, would be required. Agricultural scenario development in CAFE and SoEOR2005 should be further discussed between DG ENV and EEA (ETC/ACC).

The support of the integrated assessment models that were used in the past for the analysis that led to the Gothenburg protocol and the NEC directive didn't include specific information about urban air pollution. In an effort to improve this (undesirable) situation the City Delta city project has been launched at the end of 2001. In the City Delta project urban air pollution models for ozone and particulates are compared for 8 representative cities in Europe. First results are available since the end of 2002. The City Delta should select the models with the best performances and the highest potential to co-operate with the RAINS model. ETC/ACC will consider in 2003 if and how the urban air pollution models selected in City Delta can be implemented in the ETC/ACC integrated assessment framework.

The state of play regarding the CAFE baseline scenario has been presented at the CAFE Steering Group meeting on 17 February 2003 and the main contractor will present a draft integrated baseline scenario at the forthcoming CAFE stakeholder meeting (see also the paper by DG ENV on stakeholder involvement) 27-28 may 2003. During July to November 2003 the contractor will organize small stakeholder meetings with countries as well as industrial and environmental NGOs to review and finalize the baseline scenario by December 2003. The CAFE Steering Group should endorse the baseline for future work in CAFE on alternative policy packages (during 2004). EEA/ETC-ACC will use the CAFE meetings as the main forum to exchange with all relevant stakeholders. The CAFE process has started work on two baseline scenarios, one with and one without full Kyoto implementation. The main assumptions that drive the projected evolution of the EU15 and acceding countries energy system in the horizon to 2030 are summarized here[4].

The "without climate policies" scenario is almost identical to the Baseline scenario constructed in the context of the "Long Range Energy Modelling" framework contract by Energy and Transport DG. They are based on quantitative analysis, with the use of the PRIMES and ACE mathematical models, and on a process of communication with and feedback from a number of energy experts and organisations. A detailed analysis of assumptions and results for this scenario can be found in "European Energy and Transport – Trends to 2030" (forthcoming publication by Energy and Transport DG). While results for EU Member States are identical to those of "Long Range Energy Modelling" framework contract, small differences exist as regards acceding countries given that results provided are output of the PRIMES model (which has been developed in the meantime for those countries) and not ACE model as was the case in the "Long Range Energy Modelling" study.

The key assumptions for current EU Member States are the following:

- Assuming the continuation of current world energy market structures and taking a conventional view on fossil fuel reserves, world energy prices develop moderately as no supply constraints are likely to be experienced over the next 30 years under Baseline conditions.

- Baseline assumptions include continued economic modernisation, substantial technological progress, and completion of the internal market. Existing policies on energy efficiency and renewables continue; the fuel efficiency agreement with the car industry is implemented; and decisions on nuclear phase-out in certain Member States are fully incorporated.

- For analytical purposes the Baseline case does not include any new policies to reduce greenhouse gas emissions. This is to assist in identifying any remaining policy gaps in the energy and transport sectors with respect to the EU's Kyoto commitments.

- The Baseline macro-economic scenario assumes continued GDP growth of 2.3% pa on average over the projection period, similar to that over the past 30 years. The assumed growth rates are modest compared with the ambitions of the Lisbon strategy but also high compared with the current weak state of the EU economy.

- Furthermore the EU economy is characterised by a further dematerialisation with stronger growth occurring in high value added industrial sectors and services.

Energy import prices in acceding countries correspond with those for the current EU. The policy assumptions are also similar to those for the EU given the gradual accession of many of these countries and continuation of close economic and political relations with the others. Over the whole period, the GDP growth in the candidate countries is projected to exceed that in EU15.

The second scenario examined assumes the existence of an EU wide CO_2 emissions trading regime. The "with climate policies" scenario assumes a permit price of 12 Euro per t of CO_2 in 2010, rising to 16 Euro per t of CO_2 in 2015 and 20 Euro per t of CO_2 in 2020. In 2020-2030 the permit price remains constant at 20 Euro per t of CO_2.

1.4 DEVELOPMENT OF THE SOEOR2005 REPORT.

Why a State and Outlook report?

According to the EEA regulation article 2 the tasks of the Agency shall be:

[4] The following text is based on a note from DG Environment, Matti Vaino: Note on scenario definition. 9-5-2003, env/circa site cafe

(vi) to publish a report on the state of, trends in and prospects for the environment every five years, supplemented by indicator reports focusing upon specific issues;

In the 6th Environmental Action Programme (6EAP) the following sentences relates to 6EAP mid-term review and EEA SOER2005 reporting:

"*In the fourth year of operation of the Programme (July 2002 + 4 years) the Commission shall evaluate the progress made in its implementation together with associated environmental trends and prospects. This should be done on the basis of a comprehensive set of indicators.*

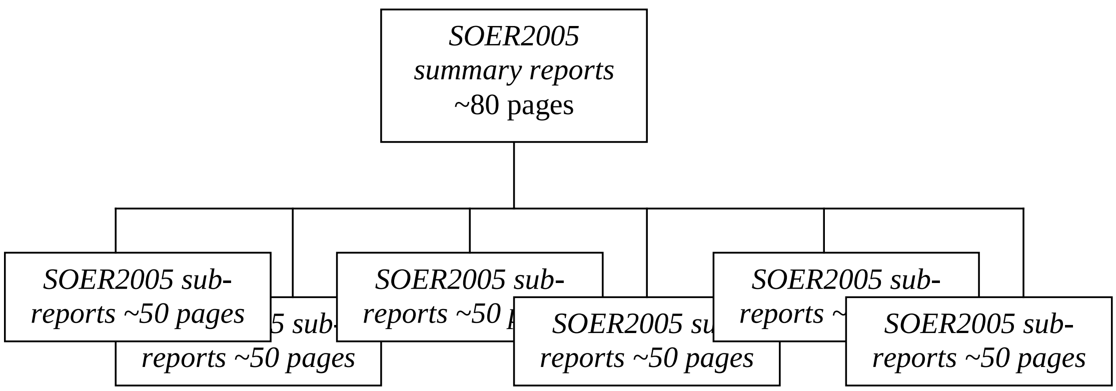
The production of this information will be supported by regular reports from the European Environment Agency and other relevant bodies. The information shall consist notably of: headline environmental indicators; indicators on the state and trends of the environment; and integration indicators";

So one of the aims of the SOER2005 and other EEA reports should be to support the Commissions 6EAP mid-term process with indicators on the state and trends of the environment and integration indicators; and evaluate prospects. The Commission is going to publish a mid-term review of the 6th Environmental Action Programme around end 2005, so a mid-2005 publication date currently seems the most suitable timing.

A new approach for the SOER2005 report?

The traditional structure with sector and environmental issue chapters together with a few overarching themes imply that much information is repeated from previous SoE reports. Another reason is that the traditional structure does not fit to the priority areas in the 6EAP and the EU Sustainable Development Strategy (SDS); and the activities on sector integration. In addition, it can be difficult to incorporate sustainable development aspects in the traditional structure.

To be able to cover the more overarching integrated themes in relation to the 6EAP and SDS priority areas EEA has in the last months worked on a proposal that the SOER2005 reporting activity could consist of 1-3 *SOER2005 summary report* of around 80-100 pages, and a number (5-9) of overarching *SOER2005 sub-reports.*



SOER2005 sub-reports

The sub-reports will be a series of reports, which constitute the EEA contribution to the 6EAP mid-term evaluation and maybe used as background for the SDS revision. All the sub-reports will have the same layout and consistency between the reports has to be ensured.

The SOER2005 sub-reports will focus on a specific issue such as *sustainable consumption and meeting the needs of the population* or *environmental aspects of enlargements.* Table 1 lists the proposed sub-reports and their relation to the 6EAP/SDS priority areas. Overlaps between sub-reports will be accepted, but the specific focus of each sub-report will minimize the actual overlap.

There are some benefits of the sub-reports: firstly, in a 50-page report it will be easier to keep the focus on a specific issue such as sector integration or enlargement and the linkage in the report can be ensured; secondly it is easier to improve the overall quality and consistency of a 50-page report compared to a 300-page report. Sub-reports may have more policy impact and can be focused on specific policy processes/events.

Proposed SOER2005 Sub-reports		6EAP and SDS priority areas
1	Changing consumption patterns and meeting the needs of the population	6EAP Environment and Health and Quality of life
2	Environmental aspects of enlargement	
3	Conserving ecosystems and biodiversity (Ecosystem goods and services)	6EAP Nature and biodiversity
4	Sustainable use and management of natural resources	6EAP Sustainable use and management of natural resources and wastes
5	Policy integration	Cardiff process on sector-environment integration
6	Climate change and the use of clean energy	6EAP Climate change& SDS Climate change and the use of clean energy
7	European Environment Outlook	
8	Global issues – Europe's impact on the global environment	
9	Environment and health	6EAP Environment and Health and Quality of life

On basis of the sub-reports and other outputs e.g. issue and sector reports and contribution to thematic strategies EEA will produce 1-3 (summary) reports:

- A report assessing progress against *6EAP/SDS priority areas*;
- A report assessing *issues relevant but not yet covered by the 6EAP* e.g. aspect of sustainable consumption or environmental aspects of the enlargement process;
- A report assessing *Europe's responsibility in relation to global issues* such as European activities affecting outside Europe or Europe's responsibility in relation to global issues such as climate change and biodiversity.

Building blocks to the SOER2005

First it is important to notice that the content, which can be included into a 50 pages sub-report, is rather limited. The above-suggested reports can easily increase to a 200 pages report, but the EEA does not have an interest in that. Therefore there is much more information that actually can be included. A big challenge will be to select the right information and restrict the sub-reports and the (summary) reports. *Small reports of a good quality could have higher and more focused policy impact.*

The building blocks to the reports will be:

- *EU policy documents* – such as 6EAP; SDS; thematic strategies or reports on sector-integration implementations, reports on environmental impact of CAP reform etc. – these documents will partly frame the sub-report; and we have to ensure that we are answering some of the policy objectives in the 6EAP and SDS priority areas;

- *Core set of indicators* – during the coming two years fact sheets including assessments will be developed for the short and mid-term indicators in the EEA core set. These fact sheets will be important building blocks for the sub-reports and it is important at an early stage in the process to ensure that the fact sheet are delivering the requested information and at time.
- *EEA sector and environmental issue reports* – a number of issue reports are planned in the coming years and parts of these will contribute to sub-reports. The *sector and environmental issue reports* also have to cover gaps in relation to 6EAP priority areas.
- *EEA environmental snapshots* – some of the snapshots will be forerunners/testing versions of parts of sub-reports. In addition, we can use the experience gained in the snapshots project teams to improve the work in the sub-report project teams.
- There will be a need for *several background notes or background reports* to feed into the sub-reports. These background documents will include specific assessments needed for the sub-reports. Some of the background documents will be produced by the EEA (e.g. by ETCs or sectors); others notes might be based on cooperation between different EEA project managers/ETCs (e.g. a note on agricultural water use as a cooperation between agriculture and water) and some have to be produced by external consultants.
- *Baseline scenarios and outlooks* – the reports will include scenarios and outlooks whenever possible. This has to be taken into account when planning the contents of the sub-reports. In addition, a separate sub-report on scenarios and outlooks will provide an overall picture of the main European developments.
- *Other cross-cutting issues* such as economic valuation; policy effectiveness analysis; aspects of governance etc. will be included as much as possible in the reports. We need to start up studies for these issues as soon as possible.
- The *environmental linkage to sustainable development* should also frame the contents of the sub-reports.
- In addition to information (indicators, notes, assessments etc.) being produced by the EEA much *external produced information* will also be used as building blocks to the sub-reports. For example, the sub-report on global issues will have to be based on much information produced outside the EEA. However, the EEA assessment will steer the selection of information as well as structure the sub-report.

Geographical coverage: The report has to cover all EEA member countries. It will also include participating countries (Balkans, Switzerland…). In the report we will develop links to the interface regions of NIS & Mediterranean; The global dimension and global issues should be covered.

Temporal coverage: Trends over 20th century (Focus on 1990 – early 2000) and outlooks to 2010/20 and beyond where appropriate.

Where are we now in the process?

For the moment EEA has produced draft implementations plans including outlines and overview of needed activities and timing of the potential sub-reports and is discussing these internally. Works on the outlines of the SOER summary reports and overall overview on how to implement the SOER2005 activities have started. In *June-July-August* a first consultation with stakeholders (European Commission; countries (EIONET) and others) of the contents of the sub-reports will be made (Web-based consultation). There will be some meetings/presentations to discuss the outlines of the sub-reports with external experts.

2. PROPOSED METHODOLOGY FOR DEVELOPING AIR AND CLIMATE CHANGE SCENARIOS FOR THE SOEOR2005 REPORT

2.1. INTRODUCTION

The main reason to develop scenarios for the SoEOR2005 report in the field of air pollution and climate change is to answer the questions raised in section 1. Considering these questions, three time horizons for projections have been defined (figure 2.1). The starting points for the short term up to 2010 (or more formally 2008-2012 for climate change) are (1) emission projections, assuming that the Kyoto and NEC targets will not be met with existing policies, and (2) emission projections assuming that the Kyoto and NEC targets will be met using additional policies (including the use of Kyoto mechanisms).

The basis for these two projections is formed by the driving forces scenarios as used in the CAFE-baseline project. Main objective of this time frame is to evaluate the possibilities of meeting the Kyoto and NEC targets and the associated costs.

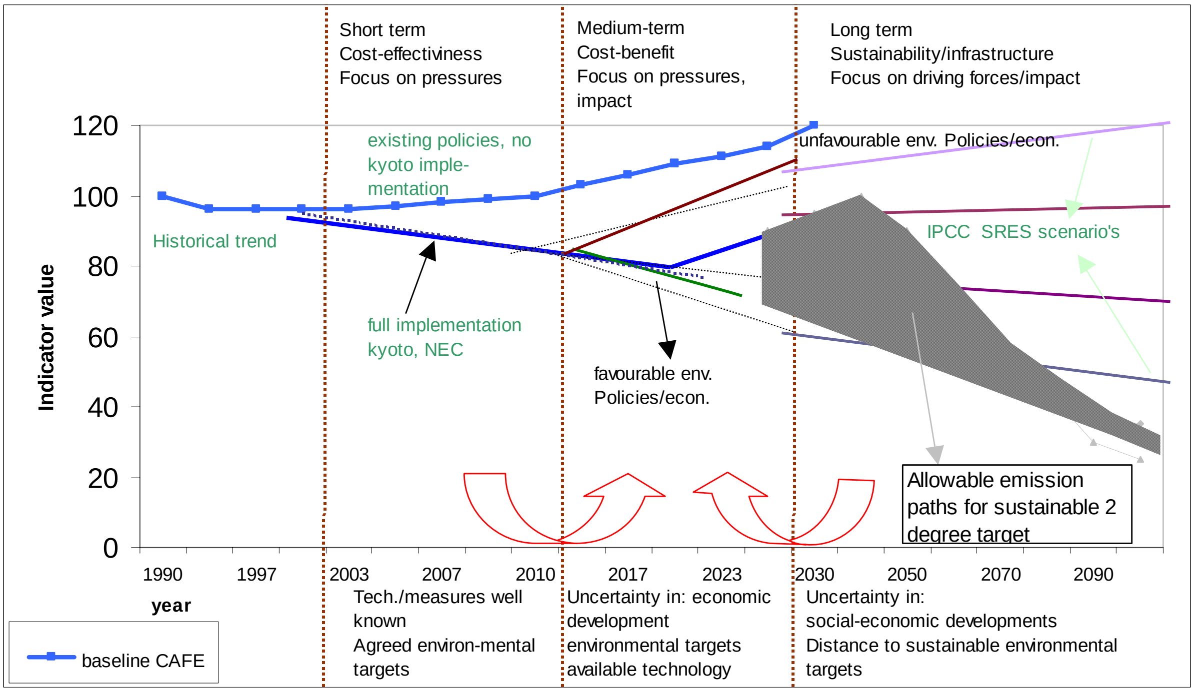


Figure 2.1: Proposed methodology for developing Air and Climate Change scenarios for the SoEOR2005 report

The next time horizon is the 2010-2020/2030[5]. The main objective of analysis in this period is to evaluate to what extent the pathways up to 2010 can further develop in an environmentally favourable (“environmentally sustainable”) way, or in an environmentally unfavourable way (“environmentally unsustainable”). Economic and technology variants as well as sensitivity runs can be considered to evaluate the effects of policies in sectors other than energy, climate and air pollution, and for different socio-economic driving forces (income, fuel prices) if not already included in the CAFE baseline project. The endpoint of this period will be in principle 2020. However, for the energy sector (power/heat generation and consumption in all sectors, including transport) the time horizon will be expanded up to 2030.

The final time horizon is 2050-2100. This long-term view is important because of the long-term perspective of climate change and its impacts. In the next section we describe the different time horizons in more detail

[5] As mentioned in the introduction the period 2020-2030 is sometimes be referred to as long-term, and the period 2050-2100 as the very long-term

2.2. PROPOSED CRITERIA FOR SCENARIOS, VARIANTS AND SENSITIVITY RUNS[6]

It is important to understand the "robustness"[7] of the scenarios developed for the SoEOR2005 report, both for the "environmentally sustainable and unsustainable" scenarios.

For both scenarios the following types of robustness analyses are relevant

- How robust is the baseline scenario under various (non-air quality) policies development such as:
  - climate change policy
  - energy policy
  - transport policy
  - agricultural reform policy
  - enlargement scenarios
  - other policies (e.g. trade, finance)
- How robust is the baseline scenario (using the policy relevant indicators) in view of uncertainty in economic developments within Europe (GDP changes, energy prices, technology changes/progress, unemployment) and under various global developments?
- How robust is the baseline scenario in view of uncertain demographic developments in Europe (number of person per households, immigration)?

In order to answer these questions, we propose a number of scenarios.

It is beyond the scope of the SoEOR2005 report to do an analysis of all potential policy developments in all relevant sectors. Moreover, this is not necessary as this exercise is essentially meant to show to the effect of alternative assumptions with regard to policy developments. Important is to define packages of scenarios. These scenarios should provide assumptions for analysis in such a way that it gives as many and as meaningful insights as possible. In addition there is a need to combine scenarios, variants and sensitivities to form scenario packages, such "environmentally sustainable" and "environmentally unsustainable" packages.. The number of these packages that should be explored through the full causal chain needs to be limitedto facilitate the use for other analysis purposes (e.g. other environmental themes like biodiversity) and improve communication both with EEA and external EEA-clients. The selection of the individual scenario runs as well as these packages will be made on the basis of transparent criteria (see below).

Policy relevance – (*<u>what</u> are we varying*?). Only variations in assumptions should be considered that are policy relevant. This means that they should be plausible. In addition, there should be a measurable effect. Thirdly, the scenarios should include assumptions and policies that can be adapted in the considered time-span. Finally, there should be a clear link between the policy analyzed and the environmental indicators as used in SoEOR2005.

Discriminatory potential – (*<u>how much</u> are we varying*?). Only those variations in assumptions should be considered that have enough discriminatory potential, and that are plausible. However, this should not exclude major technological and/or structural changes (such as e.g. change to a hydrogen economy), as long as the extent of the change is considered "plausible". This also requires a clear link to environmental indicators and for a clear and transparent selection of scenarios. Aim is to explore the potential and main impacts of socio-economic and technological assumptions.

[6] See the EEA glossary on environment outlooks in Annex 6 for further details on the terminology used.
[7] The "robustness" of a scenario is large with respect to a particular change in a driving force if its sensitivity to such a change is small.

Legitimacy/acceptance – Not being a real criterion, but rather a procedure to narrow down the range of variations in assumptions we propose a consultation round with various actors that are involved in the SoEOR2005 process. Topics to be discussed should be:

- Within ETC/ACC: important societal and policy developments that could influence the environment and the uncertainties in the analyses and assessments (e.g. NTUA, IIASA, AEA Technology);

- With EEA project managers: relevant, plausible and meaningful societal and policy assumptions to vary in the fields of climate change, energy, transport and agriculture;

- Within CAFE, in particular with stakeholders (European Commission, countries and business/environmental NGOs): societal and policy developments and the uncertainties they consider relevant, plausible and meaningful.

With stakeholders (countries and business/environmental NGOs) it would be preferable to organize in 2003 special workshops to discuss the proposed scenarios in more detail as much as feasible linked to CAFE. The first decision to make is to decide which assumptions to make with regard to the way Kyoto will be implemented (referring to the first box in figure 1). Within CAFE a stakeholder workshop is already foreseen on the CAFE baseline, including a Kyoto implementation scenario. EEA and ETC will participate in this process to discuss initial ideas for their air pollution/climate change scenario work with stakeholders. A second workshop with stakeholders could be organized to discuss the (two) main packages of scenarios ("sustainable emission pathway" and "environmentally unfavourable") and preferred end points and alternative possible developments (economic and technology variants as well as sensitivities) in sectoral policies considered important for air quality and climate change. It is proposed to establish further links to the CAFE stakeholder consultations process during 2003.

In addition EEA considers organizing one workshop specifically aimed at discussing the "environmentally sustainable" scenarios with stakeholders, early 2004.

3. SCENARIO PROPOSALS

3.1 INTRODUCTION

In this chapter a more detailed overview of a number of potential individual scenarios is presented as well as possible packages of scenarios. First, we present a set of 2010 scenarios. Then we elaborate on medium term (2020-2030) scenarios and finally on possible reference emission scenarios, covering the period up to 2100, including scenarios that can fulfill the EU target of a maximum of two degrees global average temperature increase compared to pre-industrial levels [EC, 2001]. Table 3.1 in paragraph 3.4 summarizes the scenarios discussed in this chapter.

3.2 SHORT-TERM SCENARIOS UP TO 2010

Taking the *CAFE* baseline scenarios as a starting point it implies that up to 2010 two alternative projections[8] will come available:

(1) Implementation of existing measures for climate change only, not necessarily resulting in compliance with the Kyoto Protocol targets **(NK scenario),** (No Kyoto ratification)

(2) Meeting the targets of the NEC directive/Gothenburg protocol plus the Kyoto Protocol, with additional policies, including emissions trade within the EU and use of Kyoto mechanisms (***KR-scenario). (Kyoto Ratification)***

The *first (NK-) scenario* will come available from the RAINS and PRIMES models. This projection includes national policies and measures aimed at achieving the air emission targets (ceilings). It should however be noted that according to current insights, based on national programmes, many countries will not reach their climate (Kyoto protocol) nd air pollution (NEC) targets with existing policies and measures. If not covered by the CAFE Baseline project, non-CO_2 GHGs, carbon sinks and potential use of Kyoto mechanism will be added by ETC/ACC to the results from CAFE The ETC will compare the NK-scenario with countries' own scenarios included in their national programmes (available from the EU GHG Monitoring Mechanism and the EU NEC Directive).

The *second (KR-) scenario* will also come available from CAFE/DG TREN (PRIMES) work on Kyoto implementation (for CO_2). ETC/ACC contributes by supplementing this projection with non-CO_2 gases and carbon sinks. The PRIMES results for cost-effective implementation of the KP, assuming EU internal emission trading and KP mechanisms has become available for CAFE in May 2003. These includes the underlying scenarios for driving forces. The ETC will compare the KR-scenario with countries' own "with additional measures" scenarios included in their national programmes (available from the EU GHG Monitoring Mechanism and the EU NEC Directive).It is still to be decided if additional sensitivity[9] runs would be useful to explore the importance of variations in socio-economic driving forces and policies other than energy, climate and air pollution.

CAFE baseline variant considered as a contribution from EEA ***(KR-A scenario):***

In December 2002 political agreement was reached on the EU emission trading directive. An important aspect will be the allocation of the emission per country falling under the trading regime. It could be of interest to perform an additional analysis of the implemention of the

[8] Both projections will come available in two versions, one made by the member states and one as an European wide (top-down) perspective. For the SoEOR2005 report it is proposed to use the European wide perspective and use the member state view for comparison.

[9] A "scenario" here is considered to represent a comprehensive set of input assumptions and output results through the full DPSIR chain with fully analysed and scrutinized quantification and adequate reporting of the methodology used. A sensitivy run takes one factor out the (often) DP chain with limited quantification through the remaining of the DPSIR chain.

directive, using the allocation plans as provided by countries, and to calculate the trading permit price assuming the same CO_2 reduction as under the second scenario (instead of assuming a fixed price). For the emission of sectors not falling under the directive shadow carbon price for each country will be derived. This scenario will result in a different CO_2 projections for individual EU-countries, compared to the KR-scenario, and thereby the co-benefits for air emissions will differ also.

3.3 MEDIUM-TERM SCENARIOS 2010-2020/2030

A. CAFE scenarios (NK-, KR-):

The main scenario for this period will be based on the scenarios as developed in the CAFE process. These scenarios are derived from the new energy scenarios 1990-2030 (PRIMES) and new transport forecast scenarios (SCENES)[10].

An important element of producing medium-term scenarios is the need for assumptions on possible post-Kyoto targets for a potential second (2013-2017) and/or third (2018-2022) commitment period, or for a different post-Kyoto international emissions control regime. Such assumptions are quite uncertain, because the formal international negotiations will only start around 2005. We propose to make use of the results of the CAFE baseline project. In the CAFE projection a fixed carbon price is assumed that will lead to some reduction of GHG emissions in the EU by 2020/2030, the remaining necessary reduction to comply with the Kyoto protocol is assumed to be fulfilled through the use of flexible mechanisms.

B. EEA sustainable emission pathway variant (SEP)

As a step to a long term sustainable emission pathway we propose an approach incorporating abatement targets, based on the EU commission strategy proposal for sustainable development[11] (see furthermore chapter 4), by assuming a target of an additional 8% reduction from 2010 to 2020. The most cost-effective policies and measures and associated driving forces will be analyzed in this additional scenario analysis that will be performed by the ETC/ACC consortium. The results of this sustainable emission pathway variant will becompared with the results of the CAFE baseline, to identify and explain the differences and to show the potential additional environmental benefits of a further reduction in GHG emissions by 2020 (compared to the CAFE baseline by 2020) and furthermore also by 2030.

3.4 STORYLINES FOR THE SCENARIOS

The storylines for the scenarios described in section 3.3 are presented below.

The first (NK-)baseline addresses the question what can happen to our environment if no additional sectoral environmental policies would be adopted in Europe after 2012, and the Kyoto and NEC targets would not be met, which could be considered an “Environmentally unfavourable” scenario. The 2004 review of NEC and the not yet “into force” of Kyoto leaves room for an unfavourable scenario starting from current implemented policies with no new measures from 2004 onwards. This situation could occur if Russia will not ratify the Kyoto protocol and the European Union after 2010 would focus on the further integration of the enlarged EU, giving priority to economic development over environmental concerns. In this situation we assume that there will be no additional environmental restrictions set for the sectors[12] (Energy, Transport, Agriculture, Enterprise). This scenario will therefore consist of a

[10] Scenes forecast is not expected to become available in 2003, therefore the testrun for the transport scenarios will be based on PRIMES and POLES.

[11] European Commission, 2001. A sustainable Europe for a better world: A European Union strategy for sustainable development. Communication from the Commission to the Council and the European Parliament. COM (2001) 264 final. Brussels, Commission of the European Communities and the European Council conclusions (Gothenburg, June 2001).

[12] Successfull implementation of this scenarios requires some consultations or additional support to run specific sector models as for example for the Agricultural (CAPRI) and Transport (SCENES) sectors.

combination of a number of individual analyses, which each individually change only one or a few parameters. The combination should be policy relevant, plausible and meaningful (in terms of environmental benefits)[13]

In the *KR*, *KR-A* baselines and in the SEP scenario it is assumed that the current agreed targets for e.g. NEC and Kyoto will be met, with, for the SEP-scenario a post-2010 situation based on the Commissions proposal made at the sustainable conference in Gothenburg in 2001. At the Gothenburg European Council in 2001 the European Commission proposed an European Union Strategy for Sustainable Development (COM(2001)264 final), which states that the EU should aim for its post-Kyoto commitment for an average reduction of emissions of atmospheric greenhouse gases by the European Union by an average of 1% per year over 1990 levels up to 2020 (The Kyoto protocol has established emission ceilings as an average for the period 2008-2012).
This implies an additional 8% emission reduction for the period 2010-2020. Other (than EU) countries participating in the Kyoto protocol did not (yet) make similar proposals, so we need to make assumptions about the post-Kyoto emissions of these other countries as well as assumptions for countries not participating in the Kyoto Protocol, notably the United States, Australia and the developing countries.
Proposed is a scenario whereby the Kyoto protocol with the existing parties continues, including all OECD countries. Assumed is that the Annex 1 Parties keep their commitment at the same magnitude as agreed upon in the first commitment period. For the OECD countries entering the post Kyoto Protocol it is assumed that they keep emissions for 2020 at the 2010 levels, with the exception of the US, where we assume that it will confirm its first Kyoto target of –7% compared to 1990 levels[14][15]. For non OECD/Annex 1 countries, baseline emissions are assumed minus CDM results from the first commitment period. Proposed is to take the baseline (POLES energy) scenario from the GECS project (Criqui et. al., 2002[16]) or the LREM baseline developed by NTUA.

For the period 2020-2030 global participation will be assumed and convergence to equal emission per capita by 2092[17], with an interim objective of convergence of OECD countries in a period of 50 years (for an overview of different burden share regimes see annex 5). A convergence scenario is in line with the EU proposal of 1997 that emission paths should eventually convergence to similar per capita or per GDP levels, although no timeframe or levels were specified (see also Hohne et. al, 2003).
Derived from this assumption the stabilisation year of world GHG emissions and concentrations will be calculated and the associated required global and EU emission reduction target for 2030[18]. These emission targets are consistent with an environmental goal a 550 CO2 ppm equivalent stabilization target[19] and the EU 2 degree goal for global average temperature. (see also chapter 4).

[13] Proposed is to base this scenario on the energy baseline as released by DGTREN during 2003

[14] The US abatement assumption is considered as necessary if long-term sustainable targets are to be reached. In addition, it could be mainly achieved through JI and CDM.

[15] The OECD countries joining the annex 1 country can agree on emission intensity targets or absolute emission ceilings, due to the fact we will use one scenario, i.e. the results will be the same.

[16] Criqui et. al., (2002), Criqui, P., Tulkens, P., Vanregemorter, D., Kitous, A., Tuan, Nguyen Anh, Kouvaritakis, N., Paroussos, L., Stroblos, N., Tsallas, S., Graveland, C., Bouwman, A.F., Vries, B. de, Eickhout, B., Strengers, B.J., Eckermann, F., Loschel, A., Russ, P., Deybe, D., Fallot, A., Greenhouse Emission Control Strategies (GECS) final report, November 2002, Grenoble, France, Research project EVK2-CT-1999-00010, DGresearch.

[17] 100th Anniversary of UNFCCC Climate Change convention.

[18] Similar targets, under different burden regimes have been evaluated in the recent WBGU study "Towards Sustainable Energy Systems" (2003), in the UK Energy white paper on the UK long term ambition of 60% reduction by 2050 (Energy white paper, Our energy future – creating a low carbon economy", 2003) and a recent German study "Evolution of commitments under the UNFCCC: Involving newly industrialized economies and developing countries" (Ecofys, 2003).

[19] Earlier work showed this implies a CO2 target of approximately 470 ppm.

3.5. PROPOSED VARIANTS AND SENSITIVITY RUNS

Variation in economic/energy assumptions

Autumn 2003, NTUA will publish a number of sensitivity runs carried out with PRIMES, for the European Commission, around the LREM energy baseline scenario. We propose for the SoEOR2005 report to select some of these runs (if they show significant differentiation from the baseline) to calculate the impacts on air quality for reporting in the SoEOR2005 report (as an unsustainable scenario). In annex I an overview is given of characteristics of these sensitivity runs, which are likely to include low oil/gas prices, nuclear extension to 50 years lifetime in Europe, low support to renewables, moderate economic growth, moderate energy efficiency improvement, and slow EU enlargement and convergence.

Additional sensitivities and variants are suggested around the "EEA Sustainable emission pathway (SEP)" scenario. Three types are suggested, with in brackets the year in which ETC/ACC will perform the scenario runs:

1. ***Sensitivity for high oil/gas prices (run in 2003)***

2. ***Economic variants (2004 with preparation in 2003).***

One set of variants will focus on different assumptions for socio-economic developments. These addresses the question to what extent such changes would help or constrain the European developments becoming more sustainable. This will include:

- A combination of high economic growth accompanied by rapid progress in EU enlargement and rapid economic and technological convergence between "old" and "new" member states.
- Internalization of external costs through systematic economic incentives both on demand and supply side for environmentally sound technologies and practices[20].
- A variant exploring the consequences of rapid structural economic changes in Europe associated with the goal to make the EU the most competitive knowledge economy in the world (Lisbon agreement), also including behavioural changes[21].

3. ***Technology variants (2004 with preparation in 2003).***

   These variants include technology progress stimulated by policy shifts developed around the "EEA Sustainable emission pathway (SEP)" scenario assumptions on technology efficiencies and costs (i.e. technological progress), experience and learning effects, R&D policies, etc.[22]. Due attention will be paid to the comparison of marginal costs resulting from the abatement scenarios and the technology stories and policy shift runs. The following technology lines will be considered:

   - *Renewables.* A high penetration of renewable sources (12% of the energy consumption and 22,1 % of the gros electricity consumption)[23] in 2010 and additional gains thereafter is considered. This variant can build upon an earlier PRIMES run (2002-2003). Special attention would be paid to biofuels, evaluating consistency with agriculture and land use scenarios. IMAGE (land-use change) could be used here next to PRIMES (energy system in Europe) and POLES (biofuel trade). Per country indicative targets has been set in the directive, see annex 4. For this scenario the results of the EEA report on biofuels need to be taken into account (forthcoming, 2003).

[20] A shift of agricultural subsidies to environmental and sustainable agricultural practices will be analysed in more detail in a separate scenario project subcontracted by the EEA, focusing on the implications for the environment with RAINS.

[21] To what extent behavioural changes can be quantified will be explored in 2003.

[22] There is a need to check what has already been done or is planned to be done within the CAFE and L-REM projects before deciding on the nature and the number of technology stories and policy shift runs, especially regarding the nuclear issues.

[23] Presidency conclusions Gothenburg European council 15-16 June 2001: "*Furthermore reaffirms* its determination to meet the indicative target for the contribution of electricity produced from renewable energy sources to gross electricity consumption by 2010 of 22% at Community level as set out in the Directive on Renewable Energy.", Directive 2001/77/EC, L283/33, 27-10-2001.

- *Hydrogen.* One technology variant would look at the potential of a series of individual hydrogen technologies, including a broad diffusion of fuel cells in the energy (power industry) and transport sectors. Taking into account the time scales needed to develop a full hydrogen economy and the associated complexity, for the timeframe from 2020-2030, only individual technologies will be addressed. Specific attention will be given to innovative options to reduce the environmental pressure of the transport sector by fundamental changes in transport modes and technologies.

- *C-capture and disposal*. One variant would address the potential of carbon capture (at key point sources such as power plants and refineries) and disposal (underground in aquifers and empty oil and gas reservoirs) in Europe as a means to reduce GHG emissions.

- *Nuclear.* 'Accelerated nuclear phase-out' scenario.

3.6 LONG-TERM SCENARIOS (2050-2100)

3.6.1. INTRODUCTION

A long-term (i.e. 2050-2100) view is important because of the long-term processes connected to climate change:

(a) the slow response of the climate system to GHG emission reduction measures,

(b) the slow development of impacts, for example on ecosystems and human health (in the baseline scenario with no climate change policies, but also after the implementation of policies and measures) and

(c) the inertia in socio-economic systems, e.g. the long time needed to adapt the structure of the energy system.

Thus, a long-term view is needed to evaluate the effectiveness of short-term policy action. The key question in this evaluation is:

> "Are the projected (medium-term) emissions paths up to 2030 on a possible road toachieving long-term sustainable climate and GHG concentration goals or which sustainable emission path up to 2030 is required to achieve such long-term sustainable levels?"

This question should be evaluated from the broader perspective of sustainable development, in particular because climate change impacts have and are projected to have most serious consequences in least developed countries, which are often the most vulnerable. Such a broader perspective is reflected in the ultimate objective of the UNFCCC, which states that concentrations of greenhouse gases have to be stabilised:

> "to avoid dangerous interference with the climate system …… within a time-frame sufficient to allow ecosystems to adapt naturally to climate change; to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner".

There is no global agreement at which level stabilisation should occur and in which time frame. However, the Council of Ministers of the European Union formulated a political objective on what constitutes "dangerous" interference. It agreed that:

> "global average temperature should not exceed 2 ^{o}C above pre-industrial level and therefore concentration levels lower than 550 ppm CO_2 should guide global limitation and reduction efforts" (6EAP).

For the largest part of the range of estimated climate sensitivities, the first (temperature) goal is stricter and is closer to 450 ppm CO_2 stabilisation [Eickhout et al, 2003].]. The targets of stabilization of long-lived GHGs such as CO_2 require scenario analysis with a time frame of about a century or more. Therefore, in addition to the short (2010) and medium (2010-2020/30), it is proposed that the SoEOR2005 also addresses the long-term up to 2100.

In the SoEOR2005 report, the linkages between climate change and air quality are of particular importance. Different from other world regions, the European Union has formally specified targets in the areas of both climate change and air quality, which can be taken into account in the scenario analysis for the report. Also, policy linkages between climate change and air quality have a long-term component, because significant reductions of GHG emissions (needed to achieve stabilization of GHG concentrations) and controls to meet stringent air quality goals in a cost-effective fashion may both require similar types of changes in consumption (behavior) and production systems (technology) as well as in economic structure. The specific characteristics of the energy system including a long lifetime of infrastructure may make postponement of changes more difficult in future. For example a further emphasis on developing the energy system towards the usage of unconventional oil and gas resources may not be compatible with an alternative energy system based on renewable fuels, which will need a long time to mature.

3.6.2 SELECTION OF SCENARIOS

Questions that should be addressed by a long-term scenario analysis for SoEOR2005 are:

1) What will be the *potential impacts* of and vulnerability to climate change in Europe in the long run and how would these impacts be reduced if GHG concentrations would be stabilized at different levels (including the EU long-term goal)?
2) Are there *sustainable emissions paths* up to 2020/2030 that can be the base of possible roads to meeting the long-term 2 ^{o}C temperature increase goal of the European Union?
3) How do the GHG emissions in Europe relate to the emissions in other world regions dependent on different possible future global response regimes – e.g. based on different *equity principles* (see annex V for an overview) - and regional policy and measures, taking the EU long-term climate goal as a boundary condition?
4) Which *technological and socio-economic changes* are needed in order to meet long-term goals?
5) What are the *co-benefits* in terms of reduced air pollution of scenarios, which lead to stabilization of GHG emissions? What are other side-effects within Europe, and how does climate and air quality policies in Europe affect regions outside Europe?

The following practical questions are important in the process of selecting and defining long-term scenarios, that are capable of answering these policy questions:

- How to evaluate climate change, i.e. what are appropriate climate change state and impact indicators, and which time frame is most relevant (2050, 2100, beyond 2100?)?

- How to deal with global emissions (of greenhouse gases and air pollutants) beyond 2030; e.g. assume continuation of the trends of the earlier time periods, or assume stabilization of GHG concentrations or yet other scenarios?

We propose to address these two issues by using several scenarios that are already available, notably those of the IPCC (SRES, 2000). These long-term scenarios (for 2050-2100) are not suitable for analyzing costs and benefits of climate mitigation at shorter time scales. They do however (by design) very well cover the range of plausible futures of societal driving forces and GHG emissions, and have been used to explore possible climate consequences and associated impacts. Notably, while the IPCC scenarios may be adequate in terms of projecting a wide range of GHG emissions at global and regional levels, they are somewhat conservative in accounting for likely control of ozone precursors (NO_x, CO, VOCs).

SRES scenarios do not include climate policies, but have been used in IPCC's Third Assessment Report as a basis for analysing the costs of stabilising CO_2 concentrations at various levels (Morita et al., 2001). A limited number of impact analyses for mitigation/stabilisation scenarios is available (e.g. globally from the IMAGE model, in Europe for the UK), but some additional analysis for SoEOR2005 isproposed.

With regard to *question 1* climatic changes using the SRES reference scenarios have been analyzed by different research groups, but only few results are available for impacts associated with these climatic changes. Therefore the currently available results of impact analysis at the European level [ref.] should be complemented by additional scenario analysis, with the IMAGE modeling framework.

Question 2 is already addressed in chapter 3. For SoEOR2005 several possible pathways for 2030 are extensively analysed, the so-called "Sustainable Emission Pathway" and various variants. These all build on the links between long-term and medium GHG concentration goals. . In the mid-1990s, in the Netherlands the Safe Landing Analysis was developed to analyse the links between long-term climate goals and short and medium term emissions corridors, and in Germany a similar approach was followed: the Tolerable Windows Approach , which were used in support of the negotiations of the Kyoto Protocol and its first commitment period. It is proposed that for SoEOR2005 an analysis is performed of possible global 2020/2030 pathways that are consistent with various different long-term goals, using the available results of existing modelling exercises (Safe Landing and/or Tolerable Windows) and, if relevant, to update these with new data/information.

To address *question 3* (European emissions pathways in relation to emissions pathways in other countries) existing work from the IMAGE/POLES team will be used, which includes work in support of the UNFCCC negotiations as well as post-SRES scenario exercises together with other modelling teams (REDEM, 2003). An analysis will be performed of this and other existing information on scenarios for the attainment of the long-term climate goals with different equity and burden sharing principles (see Annex V) such as a decrease of the gap between per capita emissions in developed and developing countries. Based on the outcome of this analysis a decision will be made which additional scenario(s) runs should be performed for SoEOR2005.

With regard to *question 4* (technological and socio-economic changes) also use willbe made of the post-SRES scenario exercise referred to above. In this exercise the modeling teams explored different combinations of social and technological changes to meet GHG stabilization goals. For the SoEOR2005 work an analysis will be performed of the existing available scenarios. Based on the outcome of this analysis a decision wil be made which additional scenario runs should be performed. This could focus on deep technological change towards a hydrogen energy future, which can be further elaborated using the IMAGE/TIMER model for analyzing the global and regional long-term future, and using the POLES and PRIMES models to elaborate the European detail for the short to medium term.

As to *question 5 (*co-benefits) it should be noted that earlier studies seems to suggest that most benefits can be expected before 2050. Therefore for SoEOR2005 it is proposed to focus the analysis on co-benefits for 2030 (see chapter 3) and not to perform this analysis for 2050.

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3.7 SUMMARY OF PROPOSED SCENARIO RUNS

In table 3.1 the proposed scenarios are summarized. A decision on the selection of all or a part of these proposed scenarios is foreseen in July 2003 after consultation by EEA on the SoEOR2005 with stakeholders, including member countries, the European Commission and NGOs (environmental, industrial).

Table 3.1 Summary of proposed scenarios for SoEOR2005

Period	Scenario/variant	Description activity ETC/ACC
1990-2030	CAFE: No Kyoto ratification (NK-baseline)	• Add non CO2 GHG's • Select a comparable SRES scenario for long trend projection after 2030? • Add climate change impact indicators?
1990-2030	CAFE: Kyoto ratified (KR-baseline)	• Add reduction non CO2 GHG's (2010: 12 Euro/ton CO2-equiv → 2020 20 Euro) • Add potential sinks reductions for a permit of 12 Euro (2010) → 20 Euro (2020) • Determine the remaining required emission reduction to be reached by the use of flexible mechanisms and calculate the likely costs, permit price and distribution among the instruments.
1990-2030	Variant CAFE: Kyoto ratified with allocated emission trading (KR-A baseline)	• Assume equal emission reduction as in KR-baseline, calculate the expected trading permit price and shadow carbon prices per country based on the forthcoming Commission emission trading directive proposal. • Assume full (i.e. global) trading after 2010 only
2010-2030	EEA sustainable emission pathway baseline (SEP-baseline)	• KR or KR-A scenario up to 2010 • GHG target 2020 an addition -8% for EU-25, other annex 1 countries continue a reduction similar to their current Kyoto target. Non-annex 1, OECD countries will enter the protocol[24] • Other Non-Annex 1 countries agree to baseline emissions. • Period 2020-2030 global participation assumed and convergencee to equal emission per capita by 2092[25], with an interim objective of convergence of OECD countries in a period of 50 years. Derived from this assumption the stabilisation year of world GHG emission will be calculated and the required global and EU emission reduction target for 2030 assuming a 550 CO2 ppm equivalent target[26]. Assuming full internal EU trade; the reduction and costs for each EU-country will be calculated.[27]

[24] South Korea and Mexico could be assumed to enter an obligation comparable to a constant baseline emission compared to 2010 levels. For USA it is assumed that they agree to reach first kyoto target of 2010 (-7% compared to 1990 levels). For the scenario result energy intensity targets or absolute emission ceiling can both be possible due to the use of one baseline scenario.

[25] 100th Anniversary of the UN Framework Convention on Climate Change.

[26] Earlier work showed this implies a CO2 target of approximately 470 ppm.

2010-2030	Sensitivity	Sensitivity for high oil/gas prices
	Economic variants	The following economic variants are proposed • A combination of high economic growth accompanied by rapid progress in EU enlargement and rapid economic and technological convergence between “old” and “new” member states. • Internalization of external costs through systematic economic incentives both on demand and supply side for environmentally sound technologies and practices • A variant exploring the consequences of rapid structural economic changes in Europe associated with the goal to make the EU the most competitive knowledge economy in the world (Lisbon agreement), also including behavioural changes
	Technology variants	The following technology variants are proposed (preparation 2003, delivered in 2004) • *Renewables.* A high penetration of renewable sources • *Hydrogen.* One technology variant would look at the potential of a series of individual hydrogen technologies • *C-capture and disposal*. One variant would address the potential of carbon capture (at key point sources such as power plants and refineries) and disposal (underground in aquifers and empty oil and gas reservoirs) in Europe as a means to reduce GHG emissions. • *Nuclear*. ‘Accelerated nuclear phase-out’ scenario
2030-2100	IPCC-SRES baseline variants Sustainable emission pathway	Sustainable emission pathway variant assumption: Complying with an EU target of a maximum global average temperature increase, compared to pre-industrial time of 2 degree; for the purpose of SoEOR 2005 report a compliance date of 2092 is assumed and a CO2 concentration target is derived assuming average climate sensitivity.

[27] The KR-scenario, with an internal permit price of 12 Euro/ton CO2 implicit assumes a permit price for use of flexible mechanism that is most likely substantial less then 12 Euro/ton CO2. Earlier work however, earlier work (Kiev technical report, EEA, 2003) showed considerably co-benefits for air quality targets, up to 50%. Taking this into account the internal price, from a combined cost-effective solution, could be approximately twice the price of a trading permit.

4 PROPOSED TIME SCHEDULE

The proposed methodology for the SoEOR2005 report scenario work is complex and the risk of unforeseen problems considerable. Therefore it has been decided to use the year 2003 to carry test runs to detect bottlenecks in implementing and use of the selected scenarios. In this section an overview will be given of the steps foreseen in carrying out a test run in 2003. Figure 5.1 give a short overview of the main characteristics of the work to be carried out. Table 1 give the main input and output expected from the different models and organizations (mostly within ETC/ACC) in relation to the proposed indicators to be calculated.

Table 1 Timeline and outputs (for definition of indicators see tables , below)

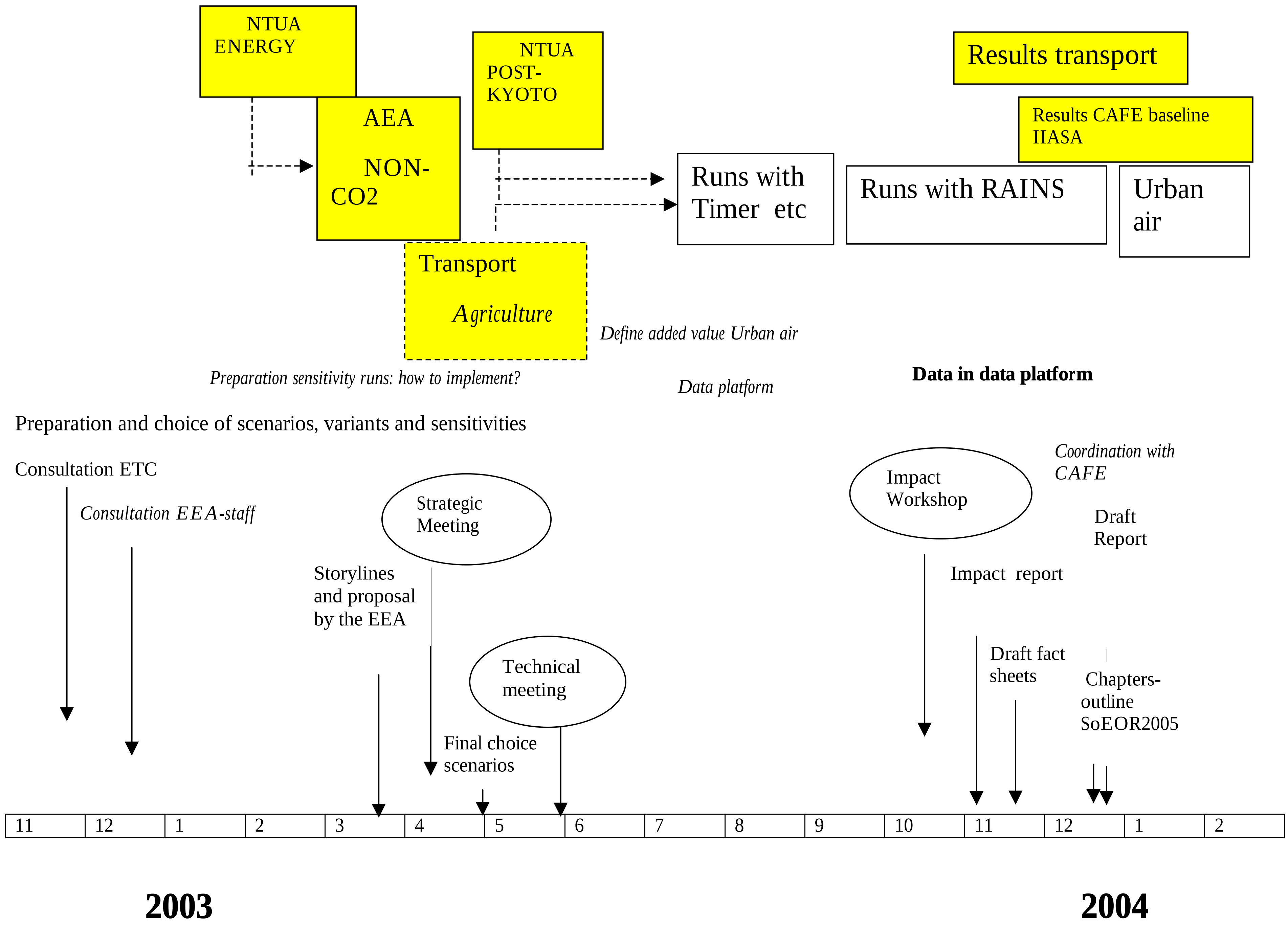
Date	Deliverable	Organisation	Model	Data input *	Indicator Output*
Already available by May 2003	Country reports for NEC directive	MS Countries (via EC to IIASA)			AP1-7 - projections for 2010 - projections extra measures to reach goal
	CAFE Baseline Energy + Transport + Kyoto –8% (KR)	NTUA	PRIMES	D1, D2	D1,D2,D3,D4 CC2
	CAFE baseline sinks + Kyoto –8%, Europe wide (KR=KR-A)	RIVM	timer	D1,D2,D3, D4, CC2	Land related emissions and sinks
June 2003	CAFE Baseline non-CO_2 GHG (KR=KR-A)	AEA T		D1,D2,D3,D4	D7, D8, D10 CC1,CC3,CC4,CC5
June 2003	Definition long term scenario goals (2050/2100) and derived interim Goal 2030	RIVM			
June 2003	Draft proposal of organisation stakeholder involvement	RIVM			
June 2003	Note on Scenario Platform	RIVM			
June 2003	Energy Kyoto + Post Kyoto (KR)	NTUA	PRIMES	D1,D2	D1,D2,D3,D4 CC1, CC6a*
June 2003	CAFE baseline sinks + Kyoto –8%, country specific (KR=KR-A)	RIVM	timer	D1,D2,D3, D4, CC2	Land related emissions and sinks
June 2003	Transport Kyoto + Post Kyoto (KR, KR-A)	NTUA	PRIMES	D1,D2	D6, CC6a*
July 2003	Test run Climate Impacts (KR,KR-A)	RIVM	IMAGE TIMER/ POLES[28]	Energy projections SRES	CC7,CC8, CC9,CC10, CC11,CC12, CC13
July/august	Define global projections (KR, KR-A, SEP)	RIVM/IPTS/NTUA	POLES/ TIMER/ PRIMES /TIMER /FAIR	Story line, baseline	…[29]
September 2003	CO2 + Non-CO2 Differentiation Europe (KR, KR-A)	NTUA, AEA T			D1,D2,D3,D4 CC1, CC6a*

[28] The Institute for Prospective Technological Studies (Joint Research Centre-European Commission) contributes to the development of air and climate change scenarios under the framework of the EEA-IPTS Cooperation Agreement "Energy and transport prospective analysis in view of the SoEOR2005 report".

[29] Indicators available at global/regional level, no EU-country specific indicators

September 2003	Proposals Agricultural scenario (SEP)	AEA		D1,D2,D3,D4 CC6a*	D2, D7, D8, D10 CC1,CC3,CC4,CC5, CC6b*
September 2003	Proposal environmental friendly transport systems+ 1 example case transport technology (SEP)	IPTS, NTUA, LAT	POLES, PRIMES, others	-	
October 2003	Workshop on Impacts	IIASA		- Results sensitivity runs	Decisions on: -What impact indicators -Final runs -Harmonisation -how to proceed writing the chapters
November 2003	Activity Data for other ETC's	ETC/ACC			
November 2003	Factsheets Transport/energy/ non-CO_2	AEA			
December 2003	Air Pollution emission and impacts (KR, KR-A) Interim Report: Scenarios+ impacts	IIASA	RAINS	D1, D2, D6, D7, D8, D9 D10	AP1-7, AP9-17, AP23-24
January 2004	Technical Report Scenarios Air and Climate Change	RIVM +Others			Conclusions and recommendation for definitive scenarios
April 2004	Workshop with stakeholders (countries, Commission, others) on environmental sustainable scenario(s)	EEA/RIVM/countries/Commission			Present and discuss draft technical report

* *CC6a = effectiveness CO_2 policy, CC6b= effectiveness non-CO_2 Policy*


NTUA ENERGY
AEA
NON-CO2
NTUA POST-KYOTO
Transport
Agriculture
Runs with Timer etc
Runs with RAINS
Urban air
Results transport
Results CAFE baseline IIASA
Define added value Urban air
Preparation sensitivity runs: how to implement?
Data platform
Data in data platform
Preparation and choice of scenarios, variants and sensitivities
Consultation ETC
Consultation EEA-staff
Strategic Meeting
Storylines and proposal by the EEA
Technical meeting
Final choice scenarios
Impact Workshop
Coordination with CAFE
Draft Report
Impact report
Draft fact sheets
Chapters-outline SoEOR2005
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2003
2004

ANNEX 1: OVERVIEW OF SENSITIVITY RUNS FOR THE LREM ENERGY BASELINE SCENARIO (PRIMES/ACE)

INTRODUCTION

January 2003 NTUA/DG TREN will publicize new energy scenarios (a baseline and a (post)-Kyoto implementation scenario) for the EU for the period 1990-2030. For the baseline also some sensitivity analyses have been undertaken by NTUA. This sensitivity runs (for a summary see below) will be published summer 2003. On request of EEA two new energy sensitivity runs will be carried out late 2002/beginning 2003; a technology frozen scenario and a scenario meeting an additional 1% Energy Intensity Target. For a summary of these scenarios see the end of the section.

SENSITIVITY RUNS PRIMES

Scenario on fossil fuels (I)

a) Examination of world market trends that could result in high oil and/or gas prices (justification for higher price trajectories especially for a case with considerably higher natural gas prices than oil prices) - focus on the geological, technological, economic and political factors underlying the price assumptions to be used in the modeling analyses with the PRIMES model;
b) PRIMES model runs for high oil and gas prices according to findings under a;
c) PRIMES model runs for moderate oil but high gas prices on the basis of findings under a;
d) In depth modeling analysis of the price case examined in an exploratory fashion under the Bon de Commande (TREN 4.1040/E/2000-001 of 6.7.2000) to support the Green Paper on energy security;

Variant on high prices in the medium term (II)

b) Energy (and transport) consequences of high medium term oil and/or gas prices (different combinations);
c) Analysis of the reaction of the overall economic system on higher oil and/or gas prices;

Scenario on non fossil fuels (III)

a) Nuclear phase-out by 2010 (revisit the case examined under the Bon de Commande (TREN 4.1040/E/2000-001 of 6.7.2000) to support the Green Paper on energy security in the light of comments from the Commission and eventually other stakeholders and in the light of improved modeling capabilities especially with regard to non-EU 15 states);
b) Nuclear lifetime of 30 years without the possibility of replacing nuclear by nuclear;
c) Extension of lifetime of nuclear plants to 50 years;
d) Introduction of a competitive new nuclear technology based on improved design and inherently safer characteristics likely to improve public acceptability;
e) Projection of high penetration of renewable sources (close to the 12% target in 2010 and with additional gains in market share beyond that date);
f) Combination of a and e to investigate to what extent renewable sources (supported with the same policy intensity as under e) are economically capable to fill the hypothetical gap caused by the nuclear phase-out in preference to fossil fuel alternatives;
g) Combination of Ib (high oil and gas prices) with IIId and IIIe (favorable development for nuclear and renewables) to show the impact of high fossil fuels prices on zero carbon fuels that receive political support;

High economic growth variant (IV)

a) Macro-economic and sectoral analysis reflecting the ambitions for high economic growth following the Lisbon summit: 3% p.a. economic growth for EU up to 2010 and higher growth for other European countries as well as higher than baseline growth thereafter;
b) Model runs with different economic parameters such as GDP and production of industrial branches;

Variant on energy efficiency (V)

a) Projection incorporating actions along the lines of the action plan for energy efficiency (COM (2000) 247 final of 6.4.2000) focusing on key actions that can be modeled; this is complemented by a development with better energy intensity for candidate countries and direct neighbors (Norway and Switzerland);

b) Combination of Va and 3e (strong support for renewables) in order to analyze possible trade-offs;

Variant summarizing both a more optimistic and a more pessimistic development (VI)

a) Optimistic development combining high economic growth (IV) with better energy intensity (Va) and a more favorable environment for zero carbon fuels (IIId and IIIe) under moderate energy prices;

b) Pessimistic development combining high oil and gas prices (3b) with a nuclear phase-out (IIIb or IIIa - to be decided at a later stage) unaccompanied by stronger support for renewables under moderate economic growth and moderate energy intensity improvements.

FROZEN TECHNOLOGY

The aim of a frozen technology scenario would be to identify the contribution of technological energy efficiency to the improvement in energy intensity. We are interested in investigating which countries and which sectors display this potential for technical improvement.

The technology performance will be frozen at 2000 levels, such that there is no improvement in energy efficiency performance. This implies that new plant (either as a result of plant replacement or satisfying increasing demand) is assumed to have the same performance as existing plant, and existing plant performance remains fixed (i.e. no retrofit improvements taken up).

Ideally, this frozen technology scenario will be run whilst maintaining the same evolution of economic structure as shown in the DG Tren baseline scenario.

MEETING ADDITIONAL 1% ENERGY INTENSITY TARGET

The aim of this scenario is to investigate the implications of meeting the Commission's target to improve energy intensity by 1% beyond that which would otherwise have happened. The models will therefore be constrained to meet an additional 1% reduction in energy intensity (defined at the economy-wide level, toe/GDP) beyond that shown in the DG Tren baseline for each EU and candidate country in the models. In addition to analyzing the contribution of the different sectors to the reduction in intensity, attention will be paid to the following points:

- The marginal cost of achieving the additional 1% intensity reduction in each country. This would be derived from the shadow costs used to drive the uptake of energy efficient options, and would be expected to be equal across all sectors (i.e. a single marginal cost value would be derived for each country).
- The total additional cost to the economy as a whole of going beyond the baseline to achieve the additional 1% intensity reduction for each country. This may require more than one run to be carried out in order to get an approximate shape of the cost curve for intensity reduction, such that the total costs can be derived as the integral under the curve.

Ideally, the same evolution of economic structure as shown in the DG Tren baseline will be maintained, in order to identify the contribution of energy efficiency to achieving the additional 1% energy intensity improvement.

ANNEX 2: COMPARISON OF EXISTING SCENARIOS ON GDP, ENERGY CONSUMPTION AND CO2 EMISSION FOR 2020

This annex presents the projections of the PRIMES baseline scenario on GDP, energy consumption and CO_2 emission for 2020 in comparison with the projections of other baseline scenarios. Such a comparison may be helpful, for example, to show the range of different projections and how PRIMES results fit into this. The other scenarios considered are those listed below:

- The Economic evaluation of sectoral emission reduction objectives for climate change — Sectoral objectives study (SOS) which was carried out by Ecofys, NTUA, AEAT (2001)
- Four scenarios from the IMAGE implementation of the SRES scenarios (Special report on emissions scenarios) prepared for the Intergovernmental Panel on Climate Change (IPCC). Each represents a different philosophy about a future world (called SRES A1, B1, A2 and B2).
- Shared baseline scenario for air pollution up to the year 2020 (EEA, 2001b) which has updated projections on air pollution and greenhouse gas emissions, based on the EU shared analysis project.
- The results of the reference, low and high scenario in the International Energy Outlook provided by the Energy Information Administration (EIA).
- The *World energy outlook (WEO)*, which is carried out by the International Energy Agency. Here the projection from 2002 is considered.

Differences between the results of the scenarios exist, caused, among other factors, by the different tools and assumptions used. As the table shows, the results of PRIMES are within the range of the estimates of the scenarios of the other studies — but at the lower end of projected changes. An extended analysis and comparison of the different studies until 2010 could be found in the "Analysis and comparison of national and EU-wide projections of greenhouse gas emissions" (EEA, 2002).

Table 1. Comparison of existing scenarios on GDP, energy consumption and CO2 emission for 2020

Energy consumption (PJ)																	
		World	**WE /EU**	**EU - 5**	**NL**	**World**	**WE /EU**	**EU - 5**	**NL**	**World**	**WE /EU**	**EU - 5**	**NL**	**World**	**WE /EU**	**EU - 5**	**NL**
		1990				1999/2000				2010				2020			
SOS																	
IPCC GJ	A1F	356392	53827			400385	59136			533399	72385			700464	83233		
	A1B	356392	53827			400385	59135			532337	72358			696615	82573		
	A1T	356387	53826			400373	59137			528845	72186			675760	81561		
	A2	356392	53827			399940	58897			504640	69825			620289	78968		
	B1	356384	53824			398907	58745			486477	67020			568191	68948		
	B2	356392	53827			397498	58564			502534	67730			610707	70879		
ShaiR		346374	54505	41761	2741					488558	62380	45773	3434	624126	65322	47710	3893
PRIMES			***55293***	***42346***	***2797***		***60815***	***44969***	***3155***		***65972***	***47605***	***3351***		***69382***	***49513***	***3559***
IEO	L	365276	63095	45686	3587	402943	69637	48535	4009	482497	75018	52649	4326	552450	78394	54865	4537
	R	365276	63095	45686	3587	365276	69637	48535	4009	519742	78816	55393	4537	644666	85991	60352	4853
	H	365276	63095	45686	3587	365276	69637	48535	4009	571231	82509	61723	4642	768113	92849	65416	5170
WEO 2002						384306	60960			466075	68036			551276	72390		
GDP (billion euros 2000)																	
		World	**WE /EU**	**EU - 5**	**NL**	**World**	**WE /EU**	**EU - 5**	**NL**	**World**	**WE /EU**	**EU - 5**	**NL**	**World**	**WE /EU**	**EU - 5**	**NL**
		1990				1999/2000				2010				2020			
SOS			6978	5446	301		8518	6545	401		10811	8220	507		13601	10297	635
IPCC	A1F	25510	7648			33039	9423			46742	12099			68069	15337		
	A1B	25510	7648			33039	9423			46742	12099			68069	15337		
	A1T	25510	7648			33039	9423			46742	12099			68069	15337		
	A2	25510	7648			33039	9423			42461	11319			52822	13110		
	B1	25510	7648			33039	9423			45432	12114			62937	15170		
	B2	25510	7648			33039	9423			44192	11388			59276	13371		
ShaiR		31315					8851			57393	11228			79988	13462		
PRIMES			***6982***	***5449***	***301***		***8545***	***6568***	***401***		***10859***	***8258***	***503***		***13641***	***10321***	***630***
IEO	L	23667	7371	5550	308	29647	8678	6485	395	37430	10206	7614	467	44895	11453	8509	528
	R	23667	7371	5550	308	29647	8678	6485	395	41784	11375	8446	519	57959	14347	10634	653
	H	23667	7371	5550	308	29647	8678	6485	395	48202	14807	9438	578	74063	17265	12828	795
WEO 2002							8312				10415				12507		
CO_2 emissions (Mt CO2)																	
		World	**WE /EU**	**EU - 5**	**NL**	**World**	**WE /EU**	**EU - 5**	**NL**	**World**	**WE /EU**	**EU - 5**	**NL**	**World**	**WE /EU**	**EU - 5**	**NL**
		1990				1999/2000				2010				2020			
SOS			3232	2515	156						4377	3271	229				
IPCC	A1F	26847	3597			29337	3670			37569	4352			47458	5067		
	A1B	26847	3597			29330	3670			36986	4334			46585	4972		
	A1T	26862	3601			29275	3663			37143	4330			45217	4913		
	A2	26847	3597			29729	3663			36373	4184			43806	4756		
	B1	26880	3597			29146	3652			33066	4019			36912	4000		
	B2	26847	3597			28640	3641			35486	3960			42354	3956		
ShaiR		21289	3068				3127			30155	3289			39534	3500		
PRIMES			***3082***	***2410***	***153***		***3118***	***2309***	***166***		***3205***	***2346***	***174***		***3444***	***2499***	***184***
IEO	L	21366	3410	2592	213	22356	3447	2475	235	26800	3652	2640	238	30672	3799	2732	242
	R	21366	3410	2592	213	22356	3447	2475	235	29003	3832	2776	246	36117	4165	2633	260
	H	21366	3410	2592	213	22356	3447	2475	235	31922	4015	2926	257	43197	4499	3252	279
WEO 2002						22639	3141			27453	3422			32728	3689		
Population (million)																	
		World	**WE /EU**	**EU - 5**	**NL**	**World**	**WE /EU**	**EU - 5**	**NL**	**World**	**WE /EU**	**EU - 5**	**NL**	**World**	**WE /EU**	**EU - 5**	**NL**
		1990				1999/2000				2010				2020			
SOS			366	267	15		378	276	16		385	281	17		388	283	17
IPCC	A1F	5302	377			6118	393			6891	406			7623	416		
	A1B	5302	377			6118	393			6891	406			7623	416		
	A1T	5302	377			6118	393			6891	406			7623	416		
	A2	5302	377			6171	395			7171	413			8196	425		
	B1	5302	377			6118	393			6891	406			7623	416		
	B2	5302	377			6093	391			6896	399			7680	402		
ShaiR		5249	364				377	275	16	7027	383	279	17	7893	384	279	17
PRIMES			***366***	***267***	***15***		***379***	***276***	***16***		***388***	***282***	***17***		***390***	***284***	***18***
IEO	L	5255	377	266	15	5972	389	274	16	6817	391	274	16	7570	387	274	17
	R	5255	377	266	15	5972	389	274	16	6817	391	274	16	7570	387	274	17
	H	5255	377	266	15	5972	389	274	16	6817	391	274	16	7570	387	274	17
WEO 2002							377				378						

Explanation of the table

- Data and projections from SOS, Shair, PRIMES and WEO refer to EU countries, while IMAGE refers to OECD European countries. The International energy outlook (IEO) 2002 refers to Western Europe.
- In the bottom up report of SOS, the changes in activity levels between 2010 and 1990 are taken from the Shared Analysis baseline scenario (the previous results of the PRIMES model). That means that population and GDP data reported in SOS are the same as the results of the previous version of the PRIMES model.
- Since it was not possible to find data for all the required regions through the IPCC report, the data from the IMAGE model were used for all the IPCC scenarios.
- For 5 EU countries specific estimates where available and their combined value is shown (EU-5: Germany, UK, France, Italy, and the Netherlands).
- The source of the world data in the ShaiR project is the POLES model.

IMAGE, ShaiR (for the world data), the US scenarios and the WEO are using US dollars as a unit for the GDP. The units for each report are:
In the table, US dollars for each different year were translated to dollars for the year 2000 using deflator data from the World Bank. Similarly, Euros 1999 were translated to euros 2000 using deflator data from Eurostat. Finally, US dollars 2000 were translated to Euros 2000 using the exchange rate for the year 2000 from Eurostat data.

The original estimate of the described scenarios was:
- IMAGE: US dollars 1995/yr
- SHaiR: US dollars 1990 and euros 1999 (for EU data)
- PRIMES: euros 2000
- UScenarios: US dollars 1997
- IEA: dollars 1995

Sources of data:

- Ecofys, NTUA, AEAT (2001d): Economic evaluation of sectoral emission reduction objectives for climate change (SOS) — Summary of Bottom-up Analysis of Emission Reduction Potentials and Costs for Greenhouse Gases in the EU (Chris Hendriks et al.), contribution to a study for the Environment DG, European Commission, by Ecofys Energy and Environment, National Technical University of Athens and AEA Technology Environment (http://europa.eu.int/comm/environment/enveco/climate_change/bottom_up_analysis.pdf)
- EIA (2002): International energy outlook, Washington, DC.
- EEA (2002): Analysis and comparison of national and EU-wide projections of greenhouse gas emissions. Topic report 1/2002.
- EEA(2001): The ShAIR scenario: Air Pollution Outlooks - an Evaluation, Integrated Assessment Methodologies and Tools applied to Air Pollution and Greenhouse Gases. Topic Report 12, Copenhagen, 2001 http://reports.eea.eu.int/topic_report_2001_12/en/tab_abstract_RLR
- European Commission (1999): European Union Energy Outlook to 2020, Brussels.
- IEA (2002): World energy outlook, Paris.
- IMAGE team (2001): The IMAGE 2.2 implementation of the SRES scenarios, a comprehensive analysis of emissions, climate change and impacts in the 21st century, RIVM CD-ROM publication, Bilthoven
- IPCC (2000): Emissions scenarios — Special report on emissions scenarios (SRES), Cambridge

- Mantzos L., M. Zeka-Paschou. Baseline scenario in context of LREM framework contract. NTUA, Athens, April 2002.

Abbreviations

EIA Energy Information Administration (US)
GDP Gross domestic product
IEA International Energy Agency
IMAGE Integrated model to assess the global environment
IPCC Intergovernmental Panel on Climate Change
Mt CO_2 Mega (million) tonnes of CO_2 equivalents
OECD Organisation for Economic Cooperation and Development
RIVM Rijksinstituut voor Volksgezondheid en Milieu (National Institute of Public Health and the Environment), the Netherlands
SAP Shared analysis project for energy scenarios (European Commission, 1999)
ShAIR The shared baseline scenario for air pollution up to the year 2020 (EEA 2001)
SOS Sectoral objectives study (Ecofys, NTUA, AEAT, 2001a)
SRES Special report on emissions scenarios (for IPCC)
UNFCCC United Nation Framework Convention on Climate Change

ANNEX 3: PROPOSED (DRAFT) INDICATORS FOR INTEGRATED ASSESSMENT OF AIR POLLUTION AND CLIMATE CHANGE.

This indicator list is still under development. The indicators in bold are seen as essential air pollution and climate change indicators.

Indicator No.	Institute	Socio-economic and demographic driving forces and exogennous input	DPSIR
D1	NTUA	GDP growth (total & by sector)	D
D2	NTUA	Energy prices (by fuel type[1])	D
D3	NTUA	Energy consumption and production (total & by sector, fuel type[1])	D
D4	IIASA	Population (total & by age, household)	D
D5[#]	IIASA/LHTAEE	Urban population (total & by age, density)	D
D6	LHTAEE/scenes	Transport growth (total & modal split)	D
D7	AEA	Agricultural demand	D
D8	AEA	Agricultural production (area, by live stock type)	D
D9	IIASA	Ecosystem (by type, area, critical load)	D
D10	AEA	Waste production (by type, e.g. landfills)	D

Indicator. No	Institute	Indicators for climate change	**DPSIR**
CC1	NTUA/IIASA /AEA	Emissions 6 GHG (total & by sector)	**P**
CC2	NTUA	Emissions CO2 (total & by sector & by fossilfuel/non fossil fuel/"sinks")	P
CC3	AEA	Emissions CH4 (total & by sector)	P
CC4	AEA	Emissions N2O (total & by sector)	P
CC5	AEA	Emissions fluorinated greenhouse gases (HFCs, PFCs, SF6)	P
CC6	AEA/NTUA/ TNO	Effectiveness of policies and measures[1] to reduce GHG emissions (by gas/sector)	R
CC7	RIVM	Concentration GHG (total & by component, world/Europe)	S
CC8	RIVM	Radiative forcing (total & by component) world/Europe	S
CC9	RIVM	Temperature world/Europe (annual mean deviations)	S/I
CC10	RIVM	Precipitation Europe	S/I
CC11	RIVM	Growing season length	I
CC12	RIVM	Global and regional river discharge & high/low river flows	I
CC13	RIVM	Ecosystem composition	I

[1] Policies and measures in the baseline scenario
[2]Method to quantify projections has still to be defined.

Indicator No.	Institute	Indicators for Air Pollution	DPSIR
AP1	IIASA	Emissions acidifying pollutants (total & by sector)	P
AP2	IIASA	Emissions ozone precursors (total & by sector)	P
AP3	IIASA	Emissions primary and secondary PM10 (PM2.5 to be developed) (total & by sector)	P
AP4	IIASA	Emissions SO2 (total & by sector)	P
AP5	IIASA	Emissions NOx (total & by sector)	P
AP6	IIASA	Emissions NH3 (total & by sector)	P
AP7	IIASA	Emissions NMVOC (total & by sector)	P
AP8	?LTHAEE	Urban emissions NOx, VOC, PM_{10}, (PM2.5), SO2	P
AP9	IIASA	Effectiveness of policies and measures[1] to reduce SO2 emissions[1]	P+R
AP10	IIASA	Effectiveness of policies and measures[1] to reduce NOx emissions[1]	P+R
AP11	IIASA	Effectiveness of policies and measures[1] to reduce VOC emissions	P+R
AP12	IIASA	Effectiveness of policies and measures[1] to reduce NH_3 emissions	P+R

AP13	IIASA	Effectiveness of policies and measures[1] to reduce PM_{10} emissions	P+R
AP14	IIASA	(Percentage) Area Exceedance Critical Loads (max, 2%, 5%) Total acidity	S
AP15	IIASA	(Percentage) Area Exceedance Critical Loads (max, 2%, 5%) Nitrogen	S
AP16	IIASA	Average accumulated exceedance (AAE) of nutrient nitrogen and acidity	S
AP17	IIASA	Exceedance days/potential exposure of ozone at the regional level	S
AP18	LTHAEE	Exceedance days/potential exposure of ozone target in urban areas	S
AP19	LTHAEE	Exceedance days/potential exposure of PM10 target in urban areas	S
AP20	LTHAEE	Exceedance days/potential exposure of SO2 target in urban areas	S
AP21	LTHAEE	Exceedance days/potential exposure of NO2 target in urban areas	S
AP22	RIVM	Aggregated exceedance AQ standards (in development)	S
AP23	IIASA	Exposure of crops/forests to ozone	S
AP24	IIASA	Human health Exposure, risk and effects by air pollutants (total (DAILy's?) & by component)[30]	I

[1] Policies and measures in the baseline scenario

Examples of potential[31] indicators for linkages between air pollution and climate change not yet included in the scenario framework

Indicator	Unit	DPSIR	Vision[1]	Type[2]
Structural changes affecting both GHG and AP emissions (sectoral economic changes)	€, %	D	S	Me
Technological changes affecting both GHG and AP emissions, e.g. development specific technologies	e.g., % in fuel mix	D	S	Me
Emissions of air pollutants and GHGs presented together	tons/year	P	S	Mo/Me
Concentrations of air pollutants which also affect climate change (sulphate, ozone and black/organic carbon) eventually expressed in CO_2 equivalent concentration units or in their contribution to the total radiative forcing of GHG and air pollutants in the European atmosphere over time.	Ppb CO_2-equivalent, W/m^2	S	S (SO_2) M (O_3) L (BC)	Mo/Me
(Index) Half-life time changes of air pollutants such as CH_4, NO_x, CO	Year/index	S	S/M	Mo
Climate change effect on percentage area exceedance of critical loads total acidity	% change	I	S	Mo
Climate change effect on percentage area exceedance critical loads Total nitrogen	% change	I	S	Mo
Climate change effect (esp. temperature) on frequency of episodes of air pollutants	% change	I	M	Mo
Nitrogen effect on the Climate change induced changes in ecosystem composition	Additional % change	I	M	Mo
Policies adopted addressing climate change and air pollution simultaneously	% reduction	R	S	Me
Effects of climate change measures on air pollutant emissions	number	R	S	Mo
Effects of climate change measures on costs of air quality policy	% change	R	S	Mo
Effects of climate change policies on urban air pollution and health	DALYs	R	M/L	Mo

DPSIR: Driving forces, Pressure, State, Impacts, Response; note that the type of indicator can be different from a climate change or air pollution perspective

[1] Vision means the time period that an indicator becomes applicable for assessments. S short (0-2 years), M medium (3-5 years), L long (6-10 years).

[30] This indicator needs further to be developed in co-operation with WHO-Europe.

[31] This indicators are proposed in a draft EEA (2003) technical report, after consultation with the countries a final set of indicators will become available. Therefore the production of these indicators have not yet been included in the workprogramme.

[2] Indicator type illustrates the main source of information. Me measurements (past trends) Mo modelling (scenarios)

ANNEX 4: REFERENCE VALUES FOR NATIONAL INDICATIVE TARGETS FOR RENEWABLE ENERGY SOURCES.

This Annex gives reference values for the fixing of national indicative targets for electricity produced from renewable energy sources (RES-E), as referred to in Article 3(2):

	RES-E TWh 1997 (**)	RES-E % 1997 (***)	RES-E % 2010 (***)
Belgium	0,86	1,1	6,0
Denmark	3,21	8,7	29,0
Germany	24,91	4,5	12,5
Greece	3,94	8,6	20,1
Spain	37,15	19,9	29,4
France	66,00	15,0	21,0
Ireland	0,84	3,6	13,2
Italy	46,46	16,0	25,0 (1)
Luxembourg	0,14	2,1	5,7 (2)
Netherlands	3,45	3,5	9,0
Austria	39,05	70,0	78,1 (3)
Portugal	14,30	38,5	39,0 (4)
Finland	19,03	24,7	31,5 (5)
Sweden	72,03	49,1	60,0 (6)
United Kingdom	7,04	1,7	10,0
Community	338,41	13,9 %	22 % (****)

(*) In taking into account the reference values set out in this Annex, Member States make the necessary assumption that the State aid guidelines for environmental protection allow for the existence of national support schemes for the promotion of electricity produced from renewable energy sources.

(**) Data refer to the national production of RES-E in 1997.

(***) The percentage contributions of RES-E in 1997 and 2010 are based on the national production of RES-E divided by the gross national electricity consumption. In the case of internal trade of RES-E (with recognised certification or origin registered) the calculation of these percentages will influence 2010 figures by Member State but not the Community total.

(****) Rounded figure resulting from the reference values above.

(1) Italy states that 22 % would be a realistic figure, on the assumption that in 2010 gross national electricity consumption will be 340 TWh. When taking into account the reference values set out in this Annex, Italy has assumed that gross national electricity production from renewable energy sources will attain up to 76 TWh in 2010. This figure includes the contribution of the non-biodegradable fraction of municipal and industrial waste used in compliance with Community legislation on waste management.
In this respect, the capability to reach the indicative target as referred to in this Annex, is contingent, inter alia, upon the effective level of the national demand for electric energy in 2010.

(2) Taking into account the indicative reference values set out in this Annex, Luxembourg takes the view that the objective set for 2010 can be achieved only if:
— total electricity consumption in 2010 does not exceed that of 1997,
— wind-generated electricity can be multiplied by a factor of 15,

— biogas-generated electricity can be multiplied by a factor of 208,
— electricity produced from the only municipal waste incinerator in Luxembourg, which in 1997 accounted for half the electricity produced from renewable energy sources, can be taken into account in its entirety,
— photovoltaically generated electricity can be raised to 80 GWh, and

in so far as the above points can be achieved from the technical standpoint in the time allowed.

In the absence of natural resources, an additional increase in electricity generated by hydroelectric power stations is ruled out.

(3) *Austria* states that 78,1 % would be a realistic figure, on the assumption that in 2010 gross national electricity consumption will be 56,1 TWh. Due to the fact that the production of electricity from renewable sources is highly dependent on hydropower and therefore on the annual rainfall, the figures for 1997 and 2010 should be calculated on a long-range model based on hydrologic and climatic conditions.

(4) *Portugal*, when taking into account the reference values, set out in this Annex, states that to maintain the 1997 share of electricity produced from renewable sources as an indicative target for 2010 it was assumed that:
— it will be possible to continue the national electricity plan building new hydro capacity higher than 10 MW,
— other renewable capacity, only possible with financial state aid, will increase at an annual rate eight times higher than has occurred recently.

These assumptions imply that new capacity for producing electricity from renewable sources, excluding large hydro, will increase at a rate twice as high as the rate of increase of gross national electricity consumption.

(5) In the *Finnish* action plan for renewable energy sources, objectives are set for the volume of renewable energy sources used in 2010. These objectives have been set on the basis of extensive background studies. The action plan was approved within the Government in October 1999.

According to the Finnish action plan, the share of electricity produced from renewable energy sources by 2010 would be 31 %. This indicative target is very ambitious and its realisation would require extensive promotion measures in Finland.

(6) When taking into account the reference values set out in this Annex, *Sweden* notes that the possibility of reaching the target is highly dependent upon climatic factors heavily affecting the level of hydropower production, in particular variations in pluviometry, timing of rainfall during the year and inflow. The electricity produced from hydropower can vary substantially. During extremely dry years production may amount to 51 TWh, whereas in wet years it could amount to 78 TWh. The figure for 1997 should thus be calculated with a long-range model based on scientific facts on hydrology and climatic change.

It is a generally applied method in countries with important shares of hydropower production to use water inflow statistics covering a time span of 30 to 60 years. Thus, according to the Swedish methodology and based on conditions during the period 1950-1999, correcting for differences in total hydropower production capacity and inflow over the years, average hydropower production amounts to 64 TWh which corresponds to a figure for 1997 of 46 %, and in this context Sweden considers 52 % to be a more realistic figure for 2010.

Furthermore, the ability of Sweden to achieve the target is limited by the fact that the remaining unexploited rivers are protected by law. Moreover, the ability of Sweden to reach the target is heavily contingent upon:
— the expansion of combined heat and power (CHP) depending on population density, demand for heat and technology development, in particular for black liquor gasification, and
— authorisation for wind power plants in accordance with national laws, public acceptance, technology development and expansion of grids.

ANNEX 5: OVERVIEW OF BURDEN SHARING PRINCIPLES[32]

INTRODUCTION

This aim of this annex is to describe the principle differences between the various burden sharing regime approaches momentarily under discussion.

A key element of any proposal for differentiation of future commitments will be equity or fairness. It should be noted that the issue of equity in future climate regimes embraces a broader package than principles and rules for the differentiation of future (mitigation) commitments. Equity also concerns the distribution of costs for adaptation to and impacts of climate change. IPCC (2001a) has indicated that particularly developing countries will be damaged by climate change because they are more vulnerable. The distribution of costs for adaptation to and impacts of climate change will probably be dealt with via policy instruments (like the adaptation fund adopted in the Marrakesh Accords), and is likely to also play a role in discussions on a fair differentiation of mitigation efforts.

As a first step in exploring the principles that can be used for future post-Kyoto commitments we start with exploring equity principles as set out in the UNFCCC.

The most explicit statement in the UNFCCC about burden differentiation can be found in Article 3.1, which states that:

"The Parties should protect the climate system for the benefit of present and future generations, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities, …" (Article 3.1) (UNFCCC, 1992).

This article confirms the relevance of the principles of responsibility and capability and the relevance of intergenerational equity but leaves open what needs can be considered equitable. The UNFCCC contains other Articles that contain important elements for further defining conditions for an equitable burden differentiation. These conditions relate to the outcomes of any differentiation of mitigation efforts, and are thus outcome based in nature. Article 3.2 states that full consideration should be given to Parties, especially developing country Parties that would have to bear a disproportionate or abnormal burdening from climate policies. This article seems to imply that whatever (principles for) distribution of the burden of mitigating climate change the outcome should meet the condition of proportionality.

Another important condition for the differentiation of commitments can be found in Article 2 about the objective of the Convention. It states that the level of stabilisation of the GHG concentrations in the atmosphere (to avoid dangerous interference with the climate system) should "(…) enable economic development to proceed in a sustainable manner (…)". This article relates to both the acceptable level of impacts resulting from the disturbance of the climate system as to the acceptable level of mitigation of climate change. Neither impacts nor mitigation should impair sustainable development. This condition seems to particularly relate to developing countries, as in the pre-ambule of the UNFCCC it is affirmed that "(…) responses to climate change should be co-ordinated with social and economic development with a view to avoiding adverse impacts on the latter, taking into full account the legitimate priority needs of developing countries for the achievement of sustained economic growth and eradication of poverty (…)".

In the context of the differentiation of mitigation efforts, the UNFCCC, thus implicitly (if not explicitly) seems to recognise the 'basic needs' principle and 'no-harm' principle: the distribution of mitigation efforts should not harm the opportunities for socio-economic development for the least

[32] Based, with permission, on: RIVM report 728001023/2003 (in preperation) Exploring climate regimes for differentiation of commitments to achieve the EU climate target, M.G.J. den Elzen, M.M. Berk, P. Lucas, B. Eickhout, D.P. van Vuuren

developed countries to meet their people's basic needs. These principles imply that mitigation regimes should either exclude the least developed countries from participation in the burden sharing (by introducing some threshold for participation) or allocate emission allowances in such a way that their development opportunities are not affected. It can be argued that it is a minimum condition because it does not account for possible negative impacts of climate change that hamper economic development and the fulfillment of basic needs.[33]

In conclusions, the UNFCCC explicitly supports the principles of responsibility and capability and implicitly seems to support the basic needs principle. In addition, it is clear that no distribution of commitments nor of the measures taken to implement them should result into abnormal and disproportional burdening of some countries.

PRINCIPLES OF DISTRIBUTIVE FAIRNESS

There is no common accepted definition of equity. Equity principles refer to more general notions or concepts of distributive justice or fairness. In the literature many different categorisations of equity principles can be found (see Banuri et al. (1996); Rose (1998); Ringius et al. (1998)). Often quoted equity principles in climate change context are the following:

- *egalitarian:* people have equal rights to use the atmosphere
- *sovereignty / acquired rights:* all countries have an equal right to use the atmosphere; current emissions constitute a status quo right
- *horizontal:* countries under similar (economic) conditions should have similar emission reduction commitments / costs
- *vertical/capability:* the greater the capacity to act/ability to pay the greater the share in the mitigation / economic burden
- *responsibility/polluter pays:* the greater the contribution to the problem the greater the share in the mitigation / economic burden
- *basic needs:* people have equal rights to fulfilling basic (development) needs; basic needs have priority (related principles: priority and no-harm)
- *Rawlsian:* the underprivileged should benefit from the distribution of costs or benefits

These general equity principles need to be distinguished from specific rules or formulas for burden sharing or emissions allocation, and from equity criteria or indicators (Ringius et al., 1998; Ringius et al., 2002; Rose, 1992). Rules for burden sharing or emissions allocation specify how the equity principle can be interpreted / applied in the context of greenhouse gas emission control. Equity criteria or indicators further specify the way rules for burden sharing or emissions allocations are to be operationalised (e.g. what data to be used).

Rose (1992) and Rose et al. (1998) has pointed at a distinction between three types of alternative equity rules for global warming regimes:

- *allocation based criteria*, defining equitable differentiation of commitments in terms of principles for the distribution of emission allowances or the allocation of emission burdens;
- *outcome based criteria,* defining equitable differentiation of commitments in terms of outcome, in particular the distribution of economic effects, and
- *process based criteria,* defining equitable differentiation of commitments in terms of the process for arriving at a distribution of emission burdens.

This distinction is also important because some equity principles can be interpreted in both an allocation-based and an outcome based way, which may result in quite different outcomes. Moreover, the distinction is important, as almost all approaches explored sofar are allocation-based approaches. A disadvantage of outcome based approaches is that they dependent on complex economic models, the outcomes of which are usually not transparent to policy-makers. On the other hand, the (perceived) costs and economic impacts of options for differentiation of

[33] The application of the no-harm principle on both mitigation and impacts is likely to result in the need for substantial compensation.

future commitments will have an important impact on the evaluating of policy options. Process based criteria are generally less suitable for ex ante evaluation because their outcomes are less predictable.

CHARACTERISATION OF THE APPROACHES EXPLORED

Ringius et al. (1998; 2002) have tried to indicate which of the various equity principles for distributive fairness mentioned in the literature are the most politically salient, that is: need to be accounted for in proposals for burden differentiation in order to make these widely acceptable in future international climate negotiations. Based on both literature and the practice of international environmental negotiations, they conclude that three principles stand out as the most relevant elements for a widely accepted approach to burden differentiation in future international climate negotiations:

- *Responsibility:* costs should be distributed in proportion to a country's share of responsibility for causing the problem;
- *Capacity:* costs should be distributed in proportion to country's ability to pay;
- *Need:* all individuals have equal rights to pollution permits, with a minimum to secure basis human rights, including a decent standard of living.

This simplified typology looks very elegant and comes close to what is said about an equitable distribution of mitigation efforts in the UNFCCC. However, there are a few important comments that need to be made.

The first relates to the rather ambiguous character of the above definition of Ringius et al. (2002) of the need principle. It seems to refer mainly to the basic needs equity principle, but also to the egalitarian equity principle. However, these principles are fundamentally different. The egalitarian equity principle is not based on the concept of need but on the concept of rights: all humans have equal user rights with respect to the global atmosphere, irrespective of their needs. Such are inalienable rights that are independent of actual needs. As indicated by Ringius et al. (2002), the basic need principle is based on the pillar of basic human rights, including the right to development. They provide ground for exempting countries from sharing in the global GHG emission control (or for providing compensation for negative effects), but not for allocating them emission rights irrespective of their actual needs as in the case of the egalitarian equity principle.

This is not to say that the egalitarian equity principle does not have relevance in the climate negotiations. In fact it has been referred to in many proposals, such as the Contraction and Convergence approach, including those of Parties to the UNFCCC (Depledge, 2000; Ringius et al., 2002). The point here is that the egalitarian equity principle is different from the (basic) need principle and also seems to have a less strong legal claim than the basic need principle, in particular given the wording of the UNFCCC.

The sovereignty principle cannot be used to legitimise unlimited GHG emissions when it is known that these are likely to be harmful to other states.
At the same time, it can be argued that countries did not know about the possible negative impacts of large scale GHG emissions and therefore their past behaviour cannot be held illegal. Moreover, it can be argued that they have become economically and socially dependent on the use of fossil fuels and that a strong reduction would result into an abnormal and disproportional burden, as referred to in the UNFCCC. The claim of status quo or acquired rights and related proposals for a flat rate reduction or grand-fathering of GHG emission permits thus still seem to have some bearing and cannot be easily dismissed (Müller, 1999)

The four principles – responsibility, capability, sovereignty and egalitarian - can thus be used to create a square embracing both principles clearly reflected in the UNFCCC as well as other salient principles. They can be further ordered as being either rights or duty based in character (Figure V.1): responsibility and capability result in a duty to contribute to mitigation, while the egalitarian and sovereignty principles establish a right to emit. The scheme can be used to characterise the position of the regime(s) that will be explored in SoEOR2005 report.

As an example a few proposed burden sharing regimes will be discussed here in relation to their position in above discussed principles.

The C&C and GC approaches are both *rights bases approaches*, based on a combination of both the egalitarian and sovereignty principles, while leaving aside the principle of responsibility.
Here, the GC approach is generally closer to the egalitarian principle than C&C as the change in relative weight of emissions (sovereignty) versus population (egalitarian) in the distribution of emission space normally is faster under GC than C&C, because of the preference voting based on population numbers[34].
The other approaches are *duty-based approaches*, with the Brazilian and Jacoby rule proposals being clearly oriented to the responsibility and capability principles, respectively. The Multi-stage approach is based on a combination of the responsibility and capability principles, but may also include elements related to the egalitarian principle, e.g. by using per capita emissions levels as burden sharing key.

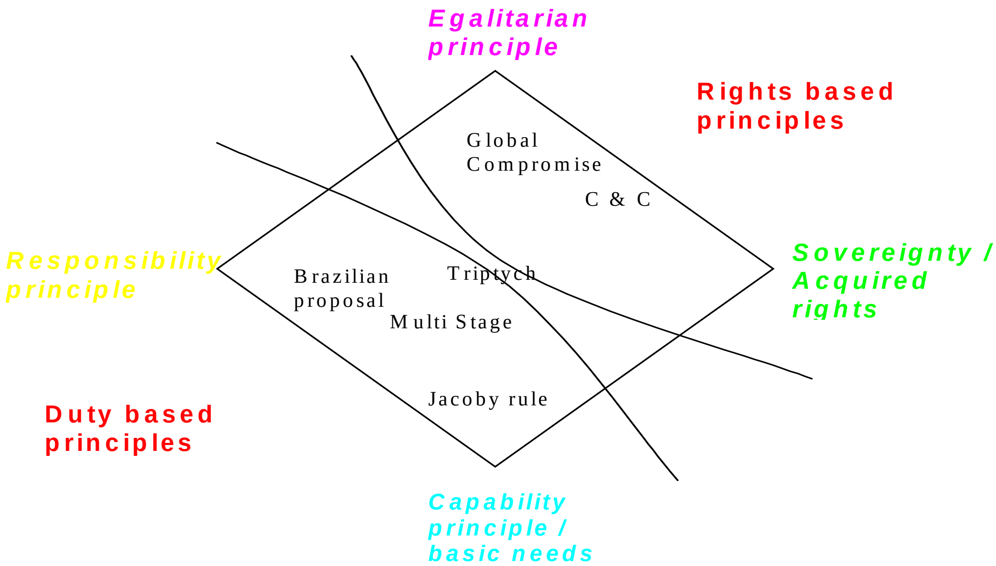

Figure V.1: Allocation based equity principles and proposals for differentiation of commitments

OTHER RELEVANT DIMENSIONS OF REGIMES FOR DIFFERENTIATION OF COMMITMENTS

In addition to equity principles, there are a number of other dimensions of architectures of possible regimes for the differentiation of future commitments (see also Berk et al. (2002)).

Problem definition (burden sharing or resource sharing): The climate change problem can be defined as a pollution problem or as a property sharing issue. These different approaches have implications for the design of climate regimes. In the first approach, the burden sharing will focus on defining who should reduce or limit his pollution and how much; in the latter approach the focus is on who has what user rights and the reduction of emissions will be in line with the user rights.

[34] In principle, C&C could result in a faster redistribution of emission space towards a per capita distribution than GC if the convergence period chosen would be very short like, 10 year. However, in most proposals for a C&C approach the convergence period is usually set at 20-40 years or more.

Emission limit: One can define the emission reduction top-down by first defining globally allowed emissions and than apply certain participation and differentiation rules for allocating the overall reduction effort needed, or instead in a bottom-up way allocate emission control efforts among Parties, without a predefined overall emission reduction effort. In the top-down approach the question of adequacy of commitments is separated from the issue of burden differentiation. In the bottom-up approach, the two are dealt with at the same time.

Participation (thresholds / timing): Another dimension is that of the degree of participation: who should participate when in sharing the burden? This issue concerns discussions on both the types of thresholds for participation and the threshold level or the timing. At the same time, there is no need for all Parties to participate in the same way.

Type of commitment: The approaches for differentiation of commitments can either pre-define the allocations of emissions over time or make the allocation dependent on actual developments in levels of economic activity, population or emissions. In ex-ante analysis this results in baseline dependent allowance schemes. The level of dependency on actual developments can vary from small, like in the case of the per capita convergence approach (dependent on population only), or large, like in the case of the Multi-stage approach (dependent on population, income and emissions only).

Form of commitment: The form of the commitment for countries can be equal for all, like the binding emission target in Kyoto Protocol, but can also be defined in differentiated ways (see e.g. Baumert et al. (1999); Claussen et al. (1998); Philibert and Pershing (Philibert and Pershing, 2001)). Instead of fixed absolute targets, commitments may be defined as relative or dynamic targets, such as a reduction in energy and/or carbon intensity levels, or in terms of policies and measures. There is also the option of non-binding commitments. In addition, the legal nature of the commitment can be either binding or voluntary.[35]

Scope of the commitment: This dimension concerns the question whether the commitment covers all GHG and sectors or is limited to particular GHGs or sectors. In particular in the case of developing countries new commitments could be limited to particular sectors or GHGs for reasons of verification and monitoring and because emissions certain sectors are difficult to predict and control (e.g. agriculture). The present commitments under the KP cover all GHGs and sectors, but exclude emissions from international aviation and maritime activities.

With the need for a broadening of the participation of developing country Parties in future emission control, Berk and den Elzen (2001) have indicated that the development of the international climate regime principally could take two different directions:

1. Incremental regime evolution, i.e. a gradual expansion of the Annex I group of countries adopting binding quantified emission limitation or reduction objectives under the UNFCCC, or,
2. Structural regime change, i.e. the adoption of a regime defining the evolution of emission allowances for all Parties over a longer time period.

The first approach would mean a gradual extension of the present Kyoto Protocol approach to differentiate the obligations of various Parties under the Convention (sometimes referred to as 'graduation'). It could be based on ad-hoc criteria, or on pre-defined rules for both participation and differentiation of commitments. This type of regime we call '*Increasing participation*'. In an increasing participation regime, the number of Parties involved and their level of commitment gradually increase according to participation and differentiation rules, like per capita income or per capita emissions.

[35] Formally, commitments are always voluntary in the sense that countries voluntarily commit themselves to international agreement. However, once ratified a country is formally bound to meet its obligations. In the case of voluntary commitments there is no formal obligation to achive a material result (e.g. reduction in emissions).

The second approach would be a shift away from the present approach towards a regime that – in absolute or relative terms - governs commitments for all Parties and their evolution over a long-term period. This type of regime we may call '*full participation*'. Examples of such approaches are the Contraction & Convergence approach and the Global Compromise approach.

Of course, other types of structurally different climate regimes can be thought of as well, like a regime based on technology standards, common policies and measures or sector-based approaches as include in the so-called Triptych approach (Phylipsen et al., 1998). The latter approach was used within the EU to help define its internal differentiation of targets for the KP. Such approaches would be more bottom-up in character, although they could be combined with specific emission targets (as illustrated in the case of the EU). Such approaches have been elaborated elsewhere (for a global application of the Triptych approach see den Elzen (2002a) and Groenenberg (2002)).

Table V.1: An example how different approaches can be characterized according to different burden sharing principles

Dimensions	Burden sharing 1	C&C	Burden sharing 2	Burden sharing 3	Burden sharing 4
Equity principles					
• Responsibility	X		X		
• Capability	(X)		X		X
• Egalitarian		X	(X)	X	
• Acquired rights		X		X	
Problem definition					
• Pollution problem	X		X		X
• Global commons issue		X		X	
Emissions limit					
• top down	(X)	X	X	X	(X)
• bottom up	X				X
Participation					
• Partial	(X)		X		X
• All	X	X	(X)	X	
Nature of Commitments					
• Pre-defined		X		X	
• Path dependent	X		X		X
Form of Commitment					
• Equal	X	X		X	X
• Differentiated			X		
Scope of the Commitment					
• Full coverage					
• Partial coverage (of sector/GHGs)	X	X	X	X	X

X= applicable; (X) = partly applicable

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ANNEX 6: EEA GLOSSARY ON ENVIRONMENT OUTLOOKS

An **outlook** depicts future developments, usually highlighting the relationship and interactions between key driving forces and their possible implications.

Prospective analysis - see outlook.

A **scenario** is a plausible description of how the future may unfold based on 'if-then' propositions. A typical environmental scenario includes a representation of the initial situation and a storyline that describes the key driving forces and the changes that lead to an image of the future. Note that scenarios are neither predictions nor forecasts.

Baseline scenarios (also referred to as ‘reference scenarios’ or ‘benchmark scenarios’) are scenarios in which no new policies or measures are implemented apart from those already adopted or agreed upon.

Alternative scenarios (also referred to as ‘policy scenarios’) are scenarios, which take into account new policies or measures additional to those already adopted or agreed upon and/or that assumptions on key driving forces diverge from those depicted in a baseline scenario.

Exploratory scenarios start with an initial situation and a set of assumptions on policies, measures and key driving forces to explore plausible future developments.

Anticipatory scenarios (sometime also referred to as ‘normative scenarios’) start with a prescribed vision of the future and then works backwards to visualise how this future could emerge.

Qualitative scenarios are narrative descriptions of future developments (i.e. presented as storylines, diagrams, images, etc.).

Quantitative scenarios are numerical estimates of future developments (i.e. presented as tables, graphs, maps, etc.), usually based on available data, past trends and/or mathematical models.

Projection - see quantitative scenarios.

A **sensitivity analysis** is an investigation of how outputs vary with changes in individual key assumptions / input variables of projections. The aim is to identify the relative (marginal) effect of an individual assumption / input variable on the projection outcomes and isolate its chain of effects.
Stress testing is a specific form of sensitivity analysis in which the effects of extreme values are investigated. The aim is to study under which conditions the boundary conditions (for example dramatic unsustainable patterns) would be reached.

An **uncertainty analysis** is an assessment of the degree to which a value (e.g. describing a future development or state) is unknown, in which the consequences of uncertainties in assumptions and/or model inputs/equations on the outputs are analysed. In model-based assessments the input variables for the uncertainty analysis usually range within values investigated by sensitivity analyses – common techniques include, for example, Monte Carlo approaches and the calculation of confidence intervals. Uncertainty can also be represented by qualitative statements, for example reflecting expert judgment.