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SCIENCE FOR A SUSTAINABLE DEVELOPMENT

DECISION-MAKING TOOLS TO SUPPORT THE DEVELOPMENT OF BIOENERGY IN AGRICULTURE

"TEXBIAG"

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SCIENCE FOR A SUSTAINABLE DEVELOPMENT
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Energy

FINAL REPORT PHASE 1

DECISION-MAKING TOOLS TO SUPPORT THE DEVELOPMENT OF BIOENERGY IN AGRICULTURE

"TEXBIAG"

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1.1. Context

Bioenergy from agriculture plays today a key role in important aspects of sustainable development such as: environment and climate change, energy economy and supply, agriculture and rural and social development.
The fight against climate change implies a reduction of greenhouse gas emissions in our atmosphere. Considerable efforts must be made, especially in the field of energy production and energy use. The recent energy crises have recalled our policy makers and economic decision-makers of the importance of a guaranteed and diversified energy supply in our economy. Agriculture in Europe is at a turning point and as a result there are important questions with regard to the diversification of agricultural production and income sources for farmers, on the use of rural and arable lands for food and non-food crops, and the contribution that agriculture can make in the fight against climate change and for renewable energy supply.

1.2. Objectives

The final objective of the project is to aim at an actual and significant contribution of bioenergy from agriculture to the mitigation of greenhouse gas emissions, to a secure and diversified energy supply and to an increase in farmer incomes and rural development.
To achieve this goal, the TEXBIAG project develops three tools:

1. A database of primary quantitative data related to environmental and socio-economic impacts of bioenergy from agriculture integrating biomass logistics;
2. A mathematical model "monetizing" bioenergy externalities from agriculture;
3. A prediction tool assessing the impacts of political decisions made in the framework of the development of bioenergy from agriculture on different economic sectors (energy, agriculture, industry, and environment).

1.3. Methodology

The project is structured as follows:

Task 1. **Database construction**:

- Conception of the database, in collaboration with the partners in charge of the development of the decision-making tools;
- Data and model collection from literature and measurements for missing data and filling the database with collected information and operation;
- Survey and analysis of existing studies carried out on logistics of biomass supply chain from agriculture;
- Feed-back from the decision-making tools and adaptation/updating of the database.

Task 2. **Externalities monetary value model**:

- Contribution to database construction through a continuously improved model;
- Analysis of existing studies and models, comparison and evaluation;
- Building of a qualitative model to put in evidence causal relationships (detection of induced effects);
- Costs / revenues analysis in order to reach monetization;
- Building of a quantitative externalities monetary value model.

Task 3. **Policy prediction tool**, based on an existing model (SPA):

- Addition to the existing tool of new targets, such as job creation (direct and indirect employment), rural development, energy supply security, added value, and other externalities;
- Addition of technology routes not yet considered in the previous model (DME, hydrogen, biogas, biorefineries);
- Addition of missing commodities such as water and other relevant externalities;

- Modelling of non-linear perturbations effects: electricity system, refineries, secondary products such as animals feeds, agro market perturbation, etc;
- Addition of the externalities monetary value model;
- Addition of potential policy measures in the existing model (quotas, subsidies, other measures,..).

Task 4. **Dissemination and valorisation of the results** of the project:
- Making a user friendly interface to use the software tool (data access & update, policy measures, sensitivity analysis);
- Dissemination of the results through communications tools (brochures, posters, website, conferences, workshops, etc).

The project consortium chose to implement a methodology based on a systemic approach. The data is collected and structured according to the needs and goals of the two decision-making tools. After data validation step, missing data will be measured and doubtful data will receive further checking.

The model on monetization of externalities of bioenergy from agriculture is built progressively using an iterative methodology of model refining through interactions with experts and with partners.

The method denoted as System Perturbation Analysis (SPA) consists in perturbing a resource and analysing all direct and indirect impacts on a given system (Belgium). The SPA is an innovative approach which is complementary to others tools such as LCA and MARKAL. The essential difference is that SPA compares a whole system before and after application of any perturbation at the resource side, in terms of any so-called 'target' which can be any well defined externality.

1.4. Results of the first phase of the project (2007-2008)

1.4.1. Database construction, bioenergy sustainability and logistics

Bioenergy routes to be studied in TEXBIAG are selected according to the Belgian market in order to ensure comprehensive results. Propositions for this selection are made but other bioenergy chains can be added in accordance with new developments on the Belgian market.

Regarding sustainability criteria for biomass and bioenergy, an extensive review of the main initiatives on the subject has been conducted. Based on this critical review, bioenergy externalities are proposed to be included in the TEXBIAG methodology.
Sustainability criteria establishment process must nevertheless come along with a wide stakeholders' consultation. Based on externalities selection, a first list of sustainability criteria and potential indicators is proposed. Surveys, workshops and conferences will help fine-tuning these sustainability criteria and choosing adapted indicators.

Discussions on indirect land-use change impacts and GHG balance calculation methodology will be further developed in the update report on sustainability criteria for biomass and bioenergy.
Certification is also discussed in this report. Characteristics, strong and weak points of existing certification systems are presented.

Concerning biomass logistics, a critical review of logistic aspects of biomass supply chain from agriculture synthesizes existing studies on the subject in Europe. Mathematical models to analyse and optimize complex biomass supply systems have been addressed in several studies. Through the analysis of more than 20 studies, it appears that logistics is a key parameter in the implementation of biomass supply chain from agriculture.

1.4.2. Externalities monetary value model

A critical review of the environmental and socio-economic impacts of bioenergy projects from agriculture synthesizes existing studies on the subject in Europe, identifies missing data and evaluates the needs of adaptation of the literature primary data to the Belgian context. This extensive study of the literature aimed at building a conceptual framework useful for the determination of valuation indicators for externalities of bioenergy from agriculture.

It appears that externalities are sometimes quantified but rarely monetized. Nevertheless, several methods to monetize externalities exist.

Valuation indicators for externalities of bioenergy from agriculture were determined in order to provide TEXBIAG partners with externalities that can be monetized and then introduced in decision-making tools.
Where there is a general agreement among initiatives and certification systems on externalities to take into account, there is little information on indicators to measure these externalities. Several indicators and their measurement methodologies still need to be described accurately.

Monetized indicators will be introduced in SPA in order to enhance policy makers' choice of the best bioenergy routes. Monetized and non-monetized indicators will be introduced in tables which will contain all monetized, quantitative and qualitative information on each bioenergy route selected (one table by bioenergy route). These tables will allow policy makers to take into account all dimensions of sustainable development in their choice of the best bioenergy routes to support.

On the basis of the selected externalities and indicators, a qualitative model is being built. This model articulates externalities or sustainability criteria in order to identify cause-effect relationships, feedback, induced and non-linear effects between them. Indicators will be used to describe and assess these potential links. The qualitative model will be iteratively refined through interactions with experts in workshop and brainstorming sessions.

On the basis of the final consolidated qualitative model, a quantitative model will be built. This model will enable, on the one hand, the monetization of measurable sustainability criteria and their introduction in SPA, and, on the other hand, the qualitative assessment of other sustainability criteria and their potential introduction in a certification scheme.

1.4.3. Policy prediction tool

This part of the TEXBIAG project aims at improving some of the weak points of the SPA software. In a first version of the software (SPA1), all the effects of perturbations on the system were considered as linear, leading to oversimplification for certain types of perturbations.

A first task covers the improvements that can be made concerning the animal feed in SPA. In SPA1, perturbations on the animal feed market were approached by linear import/export compensations, whereas the real market is more complex with qualities of products, types and composition limitations of animal feeds.
The aim of this subtask is to develop a model in order to determine what happens when increased amounts of by-products such as wheat DDGS, rapeseed meal and sugar beet meal are launched on the Belgian market. The correct modelling of this market is important because the indirect effect of the animal feed products on the Belgian GHG balances is very significant. This modelling is done through literature research with respect to the animal feed technology, consultation of the animal feed industry and federations, and national statistics.

A second task determines how refineries in Belgium will be perturbed by the introduction of biofuels such as biodiesel or bioethanol. The goal is to create a model for such a refinery perturbation. Afterwards, the model will then be incorporated in the SPA2 software whereas SPA1 considered refineries as being outside of the system boundaries. This modelling will mainly be done through consultation of the Belgian petroleum industry.

Regarding modelling of non-linear perturbations of the electrical grid, the introduction of Distributed Generation (DG) in distribution systems, such as local generation using biomass, changes the existing operation protocol. It has both positive and negative impacts on the local network. The impact of DG on distribution systems has been investigated. The models of DG units, loads and distribution network have been derived.
As these simulations are very sensitive to the quality of the parameters, the results will be grouped as follows:

- General conclusions, which are trends recognized through all the simulations (e.g. change in generation dispatch, due to biomass)

- Results from sensitivity analyses, where different parameters are changed to study their influence (e.g. congestion on lines).

A last task develops a model to see what happens when products from agriculture, both usable for food and (bio-) energy, are redirected to the production of biofuels.
For several types of feedstock such as wheat, sugar beet, maize, etc, there is not necessarily a direct link between what the farmer produces and what will be used for energy purposes, certainly not on the Belgian level because of high import shares. The simple linear import compensations considered in SPA1 are improved to have a better reproduction of the real mechanisms of market perturbations through bio-energy application. This is mainly done by analyzing national statistics and by consultation of the market players to understand the market mechanisms.
For every food crop two so-called connection matrices are calculated; one in case the crop is not used for biofuel production, one in case the crop is used as a feedstock to fulfil the Belgian bioethanol and biodiesel quota. These matrices contain possible impacts on the considered demand categories induced by a shift in crop supply.

1.5. Preliminary conclusions and recommendations

1.5.1. Bioenergy database construction

Now that the structure of the TEXBIAG database has been agreed with all partners, data is filled in, firstly based on EcoInvent, which is the most comprehensive database currently available. This database is however often related to the Swiss situation, and in other cases is often offering European averages. It has therefore to be validated in the Belgian context (adaptation of the cultivation and conversion steps to the local conditions, use of realistic data for transport, etc.). This is done through expert consultation.

1.5.2. Bioenergy sustainability and certification

Regarding the work on sustainability criteria, now that major currently available initiatives have been analysed, the next step is to validate the first recommendations for the Belgian context proposed in CRAW & FUNDP (2008).
Because bioenergy sustainability is a hot topic, regular updates will help this publication becoming a useful document for Belgian decision-makers.

1.5.3. Bioenergy externalities monetization

For each bioenergy route considered by TEXBIAG, a table will be fulfilled. This table will describe the environmental and socio-economic externalities selected in TEXBIAG, and their quantitative and qualitative indicators.
These tables will help policy makers to choose the best bioenergy routes according to sustainability criteria (externalities). At first glance, tables can assist policy makers to put aside bioenergy routes that get a "no go" (or a more nuanced information as "traffic lights colour") on qualitative assessment. Then, for the remaining bioenergy routes, monetization of some externalities can be introduced in SPA to support quantitative assessment of their impacts.

1.5.4. Policy prediction tool

Mathematical models for the Belgian animal feed market, refining industry and food market in Belgium are developed in order to improve the effect of perturbations in the SPA software. These models are capable of generating useful results if reliable input data and constrains are provided.

The introduction of bioenergy as a primary resource for distributed generation of electricity, with possible co-generation of heat, will influence the operation and safety of the electricity distribution grid when these resources are introduced in a significant quantity. However, it is difficult to generally determine this level as this is function of the presence of other resources (e.g. wind turbine, photovoltaic's) and the local technical parameters of the electricity grid. When the critical level is reached, substantial investments have to be made in the substations and cabling.

In the second phase of the research, conclusions will be formulated on the effects of introducing bio-energy in the large centralised power plants (mainly co-firing).

1.6. Perspectives for Phase II (2009-2010)

The second phase of the project will see the completion of the three specific tools developed by TEXBIAG:

1. The database of primary data on environmental and socio-economic impacts of bioenergy from agriculture, taking into account sustainability criteria and certification systems (to be) developed in the Belgian/European context;
2. The externalities monetary value model based on quantitative indicators, and qualitative assessment;
3. The policy prediction tool, based on the updated version of SPA.

These tools will then be compiled into a user-friendly interface, for a smooth utilization by policy-makers. A training session will teach a target group on the use of the integrated tool.

1.6.1. Database Construction

Due to continuous developments regarding sustainability criteria and certification systems for biomass and bioenergy, regular updates of CRAW & FUNDP (2008) are required. Beside literature review, a critical analysis and consultation with involved stakeholders will help providing decision-makers with concrete propositions for the Belgian context.

A survey to collect data on missing environmental and socio-economic impacts and on logistics will be prepared and conducted by the project partners. CRAW will collect missing data in order to complete the database and to feed the two models under construction in Task 2 (FUNDP – externalities monetization model) and in Task 3 (VUB – SPA model) as well as the certification systems to be built in Belgium (indicators).

1.6.2. Externalities monetary value model

A workshop and brainstorming sessions, with 3 or 4 experts, will allow the enhancement of indicators definition. Results from this consultation process will be validated and introduced in a reviewed publication on valuation indicators.
Brainstorming sessions will also contribute to articulate environmental and socio-economic externalities in order to design the qualitative model.
On the basis of the indicators assessed in phase 1 and on the inter-relationships between them, a quantitative model will have to be built. The financial impact of each indicator should be calculated through a cost / revenue approach.

1.6.3. Policy prediction tool

The second phase of the project will be devoted to the introduction and application of the data collected in the first years, and the necessary monetary aspects developed by FUNDP. Calculation of new externalities will be included in the SPA beside the already existing ones which are at present limited to energy and greenhouse gas balances.

The last year of the project will be devoted to the analysis phase of all available new information. In interaction with the other partners scenarios will be computed and sensitivities made to investigate the externalities of a series of policy measures.