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Cost efficiency and effectiveness of GHG mitigation policies and measures in the agro-forestry sector: a survey of the economic literature

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CONTENTS

INTRODUCTION 3

SOURCE OF THE LITERATURE 3

CLASSIFICATION OF THE LITERATURE 3

FIRST RESULTS 4

APPENDIX 1 - JOURNAL ARTICLES, PROCEEDINGS AND BOOKS 7

APPENDIX 3 - JOURNAL ARTICLES AND PROCEEDINGS CLASSIFIED PER KEYWORDS 12

APPENDIX 3 - JOURNAL ARTICLES AND PROCEEDINGS WITH ABSTRACTS 45

INTRODUCTION

The focus of this report is on the literature providing an economic evaluation in terms of cost efficiency/effectiveness of policy and/or technical measures with a specific relevance for the EU25 agriculture and forestry sector in the domain of GHG emission reductions.

The selection criteria for searching the literature is explained in the first section, while the second section is dedicated to clarify the procedure used in the classification of the articles. In the third section very preliminary results is presented with documents organised and presented according to specific keywords and statistics per each subject. Appendixes contain the list of references in alphabetical order (App. 1), the subject bibliography created on the basis of the adopted classification (App. 2) and the list of references completed of abstracts, keywords and URL where the paper is downloadable (App. 3).

This first draft is intended for circulation within the Meacap Consortium for refining the identification of all the relevant references in view of developing a review paper in preparation of the project meeting to be held in June-July 2005.

SOURCE OF THE LITERATURE

It has been decided to target the collection of references to the scientific journals for the most part. Having successfully passed the related refereeing process has been considered a minimal quality indicator.

Books have also been considered in the survey, but with lower interest, since they often report less up-to-date results and might imply a less severe refereeing procedure. Moreover as it usual, the most important results appearing in books are also reported in a more compact form in scientific articles. The references of the few books considered at the present time are listed in the annex.

Nonetheless, also grey literature (working paper, report, public discussion paper, unofficial proceedings, etc.) has been partially analysed and sometimes quoted when some important methodological aspect or a particularly relevant or original contribution was found.

Finally, it should be clarified that the survey focuses on studies targeted to the EU, nevertheless some researches analysing measures applied by non-EU countries are reported when relevant insights can be obtained on state-of-the-art methodologies and applications.

CLASSIFICATION OF THE LITERATURE

As a first step, the collected material (77 publications) has been classified according to the following criteria reflected in related keywords:

- 1 - *Geographical coverage*
- 2 - *Greenhouse gas affected*
- 3 - *Sector involved*
- 4 - *Objective of the evaluation*
- 5 - *Policy measure*
- 6 - *Methodological approach*

In some cases, more than an attribute/keyword may correspond to each criterion. This is necessarily due to complexity of the documentation that often covers simultaneously several different issues. Specific guidelines for each criterion are presented below.

1 - Geographical coverage

It refers to the geographical scope of the investigation. Usually studies range from global scale, to continental scale and country scale.

2 - Greenhouse gas affected

This refers to the specific kind(s) of agriculture emission treated by the study. They can be greenhouse gases, like CO₂, CH₄, N₂O directly relevant to global warming and climate change or other kind of emissions like NH₃. Gases can be tackled individually or altogether as "All". On the contrary, the keyword "NA" stands for "Not Available" and means that some articles do not focus particularly on any GHG, while still being of interest for the scope of the survey.

3 - Sector involved

Measures with relevance to the agricultural sectors may indirectly involve other sectors and/or vice versa. Thus it is important to highlight the economic sectors that studies tackle. These are agriculture, forestry and energy.

4 - Objective of the evaluation

This refers to the primary objective of the policy/measure(s) analysed in the survey. These can be directly targeted to climate change through improved carbon sequestration and GHG reduction or they can be related only indirectly to emission reduction for the purpose of curbing climate change, aiming more to the improvement of water quality standards, energy savings, landscape protection. Within the field of climate change strategies, the implications of measures in the agricultural sector for carbon trading system are also examined

5 - Policy measure

It refers to the policy instrument(s) used to implement a specific strategy analysed by the study. These policy tools are usually, from the more stringent to the weaker: regulations (bans or quotas), market based instruments (taxes, subsidies, property rights) and voluntary approaches.

6 - Methodological approach

It refers to the methodology pursued by the study. Approaches can be classified in: descriptive (retrospective studies describing what is being observed without the support of any particular elaboration technique), survey (studies reporting surveys of the literature), statistic and econometric (studies using statistic or econometric elaboration techniques), modelling (studies using/developing ad-hoc simulation models).

FIRST RESULTS

As mentioned before the scope of the survey is focused on European Union and many articles are referred to this scope. However, some articles regarding other countries have been inserted because of the importance they may recover for the topic discussed or for the bibliography presented. The total number of those keywords is 79, meaning that 2 of the 77 articles analyse different geographic scope in the same article.

-Australia (4)

- Austria (1)
- Belgium (1)
- Canada (1)
- Europe (18)
- Flemish Belgium (1)
- France (5)
- Germany (1)
- India (1)
- Ireland (1)
- Italy (2)
- NA (5)
- New Zealand (1)
- OECD (1)
- Poland (1)
- Scandinavia (8)
- The Netherlands (9)
- Turkey (1)
- UK (1)
- USA (11)
- World (5)

The second keyword regards the *greenhouse gas* concerned by the policy measure in the specific article and therefore explicitly analysed. As listed below, CO₂ is the GHG analysed in most of the articles, followed by the others.

- All (23)
- CO₂ (35)
- CH₄ (13)
- N₂O (14)
- NH₃ (7)
- NA (4):

Most of the papers regards the agricultural *sector*, while the others concern the agricultural sector in an indirect way but particularly focus on Energy, on Forestry or on all sectors.

- Agriculture (48)
- Forestry (20)
- Energy (19)
- All (9)

The total number of these keywords is 96, indicating that many articles are concerned with different sectors

As far as concerned with the *objective* of the policy, five different keyword has been selected:

- Emission reduction (43): Most of the chosen articles are directly concerned with *Emission reduction*, while the remaining does focus on other topics but regards somehow the GHG mitigation in an indirect way;
- Sequestration (17): this keyword indicates articles that focus particularly on Carbon sequestration in crops or forestry;
- Energy saving (13): This keyword mainly indicates articles discussing about substitution between fossil fuel and biofuel and is often linked to the Energy sector as defined in the previous section;
- Water quality standards (3): Those articles focus on water pollution by agriculture and are

linked to GHG reduction because its mitigation also concerns the gas emissions;

-NA (8): This keyword concerns articles that could not be specifically related to any of the above objectives.

The total number of this keyword is 84 indicating that only a few articles are concerned with different relevant objectives.

Most of the policy *measure* analysed in the articles regards the Market Based Instruments, while only a few are concerned with regulations or voluntary policies. Lastly, many articles do not focus on a specific policy tool but could be interesting for models used or the discussion provided.

-Regulation (8): This keyword indicates the articles where the policy measures discussed are concerned with tools such as standards or quotas;

-Market Based Instruments (23): This keyword indicates the articles where the policy measures are taxes, subsidies, or Carbon trading;

-Voluntary (2): This keyword indicates the articles where the policy measures discussed are concerned with voluntary agreements;

-All (11): This keyword indicates articles where no specific distinctions between policy tools are made but their consequences are discussed or analysed as a whole;

-NA (34): This keyword indicates those articles which do not particularly refer to a specific policy tool, but could be useful in some way to the survey.

The methodological *approach* is distributed among four categories:

-Descriptive (15): Those articles are simply describing the general setting of a specific country or a specific policy measure, without making any in-depth analysis;

-Review (10): The articles listed under this keyword make a review of the existing literature on the specific topic concerned;

-Economic (24): The articles listed under this keyword usually assess the costs of GHG mitigation and are strictly related to the final target of this survey;

-Modelling (34): Most of the articles are concerned with modelling: this category is very wide and will be specified in further analyses of the bibliography;

The total number of this keyword is 83, indicating 6 papers where the approach is double: these articles are usually concerned with modelling of the emission in the first part while the second part realise an assessment of the mitigation costs.

APPENDIX 1 - JOURNAL ARTICLES, PROCEEDINGS AND BOOKS

1. Ahammad, H.; Clements, K. W., and Ye, Q. The regional economic impact of reducing greenhouse gas emissions: Western Australia. *Resources Policy* . 2001; 27(4):225-233.
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APPENDIX 3 - JOURNAL ARTICLES AND PROCEEDINGS CLASSIFIED PER KEYWORDS

GEOGRAPHIC-Australia (4)

1. Ahammad, H.; Clements, K. W., and Ye, Q. The regional economic impact of reducing greenhouse gas emissions: Western Australia. *Resources Policy* . 2001; 27(4):225-233.
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4. Riedy, C. A Framework for economic analysis of greenhouse abatement options. National Workshop of the Economics and Environment Network; Canberra.

GEOGRAPHIC-Austria (1)

1. Haberl, H.; Erb, KH; Krausmann, F.; Adensam, H., and Schulz, N. B. Land-use change and socio-economic metabolism in Austria. Part II: land-use scenarios for 2020. *Land Use Policy*. 2003; 20(1):21-39.

GEOGRAPHIC-Belgium (1)

1. Dendoncker, N.; Van Wesemael, B.; Rounsevell, M. D.; Roelandt, C., and Lettens, S. Belgium's CO₂ mitigation potential under improved cropland management. *Agriculture, Ecosystems and Environment*. 2004; 103(1):101-116.

GEOGRAPHIC-Canada (1)

1. Thomassin, P. J. Macroeconomic impacts of reducing greenhouse gas emissions from Canadian agriculture . *American Journal of Alternative Agriculture*. 2002; 17(3):149-158.

GEOGRAPHIC-Europe (18)

1. Alcamo, J.; Mayerhofer, P.; Guardans, R.; van Harmelen, T.; van Minnen, J.; Onigkeit, J.; Posch, M., and de Vries, B. An integrated assessment of regional air pollution and climate change in Europe: findings of the AIR-CLIM Project. *Environmental Science and Policy* . 2002; 5(4):257-272.
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OBJECTIVE-Emission reduction (43)

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APPROACH-descriptive (15)

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APPENDIX 3 - JOURNAL ARTICLES AND PROCEEDINGS WITH ABSTRACTS

To download the article or the proceeding you have to follow the link provided under the section *Available at*. You should however be in possess of a personal registration ID and Password for the related Database.

1. Ahammad, H., Clements, K. W., and Ye, Q., The regional economic impact of reducing greenhouse gas emissions: Western Australia. 2001;27: 4:225-233.

Abstract: This study analyses the general-equilibrium impacts of an international climate change response policy on the economy of Western Australia (WA), one of the most mining-based and energy-intensive states of Australia. It finds that emissions would fall by up to 11% from the base level in WA. However, such environmental benefits emanate at some costs to the state economy; in terms of foregone gross state product, the costs are up to 3% of the base level. Indeed, the actual costs and benefits depend on the precise design of the climate change response policy as well as on the other policies within which it operates. For example, when emission quota permits are sold to industries and no tradeable carbon credits (i.e. credits for the carbon sequestered in Kyoto forests) are granted, emissions decline by about 8% and GSP falls by about 3% of the base levels. If carbon credits are tradeable, however, the environmental benefits could be increased and the GSP cost could be reduced substantially. Also, the reduced economic activity caused by emission abatement results in a modest fall in net government revenue, despite the additional revenue from permit sales in some cases. Accordingly, government's fiscal package surrounding the emission permits would influence the emission abatement impacts on the economy. With regard to the effects on the structure of the state economy, the oil and gas industry suffers only a slight contraction but the energy-supplying sector as a whole contracts substantially. It is therefore not surprising that the impacts on the WA economy of curbing emissions by energy and transport industries alone are quite significant when compared to those resulted from all industries' compliance with the abatement scheme. It needs to be noted that the model projections analysed in the paper are based on simplifying assumptions and tentative scenarios, and hence should be viewed with caution and not be understood as unconditional forecasts.

Keywords: GREENHOUSE GAS EMISSIONS/KYOTO TARGETS/EMISSIONS TRADING/ECONOMY-WIDE IMPACTS/CGE MODELLING/WESTERN AUSTRALIA/GEOGRAPHIC-Australia/GHG AFFECTED-all/SECTOR-All/OBJECTIVE-Emission reduction/MEASURE-MBI/APPROACH-modelling.

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2. Alcamo, J., Mayerhofer, P., Guardans, R., van Harmelen, T., van Minnen, J., Onigkeit, J., Posch, M., and de Vries, B., An integrated assessment of regional air pollution and climate change in Europe: findings of the AIR-CLIM Project. 2002;5: 4:257-272.

Abstract: This paper presents results of an assessment of the linkages between regional air pollution and climate change in Europe (the AIR-CLIM Project). The main research tool was an integrated modeling framework and the main product was a consistent set of long-term scenarios covering Europe between 1995 and 2100. Scenarios consisted of trends in emissions, acid deposition, nitrogen deposition and climate change. Critical loads and critical levels were used to assess the impacts of deposition to forest soils and a new analogous concept of "critical climate change" was developed to assess the impacts of climate change. Taking into consideration the limitations of the scope and models used in the study, preliminary conclusions were: (1) regional air pollution and climate change may be fairly weakly coupled in the natural environment, i.e. climate change was not found to have a large impact on the sensitivity of forest ecosystems to regional air pollution, nor on the distribution of deposition; nor did regional air pollution (in the form of sulfate aerosols) have a significant impact on climate change in Europe; (2) however, regional air pollution and climate change may be strongly coupled in the "policy" environment. It was estimated that virtually all of Europe at mid-century might be affected by either regional air pollution or climate change, or both, and this will require a strong policy response. Moreover, the indirect effects of climate policies were found to reduce the costs of controlling air pollution emissions by more than 50%, suggesting a strong potential financial linkage between policies to reduce greenhouse gas and air pollution emissions.

Keywords: ACIDIFICATION/ ACID DEPOSITION/CLIMATE CHANGE MITIGATION/EUROPEAN ENVIRONMENT/INTEGRATED ASSESSMENT/REGIONAL AIR POLLUTION/GEOGRAPHIC-Europe/GHG AFFECTED-all/SECTOR-All/OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-modelling.

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F&_cdi=6198&_user=606295&_orig=browse&_coverDate=08%2F31%2F2002&_sk=999949995&view=c&wchp=dGLbVzb-zSkWW&md5=3a6ab89263e50c433f675fc50bf9cf4f&ie=/sdarticle.pdf

3. Alig, R. J., Adams, D. M., and McCarl, B. A., Ecological and economic impacts of forest policies: interactions across forestry and agriculture. 98;27: 1:63-78.

Abstract: A linked model of the US forest and agriculture sectors was used to examine the economic and ecological impacts of two forest policies: a minimum harvest age limitation and a reduced public harvest policy. Simulated private responses to both policies indicate that landowners could undertake a range of adjustments to minimize their welfare impacts, but imposition of constraints on the management of existing timber stocks have particularly potent effects. Environmental changes associated with the responses include: (1) impacts on biodiversity trends and wildlife habitat conditions when economic incentives prompt afforestation of cropland in the North and less conversion of hardwood forest types to softwood plantations in the South; (2) age class distributions in all regions are 'shortened', compressing a larger inventory volume into fewer, younger age classes; (3) reductions in the area of the earliest forest successional stages, despite the concentration of inventory in the earlier ages, because of rising timber management intensity in some regions; and (4) sequestered carbon in all parts of the forest system may continue to rise even after total product volumes have begun to fall. Interregional economic impacts include higher prices for private forest land and timber products in the southern US, due to a reduced public harvest policy concentrated in the West.

Keywords: LAND REALLOCATION/FOREST SECTOR/AGRICULTURE/INTERREGIONAL/GEOGRAPHIC-USA/GHG AFFECTED-CO2/SECTOR-agriculture/SECTOR-forestry/OBJECTIVE-Sequestration/MEASURE-Regulation/APPROACH-modelling.

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4. Antle, J., Capalbo, S., Mooney, S., Elliott, E., and Paustian, K., Spatial heterogeneity, contract design, and the efficiency of carbon sequestration policies for agriculture. 2003;46: 2:231-250.

Abstract: In this paper we develop methods to investigate the efficiency of alternative contracts for Carbon (C) sequestration in cropland soils, taking into account the spatial heterogeneity of agricultural production systems and the costs of implementing more efficient contracts. We describe contracts being proposed for implementation in the United States and other countries that would pay farmers for adoption of specified practices (per-hectare contracts). We also describe more efficient contracts that would pay farmers per tonne of soil C sequestered, and we show how to estimate the costs of implementing these more efficient contracts. In a case study of a major agricultural region in the United States, we confirm that the relative inefficiency of per-hectare contracts varies spatially and increases with the degree of spatial heterogeneity. The results also show that per-hectare contracts are as much as five times more costly than per-tonne contracts—a degree of inefficiency similar to that found in assessments of command-and-control industrial emissions regulations. Measurement costs to implement the per-tonne contracts are found to be positively related to spatial heterogeneity but are estimated to be at least an order of magnitude smaller than the efficiency losses of the per-hectare contract for reasonable error levels. This finding implies that contracting parties could afford to bear a significant cost to implement per-tonne contracts and achieve a lower total cost than would be possible with the less efficient per-hectare contracts.

Keywords: SPATIAL HETEROGENEITY/CONTRACT DESIGN/SOIL CARBON SEQUESTRATION/POLICY/EFFICIENCY/MEASUREMENT COSTS/GEOGRAPHIC-USA/GHG AFFECTED-CO2/SECTOR-agriculture/SECTOR-forestry/OBJECTIVE-Sequestration/MEASURE-MBI/APPROACH-Economic.

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5. Bard, J. F., Plummer, F., and Sourie, JC, A bilevel programming approach to determining tax credits for biofuel production. 2000;120: 1:30-46.

Abstract: This paper presents a bilevel programming formulation of a leader follower game that can be used to help decision makers arrive at a rational policy for encouraging biofuel production. In the model, the government is the leader and would like to minimize the annual tax credits it allows the petro-chemical industry for producing biofuels. The crops grown for this purpose are on land now set aside and subsidized through a different support program. The agricultural sector is the follower. Its objective is to

maximize profits by selecting the best mix of crops to grow as well as the percentage of land to set aside. Two solution algorithms are developed. The first involves a grid search over the tax credit variables corresponding to the two biofuels under consideration, ester and ethanol. Once these values are fixed, nonfood crop prices can be determined and the farm sector linear program solved. The second algorithm is based on an approximate nonlinear programming (NLP) formulation of the bilevel program. An "engineering" approach is taken where the discontinuities in the government's problem are ignored and the farm model is treated as a function that maps nonfood crop prices into allocation decisions. Results are given for an agricultural region in the northern part of France comprising 393 farms.

Keywords: NONLINEAR BILEVEL PROGRAMMING/GOVERNMENT REGULATION/SUBSIDIES/GRID SEARCH ALGORITHM/AGRICULTURE/GEOGRAPHIC-France/GHG AFFECTED-all/SECTOR-All/OBJECTIVE-Energy saving/MEASURE-MBI/APPROACH-Economic.

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6. Brady, M., The relative cost-efficiency of arable nitrogen management in Sweden. 2003;47: 1:53-70.

Abstract: Arable nitrogen emissions contribute to serious water-quality problems around the globe. To reduce pollution of the Baltic Sea, Sweden has implemented a comprehensive scheme of nitrogen abatement instruments; a uniform nitrogen fertilizer tax, green payments (subsidies), and land-use regulations. The purpose of this study was to evaluate the relative cost-efficiency of the scheme and to analyze the implications of agricultural policy for the least-cost solution. Due to the expanse and heterogeneity of the study area, a spatially distributed nonlinear mathematical programming model, which linked changes in agricultural production practices on crop farms in Southern Sweden to coastal nitrogen load, was developed. Spatial variation in physical parameters, production costs, and the fate and transport of nitrogen were accounted for. Interactions between agricultural and nitrogen policy were shown to occur. Least-cost abatement measures changed radically with and without agricultural policy. Nitrogen policy can be construed as simply correcting for pollution induced by agricultural policy.

Keywords: WATER POLLUTION/NITROGEN/ENVIRONMENTAL AND AGRICULTURAL POLICY/CAP/COST-EFFECTIVENESS/POSITIVE MATHEMATICAL PROGRAMMING/BALTIC SEA/GEOGRAPHIC-Scandinavia/GHG AFFECTED-N2O/GHG AFFECTED-NH3/SECTOR-agriculture/OBJECTIVE-Water quality standards/MEASURE-MBI/APPROACH-Economic.

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7. Brink, C., Kroeze, C., and Klimont, Z., Ammonia abatement and its impact on emissions of nitrous oxide and methane in Europe. 2001 ;35: 36:6299-6312.

Abstract: Agriculture is an important source of NH₃, which contributes to acidification and eutrophication, as well as emissions of the greenhouse gases CH₄ and N₂O. Because of their common sources, emission reduction measures for one of these gases may affect emissions of others. These interrelations are often ignored in policy making. This study presents an analysis of the effects of measures to reduce NH₃ emissions on emissions of N₂O and CH₄ from agriculture in Europe. The analysis combines information from the NH₃ module of the Regional Air pollution INformation and Simulation (RAINS) model for Europe with the IPCC method for national greenhouse gas inventories. The IPCC method for estimating agricultural emissions of N₂O and CH₄ is adjusted in order to use it in combination with the RAINS database for the European agricultural sector. As an example, we applied the adjusted method to the agricultural sector in the Netherlands and found that application of several NH₃ abatement options may result in a substantial increase in N₂O emissions while the effect on CH₄ emissions is relatively small. In Part 2 of this paper we focus on the resulting emissions for all European countries for 1990 and 2010.

Keywords: EMISSION/ABATEMENT/IMPACT/EUROPE/GEOGRAPHIC-The Netherlands/GHG AFFECTED-NH3/GHG AFFECTED-N2O/GHG AFFECTED- CH4/SECTOR-agriculture/OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-modelling.

Available at: http://www.sciencedirect.com/science?_ob=MIimg&_imagekey=B6VH3-44HY19M-6-K&_cdi=6055&_user=606295&_orig=browse&_coverDate=12%2F31%2F2001&_sk=999649963&view=c&wchp=dGLbVtb-zSkWz&md5=65f6f0c61cf096b4c91043589fcfda9a&ie=/sdarticle.pdf

8. Brink, C., van Ierland, E., Hordijk, L., and Kroeze, C., Cost-effective emission abatement in agriculture in the presence of interrelations: cases for the Netherlands and Europe. 2004.

Abstract: Agriculture contributes to global warming through emissions of nitrous oxide (N₂O), and methane (CH₄), and to acidification mainly through emissions of ammonia (NH₃). Measures to reduce one of

these gases may affect emissions of others. Policies neglecting these interrelations may be suboptimal. This study investigated interrelations between abatement of ammonia, nitrous oxide, and methane from European agriculture. We first studied how emission reduction technologies simultaneously affect the emissions of these three gases. Next, we analyzed for the Netherlands how the costs of emission reduction are affected when these interrelations are included in the analysis. Cost-effectiveness analysis of emission reductions in agriculture in the Netherlands indicates that increased nitrous oxide emissions due to ammonia abatement can be avoided at low cost. Finally, we calculated at the European level the side effects on ammonia emissions and the greenhouse gases nitrous oxide and methane of various emissions scenarios for European agriculture. We estimated that nitrous oxide emissions from European agriculture may increase as a side effect of ammonia abatement, whereas ammonia emissions may decrease due to nitrous oxide and methane mitigation. The conclusion is that simultaneous reductions in emissions can be realized at lower overall costs using an integrated approach.

Keywords: COST-EFFECTIVENESS/EMISSION ABATEMENT/GLOBAL WARMING/ACID RAIN/INTEGRATED ASSESSMENT/AGRICULTURE/GEOGRAPHIC-Europe/GEOGRAPHIC-The Netherlands/GHG AFFECTED-NH3/GHG AFFECTED- CH4/GHG AFFECTED-N2O/SECTOR-agriculture/OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-modelling.

Available at: http://www.sciencedirect.com/science?_ob=MIimg&_imagekey=B6VDY-4FCRFJ7-1-1&_cdi=5995&_user=606295&_orig=search&_coverDate=02%2F01%2F2005&_sk=999999999&view=c&wchp=dGLbVzz-zSkzV&md5=83ca309dc3379557ec939082bc8e14f6&ie=/sdarticle.pdf

9. Brink, J. C., Hordijk, L., van Ierland, E. C., and Kroeze, C., Cost-effective N₂O, CH₄ and NH₃ abatement in European agriculture: interrelations between global warming and acidification policies. Expert Workshop on "Assessing the ancillary benefits and costs of greenhouse gas mitigation strategies". 2000.

Abstract: In Europe agriculture is an important contributor to emissions of the acidifying compound ammonia (NH₃) and the greenhouse gases nitrous oxide (N₂O) and methane (CH₄). Measures to reduce one of these gases may also have an impact on emissions of the others. This study investigates the effects of control options for NH₃, N₂O, and CH₄ that are available for the European agriculture on the emissions of all three gases. We found that NH₃ abatement in the European agriculture may have an adverse effect on N₂O emissions while abatement of N₂O results in a net decrease in emissions of NH₃. Reductions in CH₄ emissions slightly increase in N₂O emissions. An optimisation analysis for the Dutch agriculture shows that a shift to other NH₃ abatement options is possible to avoid the increase in N₂O emissions, but at considerable costs. If N₂O control options are available, it may be more costeffective to apply these options to reduce the N₂O emissions to the initial level

Summary: Costs of NH₃ reduction measures are assessed considering interrelations with emissions of N₂O and CH₄. The major point of the paper is that some measures to reduce NH₃ emissions increase N₂O and CH₄ emissions. Accordingly cost of measures increases if N₂O and CH₄ emissions are kept constant. The possibility to exploit in parallel N₂O and CH₄ reduction measures lowers the total cost. Paper not directly relevant for our purposes, but some indication of costs and effectiveness are reported based on several studies among which the RAINS model. Policy context is based on the scenario analysis: effect on agriculture of NH₃ emission reductions needed to achieve realistic acid deposition target in 2010 in a cost-effective way.

Keywords: AGRICULTURE/ANCILLARY BENEFITS/METHANE /NITROUS OXIDE/AMMONIA/GLOBAL WARMING/ACIDIFICATION/EUROPE/GEOGRAPHIC-The Netherlands/GHG AFFECTED-NH3/GHG AFFECTED-N2O/GHG AFFECTED- CH4/SECTOR-agriculture/OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-modelling.

Available at: <http://www.oecd.org/dataoecd/32/8/2051468.pdf>

10. Casey, J. W. and Holden, N. M., Analysis of greenhouse gas emissions from the average Irish milk production system. 2004.

Abstract: Actions to moderate the major emission contributors of enteric fermentation, fertiliser and manure management on farms should not simply move the emissions elsewhere in the system, but actually reduce them. Life cycle assessment methodology was used to provide an objective framework for estimating emissions and to evaluate emission management scenarios with respect to kg CO₂ eq emitted per unit of milk produced. An average dairy unit was defined and emissions were compartmentalised to calculate a total emission of 1.50 kgCO₂eqkg⁻¹ (energy corrected milk) yr⁻¹ and 1.3 kg CO₂eqkg⁻¹yr⁻¹ with economic allocation between milk and meat. Of the total emissions, 49% was enteric fermentation, 21% fertiliser, 13% concentrate feed, 11% dung management and 5% electricity and diesel consumption. Scenario testing indicated that more efficient cows with extensive management could reduce emissions by 14–18%, elimination of non-milking animals could reduce emissions by 14–26% and a combination of both could

reduce emissions by 28–33%. It was concluded that the evolution of the Irish dairy sector, driven by the Common Agricultural Policy (CAP), should result in reduced GHG emissions.

Keywords: LIFE CYCLE ASSESSMENT/GREENHOUSE GAS EMISSIONS/DAIRY/MILK/IRELAND/GEOGRAPHIC-Ireland/GHG AFFECTED-all/SECTOR-agriculture/OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-modelling.

Available at: http://www.sciencedirect.com/science?_ob=MIimg&_imagekey=B6T3W-4DXC2SP-5-3&_cdi=4957&_user=606295&_orig=browse&_coverDate=11%2F30%2F2004&_sk=999999999&view=c&wchp=dGLbVzb-zSkWb&md5=32daea23d0f7515b57ad80d421f25891&ie=/sdarticle.pdf

11. Cronin, A., Implications of climate change and greenhouse policy for rural and regional Australia. 2003.

Abstract: The agriculture, forestry and land management sector has participated in the Commonwealth Government's Climate Change Forward Strategy. Over the past fifteen years, successive Commonwealth, State, and Territory Governments have focused their greenhouse efforts on reducing greenhouse emissions in the energy, manufacturing, and transport sectors. Technologies required to engage with these sectors continue to develop, and the mostly point-source nature of emissions of greenhouse gases from these industries can be readily identified and addressed. The agriculture, forestry and land management sector has an entirely different set of circumstances. Enterprises in this sector cover more than 60% of Australia's land mass; emissions of greenhouse gases are varied and diffuse; little research has been done on this issue in relation to different types of agriculture and different regions. The bottom line is that a vastly increased research effort is needed to enable the agriculture, forestry and land management sector to respond to greenhouse and climate change challenges. The overriding objective of the agriculture, forestry and land management sector is to ensure that policies to reduce greenhouse gas emissions do not impose unfair and unacceptable costs on our industries, and to ensure that our sector is not disadvantaged, now and in the future. Agricultural and forestry industries must not be penalised relative to other industries in Australia and must also not be disadvantaged through the implications of greenhouse policy on trade. At the same time, Australian climate change policies should seek to create opportunities for the agriculture, forestry and land management sector to contribute through "win-win" outcomes that may come from a range of sources. The critical issue is that agriculture simply does not have the knowledge at this time on which to plan responses. The issue is not that the required knowledge is not accessible to the farmer and land manager at the appropriate enterprise or regional scale but that for the most part it simply does not exist. Further, when the required research is progressed to a point at which it can inform farmers' and land managers' decisions on responses, research outcomes need to be subjected to rigorous cost-benefit analysis before they can be applied.

Keywords: GEOGRAPHIC-Australia/GHG AFFECTED-all/SECTOR-agriculture/SECTOR-forestry/OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-descriptive.

Available at: http://www.cattlecouncil.com.au/images/4_PUBLICATIONS/General%20Reports/Climate%20Change%20Rpt.pdf

12. Dalgaard, T., Halberg, N., and Porter, J. R., A model for fossil energy use in Danish agriculture used to compare organic and conventional farming. 2001;87:51-65.

Abstract: Knowledge about fossil energy use in agricultural systems is needed, because it can improve the understanding of how to reduce the unsustainable use of limited energy resources and the following greenhouse gas emissions. This study describes and validates a model to assess fossil energy use in Danish agriculture; gives an example of how the model can be used to compare organic and conventional farming; and discusses the implications and potentials of using the model to simulate energy use in scenarios of agricultural production. The model is a development of an existing model, which was too coarse to predict measured energy use on Danish farms. The model was validated at the field operational, the crop type, and the national level, and can supplement the Intergovernmental Panel on Climate Change manual to quantify fossil energy use and subsequent carbon dioxide emissions from agriculture. The model can be used to model energy use as one indicator in a multi-criteria evaluation of sustainability, also including other agroecological and socio-economic indicators. As an example, energy use for eight conventional and organic crop types on loamy, sandy, and irrigated sandy soil was compared. The energy use was generally lower in the organic than in the conventional system, but yields were also lower. Consequently, conventional crop production had the highest energy production, whereas organic crop production had the highest energy efficiency. Generally, grain cereals such as wheat have a lower energy use per area than roughage crops such as beets. However, because of higher roughage crop yields per area,

energy use per feed unit was higher in the roughage crops. Energy use for both conventional cattle and pig production was found to be higher than that for organic production. With respect to fossil energy use per produced livestock unit, agro-ecosystems producing pigs were in both cases less energy effective than those producing cattle. Fossil energy use for three scenarios of conversion to organic farming with increasing fodder import was compared to current conventional farming in Denmark. The scenario with the highest fodder import showed the highest energy use per livestock unit produced. In all scenarios, the energy use per unit produced was lower than in the present situation. However, the total Danish crop production was also lower. In conclusion, the model can be used to simulate scenarios, which can add new information to the discussion of future, sustainable agricultural production.

Keywords: FOSSIL ENERGY/ DIESEL FUEL/ORGANIC FARMING/AGROECOLOGY/DENMARK/GEOGRAPHIC-Scandinavia/GHG AFFECTED-CO2/SECTOR-agriculture/SECTOR-Energy/OBJECTIVE-Emission reduction/OBJECTIVE-energy saving/MEASURE-NA/APPROACH-modelling.

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13. De Cara, S., Houzé, M., and Jayet, P.A., Greenhouse gas emissions from agriculture in the EU: a spatial assessment of sources and abatement costs. 2004;4.

Abstract: Agriculture contributes significantly to the emissions of greenhouse gases in the EU. By using a farm-type, linear-programming based model of the European agricultural supply, we first assess the initial levels of methane and nitrous oxide emissions at the regional level in the EU. For a range of CO₂ prices, we assess the potential abatement that can be achieved through an IPCC-based emission tax in EU agriculture, as well as the resulting optimal mix of emission sources in the total abatement. Further, we show that the spatial variability of the abatement actually achieved at a given carbon price is large, indicating that abatement cost heterogeneity is a fundamental feature in the design of a mitigation policy. We assess the efficiency loss associated with uniform standards relative to a an emission tax

Summary: The paper extrapolates marginal abatement cost curves for the agricultural sector in the EU 15 member countries starting from linear optimisation models mimicking farmers' behaviour. Data on agricultural supply functions are obtained from the 1997 Farm Accounting Data Network, data on agricultural emissions are derived from yearly emission inventories to the UNFCCC. Main results are: an hypothetical tax of 55/Euro/Ton CO₂ would allow an emission reduction by the agricultural sector of the 14.8% respect to 1990 level (recall Kyoto requirement = -8%). A 20/Euro/ton CO₂ tax (consistent with EU efficiency requirements) would allow a reduction of the 11% in GHG emission from agriculture respect to 1990. => Strong contribution of agriculture. Taxation is more efficient than an uniform standard. For the 20/Euro/Ton CO₂ tax efficiency gains are 220%. The methodological approach adopts Marginal Abatement Cost (MAC) curves built starting from linear optimisation model at the farm level.

Keywords: CLIMATE CHANGE/GREENHOUSE GAS EMISSIONS/AGRICULTURE/METHANE/NITROUS OXIDE /EUROPEAN UNION/MARGINAL ABATEMENT COSTS/GEOGRAPHIC-Europe/GHG AFFECTED-CH₄/SECTOR-agriculture/OBJECTIVE-Emission reduction/MEASURE-MBI/APPROACH-Economic.

Available at: http://www.grignon.inra.fr/economie-publique/docs_travail/docs_2004/2004_04.pdf

14. De Cara, S. and Jayet, P.-A., Agriculture and climate change in the European Union: greenhouse gas emissions and abatement costs. AAEA annual meeting . 2001.

Abstract: This paper addresses the assessment of greenhouse gas emissions from agriculture in the European Union. We first estimate and compare net emissions from agricultural activities in twelve EU countries. These estimates are based on a set of farm-unit linear-programming models. We then use these models to derive marginal and total abatement costs associated with different levels of reduction targets (dual approach) and different values of carbon-equivalent emissions (primal approach). Finally, we explore the possibility of allowing afforestation on setaside land. This paper highlights the discrepancies between countries regarding abatement costs and their sensitiveness to the accounting for carbon sequestration.

Keywords: WATER/GOVERNANCE/POLICY/GEOGRAPHIC-Europe/GHG AFFECTED-All/SECTOR-agriculture /OBJECTIVE-Sequestration/MEASURE-Voluntary/APPROACH-Economic .

Available at:

15. De Cara, S. and Jayet, P-A, Emissions of greenhouse gases from agriculture: the heterogeneity of abatement costs in France . 2000;27: 3:281-303.

Abstract: This paper addresses the assessment of greenhouse gas emissions from agriculture. The analysis focuses on the shadow prices associated with the reductions in the net emissions, taking into account the carbon sequestration by soils and trees. These estimates are based on a set of farm-unit linear programming models representing the French agricultural sector. The distribution of the shadow prices over farm types is discussed and the importance of allowing afforestation on set-aside land to achieve a cost-effective reduction in net emissions is highlighted. However, allowing afforestation on set-aside land may increase inequality in terms of revenue losses for farmers.

Keywords: AGRI-ENVIRONMENTAL POLICIES/EMISSIONS OF GREENHOUSE GASES/ABATEMENT COSTS/LINEAR PROGRAMMING/GEOGRAPHIC-France/GHG AFFECTED-CO2/SECTOR-agriculture/SECTOR-forestry/OBJECTIVE-Sequestration/MEASURE-Voluntary/APPROACH-Economic .

Available at:
http://erae.oupjournals.org/cgi/reprint/27/3/281?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=1&author1=de+cara&andorexacttitle=and&andorexacttitleabs=and&andorexactfulltext=and&searchid=1112889972927_93&stored_search=&FIRSTINDEX=0&sortspec=relevance&journalcode=eurrag

16. Dendoncker, N., Van Wesemael, B., Rounsevell, M. D., Roelandt, C., and Lettens, S., Belgium's CO₂ mitigation potential under improved cropland management. 2004;103: 1:101-116.

Abstract: Sequestration of carbon in soils and vegetation can contribute to meeting greenhouse gas emission reduction targets for individual countries under the Kyoto Protocol. In this paper, the carbon mitigation potential of a series of agricultural land-management practices that are relevant to Belgian agriculture is quantified. Reforestation of a part of the total agricultural area is also considered, and the sequestration potential is corrected for practices already in use before the 1990 baseline. Existing and future agro-environmental policies as well as regional policies aimed at reducing environmental side effects of spreading organic amendments were considered when calculating the areas for which sequestration measures could be applied. The results are brought together in a realistic scenario. The mean sequestration potential expressed in GgC per year for Belgium is as follows: additional bio-energy crops (96.2), spreading farmyard manure formerly applied to grassland on arable land (84.4) woodland regeneration (31.7), adopting no-till farming on suitable soils over a period of 20 years (15.8), the use of cover crops following winter cereals (15.2, adopted over 20 years), improved management of farmed peat soils (13.4) and organic farming (2.2). These figures suggest that, by 2010, Belgium can only expect a reduction in CO₂ emissions ranging from 0.47 to 0.90% of the 1990 greenhouse gas emissions by improving agricultural management. These measures should not however be neglected as they will have other positive effects on soil properties, and they could offer a solution to reduce emissions from the agricultural sector by 4.7–9.0% of the 1990 values.

Keywords: CARBON SEQUESTRATION/AGRICULTURAL MANAGEMENT/AGRI-ENVIRONMENTAL POLICIES/RESTRICTIONS ON SPREADING OF ANIMAL WASTES/BELGIUM/GEOGRAPHIC-Belgium/GHG AFFECTED-CO2/SECTOR-agriculture/OBJECTIVE-Sequestration/MEASURE-NA/APPROACH-modelling.

Available at:
[http://www.sciencedirect.com/science?_ob=IssueURL&_tockey=%23TOC%234959%232004%23998969998%23499990%23FLA%23Volume_103,_Issue_1,_Pages_1-263_\(June_2004\)&_auth=y&view=c&_acct=C000031459&_version=1&_urlVersion=0&_userid=606295&md5=72c5d10cd36dced0d3a9289008a0da40](http://www.sciencedirect.com/science?_ob=IssueURL&_tockey=%23TOC%234959%232004%23998969998%23499990%23FLA%23Volume_103,_Issue_1,_Pages_1-263_(June_2004)&_auth=y&view=c&_acct=C000031459&_version=1&_urlVersion=0&_userid=606295&md5=72c5d10cd36dced0d3a9289008a0da40)

17. Deybe, D. and Fallot, A., Non-CO₂ greenhouse gas emissions from agriculture: analysing the room for manoeuvre for mitigation, in case of carbon pricing. 25th International Conference of Agricultural Economists . 2003.

Abstract: Relationships between the greenhouse effect and agricultural activity are usually and firstly considered in terms of the impact of climate change on agriculture. But in reverse, farmers and herders may react to a climate policy imposing a carbon price to GHG-emitting activities, and possibly contribute to the emissions mitigation as well as to carbon sequestration. The degree of efficiency of the reactions will vary across regions of the world and across activities. A methodology considering risk associated with technology changes is proposed for estimating and accounting these reactions under production and resource constraints. For a business-as-usual scenario quantified by the integrated assessment model Image, decisions concerning land-use and alternative practices are modeled. Results indicate that main agricultural activities provide little room for manoeuvre for emissions mitigation.

Keywords: AGRICULTURE/LAND/WATER/AIR/LAND USE PATTERNS/GEOGRAPHIC-World/GHG AFFECTED-all/SECTOR-agriculture/OBJECTIVE-Emission reduction/MEASURE-MBI/APPROACH-modelling.

Available at: http://www.iaae-agecon.org/conf/durban_papers/papers/110.pdf

18. Ericsson, K., Huttunen, S., Nilsson, L. J., and Svenningsson, P., Bioenergy policy and market development in Finland and Sweden. 2004;32: 15:1707-1721.

Abstract: The use of biomass in Finland and Sweden has steadily increased over the past 25 years, up to approximately 20% of the primary energy supply in 2001. In both countries most biomass originates from forests. Forest biomass is now an integral part of modern energy systems, although primarily in industry and in the heating sector. For example, biomass accounts for 7.9% and 53% of the fuel mix in district heating in Finland and Sweden, respectively. The general energy policy of both countries has supported biomass for energy over the entire period, although specific policies have changed with time. Research, development and demonstration has been continuously supported, and some subsidy schemes have been applied, in particular, for district heating systems (DHS) and combined heat and power. Heavy taxation of competing fossil fuels seems to have been the most effective policy instrument, although this has been directed mainly at the heat and transportation fuel markets. Electricity taxes are imposed on consumption (industry is largely exempt), and do not discriminate significantly between the sources of electricity. Starting in 2003, Sweden will have a quota-based system, a renewable portfolio standard, which is expected to increase biomass-based electricity production. Both countries possess vast and not fully exploited biomass resources in the form of forests, and have a history of rational and large-scale forestry. Strong actors exist both with regard to forest ownership and the industrial processing of forest products. The user side, in particular, represented by DHS, can also be characterised by strong and professional management. Over time, structures have developed that facilitate an increased use of biomass for energy, for example, the forest industry infrastructure and extensive district heating. Actors within these structures have had the ability to react to policies, resulting in a stable growth in biomass use.

Keywords: BIOMASS ENERGY/ENERGY POLICY/BIOENERGY MARKETS/GEOGRAPHIC-Scandinavia/GHG AFFECTED-CO2/SECTOR-Energy/OBJECTIVE-Energy saving/MEASURE-MBI/APPROACH-descriptive.

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19. Erisman, J. W., Grennfelt, P., and Sutton, M., The European perspective on nitrogen emission and deposition. 2003;29: 2-3:311-325.

Abstract: Europe has been successful in reducing the emissions of several nitrogenous pollutants over recent decades. This is reflected in concentrations and deposition rates that have decreased for several components. Emissions of nitrogen containing gases are estimated to have decreased in Europe by 10%, 21% and 14% for N₂O, NO_x and NH₃, respectively, between 1990 and 1998. The main reductions are the result of a decrease in industrial and agricultural activities in the east of Europe. The reductions are a result of the economic situation, measures in the transport sector, industry, and the agricultural sector, with only a small part of the reduction due to specific measures designed to reduce emissions. The reduction is significant but far from the end goal for large areas in Europe, in relation to different environmental problems. The Gothenburg Protocol will lead to reductions of 50% and 12% in 2010 relative to 1990 for NO_x and NH₃, respectively. The N₂O emissions are expected to grow by 9% between 1998 and 2010. Further reductions are necessary to reach critical limits for ecosystem protection, air quality standards, and climate change. Emissions of nitrogen compounds result from an overload of reactive nitrogen that is produced by combustion processes, by synthesis of ammonia, or by import from other areas as concentrated animal feeds. Some improvements can be made in the efficiency of combustion processes and agricultural systems. However, measures to reduce emissions substantially need to focus on decreasing the production or import of reactive N. Reactive N ceilings for regions, based on critical limits for all N-related effects, can help to focus such measures. An integrated approach might have advantages over the pollutant-specific approach, to combat nitrogen pollution. This could provide the future direction for European policy to reduce the impacts of excess nitrogen.

Keywords: AMMONIA/NITROGEN OXIDES/NITROUS OXIDE/EMISSION/DEPOSITION/EUROPE/CRITICAL LOADS/EXCEEDANCES/POLICY/SCENARIOS/GEOGRAPHIC-Europe /GHG AFFECTED-N₂O/GHG AFFECTED-NH₃/SECTOR-All/OBJECTIVE-Emission reduction/MEASURE-All/APPROACH-descriptive.

Available at: http://www.sciencedirect.com/science?_ob=MIimg&_imagekey=B6V7X-47N68P4-3-R&_cdi=5854&_user=606295&_orig=browse&_coverDate=06%2F30%2F2003&_sk=999709997&view=c&wchp=dGLbVlb-zSkzV&md5=35879cd9706a1095792c33e0640c5d17&ie=/sdarticle.pdf

20. European Commission, Options to reduce methane emissions . AEAT-3773 . 98.

Abstract: This report is one of the final reports under a study completed by AEA Technology Environment for DGXI on the control and reduction of greenhouse gases and ozone precursors. Four gases were included in the study, the two direct greenhouse gases, methane and nitrous oxide, and the ozone precursors, nitrogen oxides (NO_x) and non-methane volatile organic compounds. In the initial phase of the study, inventories of these gases for all Member States were reviewed and updated. In the second phase of the study, measures to control and reduce emissions of these gases were identified, their technical feasibility examined, and wherever sufficient cost and performance data was available, the cost-effectiveness of the measures (in terms of ECU (1995) per tonne of pollutant) is also estimated. This report analyses methane emissions and strategies to control them. Section 2 describes the global sources of methane emissions, the significance of methane as a greenhouse gas, and the level of methane emissions in the EU. These emissions are discussed in context against emissions of the two other direct greenhouse gases (carbon dioxide and nitrous oxide) and the important emissions sources within the EU are identified. Sections 3-7 of the report consider options for the reduction of emissions from agriculture, waste, coal mining and the oil and gas industry. In each case the sources of emissions, the mitigation options available, and their costs are discussed. The costs have been calculated using an annualised cost methodology. All costs have been calculated based on an 8% discount rate and are expressed in 1995 ECUs to ensure consistency with previous work on the cost of carbon dioxide reduction options. Full details of the costing methodology, exchange rates, deflators and other factors used are given in Appendix 1. Finally each section includes an analysis of the applicability of the considered reduction options under future scenarios and projections of future emissions. Projections of more minor emissions sources are considered in Section 8 together with a discussion of the potential impact of CO₂ reduction measures on methane emissions arising from fuel combustion. Section 9 of the report examines possible variations in of measures (in all sectors) between Member States. A summary of the report is contained in Section 10, where projections of emissions and estimates of achievable reductions from all sectors are combined to give an EU wide projection of total methane emissions if a mitigation strategy were implemented. This section also contains a cost-effectiveness curve for all measures.

Keywords: GEOGRAPHIC-Europe/GHG AFFECTED- CH4/SECTOR-All/OBJECTIVE-Emission reduction/MEASURE-MBI/APPROACH-Economic .

Available at: http://europa.eu.int/comm/environment/enveco/climate_change/methane_emissions.pdf

21. European Commission, Options to reduce nitrous oxide emissions. AEAT-4180 . 98.

Abstract: This report is one of the final reports under a study completed by AEA Technology Environment for DGXI on the control and reduction of greenhouse gases and ozone precursors. Four gases were included in the study, the two direct greenhouse gases, methane and nitrous oxide, and the ozone precursors, nitrogen oxides (NO_x) and non-methane volatile organic compounds. In the initial phase of the study, inventories of these gases for all Member States were reviewed and updated. In the second phase of the study, measures to control and reduce emissions of these gases were identified, their technical feasibility examined, and wherever sufficient cost and performance data was available, the cost-effectiveness of the measures (in terms of ECU (1995) per tonne of pollutant) was also estimated. This report assesses anthropogenic nitrous oxide (N₂O) emissions and strategies to control them. Section 2 discusses the properties of N₂O, sources and sinks for the gas, and a global budget for emissions. Section 3 considers emissions within the EU, and sets these into context against global N₂O emissions and emissions of the two other direct greenhouse gases (carbon dioxide and methane). It also identifies the important emission sources within the EU. Section 4 summarises actions which are already proposed by Member States to reduce emissions. Sections 5 and 6 of the report consider in detail options for the reduction of emissions from the agricultural and chemical sectors, while Section 7 considers the options to reduce emissions from combustion processes. The cost-effectiveness of the different measures is then evaluated in Section 8. For the non-agricultural sectors, costs have been calculated using an annualised cost methodology. All costs are expressed in 1995 ECUs and have been calculated using an 8% discount rate to annualise costs to ensure consistency with previous work on the cost of carbon dioxide reduction options. Full details of the costing methodology, exchange rates, deflators and other factors used are given in Appendix 1. Section 9 contains projections of N₂O emissions up to 2020 under a 'business as usual' scenario and under a 'with measures' scenario, and Section 10 contains a summary of the report

Summary: The examined policies (Limit to inorganic fertiliser application, seasonal ban on nitrogen application, removal of price support and a phasing in of a marginal land subsidy) have the potential to reduce N₂O emission the 21% in 2010 respect to a BAU scenario. Limiting inorganic fertiliser application would imply a total cost of 148000/Euro/ton of abated N₂O. The seasonal ban would imply an additional

cost of 6750/Euro/ton N2O.

The policy context is focused on limit to inorganic fertiliser application, seasonal ban on nitrogen application, removal of price support and a phasing in of a marginal land subsidy.

Keywords: GEOGRAPHIC-Europe/GHG AFFECTED-N2O/SECTOR-All/OBJECTIVE-Emission reduction/MEASURE-MBI/APPROACH-Economic .

Available at: http://europa.eu.int/comm/environment/enveco/climate_change/nitrous_oxide_emissions.pdf

22. Ewert, F., Rounsevell, M. D. A., Reginster, I. R., Metzger, M., and Leemans, R., Future scenarios of European agricultural land use. Part I: estimating changes in crop productivity. 2005;107: 2-3:101-116.

Abstract: The future of agricultural land use in Europe is unknown but is likely to be influenced by the productivity of crops. Changes in crop productivity are difficult to predict but can be explored by scenarios that represent alternative economic and environmental pathways of future development. We developed a simple static approach to estimate future changes in the productivity of food crops in Europe (EU15 member countries, Norway and Switzerland) as part of a larger approach of land use change assessment for four scenarios of the IPCC Special Report on Emission Scenarios (SRES) representing alternative future developments of the world that may be global or regional, economic or environmental. Estimations were performed for wheat (*Triticum aestivum*) as a reference crop for the time period from 2000 until 2080 with particular emphasis on the time slices 2020, 2050 and 2080. Productivity changes were modelled depending on changes in climatic conditions, atmospheric CO₂ concentration and technology development. Regional yield statistics were related to an environmental stratification (EnS) with 84 environmental strata for Europe to estimate productivity changes depending on climate change as projected by the global climate model HadCM3. A simple empirical relationship was used to estimate crop productivity as affected by increasing CO₂ concentration simulated by the global environment model IMAGE 2.2. Technology was modelled to affect potential yield and the gap between actual and potential yield. We estimated increases in crop productivity that ranged between 25 and 163% depending on the time slice and scenario compared to the baseline year (2000). The increases were the smallest for the regional environmental scenario and the largest for the global economic scenario. Technology development was identified as the most important driver but relationships that determine technology development remain unclear and deserve further attention. Estimated productivity changes beyond 2020 were consistent with changes in the world-wide demand for food crops projected by IMAGE. However, estimated increases in productivity exceeded expected demand changes in Europe for most scenarios, which is consistent with the observed present oversupply in Europe. The developed scenarios enable exploration of future land use changes within the IPCC SRES scenario framework.

Keywords: CROP PRODUCTIVITY/MODELLING/TECHNOLOGY DEVELOPMENT/CLIMATE CHANGE/INCREASING CO₂/LAND USE CHANGE/GEOGRAPHIC-Europe/GHG AFFECTED-NA/SECTOR-agriculture/OBJECTIVE-NA/MEASURE-NA/APPROACH-modelling.

Available at: http://www.sciencedirect.com/science?_ob=MIimg&_imagekey=B6T3Y-4F7Y96F-2-1&_cdi=4959&_user=606295&_orig=search&_coverDate=05%2F20%2F2005&_sk=998929997&view=c&wchp=dGLbVtb-zSkWW&md5=f75fc77dfb6f2e0c8d6648c4cf1cedf4&ie=/sdarticle.pdf

23. Faaij, A. P., Bio-energy in Europe: changing technology choices. 2004.

Abstract: Bio-energy is seen as one of the key options to mitigate greenhouse gas emissions and substitute fossil fuels. This is certainly evident in Europe, where a kaleidoscope of activities and programs was and is executed for developing and stimulating bio-energy. Over the past 10–15 years in the European Union, heat and electricity production from biomass increased with some 2% and 9% per year, respectively, between 1990 and 2000 and biofuel production increased about eight-fold in the same period. Biomass contributed some two-thirds of the total renewable energy production in the European Union (EU) (2000 PJ) or 4% of the total energy supply in 1999. Given the targets for heat, power and biofuels, this contribution may rise to some 10% (6000 PJ) in 2010. Over time, the scale at which bio-energy is being used has increased considerably. This is true for electricity and combined heat and power plants, and how biomass markets are developing from purely regional to international markets, with increasing crossborder trade-flows. So far, national policy programs proved to be of vital importance for the success of the development of bioenergy, which led to very specific technological choices in various countries. For the future, a supra-national approach is desired: comprehensive research development, demonstration & deployment trajectories for key options as biomass integrated gasification/combined cycle and advanced biofuel concepts, develop an international biomass market allowing for international trade and an integral policy approach for bio-energy incorporating energy, agricultural, forestry, waste and industrial policies. The Common Agricultural Policy of the (extended) EU should fully incorporate bio-energy and perennial crops in particular.

Keywords: EUROPEAN BIO-ENERGY POLICY/BIO MASS RESOURCES/BIOFUELS/GEOGRAPHIC-

Europe/GHG AFFECTED-all/SECTOR-Energy/OBJECTIVE-Emission reduction/MEASURE-All/APPROACH-descriptive.
 Available at: http://www.sciencedirect.com/science?_ob=MIimg&_imagekey=B6V2W-4DYW4V2-1-1&_cdi=5713&_user=606295&_orig=search&_coverDate=12%2F21%2F2004&_sk=999999999&view=c&wchp=dGLbVtb-zSkWW&md5=e03119d8acb8fe66aefaaff79c147863&ie=/sdarticle.pdf

24. Freibauer, A., Rounsevell, M. D., Smith, P., and Verhagen, J., Carbon sequestration in the agricultural soils of Europe. 2004;122: 1:1-23.

Abstract: In this review, technical and economically viable potentials for carbon sequestration in the agricultural soils of Europe by 2008–2012 are analysed against a business-as-usual scenario. We provide a quantitative estimation of the carbon absorption potential per hectare and the surface of agricultural land that is available and suitable for the implementation of those measures, their environmental effects as well as the effects on farm income. Realistically, agricultural soils in EU-15 can sequester up to 16–19 Mt C year⁻¹ during the first Kyoto commitment period (2008–2012), which is less than one fifth of the theoretical potential and equivalent to 2% of European anthropogenic emissions. We identified as most promising measures: the promotion of organic inputs on arable land instead of grassland, the introduction of perennials (grasses, trees) on arable set-aside land for conservation or biofuel purposes, to promote organic farming, to raise the water table in farmed peatland, and —with restrictions— zero tillage or conservation tillage. Many options have environmental benefits but some risk of increasing N₂O emissions. For most measures it is impossible to determine the overall impact on farm profitability. Efficient carbon sequestration in agricultural soils demands a permanent management change and implementation concepts adjusted to local soil, climate and management features in order to allow selection of areas with high carbon sequestering potential. Some of the present agricultural policy schemes have probably helped to maintain carbon stocks in agricultural soil.

Keywords: CARBON SEQUESTRATION/KYOTO PROTOCOL/AGRICULTURE/CARBON/MANAGEMENT/GEOGRAPHIC-Europe/GHG AFFECTED-CO₂/SECTOR-agriculture/OBJECTIVE-Sequestration/MEASURE-All/APPROACH-descriptive/APPROACH-Economic .

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Abstract: The effects of likely regulatory and policy changes in the US gasoline and additives market are compared to a reference baseline. The baseline reflects existing EPA policies about fuel quality regulation and likely petroleum and gasoline expansions. The market and welfare effects are presented for implementing a renewable fuel standard; imposing a national ban on the additive MTBE; and removing the oxygen standard for reformulated fuel. Market and welfare estimates are based on adjusting product market demands and factor supplies. Product market and price analyses include quality-differentiated products, such as refinery gasoline, chemical additives and ethanol at the wholesale level; and gasoline grades in conventional, reformulated and oxygenated markets at the retail level. Factor market analyses include supplies for petroleum, natural gas byproducts, and corn. The analysis includes the welfare cost of fuel to consumers and income in agriculture and the petroleum sector.

Keywords: GASOLINE AND ADDITIVES MARKET/BIOFUELS/ETHANOL/MTBE BAN/RENEWABLE FUEL STANDARD/OXYGEN STANDARD/GEOGRAPHIC-USA/GHG AFFECTED-all/SECTOR-Energy/OBJECTIVE-Energy saving/MEASURE-MBI/MEASURE-Regulation/APPROACH-Economic .

Available at: http://www.sciencedirect.com/science?_ob=MIimg&_imagekey=B6V82-490H8YG-1-9&_cdi=5858&_user=606295&_orig=browse&_coverDate=09%2F30%2F2003&_sk=999749993&view=c&wchp=dGLbVtb-zSkzV&md5=ac8f1ce18427073686884404822612e9&ie=/sdarticle.pdf

26. Garcia-Quijano, J. F., Deckmyn, G., Moons, E., Proost, S., Ceulemans, R., and Muys, B., An integrated decision support framework for the prediction and evaluation of efficiency, environmental impact and total social cost of domestic and international forestry projects for greenhouse gas mitigation: description and case studies. 2005;207: 1-2:245-262.

Abstract: Land use, land use change and forestry (LULUCF) offer domestic and international opportunities to accomplish the targets set by the Kyoto Protocol. Design and selection of successful forestry projects are complex decision processes based on information of the carbon dioxide mitigation potential, the environmental impacts and the cost efficiency of selected scenarios. In this paper, a decision support

framework to evaluate forestry scenarios for greenhouse gas emission reduction is presented and tested on five scenarios (existing and new multifunctional forest in Flanders, Belgium, bioenergy crop with short rotation poplar and with elephant grass in Flanders, Belgium, plantation forestry in the subtropics, and, conservation of tropical rainforest). The framework is organized as a serial connection of a carbon accounting module, an environmental impact module and an economic module. Modules include a combination of models and quantitative assessment procedures. In order to make scenarios comparable, the environmental and economic modules calculate their outputs on a functional unit basis of 1 t CO₂ emission reduction. The framework is universally applicable and straightforward, transparent and quantitative. The level of data requirement is medium, but the application is fairly complex due to the interdisciplinary character of the tool. Further developments would require automated data flows between models and a user interface. Results of the test application showed that the only attractive domestic option is the establishment of new multifunctional forests. This scenario even yields a net benefit because it replaces the generally loss-making agriculture and, in addition, it provides other environmental and recreational benefits. The establishment of bioenergy plantations is a very efficient way of reducing CO₂ emissions as far as land occupation and environmental impacts per functional unit are concerned. However, it also turns out to be a very expensive option. Plantation forestry in the tropics is advantageous when evaluated over longer periods of time. Conservation of tropical forest is not eligible as a clean development mechanism (CDM) project, although it would be economically attractive for Flanders since the cost per tonne CO₂ emission reduction is close to the expected world market price. This option is thus promising for the voluntary market and for future commitment periods of the Kyoto Protocol.

Keywords: CO₂ EMISSION REDUCTION/LULUCF/CARBON BALANCE/LIFE CYCLE ASSESSMENT/LAND USE IMPACT/COSTBENEFIT ANALYSIS/FUNCTIONALUNIT/KYOTO PROTOCOL/GEOGRAPHIC-World/GHG AFFECTED-CO₂/SECTOR-forestry/ OBJECTIVE-Sequestration/MEASURE-NA/APPROACH-modelling.

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Abstract: No abstract

Summary/comments: Workshop summary, not useful, may be some of the proceedings can be useful.

Keywords: GEOGRAPHIC-Europe/GHG AFFECTED-all/SECTOR-agriculture/SECTOR-forestry/OBJECTIVE-Emission reduction/ MEASURE-All/APPROACH-descriptive.

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28. Gielen, D. J., Fujino, J., Hashimoto, S., and Moriguchi, Y., Biomass strategies for climate policies? 2002;2: 4:319-333.

Abstract: This paper discusses the results of the BEAP linear programming model that has been developed to study the optimal use of biomass and land for greenhouse gas emission reduction, notably the competition between food production, biomass production for energy and materials and afforestation. The model results suggest up to 100 EJ biomass use in case of global policies (about 20% of global primary energy use). The biomass is used for industrial and residential heating, transportation fuels and as a feedstock for plastics. In the electricity markets competing emission reduction options are more cost-effective than biomass. In case the Kyoto protocol is continued beyond 2010 the developed countries can rely in 2020–2030 on afforestation and land use change credits from developing countries, without any major use of other emission reduction strategies. However, in case of a planning perspective of more than half a century bioenergy is preferred instead of afforestation. The results indicate a limited impact on global agricultural trade, but food demand may be affected by CO₂ policies.

Keywords: BIOMASS/LULUCF/CARBON LEAKAGE/AFFORESTATION/MODELING/RENEWABLE ENERGY/GEOGRAPHIC-World/GHG AFFECTED-CO₂/SECTOR-forestry/OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-modelling.

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Abstract: An econometrically estimated family of response functions is developed for characterizing potential responses to greenhouse gas mitigation policies by the agriculture and forestry sectors in the U.S. The response functions are estimated based on results of an agricultural/forestry sector model. They provide estimates of sequestration and emission reductions in forestry and agriculture along with levels of sectoral production, prices, welfare, and environmental attributes given a carbon price, levels of demand for agricultural goods, and the energy price. Six alternative mitigation policies representing types of greenhouse gas offsets allowed are considered. Results indicate that the largest quantity of greenhouse gas offset consistently appears with the mitigation policy that pays for all opportunities. Restricting carbon payments (emission tax or sequestration subsidy) only to aff/deforestation or only to agricultural sequestration substantially reduces potential mitigation. Higher carbon prices lead to more sequestration, less emissions, reduced consumer and total welfare, improved environmental indicators and increased producer welfare.

Keywords: GEOGRAPHIC-USA/GHG AFFECTED-NH3/SECTOR-agriculture/SECTOR-forestry/OBJECTIVE-Emission reduction/ MEASURE-MBI/APPROACH-Economic .

Available at: <http://www.springerlink.com/media/CHBDH0PURH3UNHFKJJ1Q/Contributions/J/2/1/3/J2130668551Q0426.pdf>

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Abstract: This paper employs a new class of computable general equilibrium (CGE) models, developed in the context of energy-economy-environmental models to simulate the impacts of the EU economy of internal and multilateral instruments for regulation of greenhouse gases (GHGs) emissions. Climate change due to emissions gases of greenhouse gases is a long-term global environmental problem. While specific impacts on different regions as well as their timing are yet uncertain, it is reasonable to suppose that unilateral voluntary action by individual countries to reduce their net emissions of GHGs is unlikely. This is because significant reduction of net GHGs emissions by a single major net emitter, say, for example the EU, is unlikely to substantially slow down the rate of increase in concentration in the atmosphere because the emissions of GHGs worldwide is increasing rapidly with spreading industrialization. On the other hand, unilateral changes in energy use patterns are widely perceived to have adverse effects on a country's economic growth, consumer welfare and trade competitiveness. This perception is shared by both developing (DCs) and industrialized countries (INCs). Some major policy instruments have been assessed on the basis of experiments with the CGE model. The use of each of the policy instrument for direct GHGs regulation is promising. The results of the above experiments seem to show, that first, emission standards accomplish significant decreases in net GHGs emissions with negligible relative GDP and Welfare index changes and without major distributional impacts in the sense of relative changes in factor rewards. They seem to work through major reduction in coal and natural gas use and slight overall reduction in the use of petroleum. Second, auctioned tradeable permits also accomplish large decreases in net GHGs emissions, with, however a perceptible increase in the Welfare Index and significant distributional impacts in higher rewards to land owners and labor relative to capital owners. They appear to work primarily by expansion to the forest sector and associated increases offsets generation. Third, the use of a GHGs tax on positive net emissions of GHGs by industries accomplishes large reductions in net GHGs emissions with significant increase in GDP and the Welfare Index. The relative changes in factor rewards are also important and favor land owners over labor and capital owners. This instrument too appears to work primarily through considerable expansion of the forest sector and consequent increases offsets generation. Each of these instruments show sufficient promise as effective policy tools for GHGs reduction, that it would be advisable to conduct further research in each case. The choice between standards on the one hand, and market-based domestic regulatory instruments on the other, is not straightforward. These results need verification through further analysis.

Keywords: COMPUTABLE GENERAL EQUILIBRIUM/GLOBAL POLLUTION/GREENHOUSE GASES/ENVIRONMENTAL POLICY/GEOGRAPHIC-Europe/GHG AFFECTED-all/SECTOR-All/OBJECTIVE-Emission reduction/MEASURE-MBI/MEASURE-Regulation/APPROACH-Economic .

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Abstract: In this paper, we evaluate the relations between land-use and socio-economic metabolism and particularly, socio-economic biomass flows, by constructing four scenarios for Austria in 2020. The

scenarios were established using a biomass-flow model for Austria which was developed for this analysis. The model distinguishes between 15 different kinds of land use and relates demand for biomass in Austria to biomass production in Austria, considering imports and exports as well as biomass conversions in industrial processing and in livestock. We discuss four scenarios: (1) a trend scenario, based upon an extrapolation of current trends; (2) a scenario assuming the far-reaching liberalization of agricultural markets; (3) a scenario in which biomass utilization for energy and industry is maximized; and (4) a scenario based upon the approach of "cascade utilization" of biomass. We find that increasing the use of biomass as an energy source might have considerable unwanted ecological effects including, among others, a reduction in the functioning of forests as a terrestrial carbon sink.

Keywords: SOCIO-ECONOMIC METABOLISM/BIO MASS FLOWS/CARBON SINKS/BIO MASS ENERGY/ENERGY POLICY/GEOGRAPHIC-Austria/GHG AFFECTED-CO2/SECTOR-agriculture/SECTOR-Energy/OBJECTIVE-Energy saving/MEASURE-NA/APPROACH-modelling.

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32. Hamilton, C. and Quiggin, J., Economic Analysis of greenhouse policy. A layperson's guide to the perils of economic modelling. 97;15.

Abstract: This paper examines the role of economic models in the formulation of climate change policies in Australia. Particular emphasis is given to the MEGABARE model constructed by the Australian Bureau of Agricultural and Resource Economics. The Government has drawn heavily on the results of MEGABARE to support its argument that uniform abatement targets would be too costly for Australia and would impose an unfair burden on this country. While economic models are often extremely complex in structure, as a rule only a few key relationships are important for explaining their results. Moreover, modellers must make a series of assumptions about how an economy works and which factors are important to include in a model. The choice of assumptions essentially determines the results that emerge from the end of the modelling process. These facts mean that economists who build and use models can effectively determine the outcome by changing the model in sometimes obscure ways. For these reasons transparency in building models and reporting their results is crucial to their credibility. Economic models are powerful devices for providing analysis of the possible economic implications of measures to reduce greenhouse gas emissions. While there are several economic models that can provide insight into policy choices in Australia, the Government has relied almost exclusively on the MEGABARE model. The evidence provided in this paper shows that the model construction, its use in greenhouse policy analysis and the interpretation of the results have been biased in ways that exaggerate the economic costs of reducing emissions

Summary: Description of methodological approaches and investigation tools used to assess cost effectiveness of greenhouse policies.

Keywords: GEOGRAPHIC-Australia/GHG AFFECTED-all/SECTOR-All/OBJECTIVE-Emission reduction/APPROACH-descriptive/MEASURE-NA/APPROACH-descriptive/APPROACH-Economic .

Available at: http://www.tai.org.au/Publications_Files/DP_Files/DP15SUM.PDF

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Abstract: In 2002 the German Parliament decided to exempt biofuels from the gasoline tax to increase their competitiveness compared to conventional gasoline. The policy to promote biofuels is being justified by their allegedly positive effects on climate, energy, and agricultural policy goals. An increased use of biofuels would contribute to sustainable development by reducing greenhouse-gas emissions and the use of non-renewable resources. The paper takes a closer look at bio-ethanol as a substitute for gasoline. It analyzes the underlying basic German, European, and worldwide conditions that provide the setting for the production and promotion of biofuels. It is shown that the production of bio-ethanol in Germany is not competitive and that imports are likely to increase. Using energy and greenhouse-gas balances we then demonstrate that the promotion and a possible increased use of bio-ethanol to reduce greenhouse-gas emissions are economically inefficient and that there are preferred alternative strategies. In addition, scenarios of the future development of the bio-ethanol market are derived from a model that allows for variations in all decisive variables and reflects the entire production and trade chain of bio-ethanol, from the agricultural production of wheat and sugar beet to the consumption of bio-ethanol in the fuel sector

Summary: The use of sugar beet and wheat to produce bio-ethanol in Germany indeed induces savings in fossil fuel energy (much better results with sugar beet than with wheat), nevertheless other options for

land use, in particular the use of agricultural land for the cultivation of fast growing wood to produce electricity, perform better. In terms of GHG savings they seem negative in the case of bio-ethanol production from wheat, positive in that of bio-ethanol production from sugar beet (4 tons per hectare respect to the production of gasoline fuel). But the cost of doing so should not exceed 30 Euro/ton CO₂ abated which is the abatement cost estimated at the EU level, should Kyoto commitment be fulfilled. Unfortunately the cost ranges between 300 and 1000 Euro/ton CO₂. More efficient GHG reduction can be obtained elsewhere.

Political and technical measures assess 2002 tax exemption for biofuel and biofuel production from sugar beet and wheat.

Keywords: GEOGRAPHIC-Germany/GHG AFFECTED-CO₂/SECTOR-Energy/OBJECTIVE-Emission reduction/MEASURE-MBI/APPROACH-Review.

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Abstract: In Sweden, wood fuels are traditionally used in the Swedish forest products industry and for heating of single-family houses. More recently they are also become established as an energy source for district heating and electricity production. Energy policy, especially the energy taxation system, has favoured wood fuels and other biofuels, mainly for environmental reasons. There is now an established commercial market for wood fuels in the district heating sector, which amounts to 45 PJ and is growing 20 per cent annually. Price levels have been stable in current prices for a decade, mainly because of good access to wood fuels. Price levels are dominated by production costs on a market that is largely governed by the buyer. It is expected that the use of wood fuels will increase in Sweden in the future, which will push a further development of this sector on the market and bring about technological changes in the area

Summary: Analysis of development trends in the Swedish wood fuel market.

Keywords: WOOD FUEL MARKETS/PRODUCTION COSTS/WOOD FUELS/DISTRICT HEATING SECTOR/PRICE DEVELOPMENT/GEOGRAPHIC-Scandinavia/GHG AFFECTED-NA/SECTOR-Energy/OBJECTIVE-Energy saving/MEASURE-NA/APPROACH-descriptive.

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Abstract: Bioenergy has several advantages over fossil fuels. For example, it delivers energy at low net CO₂ emission levels and contributes to sustaining future energy supplies. The concern, however, is that an increase in biomass plantations will reduce the land available for agricultural production. The aim of this study is to investigate the effect of taxing conventional electricity production or carbon use in combination with subsidizing biomass or bioelectricity production on the production of biomass and agricultural commodities and on the share of bioelectricity in total electricity production. We develop a partial equilibrium model to illustrate some of the potential impacts of these policies on greenhouse gas emissions, land reallocation and food and electricity prices. As a case study, we use data for Poland, which has a large potential for biomass production. Results show that combining a conventional electricity tax of 10% with a 25% subsidy on bioelectricity production increases the share of bioelectricity to 7.5%. Under this policy regime, biomass as well as agricultural production increase. A carbon tax that gives equal net tax yields, has better environmental results, however, at higher welfare costs and resulting in 1% to 4% reduction of agricultural production.

Keywords: BIOMASS/BIOENERGY/ENERGY POLICY/PARTIAL EQUILIBRIUM MODEL/GEOGRAPHIC-Poland/GHG AFFECTED-CO₂/SECTOR-Energy/OBJECTIVE-Emission reduction/MEASURE-MBI/APPROACH-Economic.

Available at: http://www.sciencedirect.com/science?_ob=MIimg&_imagekey=B6V2W-4DTTDS-1-C&_cdi=5713&_user=606295&_orig=search&_coverDate=11%2F18%2F2004&_sk=999999999&view=c&wchp=dGLbVtb-zSkz&md5=d4dbfde7f106d46bc01cce62bcf76a09&ie=/sdarticle.pdf

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Abstract: Energy is a vital input for social and economic development of any nation. With increasing agricultural and industrial activities in the country, the demand for energy is also increasing. Formulation of an energy model will help in the proper allocation of widely available renewable energy sources such as solar, wind,

bioenergy and small hydropower in meeting the future energy demand in India. During the last decade several new concepts of energy planning and management such as decentralized planning, energy conservation through improved technologies, waste recycling, integrated energy planning, introduction of renewable energy sources and energy forecasting have emerged. In this paper an attempt has been made to understand and review the various emerging issues related to the energy modeling. The different types of models such as energy planning models, energy supply–demand models, forecasting models, renewable energy models, emission reduction models, optimization models have been reviewed and presented. Also, models based on neural network and fuzzy theory have been reviewed and discussed. The review paper on energy modeling will help the energy planners, researchers and policy makers widely.

Keywords: ENERGY MODELS/ FORECASTING MODEL/OPTIMIZATION MODEL/FUZZY LOGIC/NEURAL NETWORKS/GEOGRAPHIC-India/GHG AFFECTED-CO2/SECTOR-Energy/OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-Review.

Available at: http://www.sciencedirect.com/science?_ob=MIimg&_imagekey=B6VMY-4DS7NYR-1-1&_cdi=6163&_user=606295&_orig=search&_coverDate=12%2F15%2F2004&_sk=999999999&view=c&wchp=dGLbVzz-zSkWz&md5=ea6eefda822b63ad80329193165ecd39&ie=/sdarticle.pdf

37. Kaiser, H. M., An annotative bibliography of research on the economic effects of climate change on agriculture. 94;94: 10.

Abstract: Anthropogenic emissions of carbon dioxide and other "greenhouse" gases have the potential to substantially warm climates worldwide. While the timing and magnitude of global warming is uncertain, scientists on the Intergovernmental Panel on Climate Change (IPCC) predict that average global temperature may increase by 1.5- 4.5°C (2.7-8.1°F) over the next 100 years. Changes in precipitation will likely accompany any changes in temperature. However, the magnitude, and even direction of these changes is difficult to predict with much confidence on a regional basis. The agricultural sector may be profoundly affected by future changes in temperature, precipitation, solar radiation, and carbon dioxide concentrations. Over the past decade, there has been a growing body of research examining the potential impacts of climate change on agriculture. The purpose of this paper is to report and summarize recent research on the potential economic impacts of global climate change on agriculture. To that end, an annotative bibliography of articles is presented in this paper.

Keywords: CLIMATE/CHANGE/AGRICULTURE/GEOGRAPHIC-NA/GHG AFFECTED-all/SECTOR-agriculture/OBJECTIVE-NA/MEASURE-NA/APPROACH-Review/APPROACH-Economic.

Available at: http://agecon.lib.umn.edu/cgi-bin/pdf_view.pl?paperid=4&ftype=.pdf

38. Kuemmel, B., Langer, V., Magid, J., De Neergaard, A., and Porte, J. R., Energetic, economic and ecological balances of a combined food and energy system. 98;15: 4-5:407-416.

Abstract: **Summary:** A mixed bio fuel and food production system is economically viable (NPV of investment 3800/Euro/hectare) and can induce social cost savings in the order of 368, 302, 220 Euro/hectare/year or of 3.2, 2.7, 1.9 Euro/Gj in case of substitution of coal, fuel oil and natural gas respectively.

Keywords: BIOFUEL/AGROFORESTRY/ECOLOGICAL FARMING/EXTERNALITIES/SOCIAL COSTS/STE-ASIDE SUPPORT/ECONOMIC VIABILITY/GREENHOUSE EFFECT/GEOGRAPHIC-NA/GHG AFFECTED-CO2/SECTOR-agriculture/SECTOR-Energy/OBJECTIVE-Emission reduction/OBJECTIVE-Energy saving/MEASURE-NA/APPROACH-Economic .

Available at: http://www.sciencedirect.com/science?_ob=MIimg&_imagekey=B6V22-3V45PBB-H-1&_cdi=5690&_user=606295&_orig=browse&_coverDate=12%2F31%2F1998&_sk=999849995&view=c&wchp=dGLbVtb-zSkWz&md5=d8989096a288c552d8788d4eecec7b58&ie=/sdarticle.pdf

39. Lekkerkerk, L. J., Implications of Dutch ammonia policy on the livestock sector. 98;32: 3:581-587.

Abstract: The Dutch livestock sector is responsible for large emissions of ammonia, resulting in an ammonia deposition that greatly exceeds the critical loads for nitrogen and acidifying compounds in a large part of the country. Based on critical loads and technical possibilities for emission reduction, targets for the deposition of ammonia have been defined. According to plans for the Netherlands, in the year 2000 the deposition of ammonia should be reduced to a maximum of 1000molcha-1yr-1. In 2010 the target is to further reduce the ammonia deposition to 600molcha-1yr-1. This study examines the consequences of this environmental policy for the Dutch livestock sector. The scenario's are also applicable to regions outside the Netherlands with high livestock density and high levels of ammonia emission and deposition. In most parts of the Netherlands, planned policy measures to abate ammonia emissions are expected to achieve the ammonia deposition target of 1000molcha-1yr-1. However, extra measures are necessary in regions with non-calcareous sandy soils, which are sensitive to acidification and where livestock density is high. The deposition target can be reached in these regions (mostly in the central, eastern and southern part of the country) by a combination of extra adaptations of animal housing systems to reduce ammonia emissions,

together with relocation of holdings to other regions. If the more stringent deposition target of 600 molcha-1yr-1 is to be reached, more efforts from the livestock sector will be required. In most parts of the Netherlands housing systems with low emission rates should reduce the deposition sufficiently. In the central, eastern and southern parts it is impossible to reach the deposition target for ammonia of 600 molcha-1yr-1 with just technical measures. To meet this target will require a radical contraction of the livestock sector in these regions. Additional to measures in the Netherlands, it is important that the import of ammonia from neighbouring countries also be reduced.

Keywords: ENVIRONMENT/EMISSION/DEPOSITION TARGET /ACIDIFICATION/LIVESTOCK HOUSING/GEOGRAPHIC-The Netherlands/GHG AFFECTED-NH3/SECTOR-agriculture/OBJECTIVE-Emission reduction/MEASURE-AII/APPROACH-descriptive.

Available at: <http://www.ingentaconnect.com/content/els/13522310/1998/00000032/00000003/art00019;jsessionid=22jlr7opnomb.henrietta>

40. Lettens, S., Muys, B., Ceulemans, R., Moons, E., J. García, J., and Coppin, P., Energy Budget and Greenhouse Gas Balance Evaluation of Sustainable Coppice Systems for Electricity Production. 2003;24: 3:179-197.

Abstract: The use of bio-energy crops for electricity production is considered an effective means to mitigate the greenhouse effect, mainly due to its ability to substitute fossil fuels. A whole range of crops qualify for bio-energy production and a rational choice is not readily made. This paper evaluates the energy and greenhouse gas balance of a mixed indigenous hardwood coppice as an extensive, low-input bio-energy crop. The impact on fossil energy use and greenhouse gas emission is calculated and discussed by comparing its life cycle (cultivation, processing and conversion into energy) with two conventional bio-energy crops (short rotation systems of willow and Miscanthus). For each life cycle process, the 50ws of fossil energy and greenhouse gas that are created for the production of one functional unit are calculated. The results show that low-input bio-energy crops use comparatively less fossil fuel and avoid more greenhouse gas emission per unit of produced energy than conventional bio-energy crops during the 6rst 100 yr. Where the mixed coppice system avoids up till 0:13 t CO₂ eq./GJ, Miscanthus does not exceed 0:07 t CO₂ eq./GJ. After 100 yr their performances become comparable, amounting to 0:05 t CO₂ eq./ha/GJ. However, if the land surface itself is chosen as a functional unit, conventional crops perform better with respect to mitigating the greenhouse e/ect. Miscanthus avoids a maximum of 12:9 t CO₂ eq./ha/yr, while mixed coppice attains 9:5 t CO₂ eq./ha/yr at the most.

Keywords: BIO-ENERGY/BIO-ENERGY CROP/LIFE CYCLE/GREENHOUSE E/ECT/FOSSIL ENERGY USE/MISCANTHUS/WILLOW/MIXED COPPICE/GEOGRAPHIC-NA/GHG AFFECTED-all/SECTOR-Energy/OBJECTIVE-Energy saving/OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-modelling.

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41. Martin, S. and Seeland, G., Effects of specialisation in cattle production on ecologically harmful emissions. 99;61: 2-3:171-178.

Abstract: The effects of intensification in dairy cattle upon ecologically harmful emissions was investigated using a theoretical model of change in the traits of a dairy cattle population under selection. The demand for milk by the consumer was assumed to be a constant. Therefore, an increase in milk yield per cow and per year would lead to a reduced dairy cattle population with a lowered capacity for beef production. The effects of compensating the reduction of beef output from the dairy cattle population by additional rearing of purebred beef cattle was simulated. The amount of nitrogen (N), phosphorus (P) and methane (CH₄) emitted by the two different production systems is used to measure their degree of environmental compatibility. Limits in voluntary feed intake play an important role in the input / output relationships and were given important emphasis in the modelling process. Despite a reduction in the size of the total population (both dairy and beef cows) needed to maintain milk and beef protein production, the calculated corresponding emissions of N, P and CH₄ were 4 increased by 0.5 to 3.0%.

Keywords: DAIRY AND BEEF CATTLE/GENETIC PROGRESS/ENVIRONMENTAL PROTECTION/MODEL CALCULATION/EMISSION REDUCTION/GEOGRAPHIC-NA/GHG AFFECTED-N2O/GHG AFFECTED-CH4/SECTOR-agriculture/OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-modelling.

Available at: http://www.sciencedirect.com/science?_ob=MIimg&_imagekey=B6T9B-3XNK1RB-8-H&_cdi=5110&_user=606295&_orig=search&_coverDate=10%2F31%2F1999&_sk=999389997&view=c&wchp=dGLbVlb-zSkzS&md5=558900986cc4b083710c842d1ea2e5b7&ie=/sdarticle.pdf

42. McCarl, B. A. and Schneider, U. A., Greenhouse Gas Mitigation in U.S. Agriculture and Forestry. 2001;294:2481-2482.

Abstract: No abstract.

Keywords: GEOGRAPHIC-USA/GHG AFFECTED-all/SECTOR-agriculture/SECTOR-forestry/OBJECTIVE-Emission reduction/ MEASURE-All/APPROACH-modelling/APPROACH-Economic .

Available at: <http://www.sciencemag.org/cgi/reprint/294/5551/2481.pdf>

43. Nevens, F., Ciudad, V. G., Reheul, D., and Mathijs, E., Energy Crops in Flemish Agriculture: Possibilities and Limits. OECD Workshop on "Biomass and agriculture" .

Abstract: To determine if and how energy crops can be an appropriate track to produce green energy in Flanders, we studied the energy yields and energy efficiency (output: input ratio) of potential crops in Flemish circumstances. Provided that heat is recovered to a considerable extent, combustion of wood from short rotation coppices provides most green energy at the highest efficiency. However, i) covering the requirement for green electricity (6% of annual use) by these crops would take half of our currently utilised agricultural area; and ii) from a farm economical point of view, the best option resulted in a financial yield that was EUR 300 below the current actual yields in arable rotations. Growing crops for biofuels is less efficient and provides less energy per ha. Winter rape was the most interesting crop but i) it can hardly be fitted into the currently applied arable rotations (with sugarbeet) and ii) even without imposing taxes, the resulting biofuel is not competitive with fossil fuels. We conclude that in the small region of Flanders, where open space is rather scarce, energy crops are not the obvious track towards the use of green energy. Other possibilities, such as wind or solar energy, along with importing fuel (*e.g.* biodiesel) from countries with scale advantages seem appropriate.

Keywords: GEOGRAPHIC-Flemish/GHG AFFECTED-all/SECTOR-agriculture/SECTOR-Energy/OBJECTIVE-energy saving/MEASURE-NA/APPROACH-descriptive.

Available at: <http://webdomino1.oecd.org/comnet/agr/BiomassAg.nsf>

44. Nyström, I. and Cornland, D. W., Strategic choices: Swedish climate intervention policies and the forest industry's role in reducing CO₂ emissions. 2003;31: 10:937-950.

Abstract: Given adequate incentive, the forest industry could play a significant role in achieving Swedish objectives for reducing CO₂ emissions. Whether or not this potential can be harnessed depends on the types of energy policy interventions that are introduced. An analysis of the potential impacts of four policy-intervention strategies on the forest industry is presented in this article. The focus of the analysis is on the four strategies' impacts on forest industry electricity demand from, and renewable energy supply to, the energy system. The strategies analyzed include a reference strategy and strategies targeting electricity production, transportation and the energy system as a whole. The method applied combines scenario analysis with systems engineering modeling. Separate scenario sets were used to reflect visions of development from the forest industry and the energy sector. Separate models were used to enable a more in-depth analysis of the forest industry's role than is commonly the case in energy systems engineering studies.

Keywords: ENERGY SYSTEMS ENGINEERING MODELING/INDUSTRIAL ENERGY DEMAND/PULP AND PAPER/GEOGRAPHIC-Scandinavia/GHG AFFECTED-CO2/SECTOR-forestry/ SECTOR-Energy/OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-modelling.

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45. Oenema, O., Kukman, P., and Velthof, G., Assessment and Mitigation of Greenhouse Gas Emissions at Farm Level. International Conference on "Greenhouse Gas Emissions from Agriculture - Mitigation Options and Strategies" . 2004.

Abstract: No abstract.

Keywords:

46. Oenema O., Velthof G. , and Kuikman P., Technical and policy aspects of strategies to decrease greenhouse gas emissions from agriculture. 2001;60: 1-3:301-315.

Abstract: Agricultural activities greatly contribute to the global net flux of CH₄, N₂O and CO₂ from the terrestrial biosphere into the atmosphere. For CH₄ and N₂O, the net contribution is in the order of 40%. Because of this relatively large contribution, there is an urgent need for the implementation of effective strategies to decrease the net flux of CH₄, N₂O and CO₂ from agriculture. The objectives of this paper are to review the various measures that have been proposed so far and to discuss the constraints and challenges. A large number of suggestions for decreasing emissions of CH₄, N₂O and CO₂ from

agriculture can be found in literature. Common to most of these abatement measures is that the suggested potentials to decrease the emissions of CO₂, CH₄ and N₂O from agriculture are large. Common to most of the measures is also the 'single gas' and 'source-oriented' approach. In most papers it has been implicitly assumed that farmers are able and willing to implement the proposed measures. So far, none of the measures has been consciously implemented and tested at farm scale. The major challenge of policy makers is to formulate effective and efficient policies and measures, using the potentials of the abatement measures proposed so far, and in an international setting with still highly uncertain cause-effect relationships. Major constraints for policy makers follow from the complexities and possible feed back and side effects of abatement measures, from the many stakeholders involved, often with contrasting views, and from the unfamiliarity of farmers with the problem of climate change. Because of the many complexities and interactions involved, policy makers should follow two tracks. Priority should be given to chain-oriented measures, i.e. measures that aim at an increased carbon, nitrogen and water use efficiencies in the whole food chain, above source-oriented measures, i.e. measures that aim at decreased emission from specific sources. Chain-oriented measures should fit in with other environmental policies that aim at increasing resource use efficiency, to be effective and efficient.

Keywords: agriculture/carbon dioxide/greenhouse gas emissions/methane/nitrous oxide/policies and measures/GEOGRAPHIC-World/GHG AFFECTED- CH4/GHG AFFECTED-CO2/GHG AFFECTED-N2O/SECTOR-agriculture/OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-Review.

Available at:
<http://www.springerlink.com/media/N49BCY7F5K0TQNF02J3Y/Contributions/K/N/0/5/KN05834245053V61.pdf>

47. Olesen, J. E. and Bindi, M., Consequences of climate change for European agricultural productivity, land use and policy. 2002;16: 4:239-262.

Abstract: This paper reviews the knowledge on effects of climate change on agricultural productivity in Europe and the consequences for policy and research. Warming is expected to lead to a northward expansion of suitable cropping areas and a reduction of the growing period of determinate crops (e.g. cereals), but an increase for indeterminate crops (e.g. root crops). Increasing atmospheric CO₂ concentrations will directly enhance plant productivity and also increase resource use efficiencies. In northern areas climate change may produce positive effects on agriculture through introduction of new crop species and varieties, higher crop production and expansion of suitable areas for crop cultivation. Disadvantages may be an increase in the need for plant protection, the risk of nutrient leaching and the turnover of soil organic matter. In southern areas the disadvantages will predominate. The possible increase in water shortage and extreme weather events may cause lower harvestable yields, higher yield variability and a reduction in suitable areas for traditional crops. These effects may reinforce the current trends of intensification of agriculture in northern and western Europe and extensification in the Mediterranean and southeastern parts of Europe. Policy will have to support the adaptation of European agriculture to climate change by encouraging the flexibility of land use, crop production, farming systems etc. In doing so, it is necessary to consider the multifunctional role of agriculture, and to strike a variable balance between economic, environmental and social functions in different European regions. Policy will also need to be concerned with agricultural strategies to mitigate climate change through a reduction in emissions of methane and nitrous oxide, an increase in carbon sequestration in agricultural soils and the growing of energy crops to substitute fossil energy use. The policies to support adaptation and mitigation to climate change will need to be linked closely to the development of agri-environmental schemes in the European Union Common Agricultural Policy. Research will have further to deal with the effect on secondary factors of agricultural production, on the quality of crop and animal production, of changes in frequency of isolated and extreme weather events on agricultural production, and the interaction with the surrounding natural ecosystems. There is also a need to study combined effects of adaptation and mitigation strategies, and include assessments of the consequences on current efforts in agricultural policy to develop a sustainable agriculture that also preserves environmental and social values in the rural society.

Keywords: GLOBAL WARMING/CLIMATE CHANGE/CROPS/LIVESTOCK/POLICY/IMPACT ASSESSMENT/ADAPTATION/MITIGATION/EUROPEAN AGRICULTURE/GEOGRAPHIC-Europe/GHG AFFECTED-All/SECTOR-agriculture/OBJECTIVE-NA/MEASURE-NA/APPROACH-Review.

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48. Oude Lansink, A., Non parametric modelling of CO₂ Emission Quota . 89th EAAE Seminar: " Modelling agricultural policies: state of the art and new challenges" . 2005.

Abstract: Dutch glasshouse firms are facing the introduction of a system of tradable CO₂ emission quota. Also, the firms will be faced with a cut of CO₂ emissions of approximately 5% by the year 2010. This paper employs a nonparametric method for modeling tradable CO₂ emissions of Dutch glasshouse firms. The method is capable of generating shifts in CO₂ emissions across the sample of firms. Also, changes in volumes of outputs produced and inputs used are computed. Results show that firms using a conventional heating technology will be net purchasers of CO₂ emissions, whereas firms using more advanced heating technologies will sell part of their emission quota.

Keywords: DEA/CO₂ EMISSIONS/TRADABLE EMISSIONS/NON-PARAMETRIC MODELLING/GEOGRAPHIC-The Netherlands/GHG AFFECTED-CO₂/SECTOR-agriculture/OBJECTIVE-Emission reduction/MEASURE-MBI/APPROACH-economic.

Available at: http://www.unipr.it/arpa/dipseq/EAAE/PR/Parallel/31b3_lansink.pdf

49. Oude Lansink, A., Technical efficiency and CO₂ abatement policies in the Dutch glasshouse industry. 2003;28:99-108.

Abstract: This paper develops a short-run microeconomic simulation model of the Dutch glasshouse industry in order to investigate the relation between technical efficiency and marginal abatement costs of CO₂ emission. The model is also used to determine the effects of an emission tax and systems of tradable and non-tradable quota for groups of firms with different rates of technical efficiency. The results show that marginal abatement costs are very responsive to changes in technical efficiency. Furthermore, it is found that firms with a low technical efficiency are faced with a higher profit reduction under different abatement policies than firms with a high technical efficiency.

Keywords: CO₂ EMISSION/TECHNICAL EFFICIENCY/MICROECONOMIC SIMULATION MODEL/PANEL DATA/GEOGRAPHIC-The Netherlands/GHG AFFECTED-CO₂/SECTOR-agriculture/OBJECTIVE-Emission reduction/MEASURE-MBI/APPROACH-Economic.

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50. Pacini, C., Wossink, A., Giesen, G., and Huirne, R., Ecological-economic modelling to support multi-objective policy making: a farming systems approach implemented for Tuscany. 2004;102: 3:349-364.

Abstract: Currently, there is a major concern regarding agri-environmental issues. Farmers are viewed not only as food suppliers but also as the custodians of the countryside. This role of farmers has been officially acknowledged in the EU Common Agricultural Policy (CAP) through a number of regulations that enforce agri-environment schemes and cross-compliance. However, under some circumstances these regulations have proved to be ineffective. Organic farming can play an important role for agri-environment schemes. The main aim of this study is to show the relevance of the assessment of the environmental performance of conventional and organic farming systems for the development of efficient agri-environment schemes. An holistically designed ecological-economic model was applied under current EU regulations and different policy scenarios. The model is based on a standard linear programming farm model extended with emission and evaluation figures retrieved from ecological models. Spatial aspects, such as pedo-climatic conditions, were included in the model. The approach was implemented for the case of northern Tuscany. Results indicated that organic farming systems (OFSs) were environmentally more beneficial than conventional farming systems (CFSs) and that current CAP market and income support schemes gave cause for an intensification of farm production and for an increase of environmental harm. They also showed that conventional farmers willing to produce environmental performances comparable to those of organic agriculture or to comply with environmental sustainability thresholds (ESTs) incur opportunity costs due to the need of application of organic crop management and/or extensification of the crop plan. Conclusions were drawn on the environmental performances of OFSs and CFSs, the impact of EU policies on sustainability of agriculture, opportunity costs of environmental benefits and on the practical use of the modelling framework for policy design.

Keywords: ECOLOGICAL-ECONOMIC MODELLING/MULTI-OBJECTIVE POLICY-MAKING/FARMING SYSTEMS/ENVIRONMENTAL EXTERNALITIES/OPPORTUNITY COST/TUSCANY/ABATEMENT/GEOGRAPHIC-Italy/GHG AFFECTED-NA/SECTOR-agriculture/OBJECTIVE-NA/MEASURE-MBI/MEASURE-Regulation/APPROACH-modelling.

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51. Parris, K., Agriculture, biomass, sustainability and policy: an overview. OECD Workshop on "Biomass

and agriculture" .

Abstract: No abstract.

Keywords: AGRICULTURE/SUSTAINABILITY/POLICY/GEOGRAPHIC-OECD/GHG AFFECTED-AII/SECTOR-agriculture/OBJECTIVE-NA/MEASURE-AII/APPROACH-descriptive.

Available at: <http://webdomino1.oecd.org/comnet/agr/BiomassAg.nsf>

52. Pautsch, G. R., Kurkalova, L. A., Babcock, B. A., and Klingy, C. L., The efficiency of sequestering carbon in agricultural soils . 2001;19: 2:123-134.

Abstract: Agricultural tillage practices are important human-induced activities that can alter carbon emissions from agricultural soils and have the potential to contribute significantly to reductions in greenhouse gas emission (Lal et al., The Potential of U.S. Cropland, 1998). This research investigates the expected costs of sequestering carbon in agricultural soils under different subsidy and market-based policies. Using detailed National Resources Inventory data, we estimate the probability that farmers adopt conservation tillage practices based on a variety of exogenous characteristics and profit from conventional practices. These estimates are used with physical models of carbon sequestration to estimate the subsidy costs of achieving increased carbon sequestration with alternative subsidy schemes.

Keywords: GEOGRAPHIC-USA/GHG AFFECTED-CO2/SECTOR-agriculture/OBJECTIVE-Sequestration/MEASURE-MBI/APPROACH-economic.

Available at: <http://www.card.iastate.edu/publications/DBS/PDFfiles/00wp246.pdf>

53. Petersen, A. K. and Solberg, B., Environmental and economic impacts of substitution between wood products and alternative materials: a review of micro-level analyses from Norway and Sweden. 2005;7: 3:249-259.

Abstract: This article gives a state of the art overview on quantitative analyses from Norway and Sweden of Life cycle analyses (LCA), which compare the environmental impacts of substitution between wood and alternative materials, with emphasis on greenhouse gas (GHG) emissions, economics and methodological issues. In all studies referred to this overview, wood is a better alternative than other materials with regard to GHG emissions. Furthermore, wood is causing less emissions of SO₂ and generates less waste compared to the alternative materials. Preservative treated wood, on the other hand, might have toxicological impacts on human health and ecosystems. Impacts on acidification, eutrophication and creation of photochemical ozone vary in different comparisons. Amount of greenhouse gases avoided due to substitution between wood and steel is in the range of 36–530 kg CO₂-equivalents per m³ input of timber with 4% discount rate; depending on waste management of the materials, and how carbon fixation on forest land is included. This amount is 93–1062 kg CO₂-equivalents for substitution between wood and concrete, if the wood is not landfilled after use. Many of the LCAs could be considerably improved, if the analyses were done with several alternative assumptions regarding boundaries of the system used in the LCA. This is important, not least to map what are the main assumptions for the results obtained and to compare with other studies. It is also important to consider the time-profile of the GHG emissions and other impacts over the life-cycle—it is surprising that this is not taken more seriously. Wood as a building material is competitive on price in those studies that include costs. It is a weak point of many LCAs that costs as well as other economic aspects influencing product substitution are not included, and a major research challenge is to combine traditional LCA with economic analysis in order to make both more policy relevant. In particular, one should develop dynamic input-output models where price and income substitutions as well as technological changes and cost components are included endogenously.

Keywords: LIFE-CYCLE-ASSESSMENT (LCA)/SUBSTITUTION/COST-EFFECTIVENESS/ECONOMICS/WOOD/STEEL/CONCRETE/GEOGRAPHIC-Scandinavia/GHG AFFECTED-CO2/SECTOR-forestry/ OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-Review.

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54. Prisley, S. P. and Mortimer, M. J., A synthesis of literature on evaluation of models for policy applications, with implications for forest carbon accounting. 2004;198: 1-3:89-103.

Abstract: Forest modeling has moved beyond the realm of scientific discovery into the policy arena. The example that motivates this review is the application of models for forest carbon accounting. As negotiations determine the terms under which forest carbon will be accounted, reported, and potentially traded, guidelines and standards are being developed to ensure consistency, accuracy, transparency and verifiability. To date, these guidelines have focused on definitions, data, and reporting, not models. The

goal of this paper is to synthesize literature that may inform the development of guidelines for the application of models in areas with policy implications, such as forest carbon accounting. We discuss validation, verification, and evaluation as applied to modeling, and review common components of model evaluation. Peer review, quantitative analysis of model results, and sensitivity analysis are the most widely used approaches to model evaluation. US judicial and legislative perspectives on criteria for model acceptability are summarized.

Keywords: FOREST MODELS/ VALIDATION/VERIFICATION/SENSITIVITY ANALYSIS/GEOGRAPHIC-USA/GHG AFFECTED-CO2/SECTOR-forestry/OBJECTIVE-Sequestration/MEASURE-AII/APPROACH-Review.

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55. Pérez, I. and Holm-Müller, K., Economic incentives and technological options to global warming emission abatement in European agriculture. 89th EAAE Seminar: "Modelling agricultural policies: state of the art and new challenges". 2005.

Abstract: In this paper, a brief overview on different economic aspects of greenhouse gas emission abatement in European agriculture is given. Three different typologies of emission mitigation approaches are defined and analysed from a modelling perspective: structural, management and technological measures. Their practical implementation in the CAPRI model is then presented and some selected model results used to analyse the following questions: what is the effect of emission abatement regulation on European agriculture? and are there any indirect environmental benefits to be expected from current CAP reform?

Keywords: CLIMATE CHANGE/AGRICULTURAL MODELLING/CAP REFORM/ABATEMENT INSTRUMENTS/GEOGRAPHIC-Europe/GHG AFFECTED-AII/SECTOR-agriculture/OBJECTIVE-Emission reduction/MEASURE-Regulation/APPROACH-modelling.

Available at: http://www.unipr.it/arpa/dipseq/EAAE/PR/Parallel/40a3_perez.pdf

56. Raven, R. P., Implementation of manure digestion and co-combustion in the Dutch electricity regime: a multi-level analysis of market implementation in the Netherlands. 2004;32: 1:29-39.

Abstract: Energy from biomass is expected to be the most important renewable energy source in the Netherlands on the short term. Nevertheless, the implementation of many projects using biomass is considerably delayed, while other projects are abandoned. In this paper, the discrepancy between national policy goals on the one hand and actual implementation on the other is therefore investigated. A multi-level model is introduced in which technological development is understood as the interaction of developments at the level of technological regimes, niches and the broader context of the socio-technical landscape. Subsequently, the model is used to analyze the developments in the electricity regime and the niches for manure digestion and co-combustion. The main conclusion is that the delay of the projects is explained not only by a lack of stability within the electricity regime, but also by a mismatch of the rules of respectively the agricultural regime and the waste regime.

Keywords: ELECTRICITY SECTOR/BIOMASS/MARKET IMPLEMENTATION/GEOGRAPHIC-The Netherlands/GHG AFFECTED- CH4/SECTOR-Energy/SECTOR-agriculture/OBJECTIVE-energy saving/MEASURE-Regulation/APPROACH-modelling.

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57. Richards K.R. and Stokes, C., A review of forest carbon sequestration cost studies: A dozen years of research. 2004;63: 1-2:1-48.

Abstract: Researchers have been analyzing the costs of carbon sequestration for approximately twelve years. The purpose of this paper is to critically review the carbon sequestration cost studies of the past dozen years that have evaluated the cost-effectiveness of the forestry option. Several conclusions emerge. While carbon sequestration cost studies all contain essentially the same components they are not comparable on their face due to the inconsistent use of terms, geographic scope, assumptions, program definitions, and methods. For example, there are at least three distinct definitions for a 'ton of carbon' that in turn lead to significantly different meanings for the metric 'dollars per ton of carbon'. This difference in carbon accounting further complicates comparison of studies. After adjusting for the variation among the studies, it appears that carbon sequestration may play a substantial role in a global greenhouse gas emissions abatement program. In the cost range of 10 to 150 dollars per ton of carbon it may be possible to sequester 250 to 500 million tons per year in the United States, and globally upwards of 2,000 million tons per year, for several decades. However, there are two unresolved issues that may seriously affect the contribution of

carbon sequestration to a greenhouse gas mitigation program, and they will likely have counteracting effects. First, the secondary benefits of agricultural land conversion to forests may be as great as the costs. If that is the case, then the unit costs essentially disappear, making carbon sequestration a no-regrets strategy. In the other direction, if leakage is a serious issue at both the national and international levels, as suggested by some studies, then it may occur that governments will expend billions of dollars in subsidies or other forms of incentives, with little or no net gain in carbon, forests or secondary benefits. Preliminary results suggest that market interactions in carbon sequestration program analyses require considerably more attention. This is especially true for interactions between the forest and agricultural land markets and between the wood product sink and the timber markets.

Keywords: GEOGRAPHIC-NA/ GHG AFFECTED-CO2/SECTOR-forestry/OBJECTIVE-Sequestration/MEASURE-NA/APPROACH-Review.

Available at:
<http://www.springerlink.com/media/34UULBXVVM5RYPJ5NRE7/Contributions/P/2/1/N/P21N67K61417871L.pdf>

58. Riedy, C., A Framework for economic analysis of greenhouse abatement options. National Workshop of the Economics and Environment Network .

Abstract: Economic analysis has been central to the development of greenhouse abatement policy in Australia. Current Australian policy is to remain outside the Kyoto Protocol, while still attempting to meet the emission targets established under the Protocol. Australia's failure to ratify the Protocol has incurred international criticism; it is therefore appropriate to examine the validity of the economic analysis used to support this policy position. This paper reviews approaches to economic analysis that have been prominent in the greenhouse policy debate in Australia, including computable general equilibrium modelling, bottom-up energy sector modelling and policy-specific cost benefit analysis. Alternative approaches that have received less attention in Australia are also reviewed. Flaws in existing economic analyses include a failure to consider the net cost to society of greenhouse abatement measures, a tendency to exclude abatement benefits, inadequate consideration of ethical and moral issues, a lack of accessibility and the assumption that economic systems are in an optimal equilibrium state. In response to these flaws, an alternative approach to economic analysis termed 'integrated abatement planning' is developed. Integrated abatement planning draws on the principles of least cost planning and integrated resource planning to identify least cost greenhouse abatement measures. A primary tool is the marginal abatement cost curve, which plots abatement measures according to their total abatement over a specified time period and the marginal cost of abatement. The approach is based on an explicit ethical position that values inter-generational and intra-generational equity. Integrated abatement planning is intended as a simple, practical approach that can be used by policy makers to explore the balance between long- and short-term objectives, to test the impact of varying assumptions, and to identify a robust set of measures for meeting politically determined greenhouse reduction targets. It draws on evolutionary economic theory, notably the insight that selected policies will always be sub-optimal but will provide opportunities for learning and continual improvement of policy. Integrated abatement planning offers a way to move beyond arguments about whether greenhouse abatement is required and to focus, more productively, on the best ways to achieve abatement

Summary: Description of methodological approaches and investigation tools used to assess Greenhouse abatement options.

Keywords: GEOGRAPHIC-Australia/GHG AFFECTED- CH4/GHG AFFECTED-N2O/GHG AFFECTED-CO2/SECTOR-AII/OBJECTIVE-Emission reduction/MEASURE-Regulation/APPROACH-Review.

Available at: <http://www.isf.uts.edu.au/publications/RiedyEEN.pdf>

59. Rosenqvist, H., Roos, A., Ling, E., and Hektor, B., Willow growers in Sweden. 2000;18: 2:137-145.

Abstract: The number of willow plantations on Swedish farmland increased considerably between 1991 and 1996. The main driving forces behind this development were: (1) The introduction in 1991 of a new agricultural policy in Sweden which, through deregulation, created lower grain prices and simultaneously introduced compensation for set-aside land as well as subsidies for willow plantations on surplus arable land; (2) higher taxes on fossil fuels; and (3) the existence of a biofuel market in Sweden based on forest fuels. This paper presents a statistical study of willow growers in southern and central-eastern Sweden. Data about willow growers and a stratified random sample of non willow growers were acquired from the 1995 Farm Register compiled by Statistics Sweden. Willow growers are described according to geographical distribution, willow parcel sizes, farm sizes, and farm types. Comparisons are also made with the population of farmers who are not growing willow. A high concentration of willow growers is

recorded for central Sweden around Lake Mälaren. Willow growers are more often in the age span 50±65 years, and as compared to non-willow growers, have larger farms. They are less often focused on animal and milk production, and more often on cereal and food crop production, when compared with other farmers. Implications of the Swedish experience for policy making in the fields of energy and agriculture are discussed.

Keywords: SHORT ROTATION WOODY ENERGY CROPS/SRC/WILLOW COPPICE PLANTATIONS/BIOENERGY/SALIX/GEOGRAPHIC-Scandinavia/GHG AFFECTED-CO2/SECTOR-forestry/OBJECTIVE-NA/MEASURE-All/APPROACH-descriptive/APPROACH-economic.

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60. Rounsevell, M. D., Ewert, F., Reginster, I., Leemans, R., and Carter, T. R., Future scenarios of European agricultural land use. II: projecting changes in cropland and grassland. 2004.

Abstract: This paper presents the development of quantitative, spatially explicit and alternative scenarios of future agricultural land use in Europe (the 15 European Union member states, Norway and Switzerland). The scenarios were constructed to support analyses of the vulnerability of ecosystem services, but the approach also provides an exploration of how agricultural land use might respond to a range of future environmental change drivers, including climate and socio-economic change. The baseline year was 2000 and the scenarios were constructed for 3 years (2020, 2050 and 2080) at a spatial resolution of 10 min latitude and longitude. Time slices were defined for the climate scenarios as the 10 years before 2020, 2050 and 2080. The scenarios were based on an interpretation of the four storylines of the Special Report on Emission Scenarios (SRES) of the Intergovernmental Panel on Climate Change (IPCC) using a simple supply/demand model of agricultural area quantities at the European scale and the disaggregation of these quantities using scenario-specific, spatial allocation rules. The scenarios demonstrate the importance of assumptions about technological development for future agricultural land use in Europe. If technology continues to progress at current rates then the area of agricultural land would need to decline substantially. Such declines will not occur if there is a correspondingly large increase in the demand for agricultural goods, or if political decisions are taken either to reduce crop productivity through policies that encourage extensification or to accept widespread overproduction. For the set of parameters assumed here, cropland and grassland areas (for the production of food and fibre) decline by as much as 50% of current areas for some scenarios. Such declines in production areas would result in large parts of Europe becoming surplus to the requirement of food and fibre production. Although it is difficult to anticipate how this land would be used in the future, it seems that continued urban expansion, recreational areas (such as for horse riding) and forest land use would all be likely to take up at least some of the surplus. Furthermore, whilst the substitution of food production by energy production was considered in these scenarios, surplus land would provide further opportunities for the cultivation of bioenergy crops.

Keywords: LAND USE SCENARIOS/SPECIAL REPORT ON EMISSION SCENARIOS (SRES)/CLIMATE CHANGE/GEOGRAPHIC-Europe/GHG AFFECTED-All/SECTOR-forestry/SECTOR-agriculture/OBJECTIVE-NA/MEASURE-NA/APPROACH-modelling.

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61. Rozakis, S. and Sourie, JC, Micro-economic modelling of biofuel system in France to determine tax exemption policy under uncertainty. 2005;33: 2:171-182.

Abstract: Liquid biofuel support program launched in 1993 in France is implemented through tax exemptions to biofuels produced by agroindustrial chains. Activity levels are fixed by decree and allocated by the government to the different chains. Based on earmarked budget increase voted in the parliament, total quantity of biofuels will be increased by 50% in the horizon 2002–2003. A microeconomic biofuel activity model containing a detailed agricultural sector component, that is represented by 700 farms, is used to estimate costs and surpluses generated by the activity at the national level as well as tax exemption levels. Furthermore, Monte Carlo simulation has been used to search for efficient tax exemptions policies in an uncertain environment, where biofuel profitability is significantly affected by petroleum price and soja cake prices. Results suggest that, for the most efficient units both at the industry level (large size biomass conversion units) and at the agricultural sector level (most productive farms), unitary tax exemptions could be decreased by 10–20% for both biofuels, ethyl ether and methyl ester, with no risk for the viability of any existing chain.

Keywords: LIQUID BIOFUELS/MONTE CARLO SIMULATION/LP MODELLING/TAX EXEMPTION

POLICY/GEOGRAPHIC-France/GHG AFFECTED-CO₂/SECTOR-agriculture/SECTOR-Energy/OBJECTIVE-Emission reduction/OBJECTIVE-energy saving/MEASURE-MBI/APPROACH-modelling.

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62. Rozakis, S., Sourie, JC, and Vanderpooten, D., Integrated micro-economic modelling and multi-criteria methodology to support public decision-making: the case of liquid bio-fuels in France. 2001;20: 5:385-398.

Abstract: Decision making to determine government support policy for agro-energy industry can be assisted by mathematical programming and Multiple Criteria procedures. In this case study, tax credit policy in the French bio-fuel industry producing ethanol and esters is determined. Micro-economic models simulate the agricultural sector and the bio-fuel industry through multi-level mixed integer linear programming. Aggregate supply of energy crops at the national level is estimated using a staircase model of 450 individual farm sub-models specialising in arable cropping. The government acts as a leader, since bio-fuel chains depend on subsidies. The model provides rational responses of the industry, taking into account of the energy crops' supply, to any public policy scheme (unitary tax exemptions for bio-fuels subject to budgetary constraints) as well as the performance of each response regarding total greenhouse gases emissions (GHG), budgetary expenditure and agents' surpluses. Budgetary, environmental and social concerns will affect policy decisions, and a multi-criteria optimisation module projects the decision maker aims at the closest feasible compromise solutions. When public expenditure is the first priority, the best compromise solution corresponds to tax exemptions of about 2 FF l⁻¹ [FF: French Franc (1 equivalent to 6.559 FF)] for ester and 3 FF l⁻¹ for ethanol (current tax exemptions amount at 2:30 FF l⁻¹ for ester and 3:30 FF l⁻¹ for ethanol). On the other hand, a priority on the reduction of GHG emissions requires an increase of ester volume produced at the expense of ethanol production (2:30 FF l⁻¹ for both ester and ethanol chains proposed by the model)

Summary: Tax credit policy in the French bio-fuel industry producing ethanol and esters is determined. Micro-economic models simulate the agricultural sector and the bio-fuel industry through multi-level mixed integer linear programming. Aggregate supply of energy crops at the national level is estimated using a staircase model of 450 individual farm submodels specialising in arable cropping. The government acts as a leader, since bio-fuel chains depend on subsidies. The model provides rationale responses of the industry, taking into account of the energy crops' supply, to any public policy scheme (unitary tax exemptions for bio-fuels subject to budgetary constraints) as well as the performance of each response regarding total greenhouse gases emission (GHG), budgetary expenditure and agents' surplus. Budgetary, environmental and social concerns will affect policy decisions, and a multi-criteria optimisation module projects the decision maker aims at the closet feasible compromise solutions. When public expenditure is the first priority, the best compromise corresponds to tax exemptions of about 2 FF/L [FF: French Franc (1 Euro equivalent to 6.559 FF)] for ester and 3 FF/L for ethanol (current tax exemptions amount at 2:30 FF/L for ester and 3:30 FF/L for ethanol). On the other hand, a priority on the reduction of GHG emissions requires an increase of ester volume produced at the expense of ethanol production (2:30 FF/L for both ester and ethanol chains proposed by the model).

Keywords: AGRICULTURE/LIQUID BIO-FUELS/ENERGY POLICY/MULTI-OBJECTIVE ANALYSIS/MIXED INTEGER LINEAR PROGRAMMING (MILP)/PUBLIC EXPENDITURE/GEOGRAPHIC-France/GHG AFFECTED-CO₂/SECTOR-agriculture/SECTOR-Energy/OBJECTIVE-Emission reduction/OBJECTIVE-energy saving/MEASURE-MBI/APPROACH-modelling.

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63. Saunders, C. and Wreford, A., Mitigation of greenhouse gas emissions: the impacts on a developed country highly dependent on agriculture. 25th International Conference of agricultural economists .

Abstract: This paper focuses on the impact of mitigating greenhouse gases (GHG) on agricultural trade. In particular, the paper assesses the impact on New Zealand (NZ), which is highly reliant on agricultural trade, with a high percentage of its total GHG emissions are originating in the agricultural sector. The paper also analyses the impact of mitigation strategies in the European Union (EU), which has a low proportion of GHG coming from agriculture, a highly protected agriculture sector, and is a major market and competitor for NZ. Results from a partial equilibrium trade model, the LTEM, show clearly that while

these mitigation strategies achieve the goal of GHG reduction, producer returns are also negatively affected. The value of these changes in emissions are then calculated, based on US\$15/tonne of carbon dioxide (CO₂), and producer returns adjusted for this. Although this value of CO₂ goes some way towards offsetting the reduction in producer returns, it would need to be considerably greater in order to provide any significant compensation.

Keywords: AGRICULTURAL PRODUCTION SYSTEM/GREENHOUSE GAS EMISSIONS/ PARTIAL EQUILIBRIUM TRADE MODEL/GEOGRAPHIC-Europe/GEOGRAPHIC-New Zealand/GHG AFFECTED-AII/SECTOR-agriculture/OBJECTIVE-Emission reduction/MEASURE-AII/APPROACH-modelling.

Available at: http://www.iaae-agecon.org/conf/durban_papers/papers/057.pdf

64. Sayin, C., Mencet, M. N., and Ozkan, B., Assessing of energy policies based on Turkish agriculture: current status and some implications. 2004.

Abstract: In this study, the current energy status of Turkey and the effects of national energy policies on Turkish agricultural support policies are discussed for both current and future requirements. Turkey is an energy-importing country producing 30 mtoe (million tons of oil equivalent) energy but consuming 80 mtoe. The energy import ratio of Turkey is 65–70% and the majority of this import is based on petroleum and natural gas. Furthermore, while world energy demand increases by 1.8% annually, Turkey's energy demand increases by about 8%. Although energy consumption in agriculture is much lower than the other sectors in Turkey, energy use as both input and output of agricultural sector is a very important issue due to its large agricultural potential and rural area. Total agricultural land area is 27.8 million hectares and about 66.5% of this area is devoted for cereal production. On the other hand, Turkey has over 4 million agricultural farm holdings of which 70–75% is engaged in cereal production. Machinery expenses, mainly diesel, constitute 30–50% of total variable expenses in cereal production costs. It is observed that energy policies pursued in agriculture have been directly affected by diesel prices in Turkey. Therefore, support policy tools for using diesel and electricity in agriculture are being pursued by the Turkish government.

Keywords: ENERGY POLICY/ AGRICULTURAL POLICY/ENERGY USAGE/TURKEY/GEOGRAPHIC-Turkey/GHG AFFECTED-NA/SECTOR-agriculture/SECTOR-Energy/OBJECTIVE-NA/MEASURE-Regulation/APPROACH-descriptive.

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65. Schneider, U. A. and McCarl, B. A., Economic Potential of Biomass Based Fuels for Greenhouse Gas Emission Mitigation. 2003;24: 4:291-312.

Abstract: Use of biofuels diminishes fossil fuel combustion thereby also reducing net greenhouse gas emissions. However, subsidies are needed to make agricultural biofuel production economically feasible. To explore the economic potential of biofuels in a greenhouse gas mitigation market, we incorporate data on production and biofuel processing for the designated energy crops switchgrass, hybrid poplar, and willow in an U.S. Agricultural Sector Model along with data on traditional crop-livestock production and processing, and afforestation of cropland. Net emission coefficients on all included agricultural practices are estimated through crop growth simulation models or taken from the literature. Potential emission mitigation policies or markets are simulated via hypothetical carbon prices. At each carbon price level, the Agricultural Sector Model computes the new market equilibrium, revealing agricultural commodity prices, regionally specific production, input use, and welfare levels, environmental impacts, and adoption of alternative management practices such as biofuel production. Results indicate no role for biofuels below carbon prices of \$40 per ton of carbon equivalent. At these incentive levels, emission reductions via reduced soil tillage and afforestation are more cost efficient. For carbon prices above \$70, biofuels dominate all other agricultural mitigation strategies.

Keywords: GEOGRAPHIC-USA/GHG AFFECTED-AII/SECTOR-agriculture/SECTOR-Energy/OBJECTIVE-Emission reduction/ MEASURE-NA/APPROACH-modelling.

Available at: <http://www.springerlink.com/media/43WPULTTWKC3K6WYWQ3M/Contributions/L/L/7/4/LL741H0023Q75J72.pdf>

66. Six, J., Ogle, S. M., Breidt, J., Conant, R. T., Mosier, A. R., and Paustian, K., The potential to mitigate global warming with no-tillage management is only realized when practised in the long term. 2004;10: 2:155-160.

Abstract: No-tillage (NT) management has been promoted as a practice capable of offsetting greenhouse gas (GHG) emissions because of its ability to sequester carbon in soils. However, true mitigation is only

possible if the overall impact of NT adoption reduces the net global warming potential (GWP) determined by fluxes of the three major biogenic GHGs (i.e. CO₂, N₂O, and CH₄). We compiled all available data of soil-derived GHG emission comparisons between conventional tilled (CT) and NT systems for humid and dry temperate climates. Newly converted NT systems increase GWP relative to CT practices, in both humid and dry climate regimes, and longer-term adoption (410 years) only significantly reduces GWP in humid climates. Mean cumulative GWP over a 20-year period is also reduced under continuous NT in dry areas, but with a high degree of uncertainty. Emissions of N₂O drive much of the trend in net GWP, suggesting improved nitrogen management is essential to realize the full benefit from carbon storage in the soil for purposes of global warming mitigation. Our results indicate a strong time dependency in the GHG mitigation potential of NT agriculture, demonstrating that GHG mitigation by adoption of NT is much more variable and complex than previously considered, and policy plans to reduce global warming through this land management practice need further scrutiny to ensure success

Summary: There is evidence of a positive effect of NT management over CT management in term of GHG reduction nevertheless this requires long periods and uncertainty is still very large.

Keywords: GLOBAL WARMING POTENTIAL/GREENHOUSE GAS MITIGATION/NITROUS OXIDE/NO-TILLAGE/GEOGRAPHIC-World/GHG AFFECTED-CH₄/GHG AFFECTED-N₂O/GHG AFFECTED-CO₂/SECTOR-agriculture/OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-modelling/APPROACH-economic.

Available at: http://saturn.bids.ac.uk/cgi-bin/ds_deliver/1/u/d/ISIS/16439744.1/bsc/gcb/2004/00000010/00000002/art00001/0B37E4240B5220AE1110191869DF9CE46191F25431.pdf?link=http://www.ingentaconnect.com/error/delivery%3Bid=3o5qis3ft3r36.victoria&format=pdf

67. Smith, P., Carbon sequestration in croplands: the potential in Europe and the global context. 2004;20: 3:229-236.

Abstract: Biospheric carbon sinks and sources can be included in attempts to meet emission reduction targets during the first commitment period of the Kyoto Protocol. Forest management, cropland management, grazing land management and re-vegetation are allowable activities under Article 3.4 of the Kyoto Protocol. Soil carbon sinks (and sources) can, therefore, be included under these activities. In this paper, the role of croplands in the European carbon budget and the potential for carbon sequestration in European croplands are reviewed. The global context is then considered. Croplands are estimated to be the largest biospheric source of carbon lost to the atmosphere in Europe each year, but the cropland estimate is the most uncertain among all land-use types. It is estimated that European croplands (for Europe as far east as the Urals) lose 300 MtC per year. The mean figure for the European Union is estimated to be 78 (S.D. 37) MtC per year. There is significant potential within Europe to decrease the flux of carbon to the atmosphere from cropland, and for cropland management to sequester soil carbon, relative to the amount of carbon stored in cropland soils at present. The biological potential for carbon storage in European (EU15) cropland is of the order of 90–120 MtC per year with a range of options available including reduced and zero tillage, set-aside, perennial crops and deep rooting crops, more efficient use of organic amendments (animal manure, sewage sludge, cereal straw, compost), improved rotations, irrigation, bioenergy crops, extensification, organic farming, and conversion of arable land to grassland or woodland. The sequestration potential, considering only constraints on land-use, amounts of raw materials and available land, is up to 45 MtC per year. The realistic potential and the conservative achievable potentials may be considerably lower than the biological potential due to socioeconomic and other constraints, with a realistically achievable potential estimated to be about 20% of the biological potential. As with other carbon sequestration options, potential impacts on non-CO₂ trace gases need to be factored in. If carbon sequestration in croplands is to be used in helping to meet emission reduction targets for the first commitment period of the Kyoto Protocol, the changes in soil carbon must be measurable and verifiable. Changes in soil carbon can be difficult to measure over a five-year commitment period and this has implications for Kyoto accounting and verification. Currently, most countries can hope to achieve only a low level of verifiability during the first commitment period, whilst those with the best-developed national carbon accounting systems will be able to deliver an intermediate level of verifiability. Very stringent definitions of verifiability would require verification that would be prohibitively expensive for any country. Carbon sequestration in soil has a finite potential and is non-permanent. Soil carbon sequestration is a riskier long-term strategy for climate mitigation than direct emission reduction and can play only a minor role in closing carbon emission gaps by 2100. However, if atmospheric CO₂ concentrations are to be stabilised at reasonable levels (450–650 ppm), drastic reductions in carbon emissions will be required over the next 20–30 years. Given this, carbon sequestration should form a central role in any portfolio of measures to reduce atmospheric CO₂

concentrations over the next 20–30 years, whilst new energy technologies are developed and implemented. Given that improved agricultural management often has a range of other environmental and economic benefits in addition to climate mitigation potential, such “win-win” strategies to improve soil carbon storage are attractive and should be implemented as part of integrated sustainability policies.

Keywords: CARBON SEQUESTRATION/CLIMATE MITIGATION/CROPLAND/ARABLE LAND/EUROPE/KYOTO PROTOCOL ARTICLE 3.4/SOIL ORGANIC CARBON /CARBON MITIGATION/SOIL CARBON FLUX/GEOGRAPHIC-Europe/GHG AFFECTED-CO2/SECTOR-agriculture/SECTOR-forestry/OBJECTIVE-Sequestration/APPROACH-Review/ APPROACH-descriptive.

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68. Sutton, M. A., Dragosits, U., Dore, A. J., McDonald, A. G., Tang, Y. S., van Dijk, N., Bantock, T., Hargreaves, K. J., Skiba, U., Simmons, I., Fowler, D., Williams, J., Brown, L., Hobbs, P., and Misselbrook, T., The potential of NH₃, N₂O and CH₄ measurements following the 2001 outbreak of Foot and Mouth Disease in Great Britain to reduce the uncertainties in agricultural emissions abatement. 2004;7: 3:177-194.

Abstract: There is substantial uncertainty in the effectiveness of measures to reduce emissions of agricultural trace gases, including ammonia (NH₃), methane (CH₄) and nitrous oxide (N₂O). The only way to test whether emission abatement programmes are successful is through monitoring of air concentrations and deposition. However, where NH₃ emissions have been reduced in Europe, either through abatement policies or reductions in agricultural activity, it was difficult to demonstrate the link with reduced concentrations and deposition. The outbreak of Foot and Mouth Disease (FMD) in Great Britain in 2001 provides a major case study to test the link between agricultural emissions and air concentrations. This paper examines the spatial distribution of anticipated change in emissions and concentrations of NH₃, CH₄ and N₂O as a result of the FMD outbreak. It then assesses the extent to which atmospheric monitoring could be used to detect the changes and attribute them to the effect of FMD. Two of the areas worst affected by FMD were selected for detailed analysis: in Cumbria (N.W. England) and in Devon (S.W. England). Compared with values prior to FMD, average agricultural emissions were reduced by as much as 50–100%, with estimated reductions in atmospheric mixing ratios of 0.7–3.3 ppb for NH₃, 10–60 ppb for CH₄ and 0.1–0.7 ppb for N₂O. For NH₃ and CH₄, modelled changes are larger than the precision of analytical techniques and, where sampling is made at replicate sites, the changes are also larger than the inter-annual variability of existing monitoring data. By contrast, for N₂O only the largest changes occurring in Cumbria are expected to be detectable and distinguishable from inter-annual variability. Based on the results, a measurement strategy has been established to follow NH₃ and CH₄ concentrations during and after the period of restocking. By comparing NH₃ (a reactive gas) with CH₄ (an inert tracer), the measurements aim to distinguish constraints on the link between changing emissions and air concentrations. Improving this linkage is essential to demonstrate that the economic costs of emission abatement translate into environmental benefits.

Keywords: AMMONIA/METHANE/NITROUS OXIDE/MODELLING/ATMOSPHERIC/MONITORING/GEOGRAPHIC-UK/GHG AFFECTED-CH₄/GHG AFFECTED-CO₂/GHG AFFECTED-N₂O/SECTOR-agriculture/OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-economic.

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Abstract: This study analyses the change in Faustmannian age considering the social benefits due to carbon sequestration under the Regulation 2080/92, the subsidies provided by the afforestation program and investigates, from the social point of view, the profitability of afforesting agricultural land. The analysis refers to Calabria, a region situated in the south of Italy. Representative species are chosen for this study. The optimal harvesting age excluding social benefits varies between 32 and 40 years according to the species considered. When including social benefits, optimal harvesting age increases for a carbon price of 20 o/t to 34–44 years and is close to the one excluding them. The inclusion of subsidies to encourage afforestation shortens the optimal harvesting age to 17–20 years from the forest owner's point of view.

Interestingly the provision of subsidies contributes to a substantial increase in social loss due to the differences in optimal harvesting ages: starting from zero C price the loss vary between 65 and 165 o/ha according to the species used and increases with rising carbon prices up to 200–400 o/ha for carbon price of 100 o/t. Furthermore, results suggest that from the social point of view the profitability of afforesting agricultural land in the study region very much depends on the price of carbon, on the type of agricultural land afforested and on the species used.

Keywords: EU-AFFORESTATION POLICY/CALABRIA/CARBON SEQUESTRATION BENEFITS/OPTIMAL HARVESTING AGE/FAUSTMANN APPROACH/GEOGRAPHIC-Italy/GHG AFFECTED-CO2/SECTOR-forestry/OBJECTIVE-Sequestration/MEASURE-MBI/APPROACH-modelling.

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Abstract: Canada's commitment under the Kyoto Protocol is to reduce its greenhouse gas (GHG) emissions by 6% of its 1990 levels. Each industrial sector is investigating alternative technologies, production and management practices that can decrease their GHG emissions. The macroeconomic impacts of four mitigation strategies to reduce GHG emissions from Canada's agriculture sectors were measured using an inputoutput model. The size of the GHG reduction from each mitigation strategy depended on whether agricultural soils were included as a carbon (C) sink. Including agricultural soils as a C sink impacts on the absolute amount of GHG emissions that must be reduced and the relative importance of the various mitigation strategies. This will be a key factor in policy development. Only one strategy, improving forage quality by 15%, had positive macroeconomic impacts in all situations. It was projected that this strategy would increase industrial output by \$106.97 M (M = million; all \$ Canadian), gross domestic product at factor cost (GDP) by \$45.51 M and employment by 689 jobs. This strategy decreased GHG emissions by 0.07% below the 'business as usual' (BAU) situation when sinks were included. Increasing the adoption of zero-till farming had a positive macroeconomic impact only when the industrial sector effects were included. However, when household and industrial-sector impacts were combined, the results were decreases in industrial output of \$286.90 M, GDP of \$55.98 M and employment by 769 jobs. The mitigation strategy decreased GHG emissions by 3.06% below the BAU situation when sinks were included in the estimate. Improved soil nutrient management through more efficient use of N fertilizer had a negative net impact on the economy. This mitigation strategy had a direct impact on the agriculture and the fertilizer sectors, resulting in net decreases in industrial output of \$70.76 M, GDP of \$43.38 M and employment of 518 jobs. It was estimated that this mitigation strategy would decrease GHG emissions by 1.37% below the BAU situation. The last mitigation strategy was a permanent plant cover program. This generated the largest negative impact on the economy. It was projected to decrease industrial output by \$1192.63 M, GDP by \$392.17 M and employment by 6155 jobs. The strategy decreased GHG emissions by 1.73% below the BAU situation.

Keywords: GEOGRAPHIC-Canada/GHG AFFECTED-CH4/GHG AFFECTED-N2O/GHG AFFECTED-CO2/SECTOR-agriculture/SECTOR-forestry/OBJECTIVE-Emission reduction/OBJECTIVE-Sequestration/MEASURE-MBI/APPROACH-modelling.

Available at:

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Abstract: To evaluate environmental benefits that might accrue from conversion of farmland to short-rotation woody crops (SRWC), a hypothetical conversion of 10%, 20% and 30% of cropland was modeled in a watershed of the Lower Minnesota River. The analysis synthesized output from a watershed model (ADAPT) with literature-based estimates of productivity and economic values for water quality, forest conservation and carbon sequestration. A Monte Carlo simulation approach was used to estimate ranges of environmental benefit values for cropland conversion to SRWCs. The summed average net benefits justified annual public subsidies ranging from \$44 to \$96 ha⁻¹, depending on market scenario and conversion level. Cropland conversion to SRWCs reduced cumulative annual stream flows, sediment and nitrogen loadings by up to 9%, 28% and 15%, respectively. Reduced sediment loads resulted in potential average annual public savings on culvert and ditch maintenance costs of \$9:37 Mg⁻¹ of sediment not delivered to the watershed outlet. Hybrid poplars over a 5-year rotation produced an estimated annual economic value due to carbon sequestration of \$13–15 ha⁻¹ when used for bioenergy and \$29–33 ha⁻¹

¹(depending on conversion rate) when converted to wood products. If hybrid poplars are substituted for aspen traditionally harvested from natural woodlands, the poplars create annual forest preservation values of \$4.79–5.44 ha⁻¹.

Keywords: SHORT-ROTATION WOODY CROPS/POPLAR/WATER QUALITY/EROSION/NON-MARKET VALUATION/CARBON SEQUESTRATION/GEOGRAPHIC-USA/GHG AFFECTED-CO2/SECTOR-forestry/OBJECTIVE-Sequestration/MEASURE-NA/APPROACH-modelling.

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Abstract: A model was developed to calculate carbon fluxes from agricultural soils. The model includes the effects of crop (species, yield and rotation), climate (temperature, rainfall and evapotranspiration) and soil (carbon content and water retention capacity) on the carbon budget of agricultural land. The changes in quality of crop residues and organic material as a result of changes in CO₂ concentration and changed management were not considered in this model. The model was parameterized for several arable crops and grassland. Data from agricultural, meteorological, soil, and land use databases were input to the model, and the model was used to evaluate the effects of different carbon dioxide mitigation measures on soil organic carbon in agricultural areas in Europe. Average carbon fluxes under the business as usual scenario in the 2008-2012 commitment period were estimated at 0.52 tC ha⁻¹ y⁻¹ in grassland and -0.84 tC ha⁻¹ y⁻¹ in arable land. Conversion of arable land to grassland yielded a flux of 1.44 tC ha⁻¹ y⁻¹. Farm management related activities aiming at carbon sequestration ranged from 0.15 tC ha⁻¹ y⁻¹ for the incorporating of straw to 1.50 tC ha⁻¹ y⁻¹ for the application of farmyard manure. Reduced tillage yields a positive flux of 0.25 tC ha⁻¹ y⁻¹. The indirect effect associated with climate was an order of magnitude lower. A temperature rise of 1 °C resulted in a 0.05 tC ha⁻¹ y⁻¹ change whereas the rising CO₂ concentrations gave a 0.01 tC ha⁻¹ y⁻¹ change. Estimates are rendered on a 0.5 x 0.5° grid for the commitment period 2008-2012. The study reveals considerable regional differences in the effectiveness of carbon dioxide abatement measures, resulting from the interaction between crop, soil and climate. Besides, there are substantial differences between the spatial patterns of carbon fluxes that result from different measures.

Keywords: AGRICULTURE/CARBON DIOXIDE MITIGATION/CARBON SEQUESTRATION/LAND USE/MODEL/SOIL ORGANIC CARBON/GEOGRAPHIC-Europe/GHG AFFECTED-CO2/SECTOR-agriculture/OBJECTIVE-Emission reduction/OBJECTIVE-Sequestration/MEASURE-NA/APPROACH-modelling.

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Abstract: This paper explores two existing markets for energy produced from biomass: waste-to-energy electricity production in the Netherlands and the blending of biofuels with oil-based fossil fuels in cars in France. Both cases provide excellent material to analyse social optimality of current biomass markets vis-a-vis their fossil fuel substitute. The paper applies social cost-benefit analysis to estimate both private and environmental cost of these supplies and uses the results to evaluate actual government behaviour in both countries. The main findings for the waste-to-energy case in the Netherlands are, perhaps somewhat surprisingly, that waste-to-energy is optimal only if the alternative of landfilling is excluded as an opportunity for waste management. The case for biofuels in France shows that the take-off of this market is only due to considerable government subsidization. These subsidies cannot be defended by the difference they make in externality reduction even if the opportunity cost and benefits of set-aside land are included as well as the potential productivity improvements.

Keywords: WASTE/BIOFUELS/ENVIRONMENTAL/EXTERNALITIES/COST-BENEFIT ANALYSIS/GEOGRAPHIC-France /GEOGRAPHIC-The Netherlands/GHG AFFECTED-all/SECTOR-Energy/OBJECTIVE-Energy saving/MEASURE-MBI/APPROACH-Economic .

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agricultural sector: environmental and economic effects in Denmark. 2002 ;41: 2:345-359.

Abstract: The Agenda 2000 reform, agreed on by the EU government leaders in the spring of 1999, implies considerable changes in EU agricultural policy. The reform involves both reductions in price support and compensations in the form of hectare and animal support. The Agenda 2000 reform may have considerable environmental and economic effects, and in this article we assess these effects. Within an integrated model system, we calculate environmental effects (changes in nitrogen loading in the terrestrial environment and the Danish marine waters, changes in oxygen concentrations in the inner Danish marine waters, and changes in emissions of the greenhouse gases (methane and nitrous oxide), as well as economic effects (effects on private consumption, GDP, the balance of payments, and employment). The results indicate that the Agenda 2000 reform has significant economic costs but almost no effects on the environment—either positive or negative.

Keywords: AGRICULTURAL POLICY/ENVIRONMENTAL EFFECTS/NITROGEN LOADING/GREENHOUSE GASES/INTEGRATED MODELLING/GEOGRAPHIC-Scandinavia/GHG AFFECTED-CH4/GHG AFFECTED-N2O/SECTOR-agriculture/OBJECTIVE-Water quality standards/OBJECTIVE-Emission reduction/MEASURE-NA/APPROACH-modelling.

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Abstract: Over the years, modelling approaches have played an increasingly important role in designing agricultural and environmental policies and formulating measures to reduce nutrient emissions in The Netherlands. In recent years, increased emphasis has been put on validation of models used for that purpose. Nitrogen (N) cycling and leaching in sandy soils in The Netherlands have been intensively studied in a number of plots at the experimental dairy farm 'De Marke'. These plots differed with respect to crop rotation, fertiliser application and hydrology. The three crop rotations were, respectively, permanent grassland, 3 years with grass followed by 1 year with beets (*Beta vulgaris* L.) and 2 years with maize (*Zea mays* L.), and 3 years grassland followed by 1 year with beets and 4 years with maize. The experimental results have been used to validate two nutrient emission models, the integrated modelling system STONE for regional and national scale analyses and the ANIMO model for site-scale analyses. Comparison of the measured and simulated N fluxes and balances for the different experimental plots showed that mineral N in the top soil and hence the main N inputs into the soil system were simulated well with both models, and that nitrate leaching to groundwater was moderately well and moderately well to poorly simulated by ANIMO and STONE, respectively. The simulated nitrate leaching by STONE was often too high, which was mainly caused by underestimation of crop N-uptake. Nitrogen uptake was calculated more precisely by ANIMO, but this N uptake approach needs calibration at the site-scale and cannot be applied at larger scales. This study showed that testing of a large-scale model like STONE on measured data from field experiments can hardly be expected to be satisfactory and second, calibration of a large-scale model on well-managed experiments may be wrong for practical applications. This study also showed that in regional or national scale nutrient emission studies with a model like STONE, the model initialisation and parameterisation can only be done in a regionally schematized way. Hence, the results are generally less precise than those from modelling at the site-scale.

Keywords: AGRICULTURE/GROUNDWATER/SIMULATION/MODEL EVALUATION/NITRATE/NITROGEN/NUTRIENT EMISSION/POLLUTION/GEOGRAPHIC-The Netherlands/GHG AFFECTED-N2O/SECTOR-agriculture/OBJECTIVE-Water quality standards/MEASURE-NA/APPROACH-modelling.

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Abstract: The inclusion of forest sinks as a carbon dioxide (CO₂) mitigation strategy at the climate negotiations in Marakech 2 (November, 2001) is expected to lead to increased investments in forest establishment and management by many developed countries. Previous studies in this area have typically focused on market impacts in the forestry sector, such as changes in production, consumption, prices, and trade, as a result of sinks. Here, we consider their intersectoral linkages and examine the potential economy-wide impacts of a forest carbon policy for the US over the next 20 years. Specifically, we employ a dynamic computable

general equilibrium (CGE) model to simulate the scenario of a global forest carbon policy with and without US participation, and analyze their impacts on national economic welfare and land use distribution among the different sectors in the US. Our findings suggest that the establishment of carbon plantations in the US will have a small and favorable impact on the overall economy and particularly, on the farm and forest sectors. Alternatively, US inaction with regards to ratifying the Kyoto Protocol is likely to have adverse consequences for the economy as a whole, particularly when taking into consideration the loss of benefits foregone.

Keywords: ECONOMIC ANALYSIS/FOREST POLICY/CARBON SEQUESTRATION/LAND USE CHANGE/COMPUTABLE GENERAL EQUILIBRIUM MODEL/GEOGRAPHIC-USA/GHG AFFECTED-CO2/SECTOR-forestry/OBJECTIVE-Sequestration/MEASURE-NA/APPROACH-modelling.

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Abstract: No abstract .

Keywords: GEOGRAPHIC-USA/GHG AFFECTED-CO2/SECTOR-agriculture/OBJECTIVE-Sequestration/MEASURE-All/APPROACH-descriptive.

Available at: <http://www.blackwell-synergy.com/servletuseragent?func=synergy&synergyAction=showTOC&journalCode=ajae&volume=85&issue=5&year=2003&part=null>