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: **2.1.2**

Deliverable title: **Definition of five policy cases related to SENSOR sectors identifying policy goals and policy options**

(According to the DoW, the title was to be: "Land use policy scenarios presenting policy goals and policy options in the 6 target sectors"; but this was modified as the approach to policy scenarios was designed)

Organisation name of lead contractor for this deliverable: LEI

Partners involved: LEI, EFI, NERI, KVL

Researchers involved: Tom Kuhlman (overall editor, chapters 1-3), David Verhoog (chapter 4), Hans Verkerk, Marcus Lindner (chapters 5 & 6), Berit Kaae, Berit Hasler (chapter 7), Thomas Sick Nielsen (chapters 5 & 7), Ole Hjort Caspersen (chapter 5), Torbjörn Jansson (chapter 8)

Due date of deliverable: 1 May 2007 (project month 30)

Actual submission date: project month 40

Revision: This deliverable is an update of an earlier version submitted in July 2006 (project month 20). The present version is the fifth.

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:

The policy cases form the basis on which end users can graft their own policy scenarios to be analyzed in SIAT. This deliverable explains why and how the policy cases can fulfil that role. It also describes the policy cases selected, including their implementation in the respective models.

Activities:

Discussions on the approach to policy scenarios: at the cluster meeting in Warsaw in April 2005; at Wageningen in August 2005 (the bioenergy case); at The Hague in September 2005 (all scenarios); at the project meeting in Malta in October 2005; at Lund in December 2005 (on cooperation with M4); at Alice Holt in February 2006 (specifically dedicated to policy cases); and at the cluster meeting in Bratislava in April 2006.
Discussions on terminology (policy case, policy scenario, policy variable, etc.), leading to an agreed glossary in December 2005.
Meeting with EC officials (DG-TREN) on bioenergy in Brussels in March 2006.
Collection of policy documents and scientific literature on bioenergy.
Writing the draft report (completed 11th July).
After initial review, second draft prepared in September, and a third draft after discussions at the Saaremaa project meeting. It was decided there to have much shorter descriptions of policy cases. It was also proposed there to reduce the number of policy cases from six to five; this was confirmed as a decision at the next project meeting in Vienna, in April 2007. A third version including those was completed in April 2007. The present version is a revision after a second round of reviews in May 2007.

Results:

Report submitted here

Milestones achieved:

End user consultation by Module 7.1 (Month 4)

Deviations and reasons:

According to the implementation plan, a first version of this deliverable, describing the method, was supposed to be ready by month 12 (November 2005). The present draft was scheduled for completion in month 15 (February 2006). Delays have been due to two reasons:

The need to arrive at consensus within the consortium as to what policy scenarios are, how policy cases are related to them, what they should look like, and on what basis they should be selected. Agreement on the last of these points was achieved only in February 2006. The final list of policy cases might still be subject to revision on the basis of end user needs and recommendations.
It was decided to reallocate the main responsibility for this deliverable to LEI in October 2005. At the same time, however, the LEI team leader left the institute, which caused capacity problems as existing team members had to take over both his work and the new responsibilities.

Publications:
None so far. However, the work presented here has also been used for part of a chapter in a book on the SENSOR project to be published in early 2008 by Springer Verlag.

Meetings:
Alice Holt, 14 February 2006

Remarks concerning further SENSOR activities:
The work described in this deliverable is pivotal to progress in both M2 and M4. Together with the baseline scenario storlylines (D2.1.1) and the adaptation of the NEMESIS model (D2.1.3), it will enable the calculation of model outcomes for the national economies per scenario, on the basis of which land use and sectoral modelling can be done at NUTS-x level.

The deliverable will continue to be updated several times during the project. This updating will consist of further specifications of policy cases.

Documents:
See reference list in the report

Table of contents

EXECUTIVE SUMMARY

This document describes the sets of policy scenarios which SENSOR will be able to assess, and which the Sustainability Impact Assessment Tools (SIAT) will be able to work with. The aim of SIAT is to enable policymakers to design their own policy scenarios and immediately assess the impact of these scenarios on sustainability. This is possible only if such scenarios have been 'baked into the cake' of SIAT, so to speak. That is to say, a policy scenario must be part of a set of possible scenarios, of which the relationship with the various aspects of sustainability has been determined by modelling. Such sets in SENSOR parlance are termed policy cases, and defining them is the purpose of this deliverable.

The complete set of five policy cases must cover all six sectors with which SENSOR is concerned, and preferably in such a way that one case will have an impact on more than one sector; the cases must be relevant to SENSOR's central theme of multifunctional land use; and they must be politically relevant, in the sense that they are likely areas of EC policy formulation from 2008 onwards. After a number of discussions, the following cases were selected:

(1) Bioenergy
(2) Financial reform of the EU in 2012, with particular attention to the Common Agricultural Policy
(3) Biodiversity
(4) Forest strategy
(5) Transportation policy.

A sixth case, on regional support, was dropped due to the difficulty of adequately assessing its impact. Each case represents a problem area, within which policies can be formulated with different objectives, using different policy instruments. The report describes the general structure of a policy case. The bioenergy policy served as a pilot case and was therefore described in detail in the first draft. For the other cases only a brief summary was given. In the current report, all cases are described in detail.

Case 1. Bioenergy is seen as one of several possible solutions for three problems: climate change, the danger of exhaustion of fossil fuel resources, and the security risks involved in dependence on imported energy. The goals of a bioenergy policy are defined in terms of these three problems. The objectives, i.e. the concrete aims which the policy is designed to achieve, are identifed in relation to actual policy initiatives of the European Commission over the last ten years. On the basis of these objectives and of the technical options, a number of policy instruments are identified, which have been grouped for modelling purposes into two policy variables, to be adopted into SIAT and manipulated by end users. These variables reflect the extent of the effort to promote bioenergy and whether or not the effort is combined with a free-market policy or with protection of European feedstock producers.

Case 2. Financial reform of the EU in 2012 will probably focus on changes in the common agricultural policy (CAP). Issues are both the overall level of support to European agriculture, but also the alternative allocation of public funds – notably on research and development, in support of the Lisbon Agenda. Furthermore, there is pressure from external trading partners to reduce protection of European farmers. Assuming that these will play a role in the 2012 financial reform, the policy variables to be used in modelling are: protection of agricultural product markets through a variety of instruments; direct income support to farmers (the single-farm payments); and the option of whether any funds saved on the CAP are invested in R&D or returned to the tax-payer.

Case 3. Biodiversity is likely to remain an important issue for European policy-making. Goals are to reverse present trends in biodiversity reduction and to place species and ecosystems at a satisfactory conservation status. Specific policies promoting biodiversity, such the bird and habitat directives could be further enhanced. Two policy policy variables have been selected which can have a major and measurable effect: the expansion of the Natura 2000 area, and a more nature-oriented management of forests.

Case 4. The challenges to meet and the forest-related commitments of the EU represent a wide range of policy areas and reflect the multifunctional role of forests. This is also reflected in the specific objectives of the Forest Action Plan, which are to improve the long-term competitiveness of European forests; to protect and improve the environment; to contribute to quality of life; and to foster coordination (one wonders about the logic of including the latter objective, but there it is). Our policy case contains four variables, of which two are equivalent to the biodiversity case; the others are bio-energy from forests and afforestation.

Case 5. The transportation policy case is entirely concerned with transport in relation to tourism. It was born out of the idea to assess the impact on land use and sustainability of changes in the tax regimes of transport modes – such as the current favourable treatment of air transport. This policy case has a single variable to be modelled, namely a carbon tax on transport.

1. What is a policy case?

Author: Tom Kuhlman

1.1 Policy scenarios and policy cases

The aim of SENSOR is to construct instruments for the ex-ante evaluation of those European policies that are likely to have a bearing on multifunctional land use. These instruments, called Sustainability Impact Assessment Tools (SIAT) should enable the end user to quickly and easily determine what the impact of a policy on sustainability – environmental, social and economic – will be. That impact will be compared to the autonomous development described in the baseline scenarios (documented in D2.1.1). The SIAT should be such that it enables the end user to analyze a policy of his choosing. It is to be constructed in such a way that said end user will not need specialist knowledge on the models powering the tools, nor should he have to wait for hours for the various models to run.

This is possible if the various models and the links between them are replaced by simplified functions representing the correlations between policies, land use change and sustainability indicators. For example, consider a policy encouraging certain behaviour by fiscal means – by giving you a subsidy if you behave in the appropriate way, or tax you if you do not. SENSOR will run this policy through its macro-economic model, the land-use model and the sectoral model, with numerous iterations until the results of the various models are consistent with one another and with other criteria such as may be applied by the modellers. We now have what we may call a *policy scenario*. If we then vary the level of taxation or subsidy, we can run the models again and measure the impact once more. Once we have done this a number of times for different settings of the policy, we can plot the results for each output variable on a graph. If there is a direct correlation between the policy and the output variable, we can construct a *response function* for the correlation between that policy and that variable. To the extent that this function is valid and reliable, the policy in question can be represented by a 'button' in the SIAT interface, which the end user can set to any other values for the level of subsidy or taxation; SIAT will then generate the appropriate impact scores. Different shapes of functions can be possible, and the more measurements you do with the models, the better will be the estimation of the response function, as is shown by the linear and the logarithmic functions depicted in Figure 1.[1]

[1] This is a simplified example for the purpose of illustration. In actual fact, the response function is only one step in arriving at impact assessment. This is explained in greater detail in section 1.3.

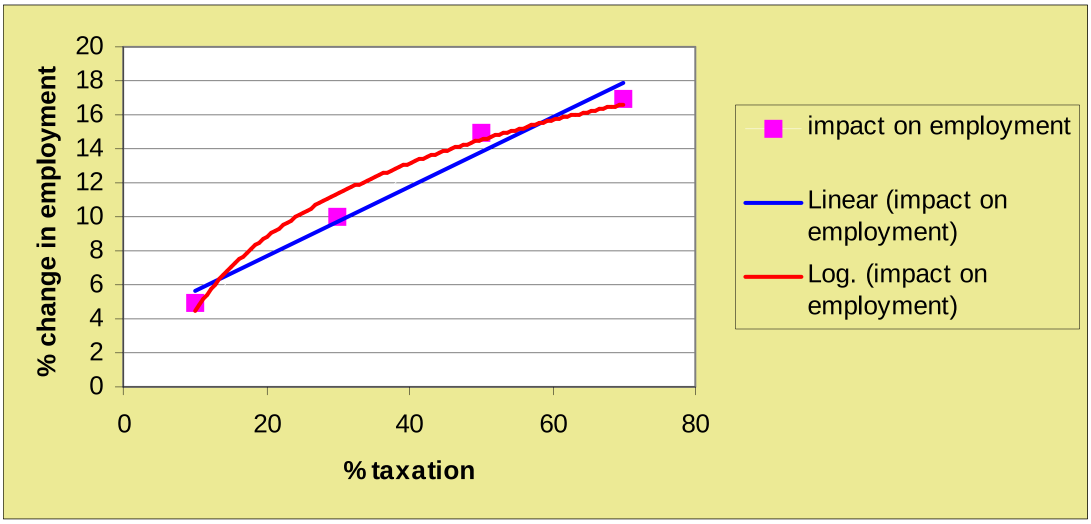

Figure 1. Two response functions for a correlation between a policy and one indicator

We have herewith a method for setting up new policy scenarios simply by interpolating between values calculated with the models. This is how we propose to solve the problem of flexibility of policy scenarios. Ideally, one would wish to have a SIAT in which the end user can design any policy scenario and assess its impact. In practice, however, SIAT can assess a policy scenario only if it contains response functions for the particular instruments that are to be applied in the policy. The flexibility consists in the settings chosen for a particular scenario, i.e. how much subsidy or taxation is to be applied, or how what quantity of greenhouse gas emissions is to be tolerated.

Hence, the flexibility of policy scenarios will always depend on the number of response functions available in the system. That number, in turn, depends on the capacity of modellers to construct these functions. Of course it is always possible to construct more, but this means returning to the models behind the SIAT meta-model and run them for a new policy variable or for new output variables.

Initially, it was thought that the policy scenarios to be run through the models would serve merely as *examples* showing the working of the methodology. However, with the above methodology it can be seen that they are examples only of settings on policy variables, which in turn are grouped into policy cases. Only those variables actually calculated by the models can be incorporated into SIAT. This insight necessitates a modification of the original ambition for SIAT where the policy scenarios are concerned. Rather than building a limited number of policy scenarios as examples for an unlimited range to be constructed by end users, we construct a number of *policy cases* within which some scenarios have been calculated through the models. Other scenarios within the same range of options can be set by the end user, and the result will then be calculated by the relevant response functions rather than by the models.

Together, these policy cases make up the full range of policies for which SIAT can be used. To be sure, SIAT can be adapted for completely new policy cases, but this can only be done by re-running the full chain of models, which will be beyond the capacity of end users. For this, the institutes responsible for the modelling would have to get together and build a new policy case following the methods developed in SENSOR.

Thus, the identification of policy cases now becomes a crucial issue. Chapter 2 described how this has been done. The cases themselves are described in the chapters that follow.

1.2. What a policy case should look like

A policy case is concerned with a particular theme, a problem area within which policies can be formulated. Thus, a case description must first contain a statement of the problem which the policy or set of policies is designed to solve or mitigate. That statement leads naturally to the goals which the policies are supposed to contribute to. A *goal* is seen here as the ultimate rationale of an action. It differs from an *objective*, which is the direct aim which the action is deemed to be able to achieve. For instance, an authority may take measures to protect the habitat of a particular species. It hopes therewith to contribute to the goal of biodiversity, but it cannot be certain that biodiversity will improve as this may depend on other factors beyond the control of the authority in question. However, it can be held to account (a) over whether it effectively protects the habitat (its objective); and (b) over whether this helps biodiversity (i.e. whether the objective contributed to the goal). One might say that the goal is the reason why an objective is thought to be worth achieving. It should normally be possible to identify goals as falling into one of the three dimensions of sustainability – social, environmental or economic.

The term policy itself we shall define loosely as a documented statement on actions which an entity (in this case the European Commission) intends to undertake. Apart from a statement of the objectives and the goals, a policy must contain a list of the means by which one hopes to achieve the objectives. These means we call *policy instruments,* of which there are several types. To the extent that a policy is aimed at influencing behaviour among the public, or on the part of companies, one can distinguish between policies that reward, those that punish, and those that attempt to persuade - carrots, sticks and sermons, as they have been dubbed (Collins *et al.* 2003). There are additional types. Instead of exhorting the public, the agency concerned can also simply provide information, leaving actors to make their own choices. Furthermore, rather than aiming at influencing behaviour of others, an agency may also undertake direct actions that can contribute to the objectives of a policy: creating institutions, and undertaking or commissioning research. Finally, it may decide to do nothing – a serious and sometimes justifiable option, which would return us to the baseline scenario.

Not all policy instruments are equally suitable for including in modelling – or in SIAT. The impact of setting up an institution, for instance, is difficult to predict quantitatively. As for ‘sermons’, it would be a rash modeller indeed who would tie a specific change in behaviour to a particular amount of expenditure on advertising;[2] and the same goes for information. Realistically, ‘carrots’, ‘sticks’ and research[3] are the instruments that best lend themselves to impact modelling. Moreover, since a particular policy can contain many different instruments, modelling all possible combinations can become very tedious – and the SIAT interface would be complex too. In order to

[2] Which is not to say that this cannot be done at all, or has never been done. Indeed, numerous studies exist to measure the impact of advertisements on sales (a famous example is Stewart 1993). The problem is whether the impact of ‘sermons’ on the public can be predicted with sufficient confidence on the simple basis of advertising expenditure.

[3] Although the outcome of any individual research project is by definition uncertain (otherwise you would not need the research in the first place), there are well-established correlations between research in general and several measures of progress such as economic growth or labour productivity.

keep the system workable, a limited number of *policy variables* will be created within each policy case. Each policy variable will represent one or more policy instruments. For instance, several different subsidies on different products can be combined into a package with fixed proportions for each product; the variable will then represent the total value of the package, and this value can be manipulated by the end user. Figure 2 shows the relationships between the various terms used here.

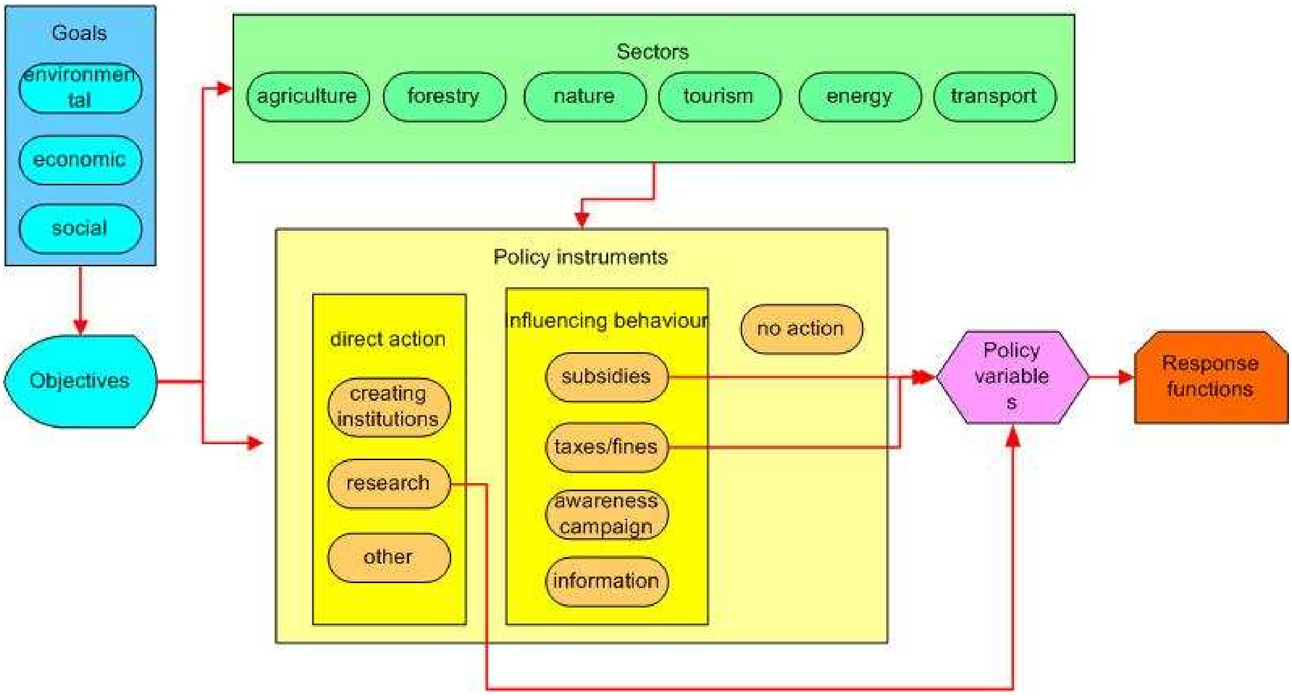

Figure 2. The structure of a policy case

1.3. Some methodological remarks

As stated in section 1.1, the output of our models is condensed into response functions. However, the models do not directly generate all of the indicators that are needed to assess the impact of a policy on sustainability. For instance, a user may want to know whether a proposed policy might have any impact on soil erosion. Let us assume that the policy leads to increased production of a certain crop in certain areas, which will be an outcome of the three-model chain containing the macroeconomic model NEMESIS, the land-use model CLUE and the agricultural sector model CAPRI. Let us further assume that this increased production is achieved partially by ploughing up pasture land. This result must be combined with information we have about the areas concerned: climate, soil type and slope – information we call *state variables*, because it refers to a permanent characteristic of that particular location. Such combination can give us a forecast of soil erosion. The point here is that, in addition to the models in the SENSOR system, we need an equation for each indicator expressing the relationship between model outcomes and indicator scores. Thus, in addition to response functions producing what we call *intermediate output*, we use *indicator functions* to arrive at indicator scores, which represent different aspects of sustainability.[4] The

[4] Indicator scores are further processed into scores on land use functions, which are visualized by means of spider

relationships between models, response functions, intermediate output, indicator functions and sustainability assessment is shown in Figure 3.

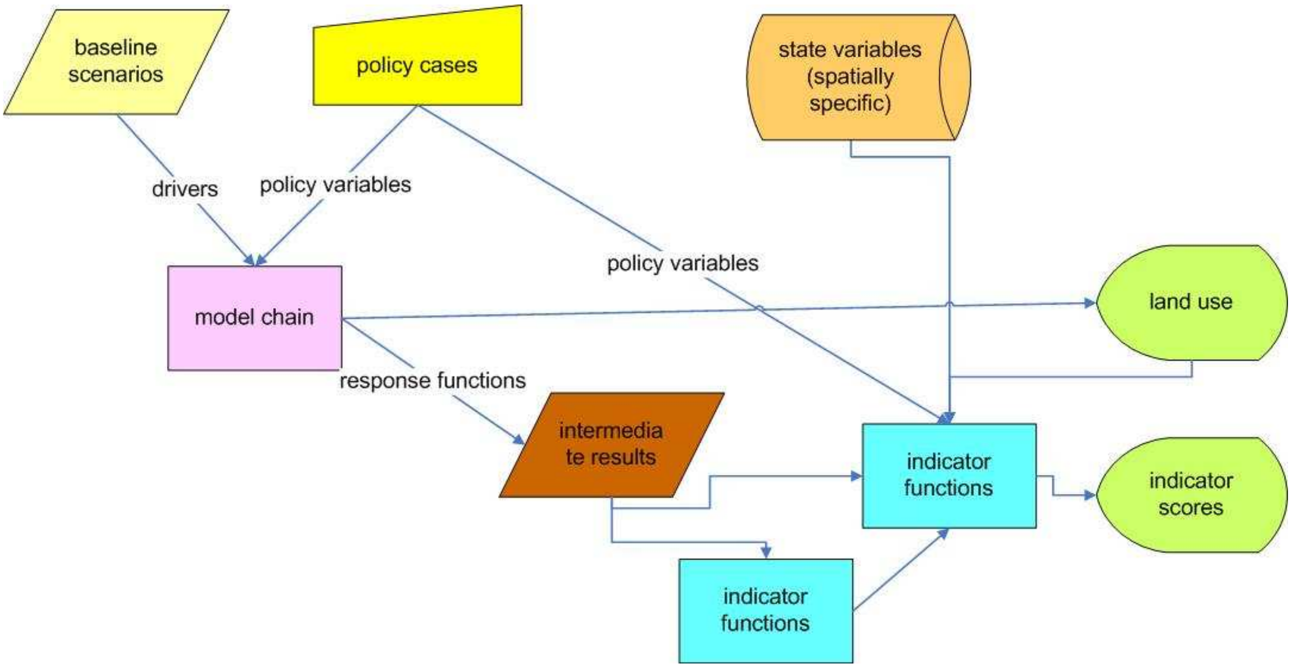

Figure 3. How policy variables are used to compute indicators of sustainability

As the figure indicates, indicator functions can contain terms referring not only to state variables (in combination with land use change) and to intermediate model output, but also other indicators as well as policy variables directly. More information on how the model chain works can be found in SENSOR Deliverable 2.2.1; on response functions in Deliverable 2.3.5; and on indicators and indicator functions in Deliverable 2.3.2.

When deciding whether or not to model a policy instrument as a separate policy variable or in combination with other instruments into a joint variable, it must be borne in mind that the models will be capable of modelling the impact of only one variable at a time – not combinations of several variables. For instance, if one opts for subsidies on bioenergy production as an instrument, one may separate this into a subsidy for ethanol and one for biodiesel. If so, the impact of each subsidy on agricultural production of the necessary feedstocks can be evaluated, but not the impact of both subsidies together. In other words, if both subsidies are actually implemented, farmers would have a choice as to whether to grow sugarbeets (for ethanol) or rapeseed (for biodiesel). Which one they would grow could not be seen in SIAT. If that result is desired, a joint policy variable containing both subsidies (in a fixed relationship) would have to be modelled. Usually, in SENSOR those instruments are combined into policy variables which will most likely be implemented together, as a package. The advantages of this approach are simplicity (both a smaller effort in modelling and ease of use by the client) and comprehensiveness. The disadvantage is that the effect of an individual policy instrument cannot be evaluated.

diagrams. This is the work of Module 3 in SENSOR (Deliverable 3.2.2). However, they can also be seen directly in SIAT, by means of maps – the work of Module 4. Land use is an intermediate output, but is also itself visualized in SIAT.

A problem in assessing the impact of policies is that European policies are often not formulated in terms of the actions a member state should undertake, but of the targets it should achieve. It is up to member states to decide how this will be done. The impact depends, of course, on that decision. That problem is solved, as is customary in impact assessment, by supposing a likely course of action that member states will take, and then assess its effects. This assumes that all member states will act in the same way – unless we have knowledge to the contrary.[5]

[5] Such knowledge on member-state policies is sometimes available, e.g. in CAPRI. In such cases, it will of course be included in SENSOR. The digital policy information system set up in SENSOR will also be helpful in this respect.

2. On the selection of policy cases

Author: Tom Kuhlman

2.1. Criteria of selection

Since the policy cases represent the full range of policy scenarios that can be assessed with the SIAT toolbox, their selection has been an important landmark. For the same reason, the decision-making process has been time-consuming. Once the decision to translate policy scenarios into policy cases had been made (Malta, September 2005), the thinking about identifying appropriate cases began. At a meeting in Alice Holt, England, in February 2006, it was decided to build a total of six policy cases. These cases would have to meet the following criteria:

(1) Taken together, the cases should cover all 6 sectors; as much as possible, cases should be identified which cover more than one sector at a time.
(2) The cases should be interesting, in the sense that they
   - have a significant impact on land use;
   - are relevant to multifunctionality, and
   - relevant to sustainable development, preferably producing significant changes in all three dimensions of sustainability as well as in land use;
   - represent hot topics in the policy debate;
   - are of long-term strategic significance, and
   - realistic, i.e. within the mandate of EC policy.
(3) They should represent new policies, in the sense of
   - newly emerging issues;
   - ideally, policies which the Commission will be developing in 2008 (the date when SENSOR should deliver its end product);
   - not revisiting recent policy developments;
   - however, existing policy themes may be chosen if it can reasonably be assumed that they will be further developed beyond 2008.
(4) They should be tractable, i.e. the models used in SENSOR should be capable of handling the impact of the chosen policy.

The end user should have a say in the final selection of cases.

As for the *type* of policy to be considered: new strategies in an early stage of the decision process, such as White and Green Papers and thematic strategies are regarded as suitable for analysis in SIAT; framework directives and regulations are less relevant. However, there is no formal restriction on the type of policy.

2.2. Cases selected

The following cases were identified based on the above criteria:

1. Bioenergy;

2. The 2012 financial reform of the EU budget, with specific reference to the Common Agricultural Policy (CAP);

3. Biodiversity policies, as related to the conservation of nature areas, but also in relation to agriculture, forestry, tourism, etc.;

4. The forest strategy;

5. European transportation policy;

6. Regional support, as presently contained in the structural and cohesion funds.

The promotion of bioenergy is likely to be an important issue in European policy-making in the years to come, as it has been for some time already. Its production will affect land use, and both production and consumption are likely to have an impact on many different aspects of sustainability as assessed in SENSOR. Moreover, it affects several sectors simultaneously: agriculture, forestry, energy and transport.

The CAP is the largest item on the budget of the European Union. It is being reformed, but further reforms may well have to be considered at the time when the next Financial Framework (the long-term budget) will be on the agenda. That will be in 2012. The SENSOR policy case will examine the major options for the CAP, as well as the option of reallocating the agriculture budget to research & development, as was proposed by the UK in 2006.

Biodiversity will continue to be a major issue for many years to come. The policy case will explore several policies designed to ehance biodiversity, such as the protection of natural areas and regulations of the agriculture and forestry sectors.

There exists a European forest strategy, which is more of a framework within which different actions are possible. In this policy case we examine the impact of policies for sustainable forest management, bioenergy production from forests, mitigating climate change through forestry, enhancing the protective role of forests, and producing more wood and other forest products (sustainably, of course).

Policies relating to transportation (promotion of public transport, road construction, etc.) have an impact on multifunctional land use and on sustainability. Fiscal treatment, in particular, by influencing the relative costs of different transport modes, will influence consumers' choices. The policy case studies the effects of these policies, in particular on spatial patterns in tourism.

Policies to reduce inequalities between regions are the second largest source of expenditure in the European Union. They are likely to have a significant impact on land use, through their influence on urbanization, infrstructure and economic development. However, the diversity of national policies makes it impossible to analyze them under a Europe-wide modelling framework. Hence, this case unfortunately had to be dropped from the list.

Chapters 3 through 7 describe the five policy cases implemented in terms of the template proposed in section 1.2. The bioenergy case (Chapter 3) is discussed in most detail, whereas the others are more succinct. This is because, after the first version of this deliverable was produced in July 2006, a new format for the other policy cases was decided in order to save time.

3. The bioenergy case

Author: Tom Kuhlman

3.1 Introduction

Bioenergy[6] has been chosen as a policy case because (a) it is an important issue in EU policy and is likely to remain so for some decades to come; (b) the production of bioenergy has a significant impact on land use; (c) it cuts across several sectors: agriculture, forestry and energy – and possibly nature as well, since bioenergy production may compete with natural land. Finally, (d) through existing instruments, impact assessments and extensive literature, it can provide a good basis for ex-post validation of results.

Following the schedule outlined in section 1.2, we begin with a discussion of goals: the problems which a bioenergy policy is supposed to help solve (section 3.2). This leads to a consideration of objectives, the concrete things which the policy is expected to achieve. We do this by describing policy initiatives already undertaken by the European Commission. Some of these initiatives have led to directives and regulations, and these are therefore part of our baseline scenario. Others are at various stages in the policy process, which means they can serve as a basis for the policy scenarios which our models will evaluate (3.3). In order to prepare for the modelling of these scenarios, we must explore some of the technical characteristics of the main bioenergy options. This is done in section 3.4. The next section discusses to what extent biofuels are likely to be imported rather than produced within the EU, and what policies could be used to manipulated these proportions. Section 3.6 identifies the impacts the policy is likely to have on sustainability, as a guideline for the modelling exercise. The final section draws conclusions from the preceding sections and identifies the policy variables to be modelled into response functions.

3.2. Goals

There are three concerns which are leading many countries towards promoting the use of bioenergy:

1. The greenhouse effect: burning fossil fuels means releasing carbon dioxide into the atmosphere which causes a rise in temperature. Burning biomass also releases CO_2, but in this case the CO_2 has first been absorbed from the atmosphere.
2. The looming exhaustion of petroleum and natural gas: supplies are finite and non-renewable, and will eventually become depleted.
3. Security: even while fossil fuels are still relatively abundant, many countries are concerned about the risks caused by dependency on an imported resource – especially where this resource comes from potentially hostile or volatile countries and must be transported over long distances where transport routes are vulnerable to disruption.

Although the last two goals are closely related, they may give rise to different policies and the outcomes of these policies will be evaluated differently according to which goal one is looking at. For instance, husbanding one's own fossil oil and gas deposits will help to provide security against

[6] Bioenergy is defined here as energy generated from biomass. This biomass can be produced specifically for the purpose of energy generation (crops), or it can be a waste product from agricultural, livestock or forestry operations (biogas, black liquor).

disruption of transport routes, but will not postpone the day when all deposits will be depleted; conversely, importing bioethanol from Brazil will help with the second goal, but not with the third.

Sometimes yet other goals are mentioned as served by policies to promote bio-energy, such as employment in rural areas, or new markets for farm products. However, such potential positive impacts should properly be considered as secondary effects of bioenergy policies, not as their rationale. After all, there are many other and possibly more advantageous ways to promote rural economies. In SENSOR, therefore, these potential effects will be included in the impact assessment, but they are not considered goals of energy policies as such.

3.3. Objectives: EU policies on bioenergy

On the basis of the above goals, concrete objectives for a bioenergy policy can be established. Such objectives must be in line with existing EU policy, which is described in this section. The European Union has supported renewable energy since the 1980s, at first mostly by funding research to promote technological progress. This support has helped to make European companies major players in the market for renewable-energy technology, and promoting the growth and competitiveness of industries related to renewable energy is an important collateral objective of European energy policies.

More needed to be done in order to meet the greenhouse-gas emission targets of the Kyoto Protocol, however, and in 1997 the Commission published a White Paper on Renewable Sources of Energy (EC 1997). This document gives an indicative target, for both the then 15 member states and the prospective new members, of doubling the overall share of renewable energy in the EU from about 6% in 1995 to 12% by 2010. Table 1 shows how this target is distributed over the various sources of renewable energy.

Table 1. Targets for renewable energy by source, 2010, in million tonnes of oil equivalent (Mtoe), EU-15[7]

	1995	**2010**	***2004 (EU-25)***
hydro-power	26.3	30.6	*26.1*
Wind	0.4	6.9	*5.0*
solar (panels)	0.3	4.0	*0.6*
solar (photovoltaic cells)	0.002	0.26	*0.09*
geothermal power	2.1	4.2	*4.5*
heat pumps	0.4	1.0	*0.9*
bio-energy (incl. municipal solid waste)	44.8	135.0	*71.4*
total renewables	74.3	182.0	*108.8*
total energy consumption	1366	1583	*1747*
share of renewables	***5.4%***	***11.5%***	***6.2%***

Source: EC 1997; 2004 figures: Eurostat & calculated from EurObservER 2005.

[7] The figures for 1995 refer to the EU-15; the quantitative targets and total energy projection for 2010 were also made for the EU-15, but the percentage target for renewable energy is meant to include the 10 new members. This table does not include the share of other sources of renewable energy, for instance tidal and wave energy. Nor does it include what the White Paper calls passive solar energy, savings to heating and cooling buildings due to better insulation and similar innovations. These savings are projected at 35 Mtoe between 1995 and 2010.

We can see from the table that bioenergy is the second most important source of renewable energy, after hydro-power. Since the perspective for expanding the latter is limited (due to environmental considerations which militate against large dams), bio-energy is set to become the most important, accounting for three-quarters of the target figure for all renewables. It can also be seen that the relatively slow progress in increasing the use of bioenergy is the main reason why overall progress is far below target. Wind power, photovoltaic cells, geothermal power and heat pumps are doing quite well, but their contribution to overall energy production is small. In hydro-power, there is good progress on small plants, but they contribute only 9% to total capacity; and while that capacity has increased, production of electricity from them has declined. This underscores the importance of bioenergy in the policy on renewables.

The White Paper outlines a number of measures which the Commission would like to undertake. These include fiscal incentives (also for investment and research); but also regulating preferential access of renewable energy to electricity networks; standardization of products; incorporating renewable energy into existing programmes; and public relations (networks of NGOs and local authorities, conferences, awards).

This White Paper has become the basis for further policy initiatives on the part of the European Commission, including several directives (which are binding on member states). These documents can supply us with several targets, i.e. objectives in quantified form, relating to bioenergy. The Biofuels Directive of 2003, for instance, specifies that 5.75% of all petrol and diesel should be biofuels by 2010; and the Directive on Renewable Electricity states that by 2010, 21% of all electricity in the EU should be produced from renewable sources – a large share of which will come from bioenergy. The Biomass Action Plan (BAP) of December 2005 (EC 2005) sets the target for the use of biomass in 2010 at 150 Mtoe – more modest than the White Paper, considering that this target is for the EU-25, not for the EU-15. Ways and means to promote the use of biomass for heating and electricity generation as well as for transport are discussed in this important document.

Summarizing this section, the principal objectives which the EC will attempt to achieve in bioenergy are (1) quantitative targets for the proportion of bioenergy in the three categories of energy output (transport fuels, electricity and heat); (2) sustainability of production; and (3) fostering a competitive bioenergy industry (also for export purposes) through technology development.

3.4. Policy instruments

The instruments which the Commission wishes to use, following the schedule of Figure 2, include:

Table 2. Policy instruments for promoting bioenergy

Carrots	Sticks	Sermons	Information	Research	Institutions
Reduction of excise duty for biofuels	Compulsory percentage of biofuel in transport fuels	Work with NGOs and local authorities	Set up networks for communicating information in the fields of technology, finance, and environment	On supply chain	Adapting regul-ations to remove barriers to bioenergy use
Subsidy for energy crops		Institute awards	Organize conferences	On efficiency of production	Standardization and labelling of products
Support to investment				On reducing negative environ-mental effects (solid waste)	Trade agree-ments on bio-fuels
Promoting use of surplus forest growth for bioenergy					
Promoting use and modern-ization of dis-trict heating					

3.5. Technical aspects

3.5.1. Introduction

We may conceptualize bioenergy issues by distinguishing between the sources of bioenergy; the forms in which it is delivered to consumers; and the ways in which the one is converted into the other (Figure 4). The sources can be annual crops producing oilseeds for biodiesel or sugar for ethanol (either directly as with sugarbeets or indirectly through starch as in cereals); wood, either surplus growth from permanent forests or dedicated plantations of fast-growing trees; and various forms of organic waste: crop residues, wood waste from forestry operations, manure from livestock farming, and also sewage and solid waste from residential areas.[8] There are also the so-called second-generation fuels: ethanol from cellulose; biodiesel from algae; hydrogen fuel made from biomass; and transport fuel made by liquefying biogas.

[8] Known as municipal solid waste (MSW). It is debatable whether this should be considered bio-energy. Here we do because it consists at least partly of organic material.

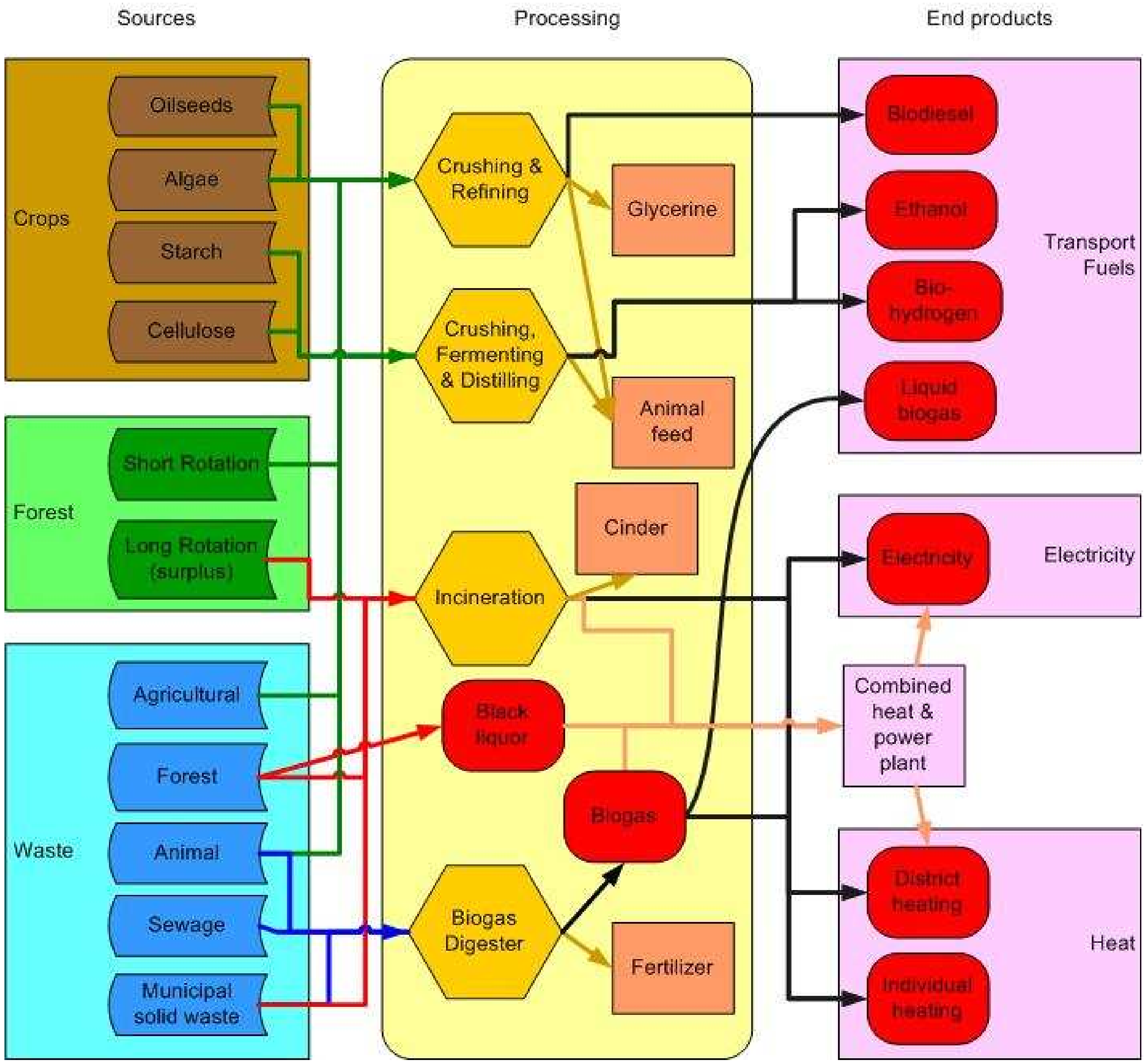

Figure 4. Overview of bioenergy options

Source: adapted from a schedule by S. Sieber

There are three basic forms in which energy is delivered: as liquid fuel for transportation, as electricity and in the form of heat for cooking or heating. So far, biofuels are used to substitute for petrol or diesel oil, not for kerosene (used in aviation). Heat and electricity can be produced from a wide variety of sources and processes, and there are also plants which produce both in combination. The term district heating refers to communal heating plants, which are important particularly in Central and Northern Europe. Biogas is treated in Figure 4 as an intermediate product, which can be compressed into liquid fuel, or used to generate electricity or heat.

In the conversion process, it is important also to consider the by-products of bioenergy: several of the waste products of producing biofuels are used as animal feed, and the production of biogas produces fertilizer as a by-product. The production process for biodiesel also leads to the production of glycerine, which like the other products can play a role in making the plant commercially viable.

Out of the possibilities shown in Figure 4, the following are considered most relevant for SENSOR:

- biodiesel made from oilseeds;
- ethanol made from starch, sugar or cellulose;
- biogas made from animal manure, crops or agricultural waste; and
- the role of forestry in bioelectricity and bioheat.

These are discussed in the following subsections. Table 3 shows their importance at present. It can be seen that municipal solid waste (MSW) is also an important source of energy, but it is not considered in SENSOR because its influence on land use is small.

Table 3. Major forms of bioenergy (Mtoe)

Form of energy	*1995*	*2004*
Biodiesel	0.15	1.7
Ethanol	0.05	0.3
Biogas	1.3	3.7
Wood	43.1	56.4
MSW	5.3	9.3
Total	49.9	71.4

Source: Eurostat, European Commission (DG-TREN)

3.5.2. Biodiesel from crops

As Table 3 shows, biodiesel is by far the most important biofuel in the EU. Its use is rising rapidly, although the 2004 figure still represents only 0.7% of total diesel consumption. In 2005, total production of biodiesel was 3.2 million tonnes (F.O. Licht 2006), equivalent to 2.75 Mtoe. The Rabobank (2005:18) expects that biodiesel consumption will rise to 4.4 Mtoe by 2010, or 2.6% of the total. The EU is the main producer and consumer of biodiesel in the world.

Many different oil crops - as well as animal fats and used cooking oil - can be used as a basis for biodiesel. It is also possible to produce biodiesel from wood, using gas as an intermediate (http://www.choren.com/en/biomass_to_energy/sundiesel_production/). The main source in Europe, however, is rapeseed, which is the feedstock for perhaps 90% of all biodiesel (Rabobank 2005:18). It is grown mainly in Germany and France with two thirds of total rapeseed production between them; significant quantities are produced also in the UK, Poland, the Czech Republic and Denmark. In 2000-2003, about 4 m ha of rapeseed were grown in the EU-25, producing 11 m tonnes of rapeseed per year (Eurostat). The production of rapeseed oil is estimated at 4.2 m tonnes, of which about 1.3 m is used for biodiesel (Rabobank 2005:22). With the fast growth in biodiesel demand, there is strong competition in demand for rapeseed oil between the food industry and the fuel sector; this has already led to a rise in price of rapeseed oil: as a vegetable oil it was traditionally cheap and comparable to soybean oil, but its market price has risen significantly and is now similar to the more high-grade sunflower oil. It is clear that increased production of biofuels based on crops which are also food crops will cause a rise in food prices.

Sunflower oil is also of some importance (notably in Italy and Spain), but as mentioned above it is a more high-grade oil and therefore more suitable for consumption. Other oils are used only in small quantities: soybean oil (mostly imported) and palm oil. The latter in particular is much cheaper, but its use in biodiesel is limited at present because of the official EU standard for biodiesel (known as EN14214). This document does not actually prohibit the use of other oils; but because the specifications are based on rapeseed, investment in R&D would be needed to certify other oils. In view of the rising demand for biodiesel, it is probably safe to assume that such investments will be made and the proportion of other oils will rise, to up to 50%. It is also possible that the European Commission will prepare an amended version of EN14214, which would provide an impetus to the biodiesel industry. Animal fats and used frying oil are presently used only on a small scale as feedstock for biodiesel, but this may well increase in the coming decades, in line with the use of other alternatives for rapeseed.

The conversion of rapeseed into oil involves crushing and refining. The former yields rapeseed meal as a by-product, which is used as animal feed, the latter results in the production of glycerine, which is used in the pharmaceutical, cosmetic and food industries. Table 4 shows the principal conversion rates from hectares to energy, for ethanol as well as biodiesel.

Table 4. Biofuel conversion rates

	Agricultural yield per hectare in 2004 (tonnes)	Annual increase in crop yield 1995-2004 (%)	Predicted annual increase in fuel yield from crop 2010-2020 (%) [9]	Oil/ethanol yield per tonne of crop produce (t)	Energy yield per tonne of fuel (toe)	*Energy yield per hectare (toe)*
Biodiesel from rapeseed	3.1	1.5	0.48	0.38	0.86	*1.0*
Biodiesel from sunflower	1.8	1.5	0.49	0.38	0.86	*0.6*
Ethanol from common wheat	6	0.8	0.48	0.27	0.61	*1.0*
Ethanol from sugar beet	59.7	2.0	0.49	0.09	0.61	*3.1*
Ethanol from lignocellulose	15	-	0.49	0.27	0.61	*2.5*
short-rotation trees	12	-	-	0.34	0.61	*2.6*
perennial grasses	6-20	-	-	0.34	0.61	*1.3-4.2*

Source: (crop yields) Eurostat; *(conversion rates)* various sources. Figures are indicative only.

Biodiesel is currently blended with petroleum-based gasoil in a proportion of 5%, which is approved by the automobile industry. However, with minor adaptation it is possible to run engines at 100% biodiesel. The demand for biodiesel is likely to rise not only as a result of the biofuels policy, but also because the proportion of diesel-powered cars is increasing and because freight transport by road (by diesel-powered lorries) is growing faster than passenger transport: from 54% in terms of tonnes of oil equivalents in 2004 to 56% in 2010 (Rabobank 2005:13).

[9] Calculated from Broek *et al.* 2003, Hamelinck 2004.

3.5.3. Ethanol from crops

Ethanol is conventionally manufactured by fermenting sugar and then distilling the result. The sugar can be obtained either from milling a crop such as sugar beet or indirectly by using enzymes to convert starch into sugar.[10] For this latter case, cereals (mostly wheat and maize) are particularly suitable. This is the way that ethanol has been manufactured up to now, but it has some major disadvantages:

- Its production cost is quite high; even with current high oil prices, domestically produced ethanol cannot compete with petrol (although imported ethanol can);
- It competes with food production;
- Its production requires high inputs of energy in the form of fertilizer, agricultural machinery, transport and distilling. This greatly limits its ultimate effect on reducing greenhouse gas emissions.

Ethanol produced from cellulose (one of the major second-generation fuels) offers much more promise in these respects: the feedstock can be any vegetable material containing fibre, such as crop waste, grass or wood. These are much cheaper to produce than starch or sugar crops, and they are also more efficient in terms of the amount of energy they generate relative to the amount spent on their production. The technology for producing cellulose-based ethanol already exists, although it is not yet commercially viable. Major efforts to achieve this are well advanced, however. Although at present the production cost of cellulose ethanol cannot yet be given which makes economic modelling somewhat difficult, it is essential for the relevance of SENSOR that this be done, for this second-generation fuel is likely to make conventional biofuels obsolete before 2025, and because its impact on land use and sustainability may be very large – and predictable.

The crops that can be used for lignocellulose fall into two groups, namely woody (short-rotation trees such as poplar, willow, black locust or eucalyptus) and herbaceous (grasses such as miscanthus, switchgrass or cereals including the straw). It is expected that ethanol based on these crops will lead to a reduction of 80-90% in greenhouse-gas emissions as compared to petrol; for sugar- and starch-based crops, the reduction is estimated at only 20% (OECD 2006:17).

The fuel ethanol industry competes not only with the food uses of sugar and cereals, but also with the alternative uses of alcohol. At present about 35% of ethanol presently produced in the EU-25 is used for fuel. The total production of fuel ethanol in 2005 was 750,000 tonnes, or 458,000 tonnes of oil equivalent (F.O. Licht 2006). Spain and France are the major producers (Rabobank 2005:36). Both production and processing capacity are rising fast, and the Rabobank projects that the EU-25 will consume 3.1 Mtoe of fuel ethanol by 2010 (*ibid.*:14).

Fermenting and distilling ethanol cost energy, which limits its competitiveness with petrol. Refining crude oil into petrol also costs energy, but this is only a loss of about 16%; in ethanol from starch, the loss is 62%, although in fibre-based ethanol it is reduced to 46%. Ethanol production from cereals also produces a by-product suitable for animal feed, called distillers' dried grains with solubles (DDGS).

[10] Wine surpluses, for instance, are also converted into ethanol for fuel. 6.4 million hl were earmarked for this in 2006 (*International Herald Tribune* of 8 June 2006). This would add some 350,000 tonnes of oil equivalent to bioenergy production – a very sizeable amount.

Ethanol is usually blended with petrol in ETBE (ethyl tertiary butyl ether). This is a chemical which contains 50% ethanol and is blended with petrol in a proportion of 5% - which means an effective proportion of ethanol of 2.5%. It can also be blended with petrol directly, and in this process a proportion of 5% ethanol can be achieved. However, this blend cannot be transported in the regular pipelines: it must be trucked to fuel depots and stored in special tanks. Most blending is therefore done with ETBE, which can be blended at the refinery. Petrol engines can in principle be adapted to run wholly on ethanol, but this is not presently done in Europe.

3.5.4. Biogas from animal manure, crops and crop waste

Biogas is a mixture of methane (CH_4), CO_2 and small quantities of other gases, produced by the anaerobic digestion of organic matter. It is produced by bacteria in swamps and animal intestines, and can be obtained for generating energy from all types of organic waste - including animal manure, vegetable matter, sewage and landfills (which continuously exude methane and CO_2). It may even be worthwhile to grow crops specifically to produce biogas.

Table 5 gives an idea of the potential of the main agricultural sources of biogas. In SENSOR, it is these sources that we shall be dealing with because of their relevance to land use, although the potential of biogas from urban waste (landfills and sewage) is probably larger than that from agricultural wastes (Braun 2005). It can be seen, when comparing with Table 4, that the biogas potential from crop waste such as sugar beet leaves adds about one third to that gained by making ethanol out of the beet; and that more energy may be gained from turning cereals into biogas (with the straw) than from using the starch alone to make ethanol. Moreover, biogas can play a role in multiple-cropping systems, where one of the crops in a rotation cycle can be used specifically for producing biogas.

Table 5. *Biogas potential of different feedstocks*

Animal manure	*wet manure per animal per year (kg)*	*biogas yield per wet kg (m³ of methane)*	*energy yield per 1000 m³ (toe)*	*energy yield per 1000 animals per year (toe)*
cattle (under zero-grazing conditions)	1,200	0.03	0.52	18.5
pigs	990	0.02-0.04	0.52	10.2-20.4
poultry	31	0.08	0.52	1.3
Vegetable material	*dry matter per hectare per year (tonnes)*	*methane yield per dry kg (m³)*	*energy yield per 1000 m³ (toe)*	*energy yield per ha per year (toe)*
sugar-beet leaves	7.5	0.32	0.52	1.2
maize (incl. straw)	12	0.29	0.52	1.8

Source: calculated from various sources. Figures are indicative only.

The largest producers at present are the UK and Germany, with respectively 1.5 and 1.3 Mtoe in 2004 (EurObservER 2005). Smaller quantities are produced in Spain, France and Italy; together these five countries account for 84% of all biogas in the EU. Growth in biogas production (see Table 3) has been below the rate required to fulfil the 2010 target of 15 Mtoe. However, it is expected that further improvements in technology may lead to much larger quantities of biogas over the next two decades (EEA 2006:26).

Biogas is produced in a digester, which requires water for its operation. This makes it less suitable for areas with a water shortage. The production process leaves a residue called digestate, which can be used as a nitrogen-rich fertilizer. Thus, even the nutrients used in growing crops for biogas are partially returned to the land. A problem with this process is that it may run against regulations restricting the application of nutrients to the soil.

Biogas can be used in the same way as natural gas, but for some applications (for instance when entering into gas pipelines) it needs to be purified: only the methane fraction is useful as fuel. Like natural gas, it can also be compressed to be used as liquid fuel in vehicles. It is most suitable for producing heat, but actually most of the gas is used for generating electricity. The joint production of heat and electricity is an efficient way of utilizing biogas potential.

3.5.5. Forestry and bioenergy

As Table 3 shows, wood is at present by far the largest source of bioenergy – as it has been of tens of thousands of years. As a matter of fact, wood energy is of relatively little importance in most of Europe (except in heavily forested regions), compared to most developing countries. There are many ways in which wood and wood waste can be used as a source of energy:

- Green wood used to make charcoal (a major activity in many poor countries, but of little importance in the EU);
- Wood taken from forests for direct domestic use (cooking and heating);
- Waste from forest harvesting operations (tree tops, branches, etc.), which can be used as a biomass fuel;
- Waste from wood-processing operations (chips and sawdust, and black liquor from pulp processing), used for electricity generation within those operations or at a short distance;
- Wood waste processed into pellets to be shipped elsewhere for use as solid fuel; they are particularly useful in that they allow wood products to be transported over longer distances, and used in a variety of incinerators.
- Surplus growth in forests, harvested as a biomass fuel (so-called complementary fellings);
- Short-rotation forest plantations grown specifically as biomass fuel;
- Biodiesel produced from wood via gas (see section 3.5.2) may become an important new source of energy from forestry.

Out of these possibilities, we shall consider in the SENSOR policy case complementary fellings and wood waste from harvesting, whether used directly or processed into chips or pellets. Short-rotation plantations are here considered as agricultural land use (see section 3.5.3).

The biomass fuel can be solid (wood or woodchips, or processed into pellets), liquid (ligno-cellulose ethanol) or gaseous. Since liquid fuels and biogas are discussed in previous sections, this section is mainly concerned with the generation of heat and electricity from forest products. Table 6 shows conversion rates from feedstock into energy for major wood products.

Table 6. Conversion rates for wood into energy

Type of conversion	*yield in odt/ha/yr*[11]	*% of energy needed for conversion*[12]	*energy yield in GJ/odt*	*in toe/ha*
wood pellets into heat	12	27%	14.5	3.9
wood residue into heat	(per 1000 m³)		9.0	-
wood into electricity[13]	12	72%	5.5	1.5
wood into ethanol	12	46%	3.3	0.9
wood into biogas	12	-	6.9	1.9

Source: various. Figures are indicative only.

The final use can be as transport fuel (ethanol or compressed biogas), heat or electricity (whether alone or co-fired with other fuels such as coal). Heat at a household or district scale is probably still the major use, but electricity is important too: in 2004, the capacity of wood-fired power stations in the EU was 7,800 MW, about 1% of total generating capacity. This represents an increase of 70% compared to 1995 (Eurostat). The increase of energy production from wood in general is more modest: 31% over the same period (Table 3).

The largest producers of wood energy in absolute volume are France, Sweden, Finland and Germany; however, in relation to its size Austria is also a major producer. Spain, Poland and Portugal also produce large quantities of wood energy (EurObservER 2005).

3.6. Domestic production or imports?

The policy options chosen in any bioenergy policy will determine to what extent the feedstock will be produced within the EU and to what extent it will be imported. Our models will have to simulate these consequences. The policy instruments that can be used in the policy case are limited by existing policies in other areas. In the case of bioenergy, the most relevant of these are in the field of international trade. We must base ourselves on the assumption that existing trade agreements will be adhered to, unless there are strong indications that these agreements will be changed. In particular, the commitments made by the EU on reducing market-distorting agricultural subsidies in the Uruguay round of world trade negotiations will have to be kept. In the present Doha round, there is strong pressure on the EU and other rich countries to further reduce agricultural support, and current restrictions on such support are likely to be tightened further if anything.

So what are these restrictions? The Agreement on Agriculture, which is part of the Uruguay Round, groups protection measures into three so-called pillars: domestic support (production subsidies); market access (tariffs, quota and the like); and export subsidies. The first pillar is further subdivided into three ‘boxes’:

---

[11] Odt: oven-dried tonnes. Yields can vary widely, from 1.5 odt/ha/yr upwards. The figure in the table is based on expectations of willow coppicing in the UK (Beale & O’Brien 2000). The figure for ethanol from wood is not directly comparable to the figures in Table 4: in that table, the energy cost of fermenting and distilling is not included in the final yield per hectare.

[12] For wood pellets into heat: energy needed for pelletization; for pellets into electricity: pelletization plus the loss of converting heat into electricity (66%); for wood into ethanol: net of the energy spent in fermenting and distilling; and for wood into biogas there is no net loss, since the output of the digester is already net of any energy lost in the process.

[13] It is also possible to pelletize wood first and then use it to generate electricity. In that case, the loss of energy is 75%, and the final energy yield 5.0 GJ/ha (or 1.4 toe).

- the amber box, which includes direct subsidies on agricultural products;
- the blue box, which includes subsidies coupled to production restrictions, for instance milk quota;
- the green box, in which are support measures that are regarded as not strongly distorting the market, such as farm payments decoupled from production;[14]

Subsidies for producing bioenergy crops can only fall under the amber box. In the Uruguay round it was agreed that the OECD countries (which include the EU) will limit the total amount of subsidies in this box to a maximum of 5% of total agricultural production. This virtually excludes any scope for subsidizing oilseed, sugar or starch crops for bioenergy. It is a little different for low-value crops (miscanthus, eucalyptus and the like), which are unlikely to be traded over large distances. However, if they are used to produce ethanol, the end product will compete with imported ethanol; this importation is governed by the market access pillar, which means there are limitations on the extent to which domestic production can be shielded from foreign competition. The only subsidies permitted are those already existing: a premium of € 45/ha, tied to a maximum of 1.5 m ha, which falls in the blue box; and the implicit subsidy contained in the permission to grow energy crops on set-aside land, to a maximum of 1 m ha, which belongs to the green box.

This means that promoting bioenergy will lead to a certain amount of additional imports. Yet, Europe does have some leeway in steering the extent of these imports. As concerns the biodiesel sector, the EU is competitive for rapeseed oil, the major feedstock. There are no import tariffs on vegetable oil, so in principle there is considerable scope for using imported oils in the future. The main barrier to this actually happening is the aforementioned standard EN14214, which makes it difficult to use oils other than rapeseed. If this standard were modified to enable other oils to be used, this would probably lead to the rapid adoption of palm oil as a major component of biodiesel – perhaps up to 40%. Palm oil is much cheaper than rapeseed oil.

For ethanol the situation is different. Whereas the EU is the world's largest producer of biodiesel, it is a much smaller player in ethanol. Total production of fuel ethanol in Brazil was nearly 8 Mtoe in 2005, and in the USA it was almost 9 Mtoe, compared to 0.5 Mtoe in the EU-25 (F.O. Licht 2006). The EU is a large net importer of ethanol, with total imports (for both fuel and other purposes), of 445,000 tonnes – as compared to domestic production of 2.1 million tonnes (*ibid.*). Ethanol is heavily protected, with import duties of € 10.2/hl of denatured alcohol (i.e. made unsuitable for human consumption) and € 19.2 for undenatured alcohol, although a large part of actual imports are from countries which can export duty-free to the EU (EC 2005:32-33). Imported bioethanol can be up to 25% cheaper than local production, so without tariffs the European ethanol industry probably would not exist. The EU is able to steer the extent to which it wants to encourage local production vis-à-vis imports by reducing import tariffs; and to a limited extent it could also increase them, by reducing access to preferential tariffs. Raising tariffs across the board would, however, run afoul of the Agreement on Agriculture and attract heavy penalties from the WTO and trading partners.

Naturally, the options of domestic production or imports would have large consequences for sustainability impact, as will be described in the next section. Therefore, these options have to be included in the SENSOR policy scenarios. We propose a single policy variable for the degree of

[14] Actually, direct income support (such as decreed in the 2003 CAP reform) does also affect market conditions, because it reduces the downside risk of being in business: European farmers are able to produce more cheaply and carry larger risks because part of their income is already guaranteed.

protection, consisting of two components: in biodiesel, the technical standard maintaining rapeseed as the main feedstock; and in ethanol, the import tariff. As a policy variable, these would vary jointly. According to the Biomass Action Plan, removing all present restrictions (the standard for biodiesel and import duties on bioethanol) would lead to all ethanol and 50% of biodiesel feedstock being imported – which at a proportion of 56% diesel and 44% petrol would mean 72% of the raw material for biofuels (EC 2005:39).

3.7. Bioenergy and sustainability

In this section we attempt to identify the principal impacts which bioenergy policies may have with regard to sustainability. We are concerned only with identifying them as a guideline to the modelling exercise. Quantification of these impacts is, of course, the task of the models themselves.

First of all, we must consider the impact on **land use** and in particular multifunctional land use, which is after all a central concept in SENSOR. In the case of oilseed, sugar and starch crops for liquid biofuels, their cultivation would lead to an expansion of arable land as compared to the baseline scenarios. This does not necessarily mean an expansion as compared to the present situation, but rather a lower rate of abandonment of arable land. In many countries there are restrictions on converting grassland, forest or natural land to arable, which are reinforced by international agreements such as the Kyoto protocol (these conversions usually involve loss of organic carbon in the soil); hence, any arable land used for annual bioenergy crops such as rapeseed, sugarbeets or maize will be at the expense either of food crops or will involve the conversion of fallow into arable land. There is also an EU-wide restriction (under the Blair House Agreement with the United States), that no more than 1 million hectares of set-aside land may be cultivated for biodiesel crops.[15] Finally, there is a restriction that lands for which direct farm payments are made may not grow crops which were formerly protected; this affects sugar and starch crops, but not rapeseed.

Crops grown for cellulose-based ethanol (i.e. fibres) will most often be classified as either perennial (short-rotation trees) or as arable (grasses and other crops). It is unlikely that grasses grown as biofuel feedstock would be classified as grassland, since the aforementioned restrictions on conversion of pasture would preclude farmers from changing to other crops.

For biogas production, two types of areas are considered the most suitable:

1. areas with sizeable intensive livestock production (pigs, poultry, zero-grazing dairy and calf-fattening), providing sufficient animal manure as feedstock; crop waste from nearby arable agriculture may be used as supplementary feedstock.
2. areas with potential for fibre-crops (miscanthus, fast-growing trees) as well as being within easy reach of manure sources for supplementary feedstock.

The first type has no impact on land use, but the impact on sustainability will be significant. Apart from producing renewable energy, the environmental impact of intensive livestock will be reduced. Consideration has to be given to the impact of applying the digestate as fertilizer on the one hand and, on the other, to the removal of crop waste (especially in relation to erosion and organic carbon

[15] Most of this area is already used for rapeseed: 0.85 m ha according to a press release from the European Commission (MEMO/06/65 of 8 February 2006). This means that removing the Blair House restriction would have a major impact on biodiesel production potential in the EU.

content of the soil). As regards the second type of production area, here there is an obvious impact on land use. As in the case of fibre crops for ethanol production, this land use may substitute for pasture or forest, but there is a difference in relation to world trade: since these low-value crops themselves are unlikely to be traded over large distances, and since the domestic production of biogas is not covered by world trade agreements, it will be possible to subsidize production of these crops if they are used for biogas.

Bioenergy from forests has no direct influence on land use, since dedicated plantations are treated as agricultural land (see above). However, it can have a large impact on **environmental sustainability**. Complementary fellings and the removal of waste mean a lower volume of dead-wood, which is one of our indicators for biodiversity. Biomass removal can have environmental benefits where there is an excess of nitrogen, and where removal of deadwood reduces the risk of fire (EEA 2006:40); but a reduction of food supply for organisms remains an inevitable consequence. EEA has assessed the potential for wood energy for the EU (minus Greece, Cyprus, Luxembourg and Malta). This potential is currently estimated at 24.1 Mtoe, which is expected to increase to 26.8 Mtoe by 2020. However, the environmentally sustainable potential in 2020 is only 15.9 Mtoe (*ibid.*:42).

The production of dedicated bioenergy crops also has major impacts on sustainability, which need to be considered in SENSOR:

- The energy cost of producing the crops: the fuel spent in cultivating and harvesting, and the energy contained in the fertilizer; as mentioned above, the net reduction of greenhouse-gas emissions for conventional ethanol may be 20%, although estimates vary widely. For biodiesel it is thought to be 50% (OECD 2006:17).
- The impact of fertilizer application for biofuel crops on emissions of N_2O (laughing gas). N_2O is about 300 times as potent a greenhouse gas as CO_2, and just replacing the nitrogen in the soil which is taken out with biomass will have a strong effect on greenhouse emissions. Crutzen *et al.* (2007) suggest that this effect will be larger than the saving in emissions from burning fossil fuels, except perhaps in ethanol made from sugar cane. Particularly high is the rate of N_2O emissions from rapeseed.
- Water used for producing the crops.
- Producing these crops on a large scale may lead to further intensification, with the familiar consequences of eutrophication, erosion,[16] soil compaction, and reduced biodiversity – unless compensatory measures are taken. These changes will also affect the landscape.
- Possibly lower air pollution from bioenergy, especially as regards NOx and particulates.

The EEA study quoted above estimated that it would be possible to sustainably allocate 18 million hectares for bioenergy crops by 2025 (*ibid.* 22). According to the figures in Tables 4-6, this would mean a potential gross energy production of between 18 and 76 Mtoe, depending on the technology chosen. However, EEA presents a much more optimistic estimate, based on second-generation bioenergy technology, an expansion of arable land and higher yields: 120 Mtoe in 2025, which would be equivalent to about 6% of total energy consumption by that time. All of this is based on lignocellulose crops, of which most will be used to generate heat and electricity directly, with biogas as the second most important product and ethanol occupying the third place. With crops

[16] Although rapeseed tends to reduce erosion, because of providing dense soil cover (Dr John Boardman, personal communication, April 2007).

dedicated to conventional liquid biofuels, a more likely energy output would be 18-63 Mtoe – depending on the biodiesel-ethanol mix.

These sustainability effects do not apply to bioenergy from waste streams, such as biogas from animal manure plus crop wastes. The potential for this (in line with the requirements of environmental sustainability) in 2025 is estimated by EEA at about 25 Mtoe for crop waste and 18 Mtoe for animal manure (EEA 2006:48).

We also need to consider impacts other than those that are the consequence of land-use and land-cover change within Europe. Prominent among these are the consequences of importing biofuel or its feedstock from other countries. This can have beneficial income and employment effects on middle-income countries such as Malaysia (palm oil) and Brazil (ethanol). However, we must also consider that the expansion of arable land needed to satisfy European demand may go at the expense of tropical forests, with consequences for biodiversity and greenhouse-gas emissions. These need to be taken into account under the relevant indicators.

Concerning the **economic** dimension of sustainability, the major questions are (1) under what conditions the EU will be able to produce the bioenergy described above; and (2) what the consequences of biofuel production will be for commodity markets. As stated above, the answers can be given only for the first-generation fuels presently being produced. Table 7 shows production costs of major liquid biofuels in the EU-15 in 2004, compared with fossil fuel prices net of tax. In evaluating these figures we must consider (a) that fossil fuel prices have risen some 90% in the last two years; (b) that production costs of biofuels are decreasing; (c) that the cost of sugar will decline with the reform of the EU sugar regime decided early in 2006; and (d) that the production cost of some agricultural feedstocks is likely to decline further with the accession of the ten new member states in 2004. In Poland, for instance, the cost of ethanol based on maize is 25% lower than in the EU-15 (OECD 2006:11). At the oil price in mid-2006 of $ 72 per barrel, ethanol from maize can compete with petrol, but ethanol from other wheat and sugar beet cannot, and Brazilian ethanol is much cheaper. Biodiesel may soon be competitive, and certainly will be if it is blended with cheaper imported oils.

Table 7. The competitiveness of biofuels (in US$)

Fuel	Price per litre (EU-15, 2004)	Corrected for energy equivalent of fossil fuel	Crude oil price at which biofuel is competitive in 2004 ($/barrel)
Biodiesel	0.607	0.69	90
Ethanol from sugar beet	0.560	0.84	95
Ethanol from wheat	0.573	0.89	98
Ethanol from maize	0.448	0.69	72
Ethanol from Brazil	0.219	0.34	29
Petrol	0.311	0.31	(actual price, 2004) 39
Diesel	0.301	0.28	

Source: OECD 2006:11-12. Fossil fuel prices are excluding taxes, industry margin and distribution costs.

The OECD has calculated the impact of large increases of biofuel production, such as contained in the policy targets of the EU Biofuels Directive, on the market for agricultural products. The conclusion is that by 2014, 49% of oilseed production, 17% of sugarbeets, and 9% of cereals will be used for biofuels *op. cit.*:25). This would lead to a large decrease of wheat exports and an increase of imports of vegetable oils. Since similar things would happen in other OECD countries (notably the United States and Canada), the prices of these commodities on the world market would increase substantially, compared with the scenario with constant biofuel production: prices for vegetable oils would rise by 15%, that of wheat by 4% and that of sugar by a whopping 60% (*ibid.*:26).[17] These higher prices will also make it more difficult to achieve the targets, because biofuel will be more expensive. The livestock sector will show moderate price rises.[18] The impact will be very different when second-generation biofuels come on stream: there will be less effect on produce markets.

The economics of biogas and forest biomass have not yet been examined. Biogas produced from waste may also have an impact on agricultural commodity markets (by making the crops producing the waste more attractive as compared to competing crops), and therewith on land use. Forest biomass from waste or complementary fellings, however, is not thought to have an effect on the price of timber.

There is little we can say at this point on **social sustainability**, most indicators for which are derived from the economic ones. The most important one is employment. According to the recent Green Paper on Energy of the European Commission, the renewable-energy business in the EU is currently worth 300,000 jobs (EC 2006:11). Certainly the decrease of agricultural employment will be slower than under the baseline scenarios.

3.8. Conclusions: policy variables

The targets of the 1997 White Paper on renewable energy are set for 2010, so the policy will need to be reviewed before that time. The 2003 Biofuels Directive (Art. 4) specifies that a progress report has to be presented by the end of 2006 and again at the end of 2008. Therefore, an instrument that can assess the sustainability impact of such a policy will be timely.

In these policy documents, targets are usually set to be achieved by a certain year, such as 12% renewable energy or 5.75% biofuels by 2010. A suitable target for renewable energy for 2025 could be 25%, i.e. a doubling of the 2010 target. Bioenergy would probably have to make up 15-18% of total energy use, which amounts to a demand of 280-350 Mtoe (four to five times the current level). However, such targets cannot be used as the basis for modelling. Instead, we must imagine policies which will achieve them, and examine what *their* impact will be. These policies are typically decided at national level and may differ from one country to another.

For liquid biofuels in road transport, two different policies are currently followed by member states to achieve the 2010 target:

- lower taxes on biofuel as compared to fossil fuel, or even no tax at all (as in Sweden and until recently in Germany);

[17] This is assuming lower oil prices in the future. If the oil price remains at it current high level, the impact of rising agricultural prices will be more pronounced – but production costs will be higher too.
[18] Important fodder crops such as maize will become more expensive, although products such as rapeseed meal will become cheaper. The price of butter will rise because it can substitute for vegetable oil.

- a **mandatory percentage of biofuel** in fuels marketed (e.g. France and Austria).

These policies will have different effects on various aspects of sustainability. Tax exemption is most commonly used up to now, but it has two drawbacks.

Firstly, there is a risk of overcompensation: the exemption should compensate only for the difference in cost price between fossil fuel and the most competitive biofuel. Setting the tax reduction too high would bring inefficient producers. Moreover, with fluctuating oil prices the exemption must also be adjusted constantly.

Biofuel production requires major investments, and tax exemptions can be granted only for a maximum of six years, according to the EU Energy Taxation Directive. This provides insufficient investor certainty (EC 2005:30).

Biofuel obligations avoid these drawbacks: they avoid large state payments and reward efficient production of biofuels. It is proposed to use biofuel obligations as our first policy variable for the bioenergy case. Apart from being more efficient in practice, they also allow a direct link between EU policy targets and their implementation at national level. Which of the two solutions is chosen would make little difference to land use, but it would have an impact on public finance.

So far, policies on biofuels have only considered those used in road transport. Aviation is another important user of fossil fuel, and moreover growing very rapidly. The quality requirement is very high, which is one reason why biofuels have not yet been incorporated in aviation fuel. Another is that this fuel is not subject to excise duties, so tax exemption would have no impact. For the more distant future (beyond 2010), it is likely that biofuel would play some part in aviation also, and a target percentage will be incorporated into our policy scenarios. The same can be done for sea transport, although its share of total fuel consumption is much smaller.

Direct subsidies to farmers for producing biofuel feedstocks do exist, as described above (section 3.3). They are, therefore, part of the baseline scenario which includes the impact of existing policies. Since international trade agreements are unlikely to permit the expansion of such subsidies, they will not be considered in our policy scenarios. In forestry, on the other hand, subsidies are very well possible, as long as they cover only products which are not traded internationally. They could be used, for instance, to stimulate the use of pre-commercial thinnings for bioenergy.

The second variable will be the promotion of and subsidy for **research and development** in bioenergy. This is likely to increase the efficiency with which bioenergy can be produced and therefore reduce its cost. This will affect the conversion rates between land and energy (i.e. crop yields and the processing of crops into energy) Such support will cover not only liquid biofuels, but all forms of bioenergy.

The third variable will be concerned with promoting specifically the **production of heat and electricity from biomass**. As can be seen in Figure 4, these forms of bioenergy mostly come from biogas and wood (including black liquor). This includes:

- Subsidies/tax exemptions for the production of biogas;
- Support for forest owners for the production of bioenergy;

- Subsidies for constructing biogas pipelines linking to natural gas lines;
- Subsidies for installing district heating systems running on bioenergy;
- Tax discounts for boilers capable of using biomass;
- Tax exemptions for electricity based on biomass.

The variable itself will be expressed as the total amount of fiscal subsidies available for the above measures. It is assumed to be complemented by legislative measures promoting access of biomass suppliers to energy networks. Such a package of measures will lead to an increase of the production of biogas and of biomass for energy in forestry. It is proposed to distribute the funds over the above activities as follows:

- Biogas production 30%
- Biogas pipes 5%
- Forestry 25%
- District heating 10%
- Boilers 10%
- Electricity 15%

The final policy variable will be concerned with the extent to which bioenergy feedstock (i.e. the raw material) and liquid fuels will be produced within the EU or imported. Policies covered under this variable are **import duties on ethanol and restrictions on biodiesel feedstocks**. These two types of products are at present the only forms of bioenergy imported into the EU. It is theoretically possible to import biomass-based electricity, fuelwood and biogas from other countries. We shall assume that the policy variable covers these options also. Although in practice it would be difficult to increase protection beyond its current extent, we shall model the consequences of full protection, i.e. all bioenergy produced within the EU.

Thus, we propose four policy variables, as contained in Table 8. For each of them minimum and maximum values for the policy options are stated, between which SIAT can operate. For the first variable, the minimum is the existing target for 2005 (which has not been achieved). For 2015, it is estimated that 58% of all road transport fuels will be diesel and 42% petrol. For 2025, these percentages will be 61% and 39% respectively, but now fuel for shipping (mostly diesel) and for aviation (kerosene) will be included. As for the maximum, the Biofuels Directive mentions a target of 20% for 2020, for road transport alone; 25% for all transport sectors by 2025 is an extremely ambitious target and therefore an appropriate maximum value for the policy variable.

The minimum value for the second and third variables means no additional funds beyond what is allocated under current policies. The maximum value for both together is equivalent to 0.1% of the EU’s GDP in 2004, or 0.3% of all public expenditure. It is comparable to what is now spent on the EU’s rural development programmes, which appears to be an appropriate maximum amount for what could be spent on bio-energy research and support to bio-energy other than liquid fuels. As for the fourth variable, in between the minimum and maximum protection scenarios, the impact of the current level of protection will also be calculated.

Table 8. Policy variables for the bioenergy case, effective from the base year

Variable code	*Description*	*Unit*	*Default*	*Maximum*
BIOE_SUP[19]	1. liquid biofuel obligation	% of total transport fuel (road transport up to 2015, all transport thereafter)	2	25
	2. research & development	millions of euros spent annually by EU and member states	0	5,000
BIOE_GASELEC	bioheat and bio-electricity	millions of euros spent annually by EU and member states	0	5,000
BIOE_MAR	import restrictions on bioenergy products	Yes/no	domestic production up to maximum potential, remainder imported	no restrictions

[19] In the scenarios calculated by the models, settings for variables 1 and 2 are run in unison; therefore they have a joint code.

4. 2012 Financial Reform/CAP

Author: David Verhoog

4.1 Introduction

In 2005 there was considerable debate in the European Council of Ministers on the long-term EU budget (known as the financial perspective) for the period 2006-2013. There was pressure from some members to reduce or abolish the Common Agriculture Policy (CAP), and there was a British proposal to spend the funds which would be released towards achievement of the Lisbon Agenda – by spending them on research & development (R&D). These proposals were unsuccessful, but in 2012 a new financial perspective will have to be decided upon, and undoubtedly two major issues will be:

- How large the budget of the European Union should be; and
- What it should be spent on.

Since the CAP is the largest part of the EU budget and because it is controversial, it is bound to figure in the discussion. Therefore, it will be useful if the SIAT toolbox would be able to analyze the consequences for sustainability and multifunctional land use on a regional basis of different options. The present policy case will allow to study the impact of reducing or abolishing the CAP, with the options either to spend the funds thereby released on R&D or returning them to the taxpayers.

Moreover, since agriculture is the most important user of land in Europe as well as a key determinant of the quality of the countryside and the environment, it is important to have at least one policy case which has a major impact on agriculture. The CAP and trade policies are important factors that determine the future of agriculture and rural development in the EU. These policies consist of export subsidies, import tariffs, production quota, tariff rate quota, product subsidies (coupled) and decoupled income payments.

4.2 Goals

The problems which the 2012 financial reform may address are:

- The high cost of the CAP to the taxpayers and consumers;
- The trade-distorting effects of the CAP, which are an obstacle to the trade liberalization desired by the EU; one aspect of this is the low competitiveness of some subsectors of European agriculture; and
- The slow progress of the Lisbon Agenda (cf. Kuhlman *et al.* 2006, p. 23-26).

Through the ongoing GATT/WTO negotiations on agricultural trade and the internal EU agricultural policy reforms the CAP has already undergone some major reforms. The 1992 reform of the CAP focused on production limits (quota) and introduced the concept of direct payments for some agricultural sectors. This was expanded to other sectors in 1999 (Agenda 2000). Many subsidy schemes operating in individual agricultural sectors have been replaced in the June 2003 reform. This latest reform now focuses on a Single Payment Scheme (SPS) instead of product-related subsidies and it further cuts the link between market price support and production (further decoupling of support from production). Farm support too is now geared to consumer concern and public priorities. Farmers will have to respect environmental, food safety and animal welfare standards, accompanied by clearer obligations to manage the farms in a sustainable way (cross-compliance). Besides this there is a strong tendency to reinforce rural development. In order to keep CAP spending beneath strict budgetary ceilings a financial discipline mechanism will be applied. This instrument, known as modulation, will ensure the transfer of CAP funds from direct aid to farmers and market measures (Pillar 1) to rural development measures (Pillar 2).

In 2005 the European Commission put some new effort into the Lisbon Strategy with its goal to create higher economic growth, jobs and greater competitiveness in world markets. Innovation (through R&D expenditure) as well as information and communication will play an important role to reach the goals set. Besides this the R&D expenditure should contribute to improve sustainability in line with the Göteborg sustainability goals.

4.3 Objectives

Based on the short term goals described above, this project wants to specify and investigate a more drastic full liberalization objective, which is in line with the Lisbon Strategy, for EU agriculture in 2025. This full liberalization is aimed at a more competitive agricultural sector in world markets. This means that the agricultural sector must be able to compete at world market prices without any support. As a consequence of this, all different kinds of existing market support measures should be abolished. On the other hand this full liberalization should not mean that the agricultural sector becomes insensitive to the environment, food safety and animal welfare. For this reason, the money saved by abolishing the market support should return through innovations in agriculture that will stimulate the agricultural sector to produce more efficiently and sustainable under the conditions of environmental, food safety and animal welfare standards.

The measures to be implemented in both models (NEMESIS and CAPRI) to reach this full liberalization will be first to abolish export subsidies and import tariffs for all agricultural sectors in order to have EU agricultural production at world market prices. Furthermore, EU domestic support will be abolished for all sectors. This means that direct income payments will no longer exist. Next, the existing quota systems for sugar and milk and the set-aside regime will be abolished. Further the Single Farm Payment (SFP) will first be redefined and coupled to green services and then will be abolished to a certain degree (scale 0% to 100%). Finally the money saved by abolishing these market support measures and the single farm payment could either be used to increase the general R&D expenditure (to be simulated in NEMESIS) or be of direct benefit for the taxpayers.

4.4 Instruments

The objectives described above must be translated into concrete instruments to enable the Sustainability Impact Assessment Tool (SIAT) to work with this CAP policy scenario. The aim of SIAT is to allow policymakers to change the given instruments in order to assess the impact on sustainability (environmental, social and economic). This impact will be visualized against the autonomous development described in the baseline.

Policy instruments for the CAP policy scenarios are:

- Reduction or abolition of EU export subsidies and import tariffs for all agricultural products;

- Reduction or elimination of all trade agreements (including bilateral tariffs);
- Reduction or abolition of market support (coupled and decoupled) in agriculture;
- Abolition of sugar and milk quota and set-aside regulations;
- Increase of R&D expenditure in the EU budget; this expenditure will be economy-wide, not for the agricultural sector alone.

4.5 Policy variables

The number of combinations of the five policy instruments listed above is potentially very large. The amount of model runs required to construct response functions covering all possible combinations would be astronomical. Fortunately, in practice a policy-maker would be interested only in a limited number of plausible combinations. The challenge of the SENSOR project is to design such combinations while also retaining a degree of flexibility so as to allow the end user to build his own policy scenarios. This is achieved by combining several policy instruments into a single policy variable that can be set by the SIAT user (see also section 1.3 of this report). The instruments contained within one such variable are considered likely to be changed in tandem. The policy variables for the present policy case are:

1. Agricultural market support (import tariffs and export subsidies) and quota (sugar and milk). Two scenarios are provided for, namely continuation of present schemes and their complete abolition – in other words, market regulation vs. a liberalization of agricultural markets.
2. Direct farm income support, such as presently provided through the single-farm payment scheme. This support is linked to services provided by farmers other than agricultural produce, e.g. maintaining the land in good condition.
3. Research & development: The amount of public expenditure saved by abolishing market support and/or reduction of farm income can be returned to the tax-payer or reallocated to research & development (public expenditure), in order to promote innovation in the economy as a whole rather than specifically on the agricultural sector. As in the case of variable 1, this variable has the form of a toggle switch – yes or no.

The baseline scenario (no change in policy) corresponds to variable 1 set to 0 (present situation) and variable 2 to 100%. Since there is no expenditure saved, variable 3 remains inactive. Figure 5 schematizes the policy options from which the SIAT user can choose.

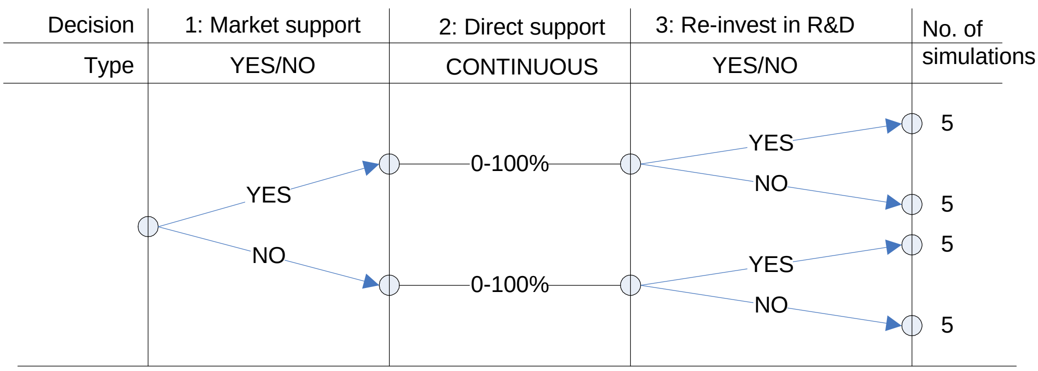

Figure 5. Variables (buttons) in SIAT for the policy case

4.6 Conclusions

The Lisbon Strategy (higher economic growth, jobs and greater competitiveness) and the Göteborg sustainability goals are high on the political agenda of the European Commission. The Commission is now on the line of decreasing expenditures on market support and direct payments (modulation) in favor of rural development.

From January 2007 onward there will be two funds: one for CAP measures related to direct aids and market related measures (EAGF-European Agricultural Guarantee Fund) and another will cover rural development (EARDF- European Agricultural Fund for Rural Development). The expenditure on the EAGF will be decreased with 3% and the expenditure on the EARDF will be increased by 22%.The total EU budget for agriculture will because of this decrease by 7%.

It is still difficult to implement the impact of increased expenditures on rural development with the current models used in the SENSOR project. For this reason we have chosen for the policy scenario that best reflects the direction the Commission wants to go with EAGF expenditures and has the Lisbon Strategy in. Since our scenario horizon is 2025 we have opted for the rather extreme scenario in which all market support measures and direct payments are abolished and where the savings of this abolishment are either used to increase general R&D expenditure in the whole economy or be returned to the taxpayers.

The models we will use to run the scenarios are CAPRI (for the agricultural sector), NEMESIS (for the economy as a whole) and CLUE (land use). The basic idea is that the strong elements of all models will be used. This means that CAPRI will provide the impact of abolishing market support and direct payments in agriculture. NEMESIS in its turn will show the effect for the agricultural sector of increased expenditures in R&D, and CLUE will show the impact on land use.

5. The biodiversity policy case

Authors: Ole Hjort Caspersen and Thomas Sick Nielsen

5.1 Goal

The last decades are characterized by a large reduction and losses of biodiversity at both European and global scale. This loss has accelerated dramatically and it is estimated in UNEP´s Global Biodiversity Assessment that biodiversity is decreasing at a faster rate now than at any other time in the past; this development is also recognized in the European Union (European Commission 1998).

Biological diversity is here recognized on three levels (European Commission 2001c):

- Genetic diversity- the variety of genetic building-blocks found among individual representatives of a species
- Species diversity – the variety of living organisms found in a particular place
- Ecosystem diversity – the variety of species and ecological functions and processes, both their kind and number , that occur in different physical settings

European landscapes have developed as a combination of physical conditions and human influence in the form of differences in land use. The biodiversity that relates to these landscapes and ecosystems influences our daily lives and is essential to maintain life as we know it. Long-term viability within sectors like agriculture and silviculture depends on sufficient biodiversity. The decline in biodiversity within these sectors derives mainly from rapid intensification, fragmentation and degradation (EEA 2004).

Existing measures have proved to be insufficient to reverse present trends, and the loss of biodiversity is likely to accelerate if no measures are taken to halt this trend. Hence the European Commission in 1998 adopted a Communication on a European Biodiversity Strategy. The strategy aims to anticipate, prevent and attack the causes of significant reduction or loss of biodiversity at the source (European commission 1998).

Hence, the goal for this policy case is to reverse present trends in biodiversity reduction and to accord species and ecosystems, including agro-ecosystems, a satisfactory conservation status.

5.2 Objectives

The European Union ratified the UN convention on biological diversity in 1993. The convention states that:

"*In ratifying the Convention, the parties have committed themselves to undertaking national and international measures aimed at its achieving three objectives: the conservation of biological diversity; the sustainable use of its components; and the fair and equitable sharing of benefits arising out of the utilization of genetic resources*." (UN, 1992)

Following ratification, the EU developed a biodiversity strategy in 1998 (European Commission, 1998), as well as more specific biodiversity action plans in the areas of conservation of natural resources, agriculture, fisheries, and development and economic corporation (European Commission, 2001c).

The 1998 biodiversity strategy defines four themes and a number of policy areas and objectives that should be further developed in the later action plans. Among the themes and policy areas, theme one: conservation and sustainable use of biological diversity; and policy areas: conservation of natural resources (1), agriculture (2), and forests (5) are the ones that can be expected to have the most immediate impact on land use patterns. Hence, these are the most relevant to SENSOR.

The 2001 biodiversity action plan (BAP) focuses on the integration of biodiversity concerns into sectoral policies (European commission, 2001c). The biodiversity action plan on conservation of natural resources aims at the protection of designated habitats and species of community interest (Birds and Habitats directives) and at setting priorities for the protection of biodiversity across the wider territory based on a range of non-biodiversity-specific instruments (e.g. the water framework directive, integrated coastal zone management, environmental impact assessment). However, it is emphasized that changes in land use are among the main sources of biodiversity loss and that biodiversity considerations also should be integrated into land-use policies.

The BAP on agriculture points to seven priorities for action, among others: ensuring a reasoned intensification in agricultural practices; maintaining agriculture in biodiversity-rich areas where agricultural activity has been weakened; using agri-environmental measures to support biodiversity; and ensuring the existence of an ecological infrastructure at the level of the entire territory.

The European Council, at its meeting in Göteborg in 2001, supported the content of the action plans and included the target that the decline in biodiversity should be ‘halted’ by 2010:
“… the European Council agrees:
− that the Common Agricultural Policy and its future development should, among its objectives, contribute to achieving sustainable development by increasing its emphasis on encouraging healthy, high-quality products, environmentally sustainable production methods, including organic production, renewable raw materials and the protection of biodiversity;
…
- that biodiversity decline should be halted with the aim of reaching this objective by 2010 as set out in the 6th Environmental Action Programme.”
(Council of the European Union, 2001)

This resolution is supported by the member countries’ ratification of the UN convention on biological diversity, which states that the loss of biodiversity should be significantly reduced by 2010.

5.3 Instruments

The instruments available at the European level for the enhancement and protection of inland biodiversity can be divided into:

- designated nature protection/site protection;
- other important policies, such as the agricultural policy; and
- horizontal environmental principles (European Commission, 2001c).

5.3.1 Nature protection

The main policy instruments for site protection at EU level are the Birds and Habitats Directives (79/409/EEC; 92/43/EEC). The Habitats Directive includes a list of “Natural habitat types of community interest whose conservation requires the designation of “special areas of conservation” and a list of “Animal and plant species of community interest whose conservation requires the designation of special areas of conservation”. Based on surveys and suggestions (sites) from the member countries, sites of community interest will be identified and eventually designated as “special areas of conservation” to form “a coherent European ecological network….Natura 2000” (92/43/EEC). Protection under the Habitats Directive is principally guided by community interests in nature protection, however the criteria set up in the directive may be applied more “loosely” should a member state have priority species represented on more than 5% of their territory - and host more than one priority natural habitat type. The approach adopted in the Habitats Directive may be further refined and used to develop the network of protected areas based on certain criteria. For wetlands the Water Framework Directive may also be developed and applied to the protection of biodiversity (European Commission, 2001c).

Following the Birds and Habitats Directives, the member states are obligated to evaluate plans and projects that may effect the designated Natura 2000 areas, and only agree to such projects or changes which have no significant adverse effects on the site. Member states must also establish the necessary conservation measures involving, if necessary, management plans for the site (European Commission 2005b).

5.3.2 Agricultural policy and forestry

The other important policy areas that affect biodiversity are agriculture and forestry. In the report by the European Environment Agency (2004) the agricultural policy (CAP) is considered to be the most relevant framework when it comes to the conservation of ‘high nature value farmland’ and thus biodiversity on farmland. The CAP is composed of two ‘pillars’ The first pillar contains the financial support to agricultural production and has since 2003 been subject to some environmental conditions. The second pillar allows member countries to implement measures that reduce the ecological impacts of agriculture, e.g. ‘agri-environment’ schemes and less-favoured-area payments. Within the framework of agri-environment schemes farmers can be supported in return for environment-friendly practices. Principally this allows for the promotion of a range of biodiversity-protecting initiatives on existing farmland. One of the challenges in the agricultural sector is that it is not just intensification of agriculture that threatens biodiversity. In many areas agricultural activities contributes positively to biodiversity and the maintenance of agriculture in less-favoured or marginal areas must also be seen as a biodiversity-enhancing contribution from the CAP. The report by the EEA (2004) suggests that less-favoured-area payments, agri-environment schemes in combination with first-pillar support, and sufficient environmental standards could contribute to the protection of high-nature-value farmland.

There is no specific Biodiversity Action Plan for the forest sector even though one was advertised in the 1998 biodiversity strategy. Objectives of the biodiversity strategy for the forest sector are mainly directed towards sustainable management of forests with respect to ecological characteristics. (European Commission, 1998). According to the BAP for the conservation of natural resources (European Commission, 2001c) nature-oriented forest management techniques (e.g. limitation of pesticides and fertilizers, increase of dead or decaying wood, protection of key habitats) should be supported through the Rural Development Regulation (1257/1999).

5.3.3. Horizontal regulations

The horizontal regulations consist of the inclusion and promotion of biodiversity concerns in other policies and principles. The BAP (European Commission, 2001c) suggests, among others, the promotion of biodiversity in Environmental Impact Assessments, Eco-labelling and Eco-audits.

5.4 Policy variables

The policy variables for use within SIAT must be derived from the European policy on biodiversity, but will also be bounded by the abilities and predictive powers of the models applied within the project. There is of course a discrepancy between, on the one hand, the policy emphasis on obligations and intentions to act in agreement with the overall objective (e.g. protect species or areas of community interest); and, on the other hand, the modelling chain within the SENSOR project, which requires translating the policy into land use or land use intensity. To represent the potential impact of the biodiversity policy in SIAT, it is therefore necessary, besides the protection of land/sites implicit in the Birds and Habitats directive, to also include variables that represent desirable practices in agriculture and forest management, and which most likely can be induced through the Community policy on biodiversity.

The model for the agricultural sector applied within SENSOR (CAPRI) provides few possibilities for modelling of biodiversity policies. The shift, within the CAP, from the ‘traditional’ first-pillar support measures towards the agri-environmental schemes of the second pillar could make an important contribution to the bio-diversity targets. However, the schemes vary considerably in content and scope between countries, and their effects cannot be modelled across the board with one-size-fits-all rules. One policy option relevant to biodiversity that is supported by the CAPRI model is a targeted promotion/subsidy of less-intensive agriculture. This is particularly relevant to agricultural land within Natura 2000 areas, where maintenance of less-intensive agriculture is likely to be desirable.

Within the forestry sector, the EFISCEN model allows for indicators of biodiversity-enhancing forest management to be included in the scenarios. Options are the incorporation of management constraints applied to forests over a certain age to allow an increasing share of old forest; and reductions to the share of deadwood that is removed from the forest (presently the removal is around 50%). These practices would lead to an increasing portion of old forest and higher volumes of deadwood, for the benefit of biodiversity.

In the context of the SENSOR project, that focuses on the effects of land use changes, the Natura 2000 network is the most relevant policy at the European level, when it comes to targeted promotion of biodiversity. Based on the obligations of the member states to protect and maintain nature areas, Natura 2000 status should significantly reduce the likelihood of future land cover changes in the Natura 2000 areas, as well as secure sustainable forest management and extensive agriculture within the areas.

For use within the modelling chain, two policy variables are suggested: Expansion of the Natura 2000 network; and General shift towards biodiversity-friendly forest management.

5.4.1 Expansion of the Natura 2000 network with incentives to promote biodiversity-friendly land management on added sites:

The main policy variable affecting biodiversity will be expansion of the Natura 2000 network. To model the effects a spatially explicit, suggestive expansion will be developed based on certain criteria: building of a coherent Natura network; existing land cover (urban, nature); location (coast, rivers); sites and species of community interest as identified in the CORINE biotope data. From a biodiversity point of view, a desirable development in the Natura 2000 areas will be to ensure the continuation of agricultural land use, but with limited intensity. Similarly, it will be desirable to ensure reduced intensity of forest management within the Natura 2000 areas. Agriculture with less intensive land use can be represented in the CAPRI model as a subsidy for low-yield exploitation of agricultural land. The EFISCEN model allows for more direct measures and the moderations to management practices can be represented as reduced felling probability of forests.

5.4.2 General shift towards biodiversity-friendly forest management:

A general shift towards nature-oriented forest management in all forest areas could be a reduced rate of felling in old forests, which will increase the age of the forest, and provide a greater volume and selection of natural forest habitats.

5.4.3 Limitations to the present scenario and modelling:

It should be noted that several observers of the field (e.g. EEA, 2006; Spangenberg, 2007) point to the fact that biodiversity loss has multiple causes. The EEA (2006) concluded that the target to halt biodiversity loss is unlikely to be reached without additional integrated policy efforts, including improvements to the biodiversity value of intensively managed farmland. In the same vein Spangenberg (2007) concluded that biodiversity conservation *"cannot be restricted to just one policy area, but has to cover a broad range of policy domains in systematic fashion"*. Thus a successful biodiversity strategy must depend upon a far broader range of measures than suggested in the present policy case. Adequate modelling of such efforts will also require major advances to the state of modelling of land use effects as well as biodiversity outcomes.

The following table summarizes the two policy variables and how they are to be implemented in the modelling framework. Each row contains a policy variable, and the columns contain information about how that variable is implemented. The field "variable code" refers to the variable in the response functions and indicator functions. "Description" contains a short description of the policy variable, suitable for display in the SIAT user interface. "Domain" denotes whether it is a continuous or discrete variable and what different values it is allowed to take. The columns bearing the names of models define how the variable is implemented in the different models.

Table 9. Policy variables in the biodiversity policy case (N2K is short for "Natura 2000")

Variable code	*Description*	*Domain*	*Default*	*CLUE-S*	*CAPRI*	*EFISCEN*	*Nature 'model'*
BIOD_N2KEXPAND	Expanded N2K network with incentives for extensification in areas	Continuous in the interval [0,1]	0	Land probability for agriculture increased by 0,2 times variable value in N2K areas No conversions allowed in N2K areas, except from semi-natural to forest	Direct payment to extensive AG in relation to share of land that is N2K. Basic subsidy is 344,5 EUR/Ha	Management practice only: 50% of available wood can be harvested in N2K areas	Expanded spatially explicit N2K network
BIOD_FOREST	Biodiversity friendly forest management	Continuous in the interval [0,1]	1	-	-	Management practice: % of available wood that can be harvested in forests older than 150 years	-

6 Forest strategy policy case

Authors: Hans Verkerk and Marcus Lindner

6.1 Introduction and goals

In 1998 the European Commission (EC) formulated a Forestry Strategy for the European Union (Council, 1999) This is a framework for actions in support of sustainable forest management (SFM), based on the co-ordination of the forest policies of the Member States and Community policies and initiatives relevant to forests and forestry. Forest policies are within the competence of member states. However, the EU can contribute to the implementation of SFM through common policies. A review report on the implementation of the EU Forestry Strategy proposed to *develop an EU Action Plan for Sustainable Forest Management, which should provide a coherent framework for the implementation of forest-related actions and serve as an instrument of co-ordination between Community actions and the forest policies of the Member States* (EC, 2005c).

That Action Plan was published in 2006. Its overall objective is to support and enhance sustainable forest management and the multifunctional role of forests (EC, 2006b). It identifies the following issues as challenges to policy-making (EC, 2006f):

- Increased globalisation has led to global markets for various forest products. EU forest owners have difficulties to compete because of their high production costs.
- To reduce the loss and degradation of forests, promoting SFM has become an important issue.
- Economic growth results in an increased demand for wood; at the same time, standing wood volumes are increasing. However, due to a poor relationship between forestry activities and manufacturing industry, this economic opportunity is not used.
- Changes in population and employment structure lead to changes in demand for wood products and also changes in other functions of forests.
- Forests can play a role in mitigating climate change. They are themselves also affected, and adaptation to climate change is needed.
- Growing concern about biodiversity led to efforts to restore habitats and natural ecosystems, but the EU’s biodiversity remains impoverished and continues to decline.
- Because of public debates on issues such as biodiversity conservation and climate change, good governance has become more important.

It may safely be assumed that these issues remain relevant to policy-making for the coming years. Furthermore, there are a number of international agreements and commitments that must play a part in EU policies, of which the International Agreement on Forests (UN-IAF, on promotion of SFM), the Ministerial Conference on the Protection of Forests in Europe (MCPFE, also on promotion of SFM), the UN Framework Convention on Climate Change (UNFCCC, on greenhouse gas emission reduction, of which the Kyoto protocol is an update), and the UN Convention on Biological Diversity (CBD) are particularly relevant to SENSOR.

Consequently, these are the challenges and commitments to be met by the EU, reflecting a wide range of policy areas and the multifunctional role of forests.

6.2 Objectives

The goals described above are specified by 18 key actions contained in the Forest Action Plan, several of which are relevant to SENSOR:

- Key action 4: Promote the use of forest biomass for energy generation;
- Key action 6: Facilitate EU compliance with the obligations on climate change mitigation of the UNFCCC and its Kyoto protocol and encourage adaptation to the effects of climate change;
- Key action 7: Contribute towards achieving the revised Community biodiversity objectives for 2010 and beyond;
- Key action 9: Enhance the protection of EU forests;
- Key action 11: Maintain and enhance the protective function of forests;
- Key action 17: Encourage the use of wood and other forest products from sustainably managed forests.

These key actions offer a wide range of possible objectives for EU forest policies. The current Forest Action Plan mostly speaks of improving coordination and communication, and facilitating research. The Action Plan will be evaluated in 2012 and may result in new policies regarding forest land use. This policy case describes some possible policies, focusing on just a fraction of the topics covered by the key actions.

6.2.1 Use of forest biomass for energy

One of the actions mentioned in the Action Plan for promoting energy generation from forest biomass is to let each member state assess *the availability of wood and wood residues at national and regional levels, in order to consider further actions in support of the use of wood for energy generation* (EC, 2006b). A study on the environmentally compatible bio-energy potential from European forests estimated an annual potential of approximately 40 Mtoe until 2030. Rising oil prices will result in an additional energy potential from competitive use of wood (Figure 6; EEA, 2006). The difficulty, however, is how to mobilize these potential resources. Technical (e.g. accessibility), economical and social factors (e.g. fragmented ownership, (un)willingness to cut trees) hamper the harvest of wood from European forests that could be used for bio-energy production (Becker et al., 2006).

Based on similar assessments, new targets for the share of forest biomass for energy will be defined. Currently, these targets are included in the target for all biomass, which is set at 150 Mtoe for the EU25 in 2010 for bio-heat and bio-electricity (EC, 2005). Discussions on targets beyond 2010 have commenced (EEA, 2006) and targets will probably be raised.

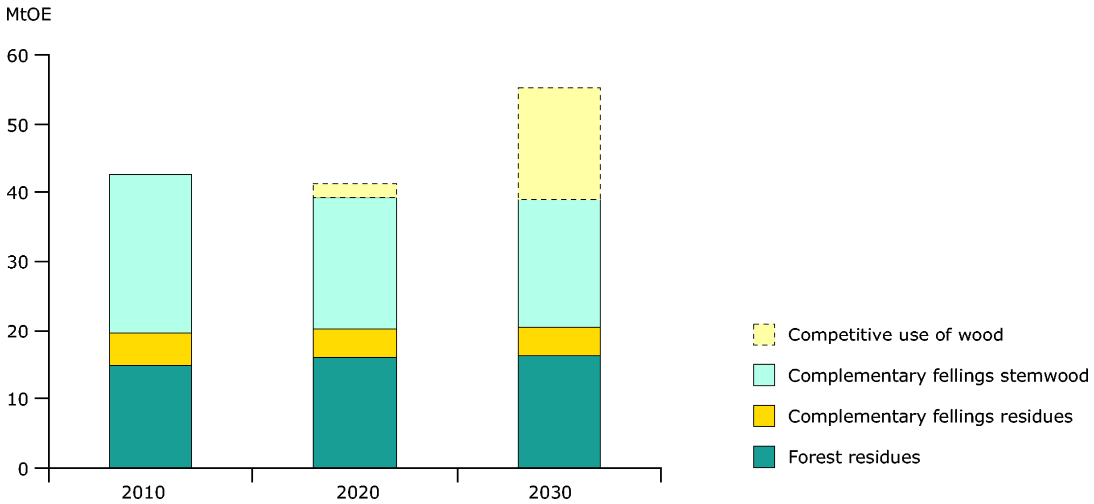

Figure 6. Environmentally compatible bio-energy potential from forests in the EU25 without Cyprus, Greece, Luxembourg and Malta (EEA, 2006).

6.2.2 Role of forests as carbon sinks and for protecting soils and water catchments

One way to achieve this objective is afforestation. Whereas it is for the member states to develop policies for this, the EU provides funding for afforestation programmes. According to the ECCP (2003) Working Group on Forest Sinks, afforestation and reforestation activities between 1990 and 2000 have extended the total EU forest area by 340,000 ha yr^{-1} -or 3%- through natural forest expansion and through planting of forests. In many cases, these plantings were supported by the EU 2080/92 Afforestation Scheme and Rural Development Regulation 1257/99. Estimates show that if this process continues at the same rate during the present decade, it may result in a sequestration potential of approximately 3.84 Mt C ha yr^{-1} during the first commitment period. In case of a sustained afforestation trend and taking into account the extension of the EU to 25 member states, a technical sequestration potential of 34 Mt C ha yr^{-1}. may be reached in the long term (ECCP, 2003). This potential is probably higher given the recent, further extension to Bulgaria and Romania.

Afforestation is pursued by national governments for various objectives; not only to contain climate change, but also to combat erosion and desertification among others. Quantitative targets for afforestation are incorporated in many national Rural Development plans until 2013 and are thus defined at the national level, rather than at the EU level. However, afforestation remains a European issue, because of its dependence on EU funding schemes. Currently funding for afforestation is included in the European Agricultural Fund for Rural Development (EAFRD; Council, 2005). The EAFRD regulation covers - similar to the Rural Development plans - the period 2007-2013. A tool to assess sustainability impacts of new afforestation schemes from 2014 onwards is therefore timely.

6.2.3 Forestry and biodiversity

Forests are home to a large number of species and as much of European biodiversity is impoverished, accelerated action is required to restore habitats and natural ecosystems. This key action refers to the Communication from the Commission on halting the loss of biodiversity by 2010 and beyond (EC, 2006e). This communication defines 10 objectives of which two are particularly relevant to the forest land use within the EU. These are:

- Objective 1: To safeguard the EU's most important habitats and species
- Objective 2: To conserve and restore biodiversity and ecosystem services in the wider EU countryside

Headline targets for these two objectives are to halt biodiversity loss by 2010 and showing recovery by 2013 (EC, 2006g). It may safely be assumed that future policies (post 2013) will aim at further recovery of biodiversity.

These objectives correspond with the view that biodiversity is not evenly spread and that certain habitats and species are more at risk than are others. The Natura 2000 network was established to protect such habitats and species. Biodiversity also resides in forests outside these areas and is strongly affected by forest management, because this alters the composition of tree species, stand density and horizontal structuring, distribution of age-classes and rotation periods, regeneration methods, etc. (EEA, 2006e). Felling cycles in managed forests are generally shorter than natural cycles and this affects the presence of older forests. Partly due to a recent development towards more close-to-nature oriented management, the share of old forests is increasing. Old forests contain generally more large trees with tree cavities and dead wood and provide therefore numerous microhabitats to forest species of various taxa (EEA, 2006e; Harmon et al., 1986; Siitonen, 2001).

6.3 Policy instruments

6.3.1 Bio-energy from forests

Regarding the use of forest biomass for energy generation, the Forest Action Plan currently focuses on research on availability and mobilisation of wood and wood residues and on development of technologies for the production of energy from forest resources. This will eventually result in a policy to mobilise these resources as energy feedstock. Wood is mainly used to produce heat and electricity. Suitable instruments for such a policy should deal both with the supply and the demand side. At the supply side a possible instrument would be support to forest owners to implement complementary fellings and/or extract harvest residues. On the demand side, possible instruments are subsidies for installing district heating systems running on bio-energy, or tax exemptions for electricity from biomass.

6.3.2 Afforestation

Afforestation policies are developed at the national level, but afforestation projects are largely funded by the EU. Currently the most relevant policy instrument is the EAFRD by which countries may *develop national afforestation guidelines and promote afforestation for environmental and protective objectives*. The EAFRD regulation covers *inter alia* establishment costs, maintenance costs and compensation for loss of income. The most relevant instrument to promote afforestation after the year 2013 will probably remain similar funding schemes.

6.3.3 Forest biodiversity

Several policy instruments to halt the loss of biodiversity are presented in the biodiversity policy case description. One of the most important instruments is the protection of important habitats through the Natura 2000 network. Currently almost 30% of the designated Natura 2000 sites concern forest habitats (EC, 2006f). Financial instruments to increase biodiversity in forests are currently included in the EAFRD, which provides support to compensate for costs and loss of income resulting from the restrictions on the use of forests as Natura 2000 or forest environment payments. Support is also available for forest environment investments that increase public amenity value, but that are not related to production (EU Council, 2005). Other instruments that have been applied for meeting biodiversity objectives are funding of research and awareness raising and public engagement (EC, 2006e).

6.4 Policy variables

The current EU Forest Action Plan covers the period 2007-2011. We assume that after this period the Forest Action Plan will result in new policies. It is these policies of which the sustainability impacts will be assessed. These new policies should address the role of forests in bio-energy production, afforestation for carbon storage and other protective functions of forests and to conserve and restore biodiversity in European forests.

The first policy variable deals with bio-energy from forests. The variable will be expressed as the total amount of fiscal subsidies for promoting the production of heat and electricity from biomass, ranging from 0 to 5 billion euros spent annually by the EU and its member states. It is assumed to be complemented by legislative measures promoting access of biomass suppliers to energy networks. The policy will be implemented in NEMESIS and provide a demand for fuelwood to EFISCEN. In EFISCEN fuelwood demand is distributed over regular wood harvests and harvest residue extraction. The variable is the same as the variable *Bio-heat and bio-electricity* (BIOE_GASELEC) in the bio-energy policy case.

The second policy variable deals with afforestation to enhance the role of forests as carbon sinks and enhance the protective functions of forests. The policy variable is defined as an annual afforestation area and can be varied between no afforestation and the total areas currently defined as national targets in, for instance, Rural Development plans for 2007-2013. The policy is implemented from 2014 onwards, i.e. after ending of the period foreseen in the EAFRD and the Rural Development plans. The policy to afforest is not assessed through a continuation of funding schemes due to given model limitations, but rather as a continuation of the afforestation targets set by each EU member state. Nationally defined afforestation targets will be disaggregated by CLUE to the grid level (1x1 km^2), by allocating afforestation patches to intermediate CLUE outputs. The total amount of allocated afforestated area is derived from national afforestation rates (as defined within the policy scenario). Afforestation is allocated based on suitability and availability of area. Suitability criteria are related to the objectives that afforestation serves in national policies, such as prevention of erosion, creating recreation opportunities near urban areas etc. Suitability criteria are therefore slope (preference for steeper slopes to prevent erosion), forest area density (preference for areas with less forest area) and accessibility (preference for shorter distance to roads). Availability of suitable land use types (e.g. abandoned agricultural land) will be given by CLUE-s. When the afforestation target is allocated to the intermediate CLUE-s outputs, CLUE-s will continue modelling land use changes but will leave the afforestation areas intact (only under very high pressure of other land use claims can they be removed). CLUE-s will provide new asymptotes for agriculture to CAPRI and NEMESIS and forest area change to EFISCEN. NEMESIS and CAPRI will model impacts on agriculture on the basis of reduced availability of agricultural land. Afforested area will be distributed over different tree species (groups) and EFISCEN will incorporate afforestation in its forest resource projections.

The third policy variable relates to biodiversity and aims at safeguarding the EU's most important habitats and species through extension of the Natura 2000 network. Expansion of the Natura 2000 network will not be limited to forests only, but will be part of a broader policy and therefore include other land use types as well. In this policy variable, Natura 2000 areas will be extended with 10, 15 and 20%. In CLUE-s this is implemented by more rigid conversions of designated areas to other land use types and no conversions to urban areas. From a biodiversity point of view a desirable development in the Natura 2000 areas will be to ensure the continuation of agricultural and forest land use, but in a form with limited intensity. Expansion of the Natura 2000 is therefore accompanied with impacts on land use management, both for forestry and agriculture. The nature protection directives only indicate the result to be achieved through national implementation. They do not prescribe any concrete conservation measures (EC, 2003) - plans must be developed and the member states must do what it takes to protect habitats and species of community interest. The EC (2003) does recommend that SFM should be applied to designated forest areas. A management regime will be specified for these areas in EFISCEN, in which wood harvesting does not exceed a sustainable harvest level and in which regeneration consists of a higher share of (indigenous) broadleaved species. More extensive management in agriculture is foreseen by a subsidy in CAPRI targeting less-intensive agriculture in designated areas. The policy is to be implemented from the year 2010 onwards. The choice to set a constraint on forest management and to provide a subsidy for agriculture in designated areas is the result of the models applied to assess policy impacts on land use. The variable is the same as the variable *Expansion of the Natura 2000 network with incentives to promote biodiversity friendly land management on added sites* (BIOD_N2K-EXPAND) in the biodiversity policy case.

The fourth policy variable aims to address biodiversity in forest management strategies. Several studies indicate the importance of older forests and dead wood for biodiversity and gave suggestions how biodiversity perspectives could be included in forest management (e.g. Heilma-Clausen and Christensen, 2005; Siitonen, 2001). In this policy variable such suggestions are included in a good-practice guideline aimed at increasing the share of old forests by reducing management intensity. This can be achieved by retaining old trees or groups of trees and (partially) exclude old forest stands (>140 years) from harvest, ranging from no reduction in harvest potentials to a complete ban of management activities in these stands and forests. The option would be temporary, such that when the forest is regenerated naturally (e.g. after a disturbance) the young forest can be managed as usual. It is assumed that this good-practice management would be implemented in public as well as privately owned forests. The policy is to be implemented from the year 2010 onwards. The variable is the same as the variable *General shift towards nature-oriented forest management* (BIOD_FOREST) in the biodiversity policy case.

To conclude, a number of policy variables are defined that relate to bio-energy, afforestation for carbon storage and other protective functions of forests and to conserve and restore biodiversity in the EU’s forests. The policy variables are summarised in Table 1.

Table 10. Overview of policy variables to be modelled within the forest strategy policy case

Variable code	Description.	Year	Domain	Default	NEMESIS	CAPRI	CLUE-S	EFISCEN	Nature 'model'
BIOE_ GASELEC	Bio-heat and bio-electricity	[2010, 2025]	Continuous in the interval [0,1]	0	Implement subsidies for bio-heat and bio-electricity	-	-	Distribute fuelwood demand over wood removals and residue extraction	-
FOR_AFFOR	Afforestation of abandoned agricultural land	[2014, 2025]	Continuous in the interval [0, 1]	0	Implement modified land use asymptotes	-	Allocate afforestation patches to intermediate CLUE outputs as % of national targets	Include afforestation and distribute afforested land over tree species	-
BIOD_ N2KEXPAND	Expanded Natura 2000 network with incentives for extensification in areas	[2010, 2025]	Continuous in the interval [0,1]	0	Implement modified land use asymptotes	Direct payment to extensive agriculture in relation to share of land that is Natura 2000. Basic subsidy is 344,5 EUR/Ha	Land probability for agriculture increased by 0.2 times variable value in Natura 2000 areas. No conversions allowed in Natura 2000 areas, except from semi-natural to forest	Apply sustainable management regime to Natura 2000 forest areas (maximum sustainable harvest level, increased share of broadleaved regeneration)	Expanded spatially explicit Natura 2000 network
BIOD_FOREST	Nature-oriented forest management	[2010, 2025]	Continuous in the interval [0,1]	1	-	-	-	Reduce management intensity in harvested in old forests	-

7. Tourism transport case

Authors: Berit C. Kaae, Thomas Sick Nielsen and Berit Hasler

7.1 Goals

Tourism is growing rapidly and resulting in increased transportation within the EU25 as well as to/from regions outside the EU25. Worldwide, over one billion people are now travelling by air (one fifth of the world's population) (Page & Connell 2006). In addition to growth in tourism, factors such as the rise of low-cost airlines have shifted tourism patterns towards higher use of air transport. This has further increased the environmental effects from tourism transport emissions compared to the less polluting ground transportation modes. The goal of this policy case is to reduce those effects.

Tourism transport has significant impacts on the environment. A study of European tourism transport (DG Enterprise European Commission, 2004) estimates that tourism accounts for 17% of all passenger transport and over 80% of air travel. In the EU, there were 932 million tourism departures by EU25 citizens in 2001 and 59% of these were by car, 27% by air, 7% by coach, 5% by rail and 2% by ferry. These trips amount to 1739 billion passenger-kilometres (pkm) and resulted in emissions of 398 million tons of CO_2, 858 million kg NOx, and 16.7 million kg particulate matter (PM) emissions in 2001. Aircraft primarily use jet kerosene for fuel which on combustion produces CO_2, H_2O, CO, HCs (unburned hydrocarbons), NO_x and SO_2. The International Civil Aviation Organization has established emission standards for HCs, CO_2 and NO_x for new aircraft, but these only apply to take-off and landing. Emissions from aircraft cause additional impact by stratospheric ozone destruction. But also emissions in the lower atmosphere are problematic where NO_x leads to ozone formation at ground level and urban smog. (Page & Connell 2006). According to the Royal Commission on Environmental Pollution (2002), emissions from aircraft lead to greenhouse gases and global warming, increased surface UV radiation, and regional pollution of air quality and noise. Furthermore, congestion of the airspace adds to the problem, as additional fuel is used while planes are stacking (circling while waiting for permission to land) and excess fuel needs to be carried in case of delays.

Transport accounts for between 50% and 75% of all the environmental impacts from tourism (DG Enterprise European Commission, 2004). Consequently, initiatives to reduce the impacts of transport are key factors in reducing the environmental effects of tourism. With the growth trend in tourism, these environmental impacts are increasing . Rather than a few yearly trips, there is now a tendency to take more frequent shorter trips, but also to go on travels further away from home. The increasing trip activities per capita make tourism grow faster than population.

In the destinations, the need to accommodate growing numbers of travellers contributes to increasing conversion of land to infrastructure . As tourism is often drawn towards attractive natural and coastal settings, this adds pressure on often sensitive areas and increases noise and local pollution.

Sustainability is a key objective set out in the treaty, for all European Community policies (European Council, 2005a). Furthermore, the Cardiff process emphasizes the integration of environment/sustainability into all areas: "The European Council invites all relevant formations of the council to establish their own strategies for giving effect to environmental integration and sustainable development within their respective policy areas." (European Council, 1998a). In this process, the transport, energy and agriculture sectors were invited to start.

This will help the EU in meeting the commitments under the Kyoto protocol. According to the European Commission, the international environmental commitments, including those under the Kyoto protocol, must be integrated into transport policy. It states that "Transport policy must contribute to achieving the objectives of European energy policy …in particular as regards security of supply and sustainability." (European Commission 2006h). Furthermore, energy consumption and the rise in demand is a particular issue especially with reference to aviation that has generally risen more than the GDP. According to the European Environment Agency (EEA 2005), global air passenger traffic has risen by an average of 9 % every year in 45 years — more than twice as fast as GDP. Emissions have risen accordingly: CO_2 emissions from international aviation have risen 73 % between 1990 and 2003, and now amount to 12 % of national emissions from transport.

7.2. Objectives

The European policy on transport reflects an acknowledgement of the strong connection between the increase in transport and the more desirable increase in wealth. Thus very few quantifiable objectives have been decided upon by the European Council – even though suggestions have been made by the European Commission.

General objectives for the transport sector are:

- Decoupling of growth in transport from growth in GDP
- Promoting a shift in modes from road to rail and especially from air transport to alternative modes whenever possible
- Fair and efficient pricing
- Reduced emissions

(European Council, 2001, p. 6)

The development towards decoupling and mode shifts is monitored by the EEA, which recently concluded that Europe had not been very successful in achieving this (EEA, 2006a). Relative decoupling between GDP and transport had only been achieved in some of the new member states and this decoupling will most likely disappear as the new members states begin to behave like the older ones. With respect to mode shares: the share of aviation is increasing (EEA, 2006a).

Fair and efficient pricing involves creating fiscal incentives to ensure that environmental and social costs are paid by the travellers. Theoretically this should promote a balance between the development in transport and the associated disutilities. The objective is also related to the "policy guiding principle" of making polluters pay (European Commission, 2005). According to the EEA (2006a) the price structures are increasingly aligned with the structure of the external cost of transport, but still well below external cost estimates.

With respect to reducing emissions, the Cardiff process of economic reforms (European Council, 1998a) and the European Transport Policy (European Commission, 2001, 2006h) refer to the commitments under the Kyoto protocol, i.e. to reduce the emissions from all sectors in the economy by 8 % by 2008-2012 compared to 1990 level. This commitment must be integrated into European transport policy. The specific implications of the Kyoto commitment remain unclear, but tentatively we can presume that tourism transport should also reduce CO_2 emissions by 8% between 1990 and 2012 at the latest. This is likely to be difficult to achieve as transport and emissions have grown considerably since 1990.

Recently the Commission and the European Council has also taken up the issue of reduction targets for CO_2 after 2012 (European Commission, 2007; European Council, 2007). In order to limit climate change to 2 degrees Celsius above pre-industrial levels, a reduction of CO_2 emissions by 30% by 2020, and 60-80% by 2050, both compared to 1990, is suggested. The European Council has declared its willingness to commit itself to such levels of reduction provided that global agreement is reached. For now, however, the European Council (2007) has agreed on a commitment to a 20% reduction in CO_2 emissions by 2020, compared to 1990. These targets are still not explicitly adopted in the European transport policy, but given the emphasis on the contributions from the transport sector (European Commission, 2007) and the prominence of the Kyoto commitment in the transport policy documents it must be expected that also the transport sector must reduce emissions by a minimum of 20% by 2020 - and most likely more thereafter.

Table 11: Targeted CO2 emission reductions. Established objectives in bold types – more radical objectives depend upon international agreement on the subject.

Year	2012	2020	2050
Reduction to CO_2 emissions compared to 1990	**8%**	**20**-30%	60-80%

7.3. Instruments

In 2001 the EC published a White Paper: European transport policy for 2010: time to decide (EC, 2001). This paper enjoins actions to control the growth in air transport. Key points include:

- Revitalising the railways
- Striking a balance between growth in air transport and the environment, including: rethinking air transport taxation and en-route navigation charges; debating the future of airports, e.g. charges and better use of capacity; revision of slot allocation systems.
- Turning intermodality into reality, including harmonisation between systems and support for the development of alternatives.
- Adopting a policy on effective charging for transport, including harmonisation of fuel taxation for commercial users; and alignment of the principles for charging for infrastructure use, and integration of external costs to encourage the use of transport modes with lesser environmental impact.

In 2006 a revision was made to the White Paper, calling for a broader and more flexible transport policy toolbox and for more comprehensive strategies. Key issues related to transport and energy/CO_2 emissions include:

- Promote energy efficiency at EU level (forthcoming action plan)

- Encourage EU actions, including voluntary agreements
- Support research, demonstration and market introduction of new technologies such as optimisation of engines, intelligent vehicle energy management systems or alternative fuels, such as advanced biofuels and hydrogen or fuel cells or hybrid propulsion
- Launch user awareness actions on smarter and cleaner vehicles and a major future-oriented programme for green propulsion and energy efficiency in transport
- develop policy measures to contain emissions from air transport

(European Commission, 2006h)

The instruments most interesting for modelling in SENSOR are those aimed at influencing the cost of transport. However, if this is to be done in such a way that external costs are internalized and if the change in cost is to be such that consumers' behaviour will be affected significantly, we need to ask ourselves how high these external costs are and what the price elasticity of the demand for transport is.

7.3.1 External cost estimates

Aviation as of today does not pay the external costs associated with flying, neither when it comes to a specific impact such as noise (Lu and Morrell, 2001) nor the climate change effect of CO_2 emissions or other impacts. Various attempts have been made to estimate the external costs: A study by the UK Department for Transport (2000) suggested that the external costs amounted to £2.75-3.6 per 1000 pkm for short-haul operations, depending on the carrier. For long-haul operations, external costs were estimated at £2.78-3.21 per 1000 pkm. Based on average fares at the time, this amounted to around 6% of the ticket price for short-haul flights and 3.5% for long-haul flights (Department for Transport, 2000). A study initiated by the German Umweltbundesamt (Dings et.al., 2003) concluded that the formation of contrails during flight is a key factor when it comes to estimating external costs. If no contrails are formed, external costs amount to around 20-30% of average ticket price for a short-distance flight (200 km) and around 5% of ticket price for a long-distance flight (6000 km). If, however, contrails are formed during half of a medium- or long-distance flight, external costs rise to 20-25% of the average ticket price. These cost estimates are fairly conservative. Other estimates of external costs are twice as high or more.

7.3.2 Effects of taxation

The United Nations climate panel suggested that charges, e.g. a carbon tax, may reduce demand for aviation (Penner et. al., 1999). A number of studies have focused on the effect of increased fuel prices or carbon taxes on the demand for aviation. Wit and Dings (2002) analysed a CO_2 tax of €30/tonne in combination with an NO_x tax of €3.6/kg - and estimated that this would reduce CO_2 emissions in European airspace by 9% in 2010, of which 4.4 percentage points through technical and operational measures by airlines and 4,5 percentage points through a reduction in demand. Tol (2007) focused on the international aviation demand by tourists and quotes Michaelis, 1997 for a ticket price increase of 7% on average following a $125tonne carbon tax. This would reduce demand by 4.4-13.3 % (using an elasticity between -0,7 and -2.1). Others have estimated lower elasticities, e.g. Witt and Witt, 1995: -0.04 - -4.34; and Crouch, 1995: -0.85. As a consequence Tol (2007) concludes that "Michaelis' lower elasticity is probably more valid" and consequently uses estimates in the same range. This also corresponds to the elasticities used by Lu and Morrell (2001) in their analysis of the effect of environmental charges. Lu and Morrell quote a range from -0.5 to -1.8. Following Tol (2007), several authors argue that the effect of increased fares in aviation will be reduced travel rather than switching modes. Tol (2007) suggests, however, that the CO_2 tax will induce a shift from long-distance to medium-distance flights as well as shifts from short to medium flights. For medium distances Tol further suggests that there will be modal shifts from holidays by air to car and train.

The results of Tol's (2007) recent study indicate that a global carbon tax of $1000/t on kerosene would result in a fall of 0.8 % in international tourist travel in 2010, and that the associated reduction of CO_2 emissions would be 0.9 %. For the tourist, the price would increase $73 for a 1000 km roundtrip. The emission effect falls to 0.19 % if the tax would be implemented in the EU only.

This rather limited effect has to be related to the general growth trend of transport and in particular air transport in Europe. In 2005, the total number of passengers transported by air (of whom 80% are tourists) in the EU25 rose by 8.5% compared to 2004, to more than 700 million. Passenger numbers rose by 8.8% in 2004 and by 4.9% in 2003. Of these passengers, 23% were carried on national flights, 42% on intra-EU25 flights and 35% on extra-EU25 flights (Eurostat 2007). So the kerosene tax may just help curb the growth in tourism while total numbers would still increase.

Beside the effects on CO_2 emissions, travel modes and flight distances, Tol (2007) investigates the shifts in destinations and travel patterns. These results are interesting in a SENSOR context because these shifts will lead to changes in land use. Implementation of an international tax will affect the Americas and Africa negatively as well as Western Europe, while Central and Eastern Europe are expected to gain because of increased tourism from their own regions as well as from Scandinavia and the UK. Asian countries will also gain. Tol (2007) further concludes that an EU tax will divert European travellers from the USA, Africa and the Middle East to Europe, and that US citizens will reduce travels to Europe. Iceland, Ireland and the UK are heavily dependent on airborne tourism and will lose market shares from this type of tax (Tol 2007:135).

7.4. Policy variables: current and potential possibilities to model a CO_2 policy scenario on tourism demand

In the SENSOR project, the results of interest from a CO_2 tax are primarily the resulting changes in tourist numbers in each NUTSx region rather than the environmental effects (emissions), as the project focuses on land use changes. For modelling purposes in the SENSOR project context, the resulting number of international tourist arrivals as well as domestic arrivals, from a CO_2 tax as well as other instruments, is therefore a key variable. When the number of tourist arrivals increases or decreases, the land-use, the transport as well as the resulting emissions change. Increases in the latter may however be affected by technological innovations reducing harmful emissions and providing higher fuel efficiency.

Land use changes are affected by substitution of destinations as well as changes in consumption and travel modes, as the latter affect the transportation system.

To model substitution and changes in consumption from price changes and other policy changes the tourism demand model developed for SENSOR (Kaae et al 2006) uses an AIDS model (Almost Ideal Demand System). Hereby price and income elasticities are estimated for all countries, allowing for assessments of both substitution patterns in tourism, e.g substitutions between destinations, as well as changes in the consumption of the good, as both these effects are important for assessing changes in land use including changes between regions.

The method allows us to approach the choice of consumption and choice of destination as a consumer choice problem, where the consumers are expected to be constrained by both income and time limitations (Divisekera, 2003). By using this approach, potential changes in GDP, income and prices in the regions can be transformed into resulting changes in demand for tourism in origin and destination regions.

As shown by e.g. Tol 2007, the modelling of a policy scenario such as a CO_2 tax on international tourism is highly complex, mainly because of data gaps. These gaps are also mentioned by Bigano et al (2006), Divisekera (2003) and others. Following Divisekera (2003), data on aggregate quantities of goods and services consumed by tourists at different destinations is virtually non-existent, even though tourism is one of the largest industries in the world.

There are two alternative proxies to estimate demand by derivation of a measure of tourism expenditure; either by tourist numbers (arrivals) or nights spent (cf. Divisekera 2003). The second opportunity, nights spent at the destination, corresponds to actual spending reported at the destinations.

So - because tourism services are bought at the destination, we have regarded the costs of the services at the destination sites most important for the demand for the different sites.Therefore the demand is currently modelled as a function of expenditure at the destinations, i.e. the receipts, the number of overnight stays and a consumer price index ratio that approximates the price level and relative prices of the destination and origin countries. The benefits of the estimated elasticities based on these data are that we have been able to establish a matrix of income elastisicities for the tourists' demand for travels from country i to country j. Hereby we are able to assess changes in travel patterns from changes in income and prices at the destinations.

Even though transport costs form a substantial proportion of total expenditures for tourism, they are not included in the present model. This is due to resource limitations and to the aforementioned data limitations. These also apply to transport.

Additional modelling is needed to include transport costs . Even though data are hard to find , it is not impossible to approximate these costs and include them in the estimates of elasticities. In modelling them, Tol (2007) uses the cheapest offers for a flight 2 months in advance including a weekend at the destination based on prices from www.expedia.com., and Divisekera (2003) also use air-fare data between destinations retrieved from official sources. This raises a problem because "effective" travel costs are not assessed this way; the price practices of airlines on the different routes are not quantified. To approach the fares actually used, Divisekera uses weighted averages of widely-used fares such as economy, excursion and seasonal fares. This approach can also be used in an extension of the present tourism model and thus enable modelling of transport costs.

Furthermore, a possible fuel taxation scenario in the SENSOR project requires assumptions on whether the tax includes all types of tourism transport or only the air transport (the most polluting). Including all types of transport would require detailed knowledge of the modal splits, costs, emissions etc. and data at this level does not appear to be available at the EU25 level. And even if the focus is exclusively on air transport, the distance needs to be related to ground transport, as passengers may shift from one type to another when prices change. In his modelling, Tol (2007) gets around the lack of data on modal split by making the assumption that all tourist travel over distances shorter than 500 km one way is ground transport while all travel beyond 5000 km is by air, and in between the fractions increase linearly with distance. Different measures are applied to island nations. This approach can also be used in revised modelling of the demand in SENSOR.

Travel distance is another necessary key parameter which is not readily available in the SENSOR project; but as also done by Divisekera (2003) and others, the assumption can be made that the travel distance is between the capitals or other main destinations.

It seems reasonable to assume that a CO_2 tax is differentiated with the actual emissions. Take-off and landing are more fuel-consuming than flight at cruising altitude, and consequently short trips produce higher emissions per kilometre. Also, the passenger capacity of the flight and occupancy influence emissions. However, the various studies (Pearce & Pearce 2000, Wit et al. 2002) operate with an "average plane" and according to Tol (2007), this means 6.5 kg C per passenger for take-off and landing and 0.002 kg. per passenger-kilometre. These emissions are quite similar to those found on www.climatecare.org.

In conclusion, modelling the effects of taxation of transport on tourist numbers is highly complex and requires re-estimations of the current model. This is possible, but the resources allocated for this part of the modelling are very limited in the SENSOR project. Furthermore, it will be very difficult to assess how the taxation will affect tourist numbers by NUTSx regions – will the tourists choose the same destination but other modes of transport? – or choose different destinations? As mentioned, the Tol's (2007) results indicate that the effects of taxation on international air travel will shift travel patterns from long-distance to medium-distance flights and from medium-distance flights to car and train transport for holidays – but these results rely on the assumptions made by Tol, and preferably they should be investigated further.

This also affects the spatial distribution of tourists: some countries will experience an increase and others a decline in the number of tourist arrivals. Tol (2007) shows that in particular island nations are negatively affected by the kerosene tax, as they rely heavily on air transport. however, the overall effects are quite small with the most affected country being the UK. A $1000/t C tax on international tourism would lead to a decline of approx. 1.5% of tourism in the UK - or around 700.000 visitors.

As the simplest transport policy variable that could be implemented in the SENSOR project would be a rise in tourism transport costs due to taxation. A percentage increase to the cost of travel would translate into increased costs of visiting a given destination and thus changes to the flow matrix for tourist travelling between the European countries. Even this simplest option will, however, require a re-estimation of the tourism model to properly reflect and identify transport costs between origins and destinations.

A focus on rising transport costs, rather than internalisation of externalities, would be warranted by the uncertainty of available external cost estimates. Results suggest that these may be 25% or more of year 2000 ticket prices, but they may also be lower. The indication is, furthermore, that the impact of rising travel cost will be quite weak, and that only a substantial increase will cause a visible effect. Increases of 25-50% appear appropriate. This, then, will be the policy scenarios to be modeled. The mode of implementation is shown in Table 12.

Table 12. Overview of policy variables to be modelled within the tourism transport policy case

Variable code	Description.	Year	Domain	Default	NEMESIS	B&B	CLUE-S	TIM	Nature 'model'
TT_ CARBTAX	Taxation on carbon dioxide emissions for transport, expressed as increase in total cost	[2025]	Continuous in the interval [0,50]	0	Increase transport price index	Estimation of NOTS0 flow based on consumer and transport price indices from NEMESIS Disaggregation to NUTSX based on geo-physical attributes.			-

8. References

Becker, G., Coleman, E., Hetsch, S., Kazemi, Y., & Prins, K., 2006: *Mobilizing wood resources. Can Europe's forests satisfy the increasing demand for raw material and energy under sustainable forest management?* Workshop background paper. UNECE/CEPI/EFI/FAO/MCPFE-LUW/Joint FAO/ECE/ILO experts network.

Braun, R., 2005: *Biogas and bioenergy system developments towards biorefineries – trends in a Central European context.* Presentation to the Baltic Biorefinery Conference 2005. Vienna: University of Natural Resources and Applied Life Sciences, Institute for Environmental Biotechnology.

Collins, J., G. Thomas, R. Willis & J. Wilsdon, 2003: *Carrots, sticks and sermons: influencing public behaviour for environmental goals.* Demos/Green Alliance, produced for DEFRA. London.

Council of the European Union, 1998. Council resolution of 15 December 1998 on a forestry strategy for the European Union. *Official Journal of the European Communities* C 56/1 (26.2.1999)

Council of the European Union, 1998a. *Presidency conclusions*, Cardiff European council 15 and 16 June 1998.

Council of the European Union, 2001. *Presidency Conclusions, Goteborg Council, 15 and 16 June 2001*. SN/200/1/01 REV1, page 8. http://www.consilium.europa.eu/ueDocs/cms_Data/docs/-pressData/en/ec/00200-r1.en1.pdf

Council of the European Union, 2005. Council regulation (EC) No 1698/2005 of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD). *Official Journal of the European Communities* L 277/1 (21.10.2005)

Council of the European Union, 2005a. *Presidency conclusions*, Brussels European Council 16 and 17 June 2005

Crutzen, P.J., A.R. Mosier, K.A. Smith & W. Winiwarter, 2007: N_2O release from agro-biofuel production negates global warming reduction by replacing fossil fuels. *Atmospheric Chemistry and Physics Discussions* 7, pp. 11191-11205.

Department for Transport, 2000: *Valuing the external costs of aviation*,

http://www.dft.gov.uk/pgr/aviation/airports/valuingtheexternalcostsofavi2843?page=5#1004

Dings, J.M.W., Wit, R.C.N., Leurs, B.A., Davidson, M.D. and Fransen, W., 2003: *External costs of aviation*, Research report 299 96 106, UBA-FB 000411, Environmental Research of the Federal Ministry of the Environment, Nature conservation and nuclear safety, Germany

Divisekera S. (2003) A model of demand for international tourism. Annals of Tourism research. 30(1), 33-49.

ECCP, 2003. Conclusions and recommendations regarding forest related sinks & climate change mitigation. Final report. ECCP - Working Group on Forest Sinks.

http://www.climnet.org/pubs/ECCPForests2003.pdf [accessed 15 November 2006]

Edwards, D., 2006: *SENSOR Policy Cases, Draft Version 2*, January 2006. Internal document.

EurObservER, 2005: European Barometer of Renewable Energies. 5th report.

http://www.energies-renouvelables.org/observ-er/stat_baro/barobilan/barobilan5.pdf.

European Commission, 1997: *Energy for the Future: Renewable Sources of Energy*; White Paper for a Community Strategy and Action Plan. Communication from the Commission, COM(97) 599 final (26/11/1997).

European Commission, 1998: Communication of the European Commission to the Council and to the Parliament on a European Community Biodiversity Strategy. Communication from the Commission, COM(98) 42 final (04/02/1998).

European Commission, 2001: Communication on alternative fuels for road transportation and on a set of measures to promote the use of biofuels. Communication from the Commission, COM(2001) 547 final (7/11/2001).

European Commission, 2001b: *White Paper - European transport policy for 2010: time to decide.* Luxembourg: Office for Official Publications of the European Communities.

European Commission, 2001c. *European Community Biodiversity Action Plans in the Areas of Conservation of Natural Resources, Agriculture, Fisheries, and Development and Economic Cooperation*. COM(2001)162final, Vols I-V:

http://europa.eu.int/eur-lex/en/com/pdf/2001/com2001_0162en.html

European Commission, 2003: *Natura 2000 and forests. 'Challenges and opportunities'. Interpretation guide*. European Commission, DG Environment, Nature and Biodiversity Unit, Forests and Agriculture Unit. Office for Official Publications of the European Communities, Luxembourg. 101 pp.

European Commission, DG Enterprise, 2004: *Feasibility and preparatory study regarding a multi-stakeholder European targeted action for sustainable tourism and transport*.

European Commission, 2005: *Biomass Action Plan*. Communication from the Commission, COM(2005) 628 final (7/12/2005).

European Commission, 2005b. *Integrated management of Natura 2000 sites*, Office for official publications of the European Communities, Luxembourg

European Commission, 2005c. Communication from the Commission to the Council and the European Parliament. Reporting on the implementation of the EU Forestry Strategy. COM(2005) 84 final (10.3.2005).

European Commission, 2006: *A European Strategy for Competitive, Sustainable and Secure Energy*. Green Paper, COM(2006) 105 final (8/3/2006).

European Commission, 2006b: *Communication of the European Commission to the Council and to the Parliament on an EU Forest Action Plan*. COM(2006) 302 final (15/6/2006).

European Commission, 2006c: *An EU Strategy for Biofuels.* Communication from the Commission. COM(2006) 34 final (8/2/2006).

European Commission, 2006d. *The EU rural development policy 2007-2013*, Office for official publications of the European Communities, Luxembourg

European Commission, 2006e. Communication from the Commission. Halting the loss of biodiversity by 2010 – and beyond. Sustaining ecosystem services for human well-being. COM(2006) 216 final (22.5.2006).

European Commission, 2006f. Commission staff working document. Annex to the communication from the Commission to the Council and to the European Parliament on an EU Forest Action Plan. SEC(2006) 748 (15.6.2006).

European Commission, 2006g. Commission staff working document. Annexes to the communication from the Commission. Halting the loss of biodiversity by 2010 – and beyond. Sustaining ecosystem services for human well-being. Technical annex. Sec(2006) 621 (22.5.2006).

European Commission, 2006h. Communication from the commission to the council and the European Parliament, Keep Europe moving – sustainable mobility for our continent. Mid term review of the European Commisson’s 2001 Transport White Paper, COM(2006) 314 final.

European Commission, 2007. Communication from the commission to the council, the European Parliament, The European Economic and social committee and the committee of the regions. Limiting global climate change to 2 degrees Celcius. The way ahead for 2020 and beyond. COM(2007) 2 final

European Council, 2007. Presidency conclusions, Brussels European Council 8/9 March 2007

European Court of Auditors, 2005. Special Report No 9/2004 Forestry Measures within Rural Development Policy. *Official Journal of the European Union* C67/1, 18.3.2005

European Environment Agency (EEA), 2004. *High nature value farmland, characteristics, trends and policy challenges*, EEA report no. 1/2004, Copenhagen

European Environment Agency, 2005: *The European environment – state and outlook 2005*, State of environment report no. 1/2005, Copenhagen

European Environment Agency, 2006: *How much bioenergy can Europe produce without harming the environment?* Copenhagen: EEA Report No. 7/2006.

European Environment Agency, 2006a: *Transport and the environment: facing a dilemma*, TERM 2005: indicators tracking transport and environment in the European Union, EEA report no. 3/2006, Copenhagen

European Environment Agency 2006b. *Progress towards halting the loss of biodiversity by 2010*, EEA Report No 5/2006, Office for official publications of the European Communities, Luxembourg

Eurostat (2007) Air transport in the EU25 - Air passenger transport up by 8.5 % in 2005. Eurostat News Release 11/2007 – 19 January 2007.

http://epp.eurostat.ec.europa.eu/pls/portal/docs/PAGE/PGP_PRD_CAT_PREREL/PGE_CAT_PREREL_YEAR_2007/PGE_CAT_PREREL_YEAR_2007_MONTH_01/7-19012007-EN-AP.PDF access date February 27 2007.

F.O. Licht, 2006: *World Ethanol and Biofuels Report* 4:17.

Harmon, M.E., Franklin, J.F., Swanson, F.J., Sollins, P., Gregory, S.V., Lattin, J.D., Anderson, N.H., Cline, S.P., Aumen, N.G., Sedell, J.R., Lienkaemper, G.W., Cromack, K., and Cummins, K.W., 1986. Ecology of Coarse Woody Debris in Temperate Ecosystems. *Advances in Ecological Research*, 15, 133-302.

Heilmann-Clausen, J. and Christensen, M., 2004. Does size matter? On the importance of various dead wood fractions for fungal diversity in Danish beech forests. *Forest Ecology and Management* 201: 105-117.

Kaae, B.C., T. Sick Nielsen, B. Hasler & S.T. Neye, 2006: *Sectoral analysis and tourism model.* SENSOR Deliverable 2.2.1e.

Kuhlman, T., P. Le Mouël & C. Wilson, 2006: *Baseline scenario storylines.* SENSOR Deliverable 2.1.1.

Lu, C. H-Y. and Morrell, P., 2001: Evaluation and implications of environmental charges on commercial flights, *Transport reviews*, 21, pp 377-395

Mederski, P.S., 2006. *Projected amount of agricultural land available to be transformed into forest area.* Contribution to the European Forest Institute by the Faculty of Forestry, August Cieszkowski Agricultural University of Poznan.

Organisation for Economic Cooperation and Development (OECD), 2001. *Environmental indicators for agriculture, methods and results*, OECD, Paris

OECD, 2006: *Agricultural market impacts of future growth in the production of biofuels.* Working Party on Agricultural Policies and Markets. AGR/CA/APM/2005)24/FINAL. Principal author: M. von Lampe.

Page, Stephen J. & Connell, Joanne, 2006: *Tourism: A modern Synthesis*, Second Edition. Thomson.

Penner, J. E., Lister, D. H., Griggs, D. J., Dokken, D. J. and McFarland, M., 1999: *Avation and the global atmosphere*, IPCC special report, WMO, UNEP

Petit, S., Firbank, L., Wyatt, B. and Howard, D. 2001. MIRABEL: Models for integrated review and assessment of Biodiversity in European Landscapes, *Ambio* vol. 30, no. 2, pp. 81-88

Rabobank, 2005: *Biofuels in the EU. Changing up gears.* Utrecht: Rabobank International. Authors: S. Hansen & M. van Vaals.

Royal Commission Environmental Pollution, 2002: *The Environmental Effects of Civil Aircraft in Flight*. London: HMSO.

Siitonen, J., 2001: Forest management, coarse woody debris and saproxylic organisms: Fennoscandian boreal forests as an example. In *Ecology of woody debris in boreal forests*. Ecological Bulletins 49. (eds B.G. Jonsson & N. Kruys), pp. 11-41. Blackwell Science, Oxford.

Spangenberg, J. H. 2007: Biodiversity pressure and the driving forces behind. *Ecological Economics* 61, 146-158.

Stewart, M.J., 1993: The effect on tobacco consumption of advertising bans in OECD countries. *International Journal of Advertising* 12:155-180.

Tol, R. S. J., 2007: *The impact of a carbon tax on international tourism*, Transportation research part D, 12, pp129-142

United Nations, 1992. *Convention on Biological Diversity*, Earth Summit, Rio de Janeiro 1992

United Nations, 2002. World Summit for Sustainable Development, Johannesburg, 2002, *Plan of Implementation*, Paragraph 44. http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/POIToc.htm

Wit, R.C.N. and Dings, J.M.W., 2002: *Economic incentives to mitigate greenhouse gas emissions from air transport in Europe*, CE solutions for environment, economy and technology, Delft, The Netherlands.