SENSOR
Sustainability Impact Assessment: Tools for Environmental Social and Economic Effects of Multifunctional Land Use in European Regions

Priority Area 1.1.6.3 "Global Change and Ecosystems"

CONTRACT No 003874 (GOCE)
Integrated Project
Start date of the Project: 01 December 2004
Duration: 48 months

- DELIVERABLE report -

Deliverable number: 2.1.1 (final)

Deliverable title: According to the DoW, the title was to be: "Example baseline scenario presenting a projection of supply and demand of goods and services in the 6 target sectors agriculture, forestry, tourism, nature protection, transport and energy infrastructure." This has, however, been modified to **Baseline scenario storylines**

Organisation name of lead contractor for this deliverable: LEI

Partners involved: IIASA, COE/CCIP

Researchers involved: Tom Kuhlman, Pierre Le Mouël, Chris Wilson

Due date of deliverable: February 2006 (project month 15)
Actual submission date: April 2006 (project month 17)
Revision: revised version after comments received

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination level		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services	☐
RE	Restricted to a group specified by the consortium (including the Commisssion Services)	☐
CO	Confidential, only for members of the consortium (including the Commission Services)	☐

For dissemination level of the deliverable see DoW chapter 8.4, p. 85

Objectives:
To present the assumptions for the baseline scenarios.

Activities:

(1) Discussions on on the approach to baseline scenarios: at Warsaw in April 2005, then at a workshop in The Hague on 20-9-05, where a paper was presented on which preliminary agreement was reached. This agreement was confirmed during further discussions in Malta in October.

(2) Collecting forecasts for world economic growth, demographic change (IIASA), changes in the labour force participation rates (IIASA), the world oil price (COE/CCIP), and on R&D expenditure. Calculating the projections on the five drivers identified for the EU-25.

(3) Writing the report.

Results:
Report submitted here

Milestones achieved:
End user consultation by Module 7.1 (Month 4)

Deviations and reasons:
There has been a delay in completing this deliverable, for two reasons:

- There was initial disagreement on what the baseline scenarios should look like. This was resolved only in month 10, ten weeks before the deadline.
- It was decided to reallocate the main responsibility for this deliverable to LEI in October 2005. Although LEI at first thought that a draft could be ready by the original deadline, this proved impossible.

Publications:
None so far

Meetings:
The Hague, 20 September 2005

Remarks concerning further SENSOR activities:
The work described in this deliverable is closely linked to deliverables 2.1.3. On the basis of these two deliverables, model outcomes per sector and per country can be calculated, with which policy scenarios can be designed and WP 2.2 can start its work properly.

Documents:
See reference list at the end of this report

Table of contents

EXECUTIVE SUMMARY 4
1. Types of scenarios 5
1.1. What is a scenario?..5
1.2. Types of baseline scenarios..6
1.3. SENSOR's choice..8
2. Drivers..10
2.1. What is a driver? 10
2.2. Demography 12
2.3. Participation rate..17
2.4. World demand 19
2.5. The oil price..22
2.6. Research & Development efforts..23
2.7. Policies..27
2.8. Institutions..27
2.9. Cultural change 28
3. The scenarios..29
3.1. The reference scenario..29
3.2. Contrasting scenarios: high and low growth..31
4. References..35

EXECUTIVE SUMMARY

This document contains the assumptions for the baseline scenarios, i.e. the scenarios which represent the autonomous developments, in the absence of policy changes. They are the counterfactual, the background against which the impact of a policy can be evaluated. The assumptions contained in this document are concerned with those factors which are exogenous to the chain of models used in SENSOR – the driving forces.

There are several different approaches possible to designing these baseline scenarios, and the choice of approach depends on the purpose for which one wants to use the scenarios. In the case of SENSOR, the objective is not to project different futures to cope with which policies might be designed. It is merely to set up a plausible counterfactual. The fewer the number of scenarios, the easier it is to evaluate a policy – although a minimum number of scenarios is needed to assess the reliability of the predicted impact. The option chosen here is to design a single reference scenario, based mainly on extrapolating past trends in the chosen drivers. However, where on the basis of expert opinion it is considered unlikely that past trends will continue, a most likely trend is chosen instead.

In addition to this reference scenario, two so-called contrasting scenarios have also been designed. These represent two extreme, but still plausible, positions for the chosen drivers – a low one and a high one. The contrasting scenarios provide a measuring stick with which it is possible to determine to what extent possible deviations from the reference story may affect the outcome of a policy. They constitute, thus, a sensitivity analysis. This does not mean that the full range of possible outcomes is captured in these three scenarios.

The drivers chosen are:

- Population growth in the EU-25
- Participation rate in the labour force, for the same area
- Economic growth in the world outside the EU-25
- The world oil price
- Expenditure on research & development in the EU-25.

In addition, three other forces which influence multifunctional land use and sustainability are kept constant in the baseline scenarios:

- Policies
- Institutions
- Culture, i.e. values and patterns of behaviour.

For the five drivers analyzed, the report describes recent trends and proposes what trend will be used for the period 2005-2025. Next, figures are given for each of the three scenarios per variable and, where applicable, per country for 2005, 2015 and 2025.

STORYLINES FOR BASELINE SCENARIOS

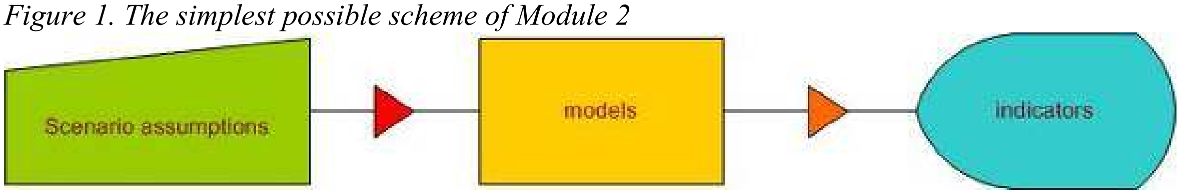
1. Types of scenarios

1.1. What is a scenario?

One might not think it necessary to define the term scenario, but one year of discussions in a consortium with researchers from many different disciplinary and national traditions teaches otherwise. The Oxford English Dictionary defines scenario as "a postulated sequence or development of events" (2005). An alternative view, aimed more at the community of modellers, is given by the Dictionary of Economics: "A history of the future of an economy as it would be on given assumptions about how it operates. The assumptions, for example about government tax and spending policies, can be varied to produce alternative scenarios" (Black 2002). Still more to the point is one given in an article comparing types of scenarios: "scenarios are descriptions of possible futures that reflect different perspectives on the past, the present and the future" (Van Notten *et al.* 2003:424).

In Module 2, our aim is to forecast the impact of possible EU policies. We do this by modelling, in which we feed a set of exogenous variables (including policies) to calculate their impact on a set of endogenous ones; these are then the indicators of sustainability (Figure 1). The models represent the supposed causal links between exogenous variables and indicators. The resulting images made up of these indicators are what should be called scenarios, according to the above definitions.

Figure 1. The simplest possible scheme of Module 2



The SENSOR Description of Work (DoW, SENSOR 2004) expresses a somewhat different view: there, Module 2 is divided into four Work Packages, of which the first (WP2.1) is aimed at constructing scenarios, whereas the other packages are concerned with land use analysis and sustainability assessment (plus one to translate the results into condensed form for the end-user interface). Thus, the scenarios in WP2.1 constitute outcomes of the macro-economic model for the six sectors with which SENSOR is concerned. The detailed analysis of what happens in the sectors and what this means for land use is the subject of WP2.2. The final outcome (the right-hand box in Figure 1) is not considered as part of the scenario.

From a conceptual point of view, this is not very satisfactory: it would be more logical to regard a scenario either as the left-hand box of Figure 1 (the exogenous variables) or as the output (a constructed image of the future). However this may be, the present paper is concerned with the left-hand box, which one may call the scenario assumptions.

One important set of assumptions is composed of policies, since it is these that the end user should be able to manipulate in SIAT. The form in which we feed these policies into the model chain was termed *policy scenarios* in the DoW. This has now been replaced by the term *policy cases*, in order to distinguish them clearly from the various *options* within these policy cases: it is these options (and their consequences) which are more deserving of the term scenarios. A policy case can then be defined as a description of a possible EU policy. Such a description will include one or more parameters for which several different values can be filled in; these values are termed policy options. The term policy case also emphasizes that they are to be regarded only as case studies, as examples in order to build the assessment tools (SIAT) which are the main end product of SENSOR. In accordance with the wishes of the client, the number of policy scenarios which SIAT should be able to handle ought to be theoretically unlimited – it is the end user who will build policy scenarios.

Just running these policy options through the models would not suffice to assess their impact, however: we need to compare them with a counterfactual, a situation in which the policy would not be implemented. Comparing them with the present situation would not do, because the impact will take place in the future. We must construct images of a future in the absence of policy changes such as modelled in our policy cases. These images are called *baseline scenarios* in the DoW. The topic of this paper is the assumptions to be used for these baseline scenarios.

Several different methods for constructing these assumptions are possible, and the next subsection describes the principal options available; the approach chosen for SENSOR is discussed in subsection 1.3. The next step is to identify the variables exogenous to our modelling framework for which assumptions have to be made: the driving forces or drivers. This is the topic of section 2.

Obviously, not all sets of values for these driving forces are equally useful or valid. The values are, in effect, statements about a possible future world. They must, therefore, possess a certain degree of plausibility. There are two ways of achieving this: by making them individually believable, and by making them consistent with one another. The former is difficult to achieve with any kind of robustness (since the future cannot be known), but it does serve as a criterion in judging the likelihood of scenarios. The latter is achievable, but it requires that we do more than just giving a list of parameter values: we must provide a coherent storyline in which the chosen values fit together. These storylines are given in sections 3 and 4, for the two types of baseline scenarios chosen.

1.2. Types of baseline scenarios

Several different approaches to the problem of constructing scenarios are possible. Van Notten *et al.* (2003) classify them on the basis of their goals, their methods and their content (why, how and what). We shall here distinguish only four approaches, on the basis of different goals. They are:

- *Extrapolating scenarios*: this type, which may also be called business-as-usual scenarios, is based on the extrapolation of existing trends. They assume that those trends will not change. In this sense, they are projections, not forecasts. An extrapolating scenario is not a statement of what is likely to happen, but only what will happen if recent trends continue to operate.

- *Expert judgment:* rather than assuming a simple continuation of past trends, in this approach experts are consulted for each driving force on the most likely developments in their particular fields. These judgments are used to tweak the trend figures. Although an adaptation of the previous method, its objective is fundamentally different as the expert-judgment approach attempts to describe a *likely* future rather than merely a *possible* one. It is a forecast rather than a projection.

- *Inclusive approaches:* here a set of possible worlds is constructed, in the hope of capturing a range within which the 'real' future will be contained. Commonly, one or more dimensions are defined along which the future may vary, leading to a multi-dimensional space. The size of this space is limited by the assumed likelihood of variation in the main parameters. One may say that this method results in a set of projections which together form a forecast. This approach has been applied by the Intergovernmental Panel on Climate Change (IPCC 2001), and that application has spawned a series of environmental studies in the Netherlands, usually involving four scenarios along two axes (dimensions) of change (De Mooij & Tang 2003, RIVM 2002, Klijn *et al.* 2005).

- *Imaginative approaches:* all of the above methods (except, to some extent, the expert-judgment one) recognize that the future is unknowable. However, the imaginative approach carries that insight furthest. Rather than making assumptions about what is likely to happen, it asks people to imagine things which *might* come to pass. Around these imagined but possible events, a set of consequences is constructed through modelling. This is the approach used in the PRELUDE project implemented by the European Environment Agency (EEA 2005).

Each of these approaches has its advantages and disadvantages. In SENSOR, the discussion initially focused on the inclusive approach, which can give a reasonable overview of plausible futures. However, there is a tradeoff here in the number of scenarios to be considered: the more you construct, the higher the chance that one of them will come true; but also, the less interesting your forecasts become. For instance, the IPCC has actually built 41 of them (IPCC 2001, p. 62). While these were undoubtedly useful for IPCC's purpose, a reader who wants to know the likely impact of a policy will not be happy with many different outcomes of each policy scenario, since this may not tell him whether the policy in question is actually a good idea or not. Building only a few plausible ones, on the other hand, leads to the possibility that what actually happens will be quite different.

Another problem with this approach is that any particular policy option will only be realistic in some baseline scenarios but not in others. For instance, a European policy which is strongly interventionist is not likely to be implemented within an overall scenario where either liberalization or the autonomy of member states is dominant. This problem can, of course, be overcome by not calculating each policy option for each baseline scenario; however, one may then wonder whether all baseline scenarios are really needed. The inclusive method is most appropriate when the purpose is to explore the spectrum of likely futures within which policies may be formulated – rather then what the impact of a given policy will be.

The imaginative approach is similar in its point of departure, but different in its aim: here there is no range of plausibility, but a much larger space within which scenarios can be constructed. The outcome provides an impression of what may conceivably happen, rather than what is likely to happen. This can be most useful for modelling the consequences of major disasters, for instance; it can also help policymakers in understanding the limitations of any policies they conceive. Thus, the PRELUDE project has formulated five scenarios based on possible developments which would require a policy response.

A major advantage of the extrapolating and expert-judgment approaches is that they provide, in principle, a single point of reference. In the former, no pronouncement is made concerning the likelihood of this reference situation actually coming to pass; in a way, the reference therewith becomes a dynamic view of the present rather than an unprovable view of the future. This makes it attractive to scientists because of its rigour and to those policymakers who recognize that, while claiming to deal with the future, they are really working in the present – assisted, with luck, by some knowledge of the past. The expert-judgment approach is more ambitious in that it believes we can know something about the future. Where that belief is justified, it will be of course an advantage if such judgment can inform our scenarios. What the outcome may lose in clarity and rigour it may gain in plausibility. In summary, the extrapolating and imaginative types are 'what if' approaches, whereas the expert-judgment and inclusive ones are statements on probable futures.

1.3. SENSOR's choice

The European Commission (Directorate General for Research and Technology Development) has made it clear that it would prefer clear and simple statements on the potential outcomes of policies. A wide array of different possible outcomes is not desired. All that is needed in the way of baseline scenarios is a counterfactual. Hence, it was decided that either the extrapolation or the expert-judgment method would best meet this need. We only need to predict the impact of a policy, not the future of which that policy may or may not be part.

However, there is an additional consideration. If the actual situation in the future would lead to a very different impact from that which we have predicted, that prediction would not be very useful. Therefore, it would make sense to produce, in addition to the main scenario, a sensitivity analysis. This could take the form of upper-bound and lower-bound values for the drivers. The package of values should be chosen so as to arrive at coherent upper- and lower-bound scenarios.

As for the choice between the extrapolation and the expert-judgment approaches, we opt for a mixture of both. This is partly for practical reasons: for some of our drivers, useful forecasts have already been made and it would be wise to use them. Where this is not the case we shall use existing trends. In the storylines given in sections 3 and 4, wherever expert judgment is used we shall compare this with trend data and critically explore any difference between them.

Thus, we construct three baseline scenarios: a reference scenario, which is largely business-as-usual but with modifications based on expert judgment where we consider this to be appropriate; and two contrasting scenarios for the high- and low-growth options.

It could be argued (and it is) that using economic growth to distinguish the upper and lower bounds is too restrictive. Other dimensions of change – cultural, institutional and environmental – are equally relevant, as is argued in the next section. There are two arguments for nevertheless choosing the economic dimension as the leading one. Firstly, it is closely linked to the other dimensions: high economic growth is linked with a particular cultural outlook and with higher environmental pressure. Secondly, making distinctions such as low economic growth combined with high population growth would mean using a multidimensional approach such as the ‘inclusive’ one described above. As will become clear in section 4, the particular combinations chosen for the contrasting scenarios do have a degree of internal consistency, even if this is perhaps less than in the reference scenario.

Policies are, of course, an important driver of change. However, for the baseline scenarios they must be kept constant, otherwise these scenarios could not serve their purpose. We shall assume, therefore, that policies remain as they are in the base year. Only policies already in operation or fully ratified will be considered in the baseline.

It must be emphasized that the reference scenario makes no statement on the likelihood of the projected developments: it merely states what would happen in the absence of any trend break in any of the driving forces. Therefore, the end product of the project would greatly benefit from updating the baseline scenarios every few years, in accordance with actual developments; otherwise the tools created in SENSOR will quickly become obsolete. There is always the unexpected, and it is more likely than not that major changes will occur.

2. Drivers

2.1. What is a driver?

As already indicated in section 1.1, drivers (or driving forces) are the exogenous variables for which we set values in a scenario. The term has been popularized by the DPSIR approach (EEA 1999:9), which conceptualizes a causal sequence of drivers, pressures, state, impact and response. In that scheme, a driver is a prime mover, a force which is not caused by something else. In reality it always is, of course, but in the model we accept it as given. We do, however, need to recognize that drivers can be causally related to each other. These relations are expressed in our storylines.

Furthermore, a driving force must itself be subject to change, otherwise it is not a force and cannot drive anything. A static condition by definition cannot cause a process of change. Factors such as soil type or topography cannot be drivers: they are constraints which could limit the scope of actions – just like a tree along the road cannot be the cause of a car hitting it. As in the previous point, 'static' here is an abstraction – nothing is ever static. When we consider a certain factor as static, we mean that within the timespan we examine, the changes in it are so small as to be irrelevant. Static factors have a place in our analysis, but not as drivers.

Thirdly, we propose that the driving force is always a human activity. This is because in SENSOR we are dealing with the interaction between humans and their biophysical environment. Autonomous changes in that environment are mostly either the result of one-off events (natural disasters), or they operate on a longer timescale than SENSOR's twenty-year perspective (e.g. climate change or geological processes). Modelling the impact of disasters is a highly useful exercise, but it hardly fits with SENSOR's objective of assessing the potential impact of policies. Climate change is a different matter: although its impact may be difficult to assess for the 20-year timespan we use in SENSOR, it is nevertheless a highly relevant issue when the slightly longer term is considered, a 50-year timespan for instance. It is, however, also now generally accepted to be at least partially caused by human action, and can therefore be considered as a impact, rather than as a driving force in its own right.

Once this has been decided, which drivers should be chosen? This is to some extent dictated by the modelling framework, but of course that framework itself is designed on the basis of which variables one wants to explain and which ones not. Taking the example of the IPCC scenarios mentioned in section 1.2, these are based on seven socio-economic drivers (IPCC 2000):

- demographic change
- globalization (economic, social and cultural)
- economic growth
- technological development
- extent to which local and regional environmental concerns shape the direction of future policy
- degree of mobilization of human and natural resources, globally and regionally
- balance of economic, social, technological, or environmental objectives in the choices made by consumers, governments, enterprises, and other stakeholders.

Several of these drivers are clearly causally linked to each other. Demography, globalization, technological development and the mobilization of resources all have a profound impact on economic growth. Conversely, economic growth also affects population growth: it leads to higher life expectancy and, at a certain point, lower fertility rates; moreover, it tends to attract migrants. Furthermore, it is strong economies which have the most resources for investing in technology.

In SENSOR, economic growth in the European Union is itself one of the variables we want to explain, in different baseline scenarios as well as in the impact of policies. It can therefore not be a driver. However, economic growth at world scale is something which should be regarded as exogenous, as one of the factors influencing European economic growth through the demand for European products and the competition for global natural resources. We shall introduce two drivers to reflect this: the growth in overall world demand (outside the EU) and the growth in demand for petroleum – which is the most important strategic natural resource which Europe needs from other parts of the world.

As regards technology, in common with modern practice in economics, this is endogenized in econometric models and regarded as a function of knowledge, which can be modelled as expenditure on research & development (R&D) and on education (Solow 2000).

The fifth and seventh drivers (and partly also the second) refer to a group of variables which we propose to divide into three categories related to each other: institutions, cultural change and policies. Following Nabli & Nugent, we define an institution as "a set of constraints which governs the behavioural relations among individuals or groups" (1989:1335). Institutions include rules – both formal and informal – and organizations. Because they change only slowly over time, institutions exert a strong influence on policies and act as constraints on them; they express the balance of power between different groups in a society. The role that institutions play in our models will be limited, because of their resilience to change. Over a period of twenty years some institutional change can occur, however.

There are many definitions of culture (Kroeber & Kluckhohn 1952), but in sociology and anthropology it is common to consider it as "learned, socially transmitted behaviour" (Keesing 1958) or as "shared values, norms and attitudes" (Merriam-Webster's Collegiate Dictionary 2004). A society may thus be seen as made up of a structural dimension (its institutions) and a cultural one. Cultural change is simultaneously constrained by institutions and able to cause institutional change. It is itself influenced by technology and by economic change. Important cultural drivers in our scenarios are consumer preferences (e.g. related to tourism, the demand for sustainably produced goods, a desire to live in the countryside), and the importance of environmental concerns. In this sense, culture was integrated into scenario development in the EURURALIS project, for instance (Van Meijl *et al.* 2005). In SENSOR, the role of culture in scenario development will be rather limited, because in an extrapolating approach it is difficult to accommodate. However, in the sectoral analysis its potential impact will be considered.

Policies are influenced both by cultural change and by institutions, and may themselves contribute to both. They are obviously needed as a driver in our scheme, since it is the impact of policies which we want to examine. As stated in section 1.3, they are kept constant in the baseline scenarios, but considered in the policy cases. Policies are also influenced by the other drivers, in that they may be a response to economic events, to demography or to technological change. In SENSOR, we consider primarily EU policies. In Modules 3 and 6 there is room for considering policies at other spatial levels, however.

This brings us to the following set of drivers for the baseline scenarios:

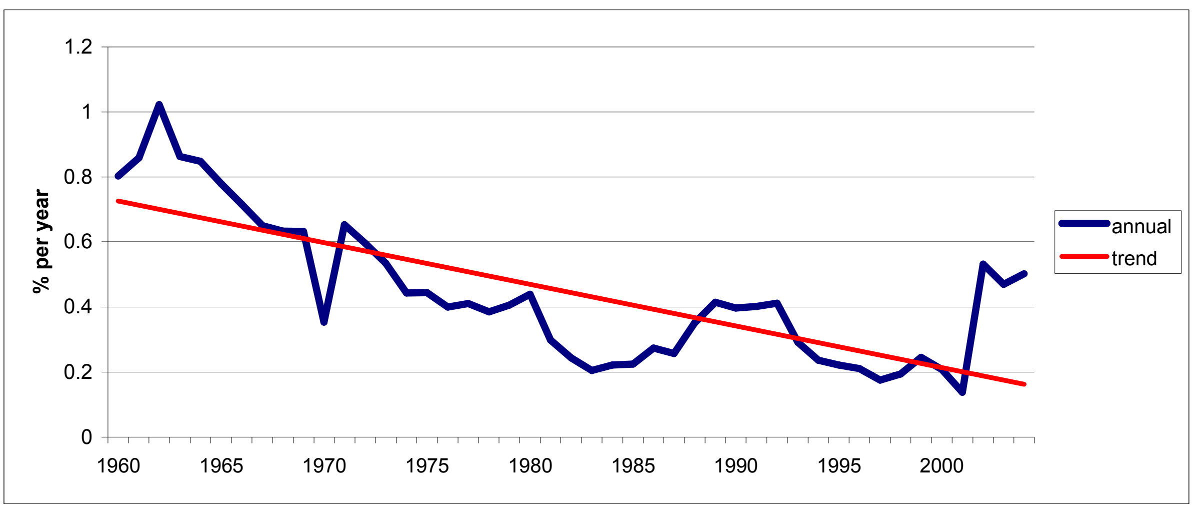
1. demographic change within Europe
2. the rate of participation in the labour force (in Europe)
3. growth of world demand (outside Europe itself)
4. the price of petroleum on the world market
5. expenditure on research and development
6. institutions
7. cultural change.

The following subsections give a brief overview of each of these drivers, the relevant recent trends in them and the method of extrapolation for the period 2005-2025. Section 3 then presents the overall storyline in which the trends in the various drivers are related to each other.

2.2. Demography

The total population of the 25 countries presently making up the European Union has experienced low and declining population growth over a long period, as Figure 2 shows. In the last few years, however, we see a rise in the overall growth rate. In order to assess which trend is the most probable over the next twenty years – the short-term rising one or the long-term declining one, we must look at the factors determining population growth. Figure 3 shows that over the last decade, migration has been the principal determinant: the net migration rate is much higher than the natural growth rate, and it changes much more rapidly.

Figure 2. Population growth in the EU-25, long-term trend



Source: Eurostat

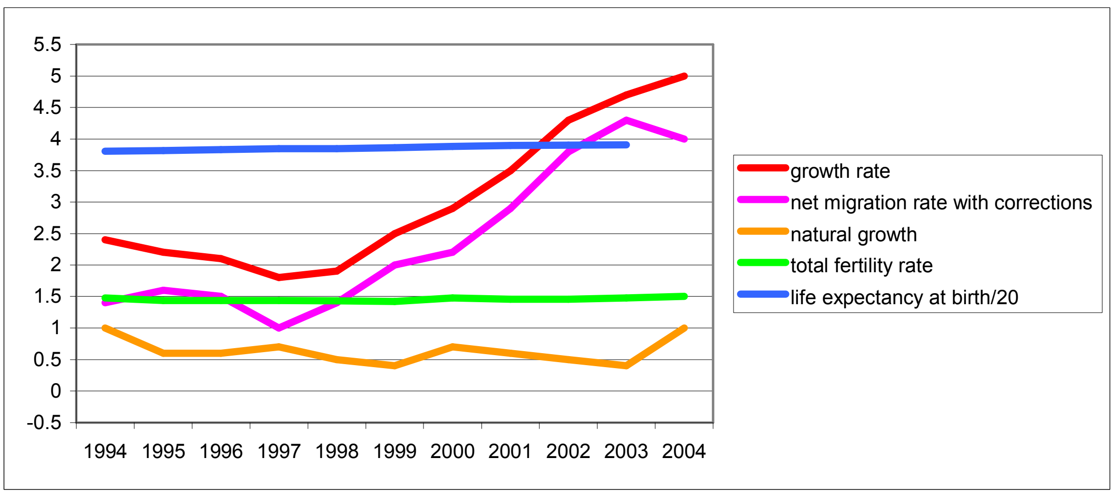
Natural growth is determined largely by three factors:

- the total fertility rate, i.e. the number of live children born per woman during her lifetime;
- life expectancy at birth; and
- the existing demographic structure, which can tell us how many women in the fertile age groups there are.

The total fertility rate has recently been fairly stable at close to 1.5 – well below the replacement rate of 2.1. It reached a low of 1.42 in 1999 and has since risen slightly to 1.5. This rise may be due to the higher fertility among immigrants from developing countries. Since the proportion of those immigrants among the total population is increasing, fertility may also continue to rise. On the other hand, reproductive behaviour is likely to converge to that of the indigenous population – which would limit the rise.

Life expectancy has risen slowly but steadily and will probably continue to do so, given the constant improvements in medical science and prosperity – barring major epidemics or impoverishment such as has happened in Russia, for example.

Figure 3. Major demographic indicators 1994-2004, EU-25



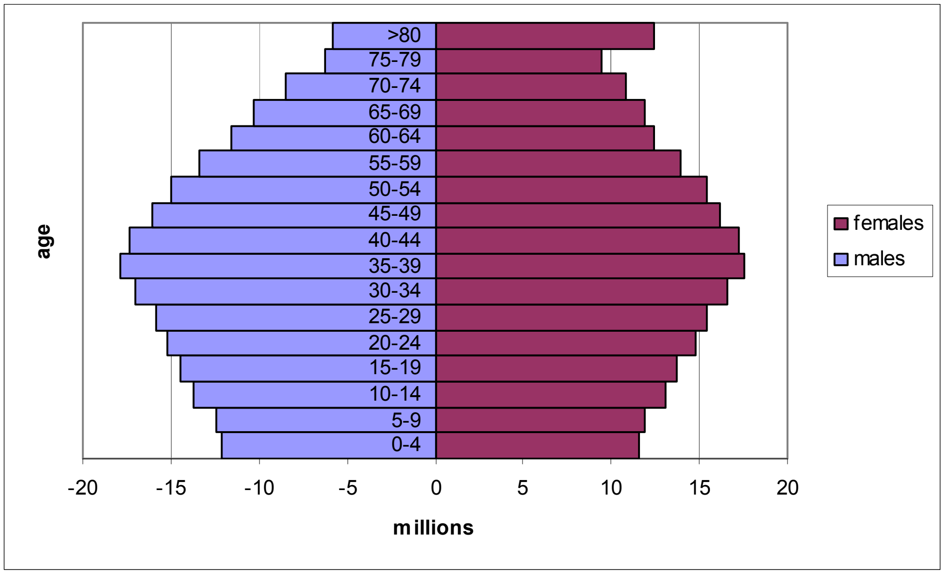
Source: Eurostat

The variations in natural growth which Figure 3 shows are due to the changes in demographic structure. As can be deduced from Figure 4, the population of the European Union is characterized by a preponderance of people in the productive age groups 15-64, who make up 67% of the total population. This is a historically high proportion: a century ago it was significantly lower. At that time, the bottom of the pyramid was much broader, due to the larger number of children and the lower life expectancy. As the age cohorts move upwards through the pyramid, it will become increasingly top-heavy: the number of children and young adults will decrease slowly while the number of elderly people will increase rapidly. Over the next few decades, therefore, the percentage of people in the economically active age groups will decline again. The demographic structure has never been as favourable as it is today, and will not be so again for a long time.[1] This will, of course, have major consequences

[1] The percentage in the productive age groups moved from 63.1 in 1975 to 66.9 in 2000, for the EU-15. The ten new member states have a slightly more favourable percentage, which brings the average for the EU-25 to 67.1 in 2000 and 67.2 in 2004.

for economic growth in the coming decades. We shall examine these consequences in section 3.

Figure 4. Demographic structure of the EU-25 countries, 2004



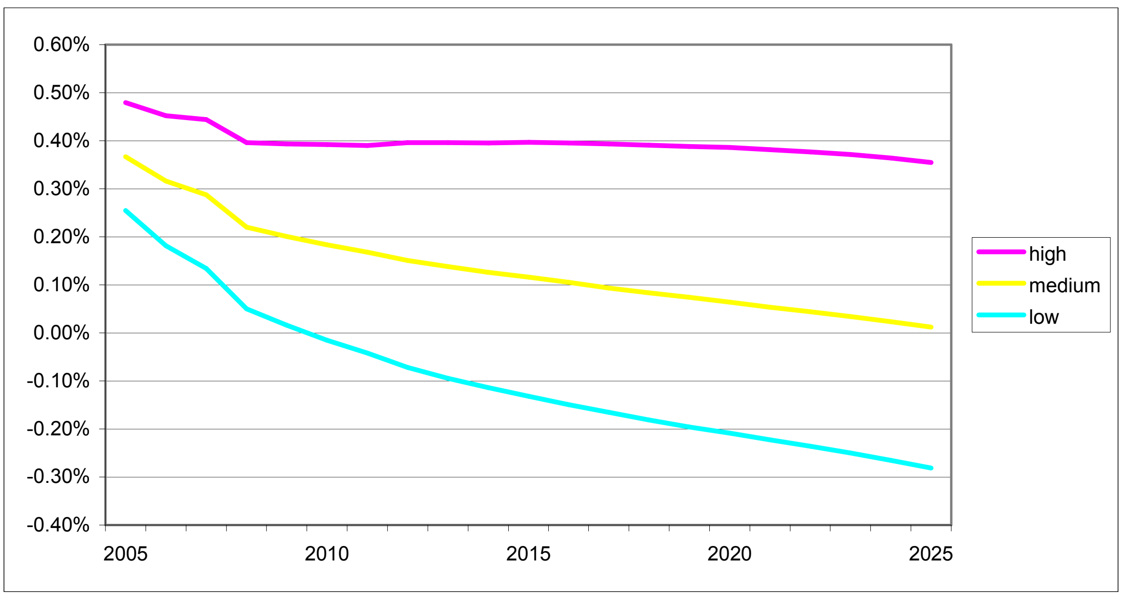
Source: Eurostat

How important is international migration as compared to natural growth? The numbers of births and deaths are much larger than those of migrants, so in that sense it is still natural growth which has the largest influence on population growth and mainly determines the demographic structure (Wilson 2004). However, as Figure 3 shows, the *difference* between births and deaths is now smaller than that between immigration and emigration – making migration a principal factor in population growth. Moreover, migration is more subject to change and less predictable than natural growth. In absolute numbers, the the migration surplus is over four times as high as the birth surplus in the EU in 2004 (Eurostat data).

Having reviewed the main trends in the components of demographic change, we can now consider what the future holds for Europe's population. The methodology used to project future population trends by virtually all demographic forecasters is known as *cohort component projection*. The method has not changed in its essentials since it was first proposed as long ago as 1895, yet projections can differ widely; what matters most are the assumptions of future trends in the components of demographic change: fertility, mortality and migration. Given how much these three elements have changed over recent decades, there is clearly a wide range of possible futures. In order to make this complexity tractable for making projections, we must narrow down the options into a few clearly defined scenarios with coherent sets of assumptions. Fortunately, in spite of the complexity of demographic patterns, it is clear that by far the single most important aspect of change for land use and its associated impacts is the total number of people in an area. Thus we can get a good grasp of the plausible range of future demographic trends through just three scenarios, each associated with a distinctly different growth rate of the overall population. The three scenarios can be termed High, Medium and Low. In each of the two contrasting scenarios there is a combination of fertility, mortality and migration that works in the same direction, either to increase (High) or decrease (Low) the rate of population growth, compared with the reference scenario. This method of combining all the elements that either increase or decrease population growth into a single scenario (known technically as "bundling") is by far the most common method in use by European national statistical offices and international organisations such as the United Nations. For most countries the projections used are the latest published by Eurostat, covering the current EU-25. They were produced after extensive consultations with the national forecasters and European experts in demographic trends and forecasting.

The SENSOR reference scenario corresponds to Eurostat's Medium projection. It sees fertility remaining well below the level of inter-generational replacement into the long term, but expects a small upturn in some countries. Life expectancy continues to improve but at somewhat slower rate than in recent decades, and immigration declines from its current level. The combined result of these assumptions is that in the reference scenario Europe's total population remains more or less constant up to 2025. The High population growth scenario has higher fertility (though still mostly below replacement level), longer life expectancy and more immigration (though still below recent rates). The combined effect is a modest growth in the total population. The Low scenario envisages fertility staying very low, with less improvement in life expectancy and much lower immigration. The overall effect is to project a marked decline in Europe's population in the not too distant future. Figure 5 shows population growth rates for the three baseline scenarios for the EU-25.

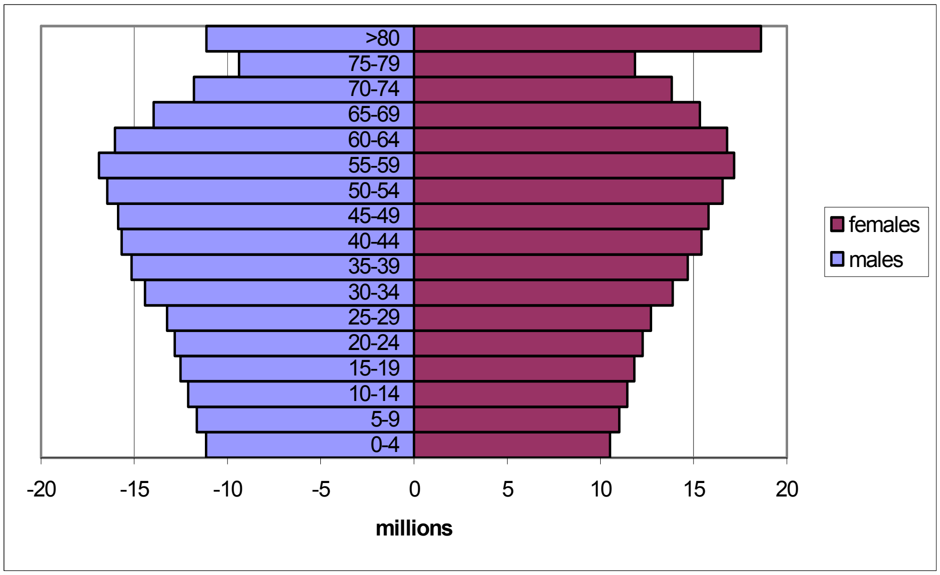
Figure 5. Projected population growth in three scenarios



Source: Eurostat population projections

The differences between the total population of the EU today and in 2025 are quite small in all three scenarios: the variations are between a maximum growth of 8% and a maximum decline of 2%, with the medium scenario arriving at a total population 2.5% above the present level – or nearly 12 million persons in absolute figures. For the demographic structure of the population, however, the changes are more dramatic, as Figure 6 shows.

Figure 6. Projected demographic structure of the EU-25 countries, 2025 (reference scenario)



Source: Eurostat population projections

In comparison with the situation in 2004 (Figure 4), the numbers of children, young people and those in the most productive age group (25-54) will all have declined in 2025, both in absolute numbers and – more importantly – as a percentage of the total. In contrast, the numbers of older workers (55-64) and the aged are increasing rapidly: the pyramid becomes increasingly top-heavy. As we can see in Table 1, these shifts are even more pronounced under the low-growth scenario. Under high-growth assumptions, the number of children grows, but the dependency ratio (the numbers of working age in relation to those too young or too old to work) becomes even more unfavourable. This is because both fertility and life expectancy are higher in the high-growth assumptions, so the first effect is to increase the numbers of children and old persons.

Table 1. Major demographic shifts under three scenarios

group	*change in numbers 2004-2025*	*% of total in 2004*	*% of total in 2025*
	Medium (reference scenario)		
children (0-14)	-9.2%	16.4%	14.4%
young persons (15-24)	-14.9%	12.7%	10.5%
most productive (25-54)	-8.8%	43.2%	38.3%
older persons (55-64)	30.4%	11.2%	14.2%
the aged (over 65)	40.7%	16.5%	22.5%
total	2.5%	100.0%	100.0%
	Low growth		
children	-23.5%	16.4%	12.8%
young persons	-20.3%	12.7%	10.4%
most productive age group	-11.4%	43.2%	39.1%
older persons	28.9%	11.2%	14.8%
the aged	37.1%	16.5%	23.1%
total	-2.2%	100.0%	100.0%
	High growth		
children	8.1%	16.4%	16.3%
young persons	-9.3%	12.7%	10.6%
most productive age group	-6.0%	43.2%	37.4%
older persons	32.2%	11.2%	13.7%
the aged	45.4%	16.5%	22.1%
total	8.2%	100.0%	100.0%

Source: Eurostat population projections

2.3. Participation rate

The proportions of people in the various age groups have, of course, large economic consequences. Almost the entire labour force is found in the 15-64 age group. Since it is illegal for children to work, where they do they are kept out of the statistics; workers over 65 are a small group. Within the 15-64 age group, actual participation in the labour force (defined as those either working or unemployed but looking for work or willing to work) also depends on age and sex: the young are often still in school, many people above 55 retire early, and among women the participation rate is still lower than for males – although the gap is narrowing.

There are large differences in sex- and age-specific participation rates between countries, and also in the way these rates are changing. For Europe as a whole, however, in recent years participation rates have risen in all groups, as Table 2 shows. The emancipation of women clearly shows both in their lower participation rate among the young (indicative of a high proportion receiving advanced education) and in the rising rates among both prime-age and older women. Over a longer period the picture is somewhat different: participation rates of women have increased for a long time, but those of the over-55s and the under-25s have declined because of early retirement and longer education periods, respectively (Carone, 2005:4).

Table 2. Labour force participation rates by age and sex, EU-25, 2004 (%)

age group	*males*	*change since 1990*	*females*	*change since 1990*
15-24	48.1	+6.2	41.1	+2.5
25-54	91.8	+24.4	75.2	+53.5
55-64	54.3	+25.1	33.8	+69.8

Source: Carone 2005/ Eurostat

Thus, apart from the total population and the numbers in the economically active age groups, we also need to forecast future changes in these age- and sex-specific participation rates, in order to arrive at the size of the working population. For the SENSOR reference scenario we take the most recent and most complete projections of the EU-25 workforce made by the European Commission. These were published in 2005 by the Working Group on Ageing (WGA) of the Directorate General for Economics and Finance (ECOFIN). They use the same Eurostat population projection as the SENSOR reference scenario, thus ensuring complete internal consistency. For countries not analysed by the WGA we took the most comparable projections made by the International Labour Organisation of the United Nations.

Forecasting the labour force in the decades ahead is not an entirely straightforward task. Over the last 30 years or so there has been a marked reduction in the number of older workers (50 plus) who are employed. This has been associated with a substantial reduction in the age at retirement. This trend has arisen not so much from changes in the normal, legally defined, age at retirement, but through the proliferation of schemes for early retirement. Faced with persistently high unemployment, most European governments have encouraged older workers to leave the work force in the hope of opening up slots for younger workers. This has, to say the least, been of ambiguous economic benefit. In any event, it is highly unlikely that this trend will continue, indeed there are already signs that it has begun to reverse. In several EU countries the average age at retirement has increased in the last four or five years. The WGA projections assume that this shift towards later retirement will continue. A second major trend in labour force participation in recent decades has been a substantial increase in the number of women in employment. This trend is likely to continue.

The attempt to increase the labour force participation of both women and older workers forms a key element in the Lisbon Agenda for improving Europe's economic competitiveness. While progress towards meeting these aspects of the Agenda has been mixed, it seems overwhelmingly likely that future trends will move in this direction. Another important aspect of these changes is that they imply very different amounts of change in different parts of Europe. For example, relatively little change is expected for the Nordic Countries that largely already meet the Lisbon criteria. In contrast, some Southern European countries (e.g. Italy) have low rates of participation of both women and older workers, and thus substantial change is to be expected there. Some other countries (e.g. France) have quite high rates of female participation, but very early retirement, thus implying an intermediate degree of change. In short, the future of the European working population is a story of convergence towards a norm already established in the Nordic Countries. The SENSOR scenarios are based on different amounts of convergence.

The reference scenario, taken from the WGA, assumes that changes will be rather slower than hoped for in the Lisbon Agenda. This scenario is shown in Table 3. The high scenario assumes more rapid convergence, with more women and older workers in the labour force than in the WGA projections. In contrast, the Low scenario assumes less rapid convergence and thus fewer female and older workers.

Table 3. Projected labour force participation rates by age and sex, EU-25, 2025 (%)

age group	*males*	*change since 2005*	*females*	*change since 2005*
15-24	50.7	+0.7	43.7	+0.7
25-54	94.1	+2.1	82.8	+7.0
55-64	65.9	+11.1	51.1	+18.0
65-71	13.9	+2.7	7.6	+2.7

Source: Carone 2005

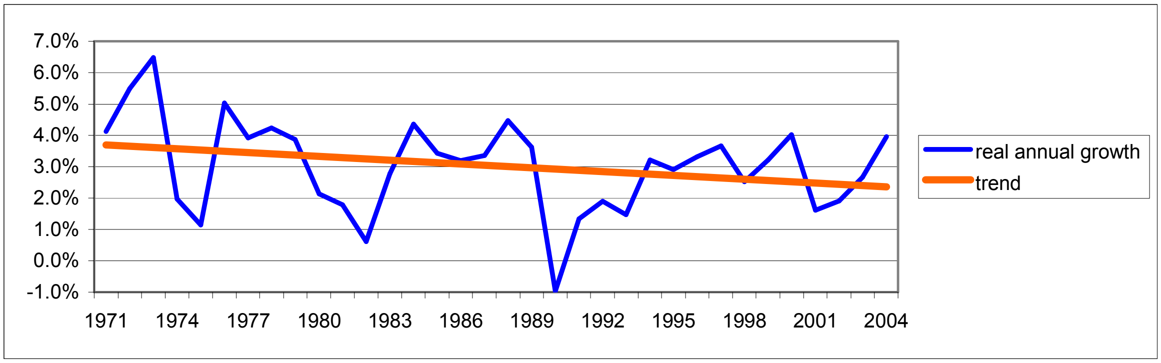
As is clear from Table 3, participation rates are likely to rise in all groups, but at modest rates compared to recent trends. Except in the age group 55-64, there is relatively limited scope for a further rise in participation. Combining these outcomes with the changes in demographic structure described in the previous section, the total labour force as a percentage of the population will be virtually the same in 2025 as it is today: 48.1% as compared to 47.7% in 2005. This masks, however, the changes which are actually expected to occur: the labour force is expected to grow as a percentage of the total population, to 49.5% in 2015; after that it will begin to decline, returning to the present level around 2025. it will continue to decline after that. What will change is that a larger proportion of the total workforce will consist of older people: the proportion of workers between 55-64 will increase from 10% today to 18% in 2025.

It must be borne in mind that this is very much a business-as-usual scenario, which is not necessarily the same as the most likely development. This is in line with our approach to baseline scenarios as sketched in section 1.3. For instance, the potential impact of pension reforms already enacted in 17 countries is included in the forecast (Carone 2005:9ff), but not further reforms which might well be considered necessary.

2.4. World demand

World demand can be equated with total world income or total production. When we speak of the demand for European products exerted by the rest of the world, one might argue that only part of the rest of the world's income will be spent on goods and services imported from Europe. That is true, but it is impossible to say what that portion is, since it is not a fixed basket of goods. Therefore we take total world income as an indicator for changes in the demand for goods from the EU. Looking at world economic growth over a longer period, there appears to be a slow downward trend, as Figure 7 clearly shows.

Figure 7. World economic growth, 1971-2004 (GDP at market prices in constant US$ of 1990)



Source: UN Statistics Division; processing: LEI

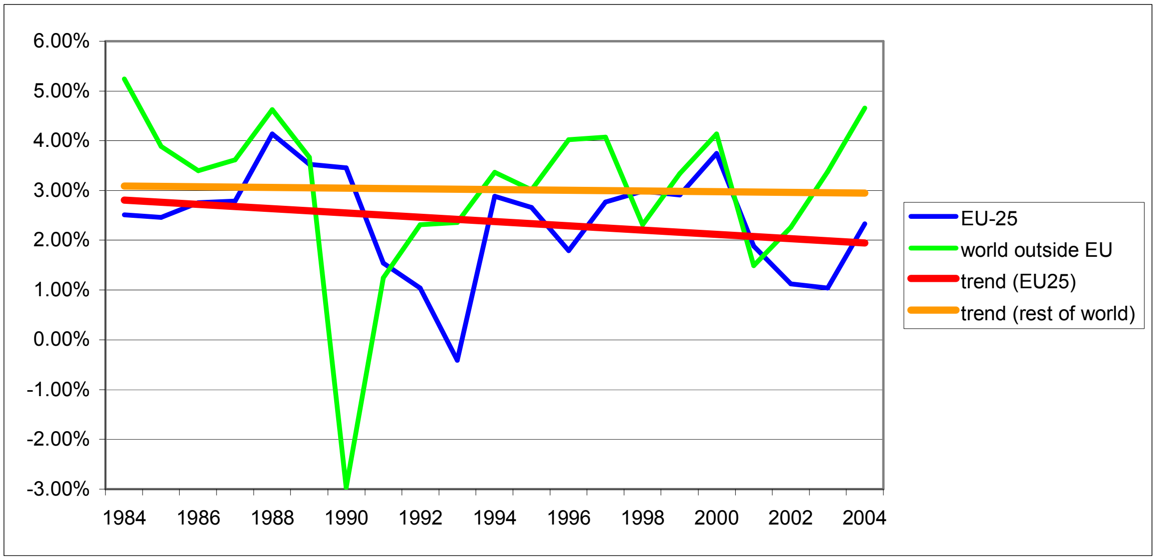
In interpreting this graph, several caveats are necessary, quite apart from the familiar comment that GDP cannot adequately measure human welfare, or that it fails to take into account the deterioration of our natural environment and the consumption of a finite stock of natural capital.

- Prices change from year to year. In the figures on which Figure 7 is based, a correction has been made for these changes, so the figures reflect real rather than nominal growth. However, since prices for different goods do not all change at the same rate, weights must be applied to the different goodes to reflect their importance in the economy. That importance, however, also changes, so a price index based on a basket of goods in one year can never adequately reflect overall price changes over an extended period.
- Prices of goods also vary from country to country. The exchange rates between national currencies only partially compensate for these differences, because they only reflect price differentials in goods traded on the world market. This can be compensated by recalculating the exchange rates on the basis of purchasing power, but that has not been done for Figure 7. One consequence of this state of affairs is that the production of poorer countries (which usually have lower costs of living) is undervalued.
- The figures are all relatively crude, and the more so for countries with underdeveloped statistical systems (in fact, some countries are not represented at all).
- Subsistence production, which by definition has no market price, is only partially represented. With development, subsistence production tends to be replaced by production for the market, which leads to an increase in GDP which does not necessarily reflect an increase in real production.

Furthermore, we must take into account that the EU itself is responsible for about 30% of total world production as measured in Figure 7.[2] This means that the trend for the other 70% could differ significantly from that for the world as a whole. When we look at the picture over the last twenty years (a similar period to the one we are forecasting), this turns out to be indeed the case (Figure 8): the growth rate for the rest of the world has been almost constant on average; most of the declining trend is precisely due to what is happening in the EU.

[2] If we correct for differences in purchasing power, that percentage decreases to approximately 20%.

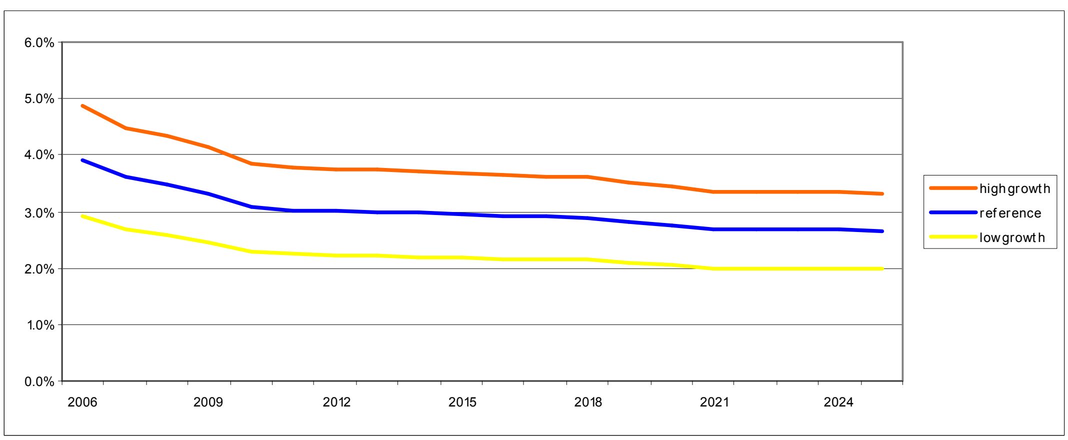
Figure 8. Economic growth in the EU-25 and the rest of the world, 1984-2004[3]
(in constant 1990 US dollars)



Source: UN Statistics Division; processing: LEI

Simply extrapolating the trend of economic growth in the rest of the world for the next 20 years would mean annual growth rates decreasing slowly from a trend figure of 2.95% today to 2.8% in 2025. More sophisticated estimates have been made, however. An example is a projection for 2030, made by the OECD. In the OECD model (called JOBS[4]), the quantity of labour and its productivity are used as drivers (Bagnoli *et al.* 2005). For those regions of the world that are outside the EU, their projection is a more rapid decline than sheer extrapolation would predict (Figure 9). By 2025, the overall growth rate is 2.7%.

Figure 9. Projection of growth in world production outside the EU-25
(real GDP at market prices)



Source: OECD (Bagnoli et al. 2005), processing: LEI

---

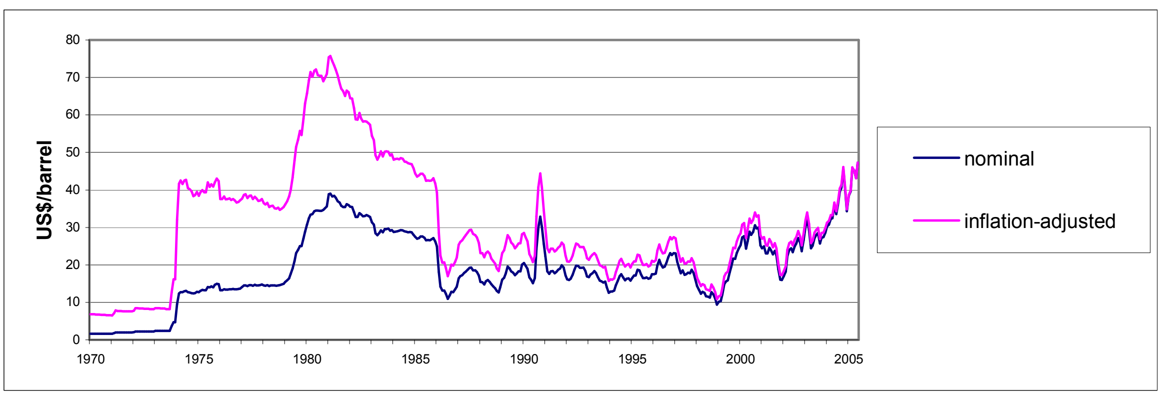
[3] The growth rate for the EU over the years before 1990 does not include the three Baltic states and Slovenia.
[4] JOBS is a global recursive dynamic computable general equilibrium model which captures international trade and focuses on environmental issues.

The OECD does not provide contrasting scenarios. In order to construct these, we have used the calculations of the PROMETHEUS model (see the next section) as a basis for establishing probability intervals. According to those calculations, world GDP growth will be between 74.2% and 124.7% of the median projection with a probability of 95%. We have used these assumptions to compute our high- and low-growth scenarios, also depicted in Figure 9.

2.5. The oil price

The changes in world oil prices over the last 35 years would have been difficult to predict with economic modelling. Wild swings as a result of political events in the Middle East dominate the picture as shown in Figure 10: the 1973/74 oil crisis associated with the Yom Kippur war, the 1979/80 crisis linked to the fall of the monarchy in Iran and the Iran-Iraq war which followed it, and the short-term hike during the first Gulf war in 1991. Dramatic falls have been due to economic rather than political events, but these too were of a short-term nature: Saudi Arabia abandoning its role as a swing producer (1986); the Asian economic crisis (1998) and the weakness of the world economy after 9/11 (2001) (EIA 2005). However, if we discount the impact of these swings (to the extent that this is possible) and correct for the effect of inflation, the real cost of oil shows a modest rise over the period 1970-2000 and a more marked rise after that. This probably reflects the real scarcity of oil quite well: although since the publication of the Club of Rome report in 1972, the world has been clearly aware that oil stocks are not inexhaustible, for a long time the increase in demand has been outstripped by the discovery of new oil fields – partly previously known sources made viable by the increase in oil prices. Thus, known stocks of oil continued to rise for many years.

Figure 10. Historical changes in the world oil price[5]



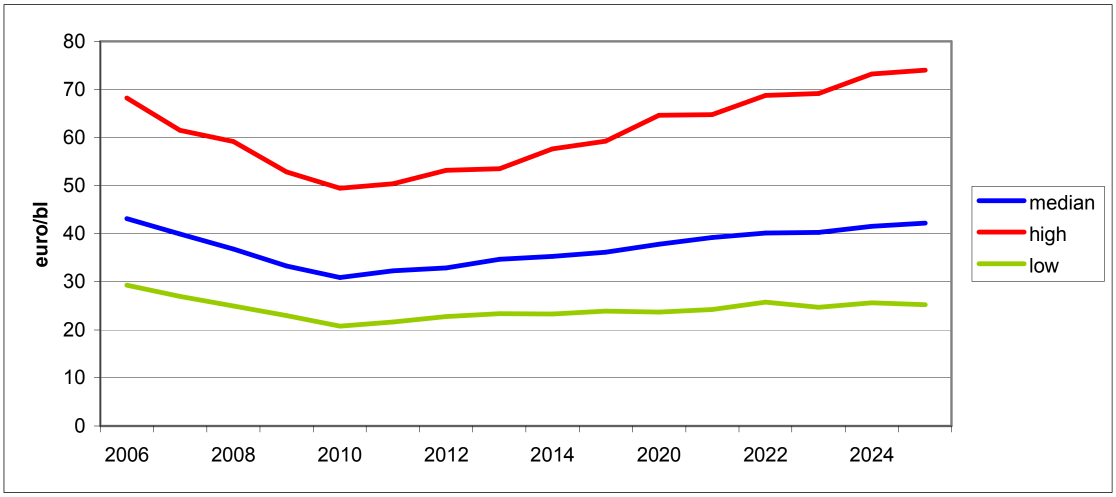
Source: US Government – Energy Information Administration

The rise in recent years, however, even though political events (the war in Iraq and the fear of disruption by terrorists in Saudi Arabia) still play a part, is believed to be due mainly to market forces – in particular the growth in demand in the emerging Asian economies (Berkmen *et al.* 2005).

[5] Refiner Acquisition Cost of Imported Crude Oil (IRAC) for imports into the United States. For 1970-73 prices are based on the official price of Saudi Light crude. The adjustment for inflation is done in constant 2005 dollars.

That view is reflected also in projections made with PROMETHEUS, a stochastic model of the world energy system developed at the National Technical University of Athens (Uyterlinde *et al.* 2004:20, 82, 87), shown in Figure 11. As the figure shows, the expectation is that oil prices will decrease over the next few years, but rise in the longer term. The high and low variants represent the 95% probability interval.

Figure 11. Projections of the world oil price, 2006-2025 (in constant € of 1999)



Source: PROMETHEUS (Institute of Computers and Communication Systems, National Technical University of Athens)

This model uses projections of world GDP on the basis of the SRES-B2 scenario of the IPCC. This results in a global growth rate of 3.0% over the period up to 2020 and 2.6% thereafter. That rate is quite close to the world growth rates of the OECD projection described in the previous section, which are 3.0 and 2.5 respectively.[6]

The EU itself exerts a considerable influence on the world oil market, both as a consumer and as a producer. Since its growth is lower than that of the world as a whole, however, the percentage of world oil which it consumes is decreasing. Moreover, because energy efficiency in Europe is relatively high and (driven by the increasing cost of energy) increasing, the growth in demand for energy is less than the growth in GDP. On the other hand, because European oil and gas reserves are being depleted rapidly, our dependence on imported fossil fuels will grow, despite the development of alternative sources of energy (Uyterlinde *et al.* 2004:53-68).

2.6. Research & Development efforts

Innovation – in marketing and organization as well as in technology – exerts a major influence on economic growth by raising the productivity of people, capital and natural resources. There are five major factors determining the rate of innovation in a society:

- the level of education of the work force;

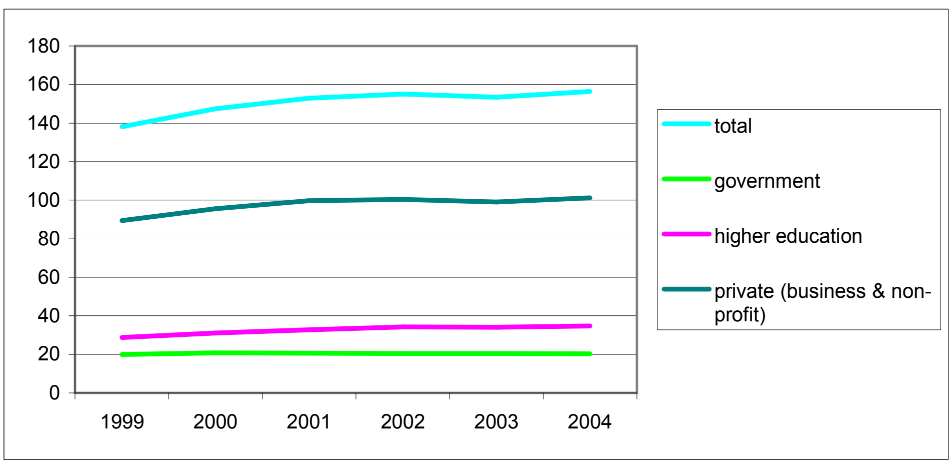
[6] Policies are assumed to remain constant, in line with the general assumption for our baseline scenarios. However, a carbon tax is assumed to be in force in OECD countries from 2005, and in non-OECD countries from 2011 (Uyterlinde *et al.* 2004:87).

- investments made in research and development (R&D);
- the willingness to innovate. The latter in turn is influenced by
    - cultural behaviour patterns;
    - institutions (e.g. intellectual property rights); and
    - policies.

Thus, R&D expenditure is one driver of innovations, and therewith of economic growth. It is itself also strongly influenced by the level of GDP (rather than by the GDP growth rate), in that the richer a country is, the more it can afford to spend on R&D – even as a percentage of total GDP. This is why the latter figure is lower in China than in the EU, even though China is a much more dynamic economy; similarly, within the EU the poorer countries tend to spend a lower proportion of their GDP than the richer ones.[7]

Data on total R&D expenditure in the EU are somewhat sketchy, however. In real terms and for the EU as a whole, they are available only from 1999, which does not give us much of a trend (Figure 12). We can see that growth in R&D expenditure has been modest at 2.5% per year in real terms; that almost two thirds of the total comes from the private sector; and that the growth has been mostly in academic research. Business has been reluctant to invest in the recent years of slow economic growth, and governments (desirous to keep their budget deficits within bounds) have been even more shy, notwithstanding a professed concern for promoting the knowledge economy.

Figure 12. R&D expenditure in the European Union, in billions of purchasing power standards (constant prices of 1995)



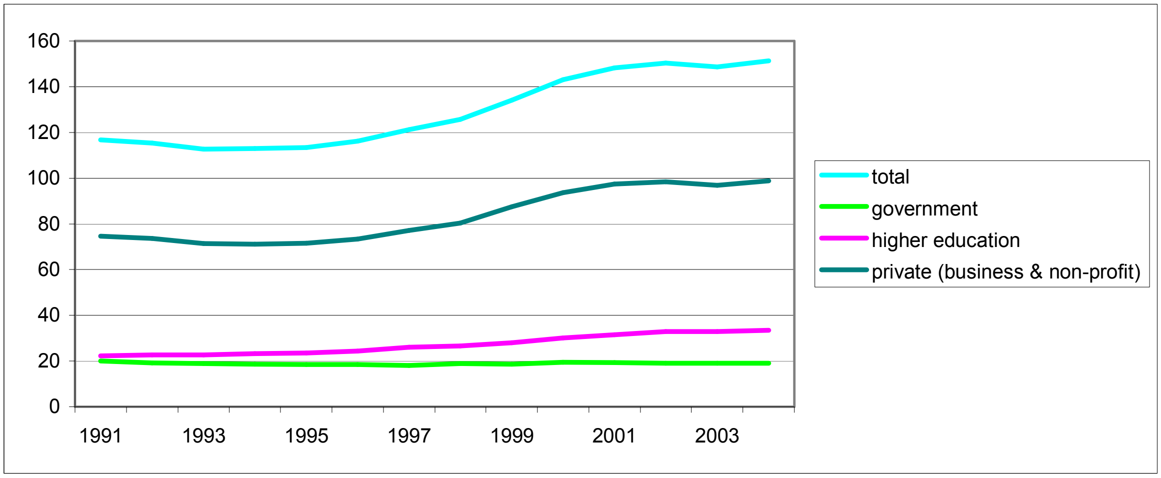
Source: Eurostat

For the 15 pre-2004 member states, a somewhat longer time series is available. This is shown in Figure 13. The picture now becomes clearer: R&D efforts in the private sector follow the business cycle fairly closely; the expenditure on academic research shows a long-term rising trend, whereas public support to R&D (outside university programmes) appears to have stagnated for a long time. Also significant is the difference between the old and the new member states: although the latter take up only a small proportion of overall R&D spending, growth is much faster there. Furthermore, in the new member states, a larger proportion of

[7] The percentages in question are 1.3 and 1.9 respectively in 2003 (Eurostat 2005).

R&D is spent by the public sector; this actually a normal feature of poorer countries and is therefore likely to converge with that of richer member states.

Figure 13. R&D expenditure in the EU-15, in billions of purchasing power standards (constant prices of 1995)



Source: Eurostat

R&D expenditure in recent years falls well short of the target specified in the Lisbon Agenda of the EU, which aims at increasing R&D to 3% of GDP by 2010. That target was proclaimed in 2000, since when the actual R&D intensity (as the quantity is called) has fluctuated around 1.9%. Thus, the chance of achieving the Lisbon target is rather remote. We shall use the target as a basis for our high-growth scenario. The business-as-usual scenario we shall base on simple extrapolation of the trend for the EU-15 over the last 14 years. Whereas this may seem somewhat pessimistic, because the new member states have faster growth R&D expenditure, we believe that it is realistic as we shall presently argue.

The EU is falling behind rather than catching up, as some data collected to review progress on the Lisbon Agenda make clear: in Europe, although expenditure on education is not far behind the USA, expenditure on tertiary education is much higher in America (Table 4). It is then not surprising that the number of researchers in Europe is also relatively low and increasing only slowly. Finally, there is a tendency for more investment in R&D flowing from Europe to the US than the other way round, which indicates that Europe is losing its attractiveness as an environment for innovation (Duchêne & Hassan 2005:34-35). As these authors state: “It risks leading Europe into a worrying vicious circle as the loss of high value-added R&D activities and jobs is undermining further its capacity to retain such activities.” (*Ibid.)*

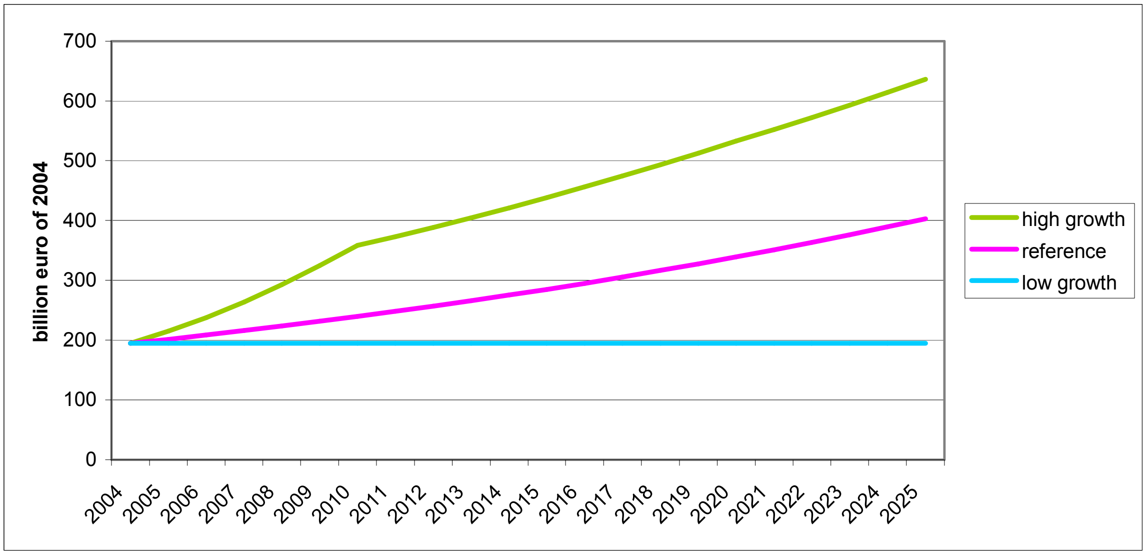
Table 4. Some factors influencing the potential for growth in R&D expenditure

Education expenditure as % of GDP, 2001	EU25	USA	Japan
All education:			
Public	5.10	5.08	3.57
Private	0.60	2.22	1.17
Total	5.70	7.30	4.74
Tertiary education:			
Public	1.08	1.48	0.54
Private	0.20	1.77	0.61
Total	1.28	3.25	1.15
Researchers per '000 labour force, 2003	5.4	9.0	10.1
Growth in no. of researchers, per year 1997-2003	2.8	3.2	2.1

Source: Duchêne & Hassan 2005

These observations must inform our perspective towards the future. Hence, our business-as-usual scenario is based on the expectation that the effect of the vicious circle referred to above will be minor, and just enough to cancel out the effect of higher R&D growth in the new member states. For our low-growth scenario, however, we assume that R&D expenditure for the EU as a whole will stagnate in real terms at the 2004 level as a result of the low priority of higher education, and the attractiveness of more dynamic parts of the world as research and innovation environments. The high-growth scenario assumes that the target of 3% of GDP by 2010 is achieved for the EU as a whole. After that date, R&D expenditure will continue to rise, but a a slower rate to reach 3.5% of GDP by 2020; that same rate will then be maintained until 2025. Figure 14 shows the three trends.

Figure 14. Projection of R&D expenditure, 2005-2025[8]



2.7. Policies

As stated in section 2.1, policies are kept constant for the baseline scenarios; this is indeed the point of having baseline scenarios in the first place. With 'constant' we mean here all such policies which are already in force, or (in the case of EU policies) which had been approved by the European Council as of 1st December 2005. All such policies as may have been initiated by the European Commission but not ratified by the European Council may be regarded under policy scenarios, but not in the baseline. To the extent that national policies are relevant, no change in them is assumed to happen, save for the extent that they are already part of a particular baseline scenario (e.g. the promotion of R&D investment in a high-growth scenario).

2.8. Institutions

Institutions are a crucial factor in determining what change may take place in a society. Economic growth is heavily influenced by the freedom of markets, the protection of property and the enforcement of contracts. Access to financial services such as credit and insurance and bureaucratic obstacles to establishing a business determine whether or not small

[8] For the reference scenario, we have taken the linear trend in the EU-15 data over 1991-2004, in terms of constant 1995 purchase power parity. This trend has been applied to the nominal R&D expenditure over 2004.

For the high-growth scenario, we have taken the percentage of GDP as leading. This percentage smoothly increases from the current 1.94 to 3.0 in 2010; it is then assumed to increase further to 3.5 in 2020 and 4.0 in 2030. For the sake of comparison, the percentage is currently 2.59 in the US, 3.15 in Japan and 4.27 in Sweden (Duchêne & Hassan 2005:22. For GDP, we have used the OECD projection for the EU as a basis, using the method mentioned in section 2.4 to calculate the high-growth variant.

For the low-growth scenario, as stated in the text, R&D expenditure is kept constant in real terms. As a percentage of GDP, it declines (using low-growth projections of GDP) from 1.9 to 1.4% in 2025. In the reference scenario, this percentage increases modestly to 2.6%.

businesses can flourish. The existence and patterns of voluntary organizations are an important factor in economic growth (Narayan & Pritchett 1999) but also have an impact on social issues such as emancipation.

In the macro-economic baseline scenarios with which this paper is mainly concerned, we shall not consider institutional change. In the policy cases, however, changes in institutions may be necessary in order to make some policies succeed.

2.9. Cultural change

Culture is intimately linked with institutions. For instance, the foundations of legal systems and the historical development of the state critically shape the way people view themselves in relation to each other and to the state (see, for instance, North & Thomas 1973 or Putnam 1993). This has an impact on, for instance, the form environmental activism can take in different countries. Thus, institutions influence culture. On the other hand, whereas institutions give a certain stability to social and cultural patterns, cultural change can end up making them anachronistic and force institutional change.

Culture also influences policies. People's views on issues such as the environment, gender relations, or multiculturalism change with the times. Politicians need to adjust themselves to such changes, especially in democratic societies.

Cultural elements most likely to influence multifunctional land use include

- consumer preferences related to agricultural and forest products, e.g. on organic farming, on genetic modification, animal welfare, or whether social standards are adhered to.
- Preferences related to tourism: interest in transcontinental travels, second homes, landscape esthetics, active as opposed to relaxing holidays, cultural interests.
- Environmental attitudes.
- Preferences related to residential choice (urban vs. rural).
- The importance attached to increased mobility.
- Importance attached to participation in decision-making.

In the macro-economic baseline scenarios, these cultural elements, like institutions, are kept constant. However, when we are dealing with sectoral analysis, we shall consider the potential impact of cultural change.

3. The scenarios

3.1. The reference scenario

In this section, we present the overall storyline of our reference scenario for the five drivers to which the macro-economic model responds. With all drivers, we must bear in mind that the causality between them and the dependent variables in our model is not one-way: economic growth in the EU will lead to more immigration and thus population growth; it will encourage more women to work, and thus raise the labour force participation rate; it will also cause higher economic growth in the rest of the world; it will lead to more demand for energy and thus exert an upward pressure on oil prices; and it will make more resources available for research & development. Therefore, it will be necessary to compare the output of our macro-economic model with the GDP assumptions on which the predictions for the drivers were based.

The internal consistency of the patterns of change in these five drivers has already been checked to the extent possible. GDP growth has been chosen as the criterion for this consistency. R&D expenditure, the labour force participation rate and world demand follow a similar pattern and may be assumed to be consistent with each other. For the world oil price, a different GDP forecast has been used, but this differs only marginally from the OECD projection we have used. The population forecast of Eurostat has been made independently of GDP growth. Population growth has been used as a driver in the OECD forecast, and the total population figures for the EU-25 they use are very close to those of Eurostat: 0.17% higher in the target year 2025.

The reference scenario, then, presents the most likely development of world demand and of world energy prices, combined with the most likely population figures for each of the 25 EU member states as well as the proportions of those populations who will be available for income-earning activities following recent trends and existing policies. For R&D expenditure, too, we assume that recent trends will continue. Table 5 presents the relevant figures.

Table 5. The reference scenario for five drivers

		2005	2015	2025
oil price (in constant euros of 2004, per barrel)		46.8	39.8	46.5
world GDP excluding EU25 (in millions of constant euros of 2004)		31,389,612	43,153,113	56,707,663
population (number)	**EU-25**	458,490,171	467,306,493	470,057,265
	Austria	8,139,754	8,357,541	8,500,626
	Belgium	10,424,797	10,673,530	10,898,439
	Cyprus	739,168	827,793	896,858
	Czech Rep.	10,197,499	10,012,015	9,811,677
	Denmark	5,411,252	5,497,974	5,556,633
	Estonia	1,346,015	1,278,926	1,224,074
	Finland	5,232,566	5,353,499	5,438,812
	France	60,183,227	62,615,692	64,392,005
	Germany	82,599,773	82,864,226	82,107,628
	Greece	11,082,573	11,390,004	11,393,535
	Hungary	10,095,698	9,834,250	9,588,374
	Ireland	4,077,106	4,554,894	4,922,321

	Italy	58,189,344	58,630,230	57,750,958
	Latvia	2,305,075	2,174,230	2,068,066
	Lithuania	3,429,259	3,257,650	3,133,654
	Luxembourg	455,967	498,689	544,009
	Malta	403,905	438,881	467,809
	Netherlands	16,331,012	16,957,169	17,428,784
	Poland	38,136,691	37,428,487	36,836,280
	Portugal	10,523,792	10,761,957	10,729,751
	Slovakia	5,375,638	5,308,995	5,236,550
	Slovenia	1,999,722	2,018,808	2,014,180
	Spain	42,920,329	45,264,179	45,555,524
	Sweden	9,010,257	9,372,926	9,768,566
	UK	59,879,752	61,933,948	63,792,152
labour force (number)	**EU-25**	218,914,345	231,292,879	225,896,620
	Austria	4,389,760	4,636,289	4,502,421
	Belgium	5,046,725	5,245,097	5,168,800
	Cyprus	431,391	509,011	528,340
	Czech Rep.	5,616,162	5,730,291	5,344,422
	Denmark	2,980,129	3,096,089	2,987,862
	Estonia	758,496	721,274	675,877
	Finland	2,830,343	2,940,730	2,842,487
	France	30,276,241	31,193,049	31,729,973
	Germany	46,237,467	45,733,262	43,178,669
	Greece	5,716,987	5,779,367	5,607,465
	Hungary	4,826,275	4,842,999	4,688,714
	Ireland	2,189,836	2,493,177	2,710,469
	Italy	27,671,764	28,074,802	26,984,579
	Latvia	1,328,691	1,254,447	1,154,608
	Lithuania	1,929,386	1,917,210	1,777,841
	Luxembourg	224,557	247,162	260,328
	Malta	180,436	207,369	215,709
	Netherlands	8,862,109	9,295,744	9,192,226
	Poland	19,989,375	20,092,708	19,668,609
	Portugal	5,967,501	6,040,641	5,891,829
	Slovakia	3,032,985	3,114,978	2,992,214
	Slovenia	1,093,591	1,093,576	1,057,143
	Spain	23,116,981	24,720,504	24,421,150
	Sweden	4,979,818	5,322,257	5,279,012
	UK	31,968,870	33,893,902	33,392,953
R&D expenditure (all sectors, in millions of constant euros of 2004)	**EU-25**	198,885	254,567	326,225
	Austria	5,477	6,975	8,884
	Belgium	5,598	7,130	9,081
	Cyprus	48	76	120
	Czech Rep.	1,152	1,827	2,897
	Denmark	5,190	6,611	8,419
	Estonia	87	137	218
	Finland	5,382	6,854	8,730
	France	36,521	46,512	59,238
	Germany	56,449	71,893	91,562
	Greece	990	1,261	1,606
	Hungary	755	1,198	1,900
	Ireland	1,824	2,323	2,959
	Italy	15,791	20,111	25,614

	Latvia	49	78	123
	Lithuania	143	227	361
	Luxembourg	459	585	744
	Malta	13	21	33
	Netherlands	8,869	11,295	14,386
	Poland	1,193	1,891	3,000
	Portugal	1,035	1,318	1,679
	Slovakia	182	289	458
	Slovenia	438	694	1,101
	Spain	9,165	11,672	14,866
	Sweden	10,681	13,604	17,325
	UK	31,394	39,983	50,922

3.2. Contrasting scenarios: high and low growth

For the contrasting scenarios, internal consistency is harder to achieve, because the drivers have different bandwidths: the low variant in one does not necessarily have the same probability as in another. Therefore, these scenarios should be interpreted with caution: they do not so much represent a possible image of the future in themselves as a lower and upper limit for each of the strategic variables. Tables 6 and 7 show the Low- and High-growth scenarios, respectively.

Table 6. The low-growth scenario for five drivers

		2005	2015	2025
oil price (in constant euros of 2004, per barrel)		46.8	26.4	27.8
world GDP excluding EU25 (in millions of constant euros of 2004)		31,067,181	39,380,351	48,261,893
population (number)	**EU-25**	457,980,121	457,569,881	447,801,455
	Austria	8,130,105	8,181,623	8,106,414
	Belgium	10,417,631	10,514,198	10,492,346
	Cyprus	736,073	783,028	806,775
	Czech Rep.	10,185,930	9,782,947	9,277,570
	Denmark	5,406,659	5,404,059	5,320,220
	Estonia	1,341,028	1,224,181	1,122,216
	Finland	5,229,990	5,270,514	5,225,530
	France	60,150,712	61,675,119	62,095,900
	Germany	82,472,618	80,737,695	77,473,598
	Greece	11,068,324	11,111,300	10,756,071
	Hungary	10,084,833	9,599,260	9,041,721
	Ireland	4,072,373	4,451,415	4,673,627
	Italy	58,156,128	57,872,668	56,022,570
	Latvia	2,300,653	2,106,385	1,928,321
	Lithuania	3,423,202	3,161,401	2,928,146
	Luxembourg	455,397	483,438	502,696
	Malta	402,766	419,519	424,519
	Netherlands	16,318,474	16,628,254	16,609,777
	Poland	38,093,741	36,524,019	34,736,306
	Portugal	10,497,992	10,475,270	10,115,562
	Slovakia	5,369,329	5,180,783	4,929,527

	Slovenia	1,992,111	1,929,337	1,850,370
	Spain	42,870,954	44,371,868	43,583,513
	Sweden	8,999,334	9,140,660	9,261,563
	UK	59,803,764	60,540,940	60,516,597
labour force (number)	**EU-25**	217,544,696	225,897,840	218,743,721
	Austria	4,036,981	4,244,899	4,112,792
	Belgium	4,472,996	4,676,338	4,594,230
	Cyprus	370,164	443,349	454,027
	Czech Rep.	5,134,724	5,114,482	4,793,838
	Denmark	2,873,313	2,885,649	2,814,118
	Estonia	659,573	637,733	576,578
	Finland	2,628,080	2,644,708	2,568,383
	France	27,317,722	28,219,568	28,116,491
	Germany	40,821,023	42,023,019	39,191,291
	Greece	5,076,640	5,245,645	5,069,453
	Hungary	4,249,064	4,332,557	4,148,775
	Ireland	1,962,854	2,244,488	2,417,543
	Italy	24,566,631	25,236,206	24,547,252
	Latvia	1,134,901	1,147,283	1,026,484
	Lithuania	1,654,074	1,693,239	1,581,069
	Luxembourg	200,278	220,724	225,308
	Malta	165,196	183,183	184,252
	Netherlands	8,513,893	8,780,911	8,600,201
	Poland	17,398,697	18,226,136	17,126,985
	Portugal	5,373,316	5,504,416	5,317,555
	Slovakia	2,711,413	2,839,762	2,681,076
	Slovenia	962,791	974,896	907,377
	Spain	20,383,134	22,210,941	22,093,545
	Sweden	4,594,122	4,777,057	4,750,012
	UK	30,265,207	31,477,153	30,893,145
R&D expenditure (all sectors, in millions of constant euros of 2004)	**EU-25**	194,047	194,047	194,047
	Austria	5,346	5,346	5,346
	Belgium	5,465	5,465	5,465
	Cyprus	46	46	46
	Czech Rep.	1,100	1,100	1,100
	Denmark	5,066	5,066	5,066
	Estonia	83	83	83
	Finland	5,253	5,253	5,253
	France	35,648	35,648	35,648
	Germany	55,100	55,100	55,100
	Greece	967	967	967
	Hungary	721	721	721
	Ireland	1,780	1,780	1,780
	Italy	15,414	15,414	15,414
	Latvia	47	47	47
	Lithuania	137	137	137
	Luxembourg	448	448	448
	Malta	12	12	12
	Netherlands	8,657	8,657	8,657
	Poland	1,139	1,139	1,139
	Portugal	1,010	1,010	1,010
	Slovakia	174	174	174
	Slovenia	418	418	418

	Spain	8,946	8,946	8,946
	Sweden	10,426	10,426	10,426
	UK	30,644	30,644	30,644

Table 7. The high-growth scenario for five drivers

		2005	2015	2025
oil price (in constant euros of 2004, per barrel)		46.8	65.3	81.6
world GDP excluding EU25 (in millions of constant euros of 2004)		31,698,608	47,073,603	66,107,672
population (number)	**EU-25**	459,007,117	477,948,714	496,427,876
	Austria	8,151,199	8,567,621	9,049,320
	Belgium	10,435,303	10,881,370	11,414,212
	Cyprus	742,275	879,072	1,011,571
	Czech Rep.	10,209,736	10,289,079	10,517,082
	Denmark	5,415,631	5,579,549	5,763,688
	Estonia	1,351,012	1,339,167	1,348,031
	Finland	5,236,759	5,438,857	5,644,004
	France	60,231,790	63,642,688	66,995,627
	Germany	82,693,189	84,826,440	87,256,383
	Greece	11,095,824	11,618,537	11,924,933
	Hungary	10,106,309	10,087,253	10,238,813
	Ireland	4,081,950	4,660,456	5,181,891
	Italy	58,250,545	59,819,878	60,613,151
	Latvia	2,309,490	2,249,386	2,239,608
	Lithuania	3,435,339	3,362,418	3,379,985
	Luxembourg	456,444	509,567	573,148
	Malta	405,038	460,384	521,157
	Netherlands	16,355,070	17,340,945	18,358,901
	Poland	38,178,882	38,487,381	39,550,705
	Portugal	10,524,031	10,993,697	11,314,020
	Slovakia	5,381,936	5,437,364	5,569,060
	Slovenia	2,007,378	2,121,392	2,221,187
	Spain	42,973,051	46,336,685	47,983,340
	Sweden	9,018,766	9,540,947	10,201,221
	UK	59,960,170	63,478,581	67,556,838
labour force (number)	**EU-25**	216,736,943	228,357,645	230,588,981
	Austria	4,016,319	4,328,288	4,416,358
	Belgium	4,439,034	4,690,791	4,800,155
	Cyprus	367,108	476,225	524,994
	Czech Rep.	5,134,724	5,114,482	4,793,838
	Denmark	2,860,935	2,917,639	2,919,899
	Estonia	660,374	682,411	664,069
	Finland	2,616,144	2,646,948	2,646,615
	France	27,147,136	28,248,686	28,783,990
	Germany	40,684,543	42,803,188	42,354,027
	Greece	5,061,546	5,316,030	5,316,601
	Hungary	4,204,626	4,319,678	4,303,697
	Ireland	1,946,617	2,286,849	2,573,105
	Italy	24,629,522	25,239,502	25,208,012
	Latvia	1,126,735	1,173,389	1,112,232
	Lithuania	1,646,338	1,742,603	1,715,625
	Luxembourg	198,610	227,896	249,941

	Malta	163,381	190,440	211,352
	Netherlands	8,460,101	8,928,695	9,132,914
	Poland	17,322,729	18,278,579	18,073,719
	Portugal	5,349,946	5,632,774	5,677,591
	Slovakia	2,697,534	2,834,376	2,821,346
	Slovenia	960,957	1,035,289	1,026,247
	Spain	20,231,947	22,318,588	22,979,576
	Sweden	4,575,750	4,862,733	4,980,626
	UK	30,240,671	32,288,636	33,069,285
R&D expenditure (all sectors, in millions of constant euros of 2004)	**EU-25**	211,864	247,479	309,629
	Austria	5,834	6,812	8,519
	Belgium	5,964	6,963	8,708
	Cyprus	51	61	78
	Czech Rep.	1,227	1,465	1,872
	Denmark	5,529	6,456	8,073
	Estonia	92	110	141
	Finland	5,733	6,694	8,371
	France	38,904	45,423	56,804
	Germany	60,132	70,209	87,800
	Greece	1,055	1,232	1,540
	Hungary	805	960	1,228
	Ireland	1,943	2,269	2,837
	Italy	16,821	19,640	24,561
	Latvia	52	62	79
	Lithuania	153	182	233
	Luxembourg	489	571	714
	Malta	14	17	21
	Netherlands	9,448	11,031	13,795
	Poland	1,270	1,516	1,938
	Portugal	1,103	1,287	1,610
	Slovakia	194	232	296
	Slovenia	466	556	711
	Spain	9,763	11,399	14,255
	Sweden	11,378	13,285	16,614
	UK	33,443	39,047	48,830

4. References

Bagnoli, P., J. Château & S. Sahin, 2005: *A macroeconomic baseline with structural change.* Paris: OECD.

Berkmen, P., S. Ouliaris & H. Samiei, 2005: *The structure of the oil market and causes of high prices.* Washington: International Monetary Fund. http://www.imf.org/external/np/pp/eng/2005/092105o.htm

Black, J., 2002: *A Dictionary of Economics*. Oxford University Press.

Carone, G., 2005: *Labour force projections: a set of data for assessing the long-run economic impact of ageing.* Unpublished paper prepared for the Joint Eurostat-UNECE Work Session on Demographic Projections, Vienna, September 2005.

Duchêne, V., & E. Hassan, 2005: *Key Figures 2005 on Science, Technology and Innovation - Towards a European Knowledge Area.* Brussels: European Commission, Directorate General for Research.

EEA – European Environment Agency, 1999: *Information for improving Europe's environment; An introduction to the European Environment Agency*. http://org.eea.eu.int/documents/brochure/brochure_index.html

EEA, 2005: *PRELUDE – Land use scenarios for Europe.* http://scenarios.ewindows.eu.org/reports/fol077184

Energy Information Administration, 2005: *Annual Energy Review.* US Government. http://www.eia.doe.gov/emeu/aer/petro.html

Eurostat, 2005: *Research and Development in the EU.* News Release 156/2005.

Intergovernmental Panel on Climate Change (IPCC), 2000: *Special Report on Emissions Scenarios,* Section 4.2.1. http://www.grida.no/climate/ipcc/emission/091.htm

IPCC, 2001: *Third Assessment Report, Working Group 1 Technical Summary.* http://www.grida.no/climate/ipcc_tar/vol4/english/pdf/wg1ts.pdf

Keesing, F.M., 1958: *Cultural Anthropology.* New York: Rinehart & Co.

Klijn, J., L.A.E. Vullings, M. v.d. Berg, H. van Meijl, R. van Lammeren, T. van Rheenen, A. Veldkamp, P.H. Verburg, H. Westhoek, & B. Eickhout, 2005: *The EURURALIS-study: Technical document.* Wageningen: Alterra, report 1196.

Kroeber, A.L., & C. Kluckhohn, 1952: *Culture: Critical Review of Concepts and Definitions.* Cambridge, Mass.: Peabody Museum Papers 47:1.

Meijl, H. van, T. van Rheenen, B. Eickhout & A. Tabeau, 2005: The impact of different policy environments on land use in Europe. *Agriculture, Ecosystems and Environment* (forthcoming).

De Mooij, R., & P. Tang, 2003: Four futures of Europe. The Hague: CPB-Netherlands Bureau for Economic Policy Analysis.

Nabli, M.K. & Nugent, J.B., 1989: The new institutional economics and its applicability to development. *World Development*, Vol. 17, No. 9, pp. 1333-1347.

North, D.C., & R.P. Thomas, 1973: *The Rise of the Western World: A New Economic History.* New York: Cambridge University Press.

Van Notten, P.W.F, J. Rotmans, M.B.A. van Asselt & D.S. Rothman, 2003: An updated scenario typology. *Futures* 35:5, pp. 423-443.

Oxford Dictionary of English (revised edition), 2005. Edited by Catherine Soanes & Angus Stevenson. Oxford University Press.

Narayan, D., & L. Pritchett, 1999: Cents and sociability: household income and social capital in rural Tanzania. *Ecnomic Development and Cultural Change 47:4*, pp. 871-97.

Putnam, R.D., with R. Leonardi & R.Y. Nanetti, 1993: *Making democracy work. Civic traditions in modern Italy.* Princeton, N.J.: Princeton University Press.

RIVM – National Institute for Public Health and the Environment, 2002: Nationale Natuurverkenning 2, 2000-2030 (National Nature Outlook). Bilthoven: RIVM/Alphen a.d. Rijn: Kluwer.

SENSOR, 2004: *Sixth Framework Programme Contract for Integrated Project, Annex I - Description of Work.* http://www.sensor-ip.org (internal document).

Solow, R.M., 2000: *Growth Theory: An Exposition. 2nd Edition.* New York & Oxford: Oxford University Press.

Uyterlinde, M.A, G.H. Martinus & E. van Thuijl (eds.), 2004: *Energy trends for Europe in global perspective. Baseline projections by twelve E- models in the CASCADE MINTS project.* Petten: Energieonderzoek Centrum Nederland (ECN).

Wilson, C., 2004: *Demographic transitions in Europe and the Mediterranean.* Paper presented at meeting of REMSH Network, Durham, UK, 3rd July 2004. Laxenburg (Austria): IIASA, unpublished paper.