Biomass for energy production in the context of selected European and international policy objectives

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Abstract— **Biomass based energy production has attained a significant market share within the developing renewable energy market. In comparison to alternative renewable energy sources, biomass has several special features: it is not inexhaustible in the short term (limitation of arable land) and it is not only an energy source. Other usages like food or feed compete with energy production for this resource. A number of problems arise which have a direct impact on the fulfillment of policy objectives which are connected with its promotion. Primarily, the production of bioenergy has significant impacts on coupled biomass markets. Further, a change in production intensity or arable land use increases the use of nutrient loads and agro - chemicals. When evaluating renewable energy production, the wide range of political objectives has to be considered. Therefore, the focus of the overall study will be on three objective areas: promotion of the agricultural sector, environmental protection (reduction of GHG emissions) and maintenance of food supply security. The objective of this study is to combine an analysis of selected economic and ecological impacts of an increased biomass based energy production (primarily biofuels) under the assumption of European and international quantity targets by adjusting and applying the agricultural sector model CAPRI (Common Agricultural Policy Regional Impact Analysis). This poster intends to display the methodical approach of the intended analysis.**

Keywords— **Bioenergy, Biofuels, Biomass production, Impact analysis.**

I. INTRODUCTION

Since the early nineties, the European Union (EU) and other nations worldwide are discussing to amend the course of their long term energy strategies in a way that they will abate significant current and future problems such as the global warming effect, the regional concentration and limits of fossil energy resources and the rapidly increasing global demand for energy. The market launch of renewable energies and fuels can be seen as a possible counteractive measure. The EU has enacted two binding directives [1,2] which set quantity targets for renewable energies and fuels in the current and future energy supply up to 2010 (Renewable electricity in 2010: EU 22%; Biofuels in 2010: 5.75%; Total renewable energy consumption in 2010: 12%). Until 2020 these targets are to be enlarged considerably [3]. Given that nearly 66% of renewable energy production in the EU in 2004 was based on biomass (hereafter referred to as bioenergy), the demand for biomass will increase rapidly during this time horizon [4]. In relation to other renewable energy sources like wind-, geothermal-, hydro- and solar power, biomass has specific features which have to be considered: 1) The global limitation of the availability of arable land. Biomass is not inexhaustible in the short term. 2) Biomass is not only an energy source, other usages like food, feed, or additional industrial compete with energy production for this resource. From these specific features a number of problems arise. Primarily, the production of bioenergy will have significant impacts on coupled biomass markets, like food or feed markets, including world prices, production, trade flows and land use [cp. 5, 6]. Existing studies estimate that compared to a situation with unchanged biofuel quantities at their 2004 level crop prices in 2014 increase by between 2% in the case of oilseeds and almost 60% in the case of sugar [7]. The growing demand for bioenergy crops may create further competition for land and water between existing agricultural activities, energy production and the use of agricultural land for nature conservation and urbanisation needs. This could result in additional negative environmental pressure from cultivating bioenergy crops [8]. Further, a change in production intensity on arable land could increase the use of agro - chemicals and thereby nutrient loads which might substantially counteract the objective of reducing GHG (GreenHouseGases) emissions. Another issue

are indirect emissions resulting from land use where carbon stocks from grassland or forest are released.

When evaluating renewable energy strategies, the wide range of political objectives connected to its promotion has to be considered. Besides primary objectives like the reduction of GHG and the decrease of European dependency on energy imports, a lot of other objectives are affected, like the increase of agricultural incomes, rural development, food supply security, or the development of low income countries [9]. The use of a particular energy source needs to consider all these economic and policy objectives as not the efficient promotion and market launch itself but rather the resulting environmental, economic and social effects arising from this development determine the social benefits.

II. RESEARCH OBJECTIVE

Whereas existing economic modelling studies have basically analysed impacts of bioenergy on agricultural production, land use and agricultural commodity prices [cp. 5, 7, 10], the objective of the intended analysis is to combine an analysis of selected economic and ecological impacts under the assumption of European and additional international quantity targets by adjusting and applying the agricultural sector model CAPRI (Common Agricultural Policy Regional Impact Analysis). An advantage of the CAPRI model, which was especially developed to analyse CAP (Common Agricultural Policy) and European trade policies, is the well developed representation of agricultural supply behaviour in Europe under consideration of current CAP measures and global trade agreements for agricultural products. Because CAP policies and global trade negotiations are relevant drivers for most agricultural product prices and thus drivers for production decisions, an estimation of realistic market behaviour for the biomass market will be impossible without a detailed consideration of those policies. Impact assessment based on the CAPRI model contributes new information relative to existing studies by deepening the focus on effects on European agricultural markets, farm income, consumer welfare and on certain environmental indicators. The key activity before applying the model will be the adjustment of CAPRI to allow for the simulation of shocks of bio-energy/-fuel demand. In a second step, the current ability of CAPRI in generating relevant environmental indicators shall be extended. This overall analysis will contribute to a more detailed analysis of trade-offs between different objectives connected to the promotion of bioenergy.

III. METHODOLOGY

The CAPRI model is a spatial economic model focussing on the agricultural sector. Production, demand, trade and prices of agricultural products are interacting and simulated simultaneously, other product markets are not taken into account. The model consists of two interlinked modules: 1. a globally closed spatial multi-commodity model for primary and secondary agricultural products based on the Armington assumption (market module) and 2. NUTS II (Nomenclature of Territorial Units for Statistics, level 2) aggregate non-linear programming models for EU27, Norway and Western Balkans which capture in detail farming decisions (regional supply module). The model is able to simulate differentiated CAP and trade policy instruments (e.g. most favourite nation tariffs, preferential agreements, tariff rate quotas, export subsidies) and includes different environmental and energy indicators like NPK output, ammonia emissions, NPK losses by leaching and soil storage, output of greenhouse gases (nitrous oxide, methane), water balances, nitrate concentrations in ground water, and their driving forces (mineral fertilizer consumption, consumption of pesticides, irrigation shares, energy consumption, livestock densities, shares of arable / grass land or permanent crops) [11]. [12] emphasised in an evaluation of models' suitability for analysing international trade of biomass and bioenergy products that the economic theory included in CAPRI, the spatial aspect (CAPRI works in Europe on NUTS II level) and the included environmental aspects are strong points of the model.

In preparation for the analysis, the model has to be adapted to be able to simulate impacts of projected developments on the bio-energy and -fuel market as bioenergy products (like biodiesel and bioethanol) are not fully integrated in the CAPRI market module and the bioenergy demand (driven by energy prices and

policies) is not endogenous. Regarding the latter, this problem can be solved through either linking CAPRI with an energy sector or whole economy model or through a scenario analysis. A model interface with an energy sector model which includes demand for bio-energy/-fuel as a function of prices and prices of competing fuels and relevant European energy and environmental policies is a promising approach and is currently discussed within the EU-LIFE project 'EC4MACS' [13], where CAPRI and the PRIMES energy model [14] are involved. The bioenergy demand is then either taken as the variable linking the CAPRI model to an energy market model or is treated as the variable for which different future scenarios of development are defined.

In both cases (scenario analysis or model linkage), the incorporation and specification of the major activities describing the processing of agricultural raw products into bioenergy (including e.g. processing technologies, conversion coefficients, feedstock demand distribution) is required. Furthermore, as biofuels are well transportable and global production costs vary strongly between countries, it will be necessary to implement biofuel trade into the global market module of CAPRI. The neglect of global trade will lead to an overestimation of impacts on European agriculture and environment and will not display a realistic market projection.

Fig. 1 gives an overview of the intended integration of biofuels which has the objective to implement a behavioural module of the biofuel processing industry (including endogenous demand functions for biofuel feedstock) linked with a global biofuels market module (including global production and trade flows) in the CAPRI model.

Biofuels included in the analysis are only 'first generation biofuels' (bioethanol and biodiesel). Biogas as an energy source will be implemented if possible. The so called 'second generation biofuels' will not be taken into account as they are still in a developing status and their readiness for market use is very uncertain. As the indented time horizon of this simulation will in all probability not exceed 2020 this assumption seems to be acceptable.

The analysis will be done in the following steps.

1. Identification and detailed description of policy objectives which are connected with the promotion of bioenergy and which can be deeper analysed within the CAPRI model approach. Currently three objective areas have been identified: Promotion

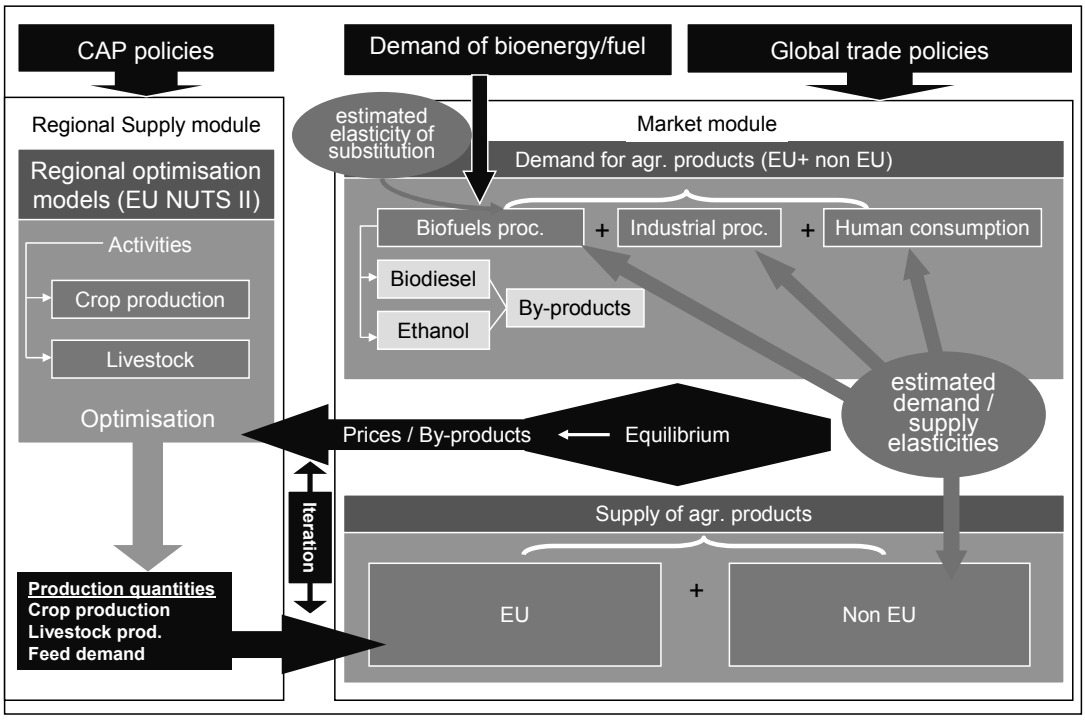

Fig. 1 Implementation of biofuels in CAPRI

of the agricultural sector, reduction of climate relevant emissions and environmental protection, and maintenance of global food supply security.

2. Implementation of bioenergy processing products in the CAPRI market module as described before.

3. Operationalisation of the selected objectives. Indicators have to be identified to measure the level of fulfilment of selected objectives. The current CAPRI version already includes a set of environmental and economic indicators or variables which can be interpreted in conjunction with these objectives. Table 1 gives an overview of these indicators.

Table 1 Indicators for selected objective areas in the CAPRI model

Objective area	Indicators / Variables	
Agricultural sector	- Net production - Revenues (€/ha) - Costs (€/ha) - Trade balances	- Income (€/ha or heat) - Producer prices - Producer welfare
Environmental impacts	- Nutrient balances (Nitrate, Phosphate, Potassium) - CH4 (methane) emission - N2O (nitrous oxide) emissions - Land use/ activity - Global warming potential	- Ammonium output - Energy consumption + costs per product and ha - Indicators on configuration and biodiversity (Shannon index, UAA, Simpson's diversity index)
Food supply security	- Trade balances of energy and food crops	- Market and consumer prices - Consumer welfare

If it will be useful and possible, the implementation of further indicators in the model has to be discussed. In the case of existing environmental indicators which are already implemented in CAPRI, the problem arises that most of them are only calculated for European countries or regions. As it is to be expected that a significant quantity of European biofuel demand (especially bioethanol) will be met by imports from non EU countries, a significant share of environmental impacts arising from the biofuel production will occur outside the EU. For this reason it is intend to enlarge the calculation of basic environmental indicators to a global coverage.

3. As a first approach a scenario analysis is intended, carefully designed to reflect current knowledge and uncertainties on the energy market as well as different policy options. The baseline and different 'bioenergy scenarios' will be defined such that the trade-offs or complementarities between the different policy objectives can be identified. The scenarios imply variations in future development of drivers for bioenergy demand (development of fossil energy markets, bioenergy promotion policies (EU and selected non EU countries), favoured bioenergy production technologies which have different feedstock requirements, trade policies for bioenergy products) and drivers for biomass supply (agricultural policies, availability of arable land, yield levels, sustainability aspects, development of additional demand for biomass (food, feed), trade policies for agricultural commodities) .

4. Simulation runs of scenarios.

5. Analysis of simulation results. Within the different scenario assumptions different market impacts and indicator values are expected. The analysis of the indicators at European and international level will give detailed information about trade-offs and complementarities between policy objectives under different bioenergy strategies (reflected in the modelled scenarios).

IV. DATA NEEDS

Data is needed for the implementation of bioenergy products (primarily biofuels: biodiesel, bioethanol) and their by-products in the CAPRI market module. Furthermore, data is needed for the enlargement of the environmental indicator coverage to non EU countries. Concerning the implementation of the bioenergy products biodiesel and bioethanol in the CAPRI market module data is needed for marketable production quantities of biofuels in EU and non EU countries and data defining the processing like conversion coefficients of biofuel feedstock and by-product production. To estimate demand and supply elasticities for European and non EU countries it will be essential to get market and trade balances of biofuels on a global scale. For the estimation of feedstock substitution elasticities of the biofuel processing industry time series on feedstock

consumption in relation to different price levels will be required. If the biofuel product implementation in the market module has been completed, detailed data on trade polices regarding these products will be collected for the completion of the market module.
Concerning the improvements of environmental indicators, data is needed which allows for an estimation of environmental impacts related to a shift in domestic production structure of a specific country. The concept of estimating these indicators in relation to a specific production activity level, like it is done for EU27, is not directly applicable to non EU countries, because CAPRI estimates only production quantities for these countries. However, estimates on yield levels and acreages are available for most countries with large agricultural sectors.

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