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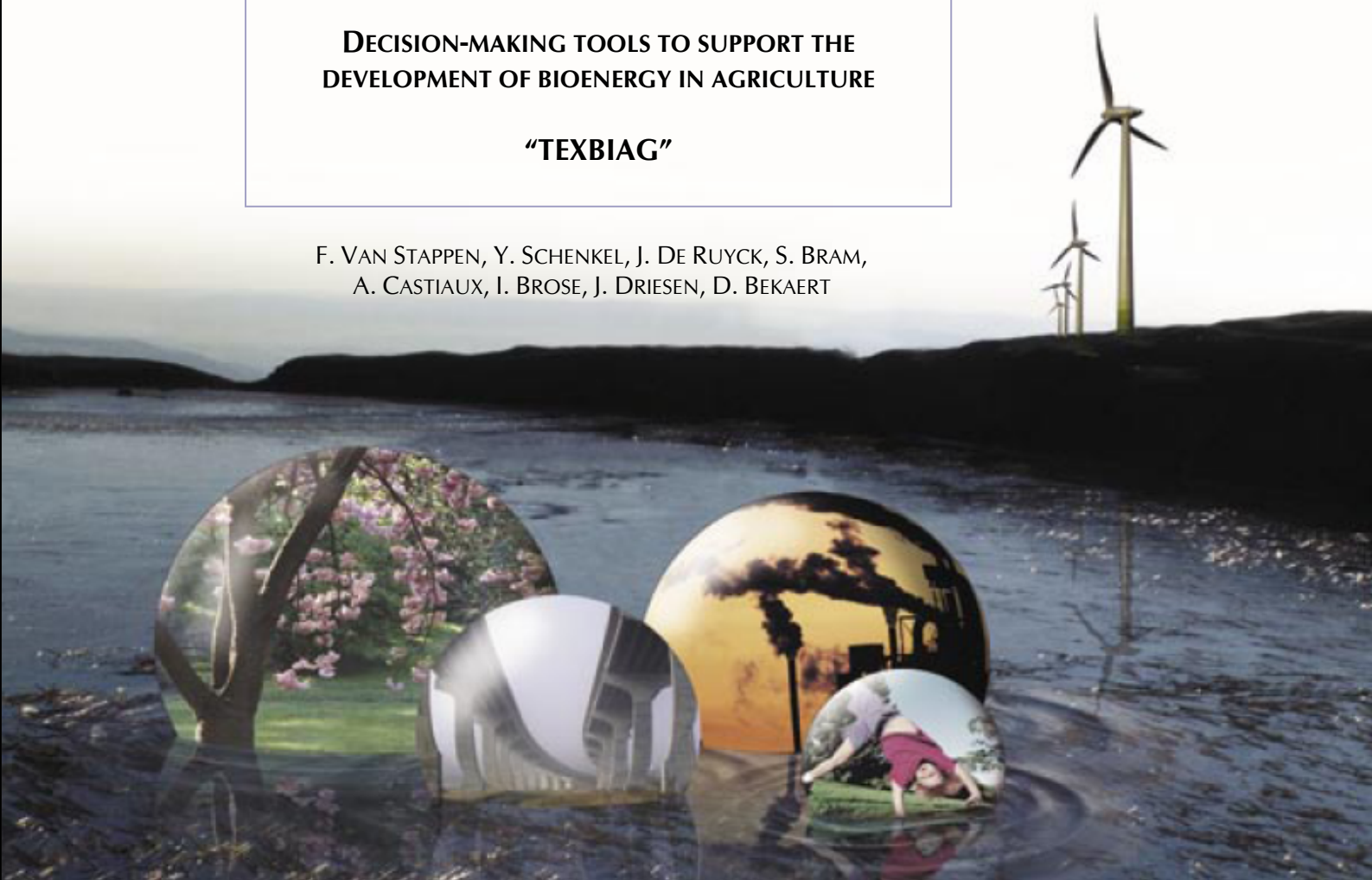
SCIENCE FOR A SUSTAINABLE DEVELOPMENT



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

“TEXBIAG”

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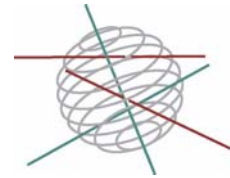
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SCIENCE FOR A SUSTAINABLE DEVELOPMENT
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Energy

FINAL REPORT PHASE 1

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

“TEXBIAG”

SD/EN/05A

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Abbreviations and Acronyms

ATFS	American Tree Farm System
BEAM	BioEnergy Assessment Model
BEAVER	Biomass Economic Appraisal & eValuation ExpeRt
BELSPO	Belgian Scientific Policy
BEMEF/AFACA	Beroepsvereniging van de mengvoederfabrikanten / Association professionnelle des fabricants d'aliments composés pour animaux (feed producers association)
BIOCOST	Bioenergy Crop Production Cost
BIOSEM	BIOMass Socio-Economic Multiplier
CASCADE MINTS	Case study comparisons and development of energy models for integrated technology systems
CASES	Cost Assessment for Sustainable Energy System
CBD	Convention on Biological Diversity
CGE	Computable General Equilibrium
CH ₄	Methane
CITES	Convention on International Trade in Endangered Species
CO	Oxide of carbon
CO ₂	Carbon dioxide
COI	Cost Of Illness
CRAW	Centre wallon de Recherches agronomiques
DDGS	dried distillers' grain with solubles
DG	distributed generation
DME	di-methyl ether
eq	equivalent
ETBE	ethyl tertio butyl ether
EU	European Union
Eugene	EUropean Green Electricity NETwork
EurepGAP	Eurep Good Agricultural Practices
FPS	Federal Public Service
FSC	Forest Stewardship Council
FT	Fischer-Tropsch (transport biofuel)
FUNDP	Facultés Universitaires Notre-Dame de la Paix
g	gramme
GAP	Good Agricultural Practices
GGL	Green Gold Label
GHG	Greenhouse gases
GlobalGAP	Global Good Agricultural Practices
GMO	Genetically Modified Organism
IFOAM	International Federation of Organic Agriculture Movements
ILO	International Labour Organization
ILVO	Instituut voor Landbouw and Visserijonderzoek
IPCC	International Panel on Climate Change
KUL	Katholieke Universiteit Leuven
LCA	Life cycle analysis
LCI	Life cycle inventory
LUC	land-use change
MJ	Mega Joule
NMVOG	Non Methane Volatile Organic Compounds
NO _x	Oxides of nitrogen
N ₂ O	Nitrous oxide
O ₃	Ozone
PAH	Polycyclic Aromatic Hydrocarbons
PEFC	Programme for the Endorsement of Forest Certification or Pan-European Forest Council
PM	Particulate Matter
RECAP	Renewable Energy Crop Analysis Program
RSPO	Roundtable on Sustainable Palm Oil
RTFO	Renewable Transport Fuel Obligation
SAN/RA	Sustainable Agricultural Network/ Rainforest Alliance

SFIS	Sustainable Forestry Initiative Standard
SO ₂	Sulphur dioxide
SPA	System Perturbation Analysis
SPA1	System Perturbation Analysis, First version
SPA2	System Perturbation Analysis, Second version
VUB	Vrije Universiteit Brussel
WHO	World Health Organization

Glossary

Externalities:

"An externality is present whenever the well-being of a consumer or the production possibilities of a firm are directly affected by the actions of another agent in the economy" (Mas-Colell *et al*, 1995). Externalities are goods which have positive or negative interest for economic agents but that are not sold on market. As externalities are market imperfections, they can prevent Pareto efficient allocation of resources (Varian, 1994).

Internal costs:

By comparison to externalities which are external costs, internal costs are all the costs that a firm supports to produce its final output: start-up costs, investment and capital costs, raw materials and supplies, operating costs, maintenance costs, R&D, taxes, risk...

Principle (or theme):

Broad goal not directly measurable

Criterion:

Translation of principle in measurable requirements, which allow to judge if a principle is fulfilled (Forest Stewardship Council, 2002)

Indicator:

Quantitative or qualitative parameter (or set of parameters) measurable, which allows to check if a criterion is met

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1. Summary

1.1. Context

Sustainable agriculture leads to important questions about the diversification of agricultural productions and sources of incomes for farmers, the use of rural and arable lands for food and non-food crops, the contribution of agriculture to climate change fighting and renewable energy supply.

The lack of primary and reliable data on bioenergy externalities from agriculture and the lack of decision-making tools are important non-technological barriers to the development of bioenergy from agriculture on a large scale, and, consequently, to the achievement of the national and regional objectives of sustainable development in greenhouse gases mitigation, secure and diversified energy supply, rural development and employment and agriculture future.

1.2. Objectives

The final objective of the project is therefore to lead to an actual and significant contribution of bioenergy from agriculture to the mitigation of greenhouse gases emission, to a secure and diversified energy supply, to farmers' incomes and rural development.

To reach this final objective, it is necessary to grasp the modifications that will affect land use on the one hand, and the energy utilizations and conversions of biomass on the other hand. To support this, it is also imperative to develop a comprehensive and reliable knowledge of the environmental and socio-economic impacts (externalities) of bioenergy from agriculture, which condition its long term 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

Applying the principles of the systemic methodology, the project implementation 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, etc.);
- 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

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 Ecolnvent, 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, photovoltaics) 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 bioenergy 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.

2. Context

Bioenergy from agriculture is today at the heart of sustainable development, integrating its key components: environment and climate change, energy economics and energy supply, agriculture, rural and social development.

Fighting against climate change imposes the mitigation of greenhouse gases in our atmosphere. Considerable efforts have to be pursued, especially in the field of energy production and use.

Concerning energy supply, the limitation of fossil fuels import is a crucial matter: beside the rational use of energy, the contribution of renewable sources, including biomass, for energy production is of considerable importance. It is worth to note that, in addition to the limitation of fossil fuels import, implementing renewable energy sources offers other attractive economic advantages, such as jobs creation, technology development, technology export, etc.

Sustainable agriculture leads to important questions about the diversification of agricultural productions and sources of incomes for farmers, the use of rural and arable lands for food and non-food crops, the contribution of agriculture to climate change fighting and renewable energy supply.

The lack of primary and reliable data on bioenergy externalities from agriculture and the lack of decision-making tools are important non-technological barriers to the development of bioenergy from agriculture on a large scale, and, consequently, to the achievement of the national and regional objectives of sustainable development in greenhouse gases mitigation, secure and diversified energy supply, rural development and employment and agriculture future. Furthermore, the recent worldwide controversies about transport biofuels, food shortages and increasing prices have demonstrated the urgent need for sustainability criteria applied to biofuels and bioenergy.

3. Objectives

Within the current sustainable development framework, the final objective of the TEXBIAG project is to lead to an actual and significant contribution of bioenergy from agriculture to the mitigation of greenhouse gases emission, to a secure and diversified energy supply and to farmers' incomes and rural development.

To reach this final objective, the project develops three specific 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).

The long-term impacts of the project are expected to be:

1. An increase of the level of awareness among policy makers regarding policy gaps and policy implementation issues in Belgium regarding bioenergy from agriculture;
2. The implementation of policy reinforcement and policy implementation guidelines in renewable energy;
3. Stimulation of rural development by creating employment opportunities in relation to the implementation of bioenergy projects from agriculture;
4. An improvement of the local environment and living conditions through the introduction of modern and efficient bioenergy technologies;
5. An improvement of the global and local environment through the introduction of modern and efficient bioenergy technologies by reducing the air emissions associated to fossil fuels combustion hereby reducing the amount of Greenhouse Gases (CO₂, CH₄, N₂O and O₃) emissions.

The target groups will see their capabilities increased in the following areas:

1. Opportunities for improvement of policies implementation in the field of bioenergy from agriculture;
2. Solutions/options and opportunities for bioenergy from agriculture;
3. Environmental, economic and social benefits of bioenergy from agriculture.

4. Methodology

The lack of primary and reliable data on bioenergy externalities from agriculture, the lack of decision-making tools, are important non-technological barriers to the development of bioenergy from agriculture on a large scale, and, consequently, to the achievement of the national and regional objectives of sustainable development in greenhouse gases mitigation, secure and diversified energy supply, rural development and employment, agriculture future.

To tackle these barriers and achieve the specific objectives of the project, 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. A specific attention is given to bioenergy logistics and their impacts on greenhouse gas effects and on socio-economic aspects. After data validation step, doubtful data will receive further checking and an effort will be made to try to measure missing data. The database created is evaluated with the other partners of the project and is improved consequently.

Concerning the monetization of externalities of bioenergy from agriculture, it is built progressively using an iterative methodology of model refining through interactions with experts and with partners.

A methodology and corresponding software tool has been developed under the SPSPDII project Libiofuels to assist decision makers in the field of bioenergy in general. The method denoted as System Perturbation Analysis (SPA) consists in perturbing a resource (e.g. replacing a food crop by non-food crop on a single hectare) and analysing all direct and indirect impacts on a given system (Belgium). The tool needs further development to compute impacts other than energy and CO₂eq, namely other effects on environment, employment, added value and others. The model also needs refinements such as modelling of perturbations on the sugar market, electric grid and refineries. 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.

SPA is used as evaluation tool. SPA applies to a well defined system (see Figure 1) where 'resources' are transformed into 'products' through given 'conversion routes'. The conversion routes also consume 'commodities' which are defined as all secondary resources needed in a conversion route. These are mainly gasoil, natural gas and electricity, and some others which are expressed in megajoules (MJ) of extra primary energy (e.g. seeding, hexane, isobutylene, ...). The conversions lead to impacts such as CO₂ emissions, costs, losses or energy savings, employment, added value etc, which are called 'targets' and which will include all the searched externalities. Water consumption will be added as extra commodity, and any other commodity which is relevant for the calculation of externalities.

In order to quantify the externalities, one single resource chosen by the user is perturbed with a specified amount (Figure 1). This automatically leads to a perturbation of at least one main product and in general also of several by-products. Since there is no consideration of any demand side management the amounts of products are considered to be constant. The perturbations on the products must therefore be compensated by perturbations on at least one other resource, which on his turn may induce other perturbations in the products, etc. As an example, a hectare of set aside land can be converted into local wheat production for replacing gasoline by ethanol. The wheat production will automatically induce by-products such as straw and a residue used in animal feed, which on their turn will affect the production or import of straw and animal feed, etc.

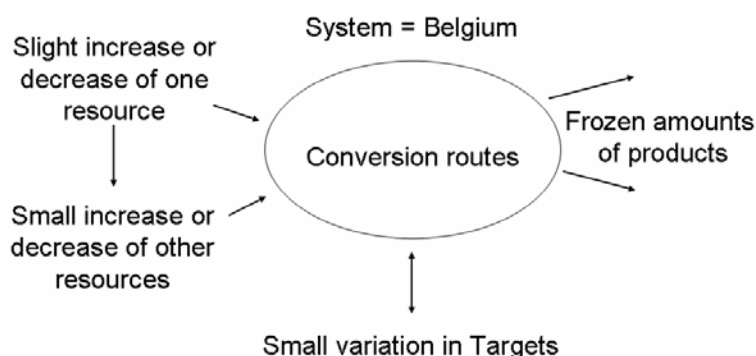


Figure 1 - Principle of SPA

The tool needs further development to compute impacts other than energy and CO₂eq, namely other effects on environment, employment, added value and others. The model also needs refinements such modeling of perturbations on the sugar market, electric grid and refineries.

Applying the principles of the systemic methodology, the project implementation is structured as follows (see also Figure 2):

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.

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.

3. Policy prediction tool:

- 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, etc.);
- 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,..).

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).

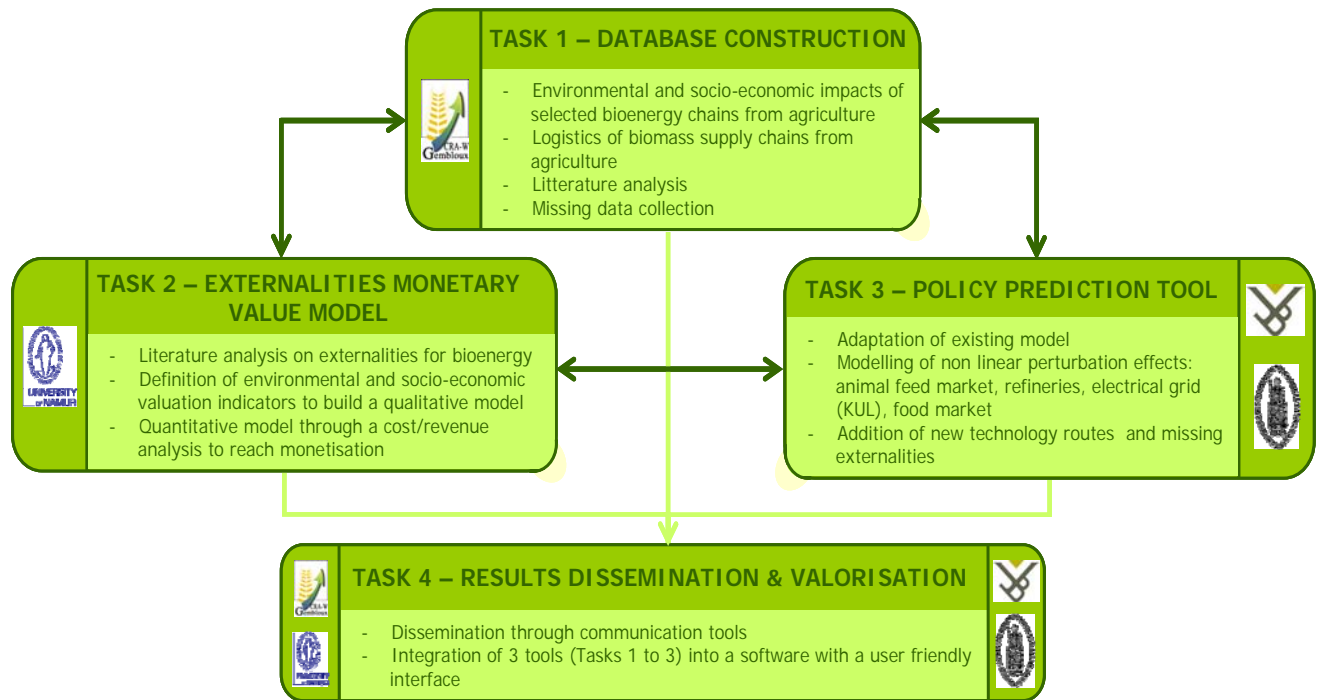


Figure 2 - TEXBIAG work programme

5. Results of the first phase of the project

In accordance with the work programme and timetable, the following tasks were led by the consortium during the first phase of the project.

5.1. Database construction and bioenergy externalities

5.1.1. Conception of the database

An Ecoinvent¹ licence has been purchased in order to start collecting data from this extremely well comprehensive database. The Ecoinvent database comprises LCI data from the energy, transport, building materials, chemicals, paper and pulp, waste treatment and agricultural sectors.

Raw data are extracted in order to be compiled and used in models developed by TEXBIAG (VUB's SPA model and FUNDP's monetary valuation model).

Ecoinvent offers several advantages:

- Sources are clearly mentioned;
- Data quality is assessed and uncertainties are quantified. These 2 first points ensure data are primary and not approximated from derived studies;
- The country concerned by a dataset is specified. It can be valid for one country or for Europe in general;
- This database is a joint effort emanating from several research institutes in Switzerland and elsewhere in Europe. Tasks have been distributed according to the expert knowledge of the partners;
- The database is updated regularly and new routes are added (latest update in November 2007).

For the TEXBIAG project, data are also collected from several other sources:

- Update from the SPSDII Libiofuels project.
- PhD thesis on LCA of bioenergy from agriculture carried out in the Agricultural University of Gembloux.
- Literature review.

Bioenergy chains are treated separately and compiled from the different sources. Once extracted, data for each bioenergy chain are arranged by CRA-W in Excel sheets. It has been decided, in accordance with the consortium, to present data in flow charts. This step-by-step spreading gives a visual presentation of each bioenergy chain, allowing the user² to differentiate data related to each step.

To illustrate this, a typical chain is represented in Annex 1.

Flow charts for selected bioenergy chains will therefore be drawn with attached inputs and outputs. Outputs such as emissions (environmental externalities) are obviously the most available. The way to integrate socio-economic externalities into this database still needs to be evaluated.

As approved by the first Follow-up Committee meeting, biomass resources to be studied are:

- Oil rich:
 - Rapeseed
 - Soybean
 - Palm oil
 - Jatropha
 - Hemp
 - Flax
- Sugar rich:
 - Cereals
 - Sugar beet

¹ www.ecoinvent.ch

² Currently the consortium but, at the end of the project, users of the decision-making tools.

- Maize
- Potato
- Sugar cane
- Lignocellulosic:
 - Grass
 - Miscanthus
 - SRC
 - Cultural residues (straw, stover)
- Wet:
 - Animal by-products (manure, slaughterhouse residues, cheese whey, etc.)

Moreover, the bioenergy conversion routes (to produce heat and/or electricity or mechanical power) to be explored are:

- Combustion
- Vegetal oil to biodiesel
- Sugar/starch to ethanol/ETBE
- Lignocellulose to ethanol/ETBE
- Gasification to methanol/MTBE
- Gasification & FT-synthesis
- Anaerobic digestion
- Gasification to DME
- Biomass to hydrogen
- Biorefineries

However experts assessing the project for its mid-term evaluation advised focusing on less biomass resources and conversion technologies in order to ensure comprehensive results and avoid the risk of spreading oneself too thin. Bioenergy routes to be studied in TEXBIAG must be selected consequently. Propositions for this selection are made in the table below according to relevant bioenergy routes for the Belgian market and in comparison with foreign initiatives (Cramer Commission for the Netherlands, Biofuel Quota Law for Germany, RTFO for United Kingdom and the proposal for a new RES Directive of the European Commission). Other bioenergy chains can be added in accordance with new developments on the Belgian market.

Table 1 - Proposed bioenergy chains to select in the Belgian context (CRAW & FUNDP, 2008)

Biofuel	Resource	NL	DE	UK	EC	Propositions for BE
Ethanol	Sugarcane	✓	✓	✓	✓	✓
	Sugar beet	✓	✓	✓	✓	✓
	Wheat	✓	✓	✓	✓	✓
	Maize	✓	✓	✓	✓	✓
	Molasses			✓		
ETBE from ethanol	Sugarcane	✓		✓	✓	✓
	Sugar beet	✓		✓	✓	✓
	Wheat	✓		✓	✓	✓
	Maize	✓		✓	✓	✓
	Molasses			✓		
TAAE from ethanol				✓		
Biodiesel (FAME)	Tallow	✓		✓		
	Used cooking oils and fats	✓		✓		✓
	Palm oil	✓	✓	✓	✓	✓
	Soybean oil	✓	✓	✓		✓
	Rapeseed oil	✓	✓	✓	✓	✓
	Sunflower oil	✓			✓	
	Waste vegetable or animal oil				✓	✓

Pure Plant Oil (PPO) ³	Tallow	✓				
	Used cooking oils and fats	✓				
	Rapeseed	✓	✓		✓	
	Palm oil		✓			
	Soybean oil		✓			
Hydrogenated vegetable oils	Palm oil		✓	✓	✓	✓
	Soybean oil		✓	✓		✓
	Rapeseed oil		✓	✓	✓	✓
	Sunflower oil				✓	✓
Bio-methane from anaerobic digestion	Municipal solid waste	✓		✓	✓	✓
	Landfill gas	✓				✓
	Manure			✓	✓	✓
Bio-methanol	Glycerine (by-product of FAME production)	✓				✓
MTBE from bio-methanol	Glycerine (by-product of FAME production)	✓				✓
NExBTL	Nesté Oil process	✓				
Bioenergy technology	Resource	NL	DE	UK	EC	Propositions for BE
Co-firing in coal-fired power plants (*)	The biogenic fraction of municipal solid waste	✓				
	Wood (chunks and pellets)	✓				✓ (°)
	Woody by-products	✓				✓ (°)
100% biomass-fired power plants	Wood pellets (les Awirs)					✓
	Bio-oil (rapeseed and palm oil)					✓
CHP combustion with delivery of heat and power	The biogenic fraction of municipal solid waste	✓				
	Wood (chunks and pellets)	✓				✓
	Woody by-products	✓				✓
	Vegetable oils: rapeseed and palm	✓				✓
	Bone meal	✓				
	Energy corn	✓				✓
	Dried sewage sludge	✓				
Anaerobic digestion for power production	Landfill gas	✓				
	Manure	✓				✓
	The biogenic fraction of municipal solid waste	✓				
	Energy corn	✓				✓

(*) Consider also biomass co-fired in Belgian coal-fired power plants (olive cake, sewage sludge, coffee ground).

(°) Consider wood products co-fired in Belgian coal-fired power plants (chips, dust, pellets).

5.1.2. Sustainability criteria and certification for biomass and bioenergy: state-of-the-art and propositions in the Belgian context

In response to the current worldwide-shared concerns about biomass and bioenergy sustainability and at the request of the FPS Health, Food Chain Safety and Environment, a major re-orientation of the work programme of Tasks 1 & 2 has been approved by the TEXBIAG follow-up committee. In consequence, from January 2008, the work programme also focuses on sustainability criteria of bioenergy from agriculture. An extensive review of the literature has been conducted and is discussed in CRAW & FUNDP (2008).

³ Due to its high price, PPO will probably remain a secondary choice for Belgium.

A table in Annex 2 summarizes the characteristics of the main studied initiatives (Cramer Commission for the Netherlands, Biofuel Quota Law for Germany, RTFO for United Kingdom, RSPO for the palm oil industry and the proposal for a new RES Directive of the European Commission) regarding their:

- Scope: bioenergy or biofuels only;
- System implementation: voluntary or mandatory scheme;
- Choice of sustainability criteria: methodology, level of details;
- Propositions for dealing with indirect land-use changes, if any;
- GHG calculation methodology, if any, with:
 - GHG emission targets;
 - Selected bioenergy chains (see also Table 1);
 - Methodology for default values propositions (for bioenergy and fossil energy references);
 - Direct land-use changes evaluation process;
 - Co-product allocation choice;
- Under development or implemented certification system;
- Strong points and weaknesses.

Strong points and drawbacks of these five systems are in addition summarised in the table below

Table 2 - Main characteristics of major initiatives regarding bioenergy sustainability criteria and certification (CRAW & FUNDP, 2008)

	Advantages (strong points)	Drawbacks (weaknesses)
NL : Cramer Commission	<ul style="list-style-type: none"> ▪ Not limited to biofuels ▪ Most complete initiative ▪ Stakeholders involved ▪ Smallholders considered ▪ Well-developed GHG methodology 	<ul style="list-style-type: none"> ▪ Lacks own direct LUC assessment (uses IPCC's) ▪ Lacks certification system (but probably under development)
DE : German Biofuels Quota Act	<ul style="list-style-type: none"> ▪ Own direct LUC assessment method ▪ Well-developed GHG methodology ▪ Certification process well developed 	<ul style="list-style-type: none"> ▪ Vague and not detailed criteria
UK : Renewable Transportation Fuels Obligation	<ul style="list-style-type: none"> ▪ Well-developed GHG methodology ▪ Certification process well developed 	<ul style="list-style-type: none"> ▪ Reporting scheme with possibility just to claim "unknown" is weak
RSPO : Sustainable Palm Oil Scheme	<ul style="list-style-type: none"> ▪ Very complete set of criteria, indicators and guidance 	<ul style="list-style-type: none"> ▪ GHG methodology is very much lacking
EC: Proposal for new RES Directive and FQD	<ul style="list-style-type: none"> ▪ Well-developed GHG methodology 	<ul style="list-style-type: none"> ▪ Insufficient criteria ▪ Certification system not yet developed

Based on this critical review of existing initiatives, the following bioenergy externalities are proposed to be included in the TEXBIAG methodology (CRAW & FUNDP, 2008):

1. Environmental externalities:

- **Global warming:**
 - **Greenhouse gas balance** (CO₂, CH₄, N₂O, O₃);
 - **Carbon stocks** (above- and below-ground carbon sinks);
 - **Direct land-use changes:** carbon balance over a time span of 20 years;
 - Co-product allocation: to be discussed;
- **Biodiversity** protection:
 - Based on existing laws, regulations, international conventions (CBD) and 'High Conservation Value' areas;
 - The **GMO** issue should be considered as well;
- **Environment** protection:

- **Soil** quality conservation (soil structure and fertility);
 - **Water** quality conservation (ground- and surface-water quantity and quality);
 - **Air** quality conservation (CO, NO_x, SO₂, metal, PM, NMVOC, PAH, benzene);
 - Sound use of **pesticides** (Integrated Pest Management practices);
- 2. Socio-economic externalities:**
- **Competition with food;**
 - **Social well-being**, based on international conventions:
 - Good working conditions: decent salary, working hours, contracts (limited temporary workforce), no child labour, etc.;
 - Human rights respect;
 - **Land property rights**, compliance with customary laws and legal rights;
 - **Local prosperity**: based on economic performance indicators (direct, indirect and induced employment creation for local staff, local expenses, etc.);
- 3. Indirect land-use changes⁴:** induced negative effects on:
- Greenhouse gas emissions (through deforestation for instance);
 - Biodiversity;
 - Competition with food, local energy supply, medicine and building materials;
 - Prosperity and economy.

Sustainability criteria establishment process must nevertheless come along with a wide stakeholders' consultation. Based on CRAW & FUNDP (2008), FUNDP & CRAW (2008b) proposes a first list of sustainability criteria and potential indicators. Surveys, workshops and conferences will help fine-tuning these sustainability criteria and choosing adapted indicators. The report will be updated according to this consultation process. It is indeed important to select credible and feasible indicators, matching real conditions.

Criteria adaptation (softening) for smallholders should also be considered in order not to exclude small producers from the certification process.

Discussions on indirect land-use change impacts and GHG balance calculation methodology will be further developed in the update report of CRAW & FUNDP (2008) to be released according to new developments beginning of 2009.

Certification is also discussed in CRAW & FUNDP (2008). Existing certification systems are using three different methods: track and trace, mass balance, book and claim. They are summarized in the following table.

Table 3 – Characteristics of the 3 most common certification systems (adapted from Cramer et al, 2007)

	TRACK & TRACE	MASS BALANCE	BOOK & CLAIM
Traceability	<ul style="list-style-type: none"> ▪ Fully traceable to the source ▪ Certified biomass completely separated from non-certified biomass ▪ All companies involved in chain need to be certified 	<ul style="list-style-type: none"> ▪ Partly traceable to the source ▪ Certified biomass mixed with non-certified biomass ▪ All companies involved in chain need to be certified 	<ul style="list-style-type: none"> ▪ Biomass not traceable to the source ▪ End user submits certificates that guarantee sustainability ▪ Only the primary producer (farmer/forester) is certified

⁴ Indirect land-use changes are very difficult to estimate mainly because they are global. No reliable method for assessing indirect LUC is available yet but a lot of research efforts are nonetheless under way since the whole scientific community agrees on the fact that these indirect effects can lead to disastrous consequences in terms of GHG emissions, biodiversity losses and socio-economic impacts.

Implementation	<ul style="list-style-type: none"> ▪ Short chains ▪ Small volumes ▪ Niche markets 	<ul style="list-style-type: none"> ▪ Short chains ▪ Small and large volumes 	<ul style="list-style-type: none"> ▪ From short to long and very complex chains ▪ Small and large volumes ▪ Introduced rapidly and easily ▪ Parties involved in certification restricted to end users and primary producers ▪ Willingness of primary producers great because of financial remunerations ▪ Higher price for sustainable biomass profit directly to primary producers ▪ Companies are not hampered in their daily activities
Drawbacks	<ul style="list-style-type: none"> ▪ Operational costs for physical separation ▪ Sustainable status lost if tracing system left ▪ Willingness of primary producers smaller when chain is longer 		Small number of verification moments (chance of misuse is relatively large): <ul style="list-style-type: none"> ▪ Periodical (physical and administrative) verification of the producers by an independent party; ▪ It is of the essence to set up a good registration and redemption system. In case of conversion steps after production, certification must also take place.
Verifiability	A lot of verification moments (chance of misuse is small): <ul style="list-style-type: none"> ▪ Verification if supplier has been certified by each customer in the chain; ▪ Periodical (physical and administrative) verification of the producers by an independent party; ▪ Verification of each transaction between two parties in the chain by an independent party. 		
Risks	Farmer/forester supplies more certified product than he could actually have produced.		Double issue of certificates by producers and double claims when certificates are used.
Choice	Adapted for certification systems for a sustainable use of biomass because quantity (track & trace) or at least percentage (mass balance) of biomass is assessed.		Adapted for certification systems for a sustainable production of biomass because producer is directly rewarded for his efforts.

Even if the Track&Trace (segregation) and the Mass Balance approaches are usually perceived by authorities, NGOs and the general public as the most credible certification systems, because certified product is kept separated from non-certified product all along the supply chain, it seems that the Book&Claim system offers the non negligible advantage to be easier and quicker to implement, especially for long chains and large volumes. Furthermore this system allows the primary producer to be directly rewarded for his efforts.

For the time being, it seems consequently that there is no preferable option for biomass and bioenergy certification.

Further research (surveys and field tests) should enable grasping better the pros and cons of the three systems and possibly selecting the most suitable for biomass and bioenergy certification in the Belgian context.

Independent bodies carrying out third party certification should be acknowledged by Federal authority, providing they comply with endorsed national or European standards, possibly with additional requirements.

Controls by third parties should be frequent enough to guarantee continuous compliance with criteria and certificates validity should be time-limited.

Control reports issued by independent bodies should be transparent and exhaustive and a public summary could be available.

5.1.3. Survey and analysis of existing studies carried out on logistics of biomass supply chain from agriculture

Fuel supply chain (or "logistics") consists in a series of sequential steps as planting, growing, harvesting, comminution, densification, drying, storage, transport and handling. The combination of these steps depends of the kind of biomass as well as on the needs of the energy conversion plant and determines feedstock form and costs.

Mathematical models to analyse and optimize complex biomass supply systems have been addressed in several studies. Amongst those studies, one can mention a model developed to compare the possible bioenergy supply chains and assess the influence of key parameters, such as distance, timing and scale of performance. For structuring international systems, four general systems components have been defined: biomass production, pre-treatment, transport and energy conversion. Considering all the transportation means (truck transport, train, ship) and bioenergy commodities, many chains are possible to move bioenergy from one region/country to another. A flexible modular spreadsheet has been developed to enable the technical-economic analysis of a large variety of chains. To synthesize, the user has firstly to define a chain. Then the chain is processed by the spreadsheet, to yield results on costs, energy use and CO₂ emissions for each step in the chain and cumulative for the end product. In each step along the transport chain, a biomass processing operation can be chosen and characterized by user input parameters (dedication, transport distance, etc.). The model processes all the steps in consecutive order. After each step the results for costs, energy use and emissions are selected for the overview and the new biomass characteristics are written to the next step.

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. According to some authors, the main characteristics of supply logistics are raw material randomly distributed, time and weather-sensitive crop maturity, variable moisture content, low bulk density of agricultural materials and a short time window for collection with competition from concurrent harvest operations. This is the reason why several simulation models were developed to analyze and optimize these complex systems. There were successfully applied to commodities as sugar, cotton, energy crops, grains / forage and wood products.

A lot of data are needed to be used in the Decision Support Systems. The main fields where data are needed are:

- Biomass sources (composition [%C, H, O, N], cost, average yield, availability, moisture, supply window, etc.);
- Treatment (type of treatment [sizing, drying, densification, etc.], energy needed, average particle size, bulk density, cost, etc.);
- Conversion to motor fuel or electricity (efficiency, product heating value, cost, etc.);
- Transport (type of transport [truck, train, ship], capacity, cost, speed average, load/unload speed, etc.).

In Belgium, there are existing data for each of the main fields of interest, but they are not yet synthesized. It is therefore important to collect and harmonize them. For this purpose, it is necessary to identify for the Belgian context: the main available biomass sources, the main treatments used to process them and the main transportation means used inside the Belgian territory (or from abroad if we consider imported biomass).

A critical review of logistic aspects of biomass supply chain from agriculture synthesizes existing studies on the subject in Europe (CRAW, 2008).

5.2. Externalities monetary value model

5.2.1. Literature analysis

A critical review of the environmental and socio-economic impacts of bioenergy projects from agriculture synthesizes existing studies on the subject in Europe (FUNDP & CRAW, 2008a), identifies

missing data and evaluates the needs of adaptation of the literature primary data to the Belgian context.

This extensive study of the literature, taking into account the existing works concerning bioenergy externalities and focusing on methods and models proposed in this field, aimed at building a conceptual framework useful for the determination of valuation indicators for externalities of bioenergy from agriculture.

In this report, the most relevant models and methods for the TEXBIAG project have been described: externalities evaluation models, such as BIOSEM, RECAP, BEAM, BIOCOST, BEAVER, MULTISEE, etc. Other models taking into account biofuel and/or biomass for bioenergy, such as Energy, CGE, Agricultural Equilibrium, and Agricultural and Forestry Programming models, are also presented. Some examples of projects using the models described are given (CASCADE MINTS, NaRoLa). Existing methods to monetize externalities are finally described: Revealed preferences methods (Market price, Travel cost method, Hedonic price, Averting behaviour or Defensive expenses, Cost Of Illness (COI)), Stated preferences methods (Contingent valuation method, Choice modelling or Choice experiment method, Deliberative monetary valuation) and Benefits transfers.

From this extensive study of existing models and methods, and of their implementation by ongoing projects, it appears that a large part of them is mostly interested in economic viability and cost-effectiveness of bioenergy routes, and by the comparison of these (bio)energy routes. Some environmental externalities are sometimes taken into account (especially emissions). Some socio-economic externalities are also considered (especially direct employment) but, most of the time, at local level (case study of local initiative).

It also appears that externalities are sometimes quantified (tons of CO₂ emitted, number of jobs created...) but rarely monetized (cost of one ton of CO₂, benefits from job creation, etc.). Nevertheless, several methods to monetize externalities exist.

There are several reasons of the inadequacy of existing works to the TEXBIAG goals:

- Lots of models evaluate internal costs of bioenergy while the TEXBIAG project has to assess externalities from bioenergy. Internal costs evaluation is not a priority even if a few internal costs can be assessed, at the end of the project, to monetize some streams in SPA.
- Lots of models assess impacts on local or regional level or for isolated initiatives while we need to assess bioenergy externalities on a national level.
- Few bioenergy externalities are evaluated by different models while we want to study more externalities in an integrated system.
- Bioenergy externalities are only quantified by existing models while we also want to monetize these externalities.

5.2.2. Determination of valuation main indicators

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 to support bioenergy. The selection of externalities was based on CRAW & FUNDP (2008) and the extensive study of the literature and the conceptual framework developed in FUNDP & CRAW (2008a).

At the request of the FPS Health, Food Chain Safety and Environment, externalities must also fit biomass and bioenergy sustainability criteria in order to develop a certification system of bioenergy or biomass. Thus selected externalities and indicators were also derived from reviewed existing sustainability criteria initiatives and certification systems (Cramer Commission, RTFO, RSPO, Basel Criteria for Responsible Soy Production, Utz Codes of Conduct, EurepGAP-GlobalGAP, IFOAM, SAN/RA, FSC, PEFC, ATFS, SFIS, Eugene, GGL, Öko-Institut).

FUNDP & CRAW (2008b) describes the relevant externalities and indicators for the TEXBIAG project.

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. TEXBIAG intends to take part in this exploratory process.

Some of the selected externalities are already measurable by more easily defined indicators:

- Greenhouse Gases (GHG) emissions, including direct land-use change,
- Carbon stocks,
- Air quality.

They can be quantified and, probably, monetized on the basis of their impacts on health, global warming and soil and water quality.

Some other externalities still need well-defined indicators to be measured:

- Indirect land-use change,
- Health (to monetize emissions impacts),
- Soil quality,
- Water quality,
- Agrochemicals,
- Biodiversity,
- Genetically Modified Organism (GMO),
- Local prosperity.

TEXBIAG plans to organise brainstorming sessions, with a few experts, for each of these externalities. Experts will have to define indicators to measure these externalities. These brainstorming sessions will help identifying if it is possible and relevant to monetize these externalities.

Finally, some externalities cannot get a better indicator than a go/no go or a "traffic lights colour":

- Working conditions,
- Property rights,
- Local well-being.

Qualitative indicators to be used by policy makers to assess these externalities will be developed.

Two last externalities are interesting to study but their impact assessment seems beyond the scope of the TEXBIAG project (see FUNDP & CRAW, 2008b):

- Competition with food,
- Energy security.

Monetized indicators will be introduced in VUB's System Perturbation Analysis (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.

5.2.3. Elaboration of a qualitative model

On the basis of the externalities and indicators selected in FUNDP & CRAW (2008b), FUNDP begins to construct a qualitative model. This model articulates the different 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. A first draft of the qualitative model is presented in FUNDP & CRAW (2008c). An example of simple articulation of major externalities or sustainability criteria is given by Figure 3 below.

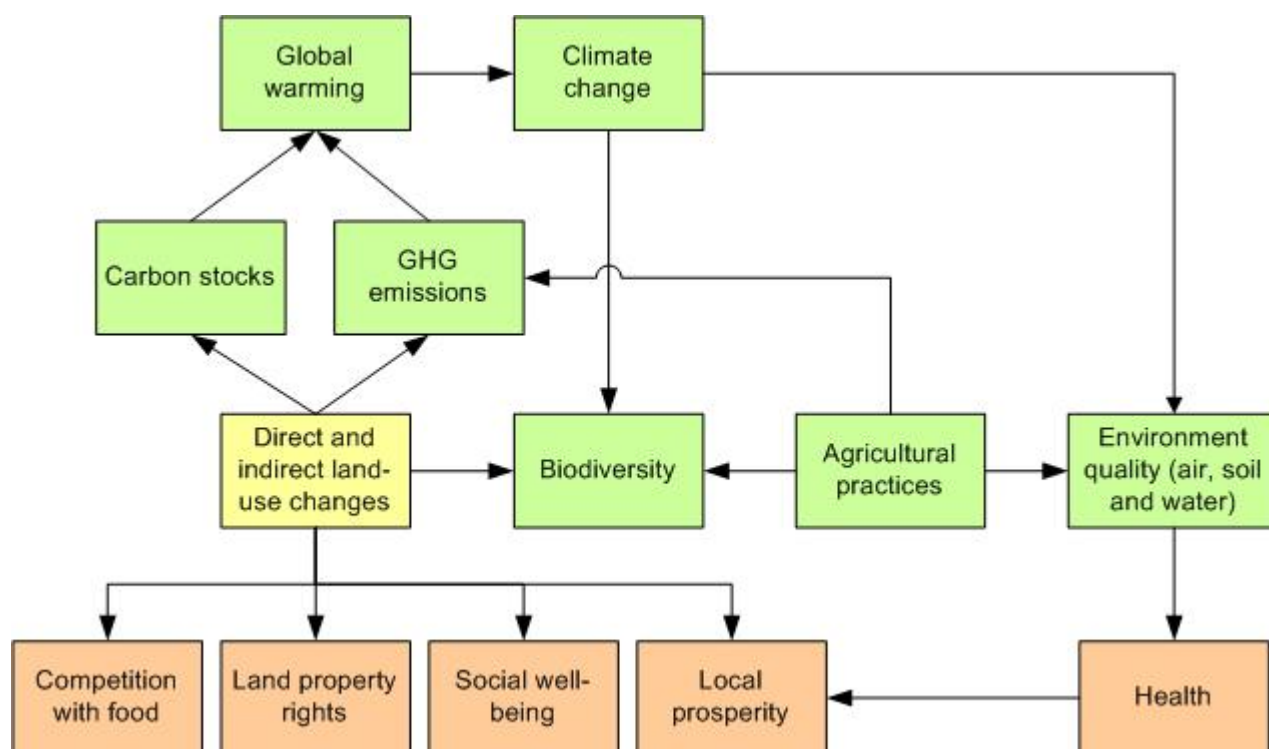


Figure 3 - Simple articulation of major sustainability criteria (Source: FUNDP & CRAW, 2008c)

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.

5.3. 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.

5.3.1. Animal Feed Market Modelling

VUB & CRAW (2008) covers the improvements that can be made concerning the modelling of animal feed in SPA. In SPA1, perturbations of 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.

In the proposed model, six different animal types are distinguished: pigs, piglets, beef cattle, dairy cattle, bulls and poultry. For each type, an average diet is calculated to know the most important specifications and their recommended amounts. Resources having the potential to be used in animal feed mixtures in Belgium are selected and a corresponding price and utilization range is estimated.

The model calculates feed compositions using the concept of linear programming including some constraints; it looks for the cheapest combination of resources under the conditions that the feed needs, expressed by the animal's diet, are satisfied and the resource volumes are located within their specified utilization range.

Feedback is already given by the ILVO during a meeting (June 2008); the concept of linear programming is also applied by feed mixers, but some of the model inputs and constraints need further validation.

5.3.2. Refinery Modelling

VUB (2008a) 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.

An oil balance for Belgium, provided by the Belgian Petroleum Federation, is studied to view the context in which refineries in Belgium operate. A good knowledge and understanding of this balance is necessary for the development of a representative refinery perturbation model:

- Refining industry in Belgium converts crude oil, mainly coming from Russia and the Middle East, into more usable oil products for Belgium and other (neighbouring) countries.
- Some oil products are produced in excessive amounts and are exported while the production of others can not cover the demand in Belgium, resulting in import.
- The unbalance between the use of gasoline and diesel in Belgium and Europe certainly plays a role.
- The refinery output product distribution strongly depends upon the type of crude oil.

Refining plants upgrade the value of oil products: they take in crude oil and convert it into several oil products, generally less heavy products (e.g. fuel oil) and more light products (e.g. gasoline, kerosene and diesel type products).

There are 4 main combinations of conversion units, giving rise to the following types of configurations: simple, semi-complex, complex and complete conversion refineries. In Belgium, 1 simple and 3 semi-complex refineries are present.

Refining processes need electricity and steam:

- Electricity is generated in the refinery or purchased from the grid. If generated on site, either refinery fuel gas or imported natural gas is used as a fuel (or combinations). Additional to refinery fuel gas, imported natural gas can be used.
- Steam can be produced directly by heaters or indirectly by heat recovery. As for electricity, the firing of furnaces can be done by refinery fuels or imported natural gas. For heat generation refinery fuels can be gaseous, liquid (Heavy Fuel Oil) or even solid (Petroleum Coke).

Refinery emissions depend on the crude oil's weight and the degree of cracking, determined by the product yield: a high share of light products requires more processing and so, more CO₂ emissions: an average simple refinery in North West Europe taking in 1 ton of crude oil, will emit about 0.21 ton CO₂, while a semi-complex refinery has an emission of about 0.34 ton CO₂ per ton crude.

Introducing biodiesel and bioethanol on the oil market has some potential effects on the refining industry:

- From a technical point of view, no impact is expected except the need for a blending unit. Moreover, the question is how the sector should be structured in order to withstand major disruptions; with the increasing number of biofuel producers, the chances of losing this biofuel capacity for a longer period and over a larger area, for example due to drought, could easily lead to a shortage of required fuels.
- From an economic point of view, the question is how the market outlook will change when biofuels are introduced. At the moment, Europe is a net importer of diesel fuel and a net exporter of gasoline. Three significant trends are observed for the European refinery production:

- A growing fuel demand of the transport sector.
- A diminishing market for heavy fuel oil.
- An expansion of the market for automotive diesel fuel at the expense of gasoline, driven by transport and fiscal policies.

The high demand for diesel in Europe is expected to keep the refinery diesel output as high as possible so that the additional amount of biodiesel probably will be compensated by a reduction of import. In contrast, the production of bioethanol will further elevate the current export of gasoline from Europe to elsewhere.

5.3.3. 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.

The increasing introduction of DG has resulted in new challenges for modelling techniques and assessing power quality of newly introduced DG units in the system. Different technical challenges have emerged when integrating a large portion of DG into the distribution system.

Distributed generation affects the voltage profile of the system by power injection. It can improve and support the voltage profile and voltage stability of the distribution system, mainly with synchronous generators or power electronic systems mimicking this behaviour.

This allows the distribution system to withstand higher loading conditions and may eventually defer the construction or upgrade of new transmission and distribution infrastructures. In addition, the power injection from DG may reduce the power losses up to some certain level of penetration. However, the protection systems have to be altered from a certain penetration level on, in order to maintain the same safety level.

The location of DG unit and the type of network connection (cable, overhead line) has a major impact on the voltage stability of the system. The power factor of DG has a strong influence on the voltage rise. Before making any decision regarding the connection of a distributed generator, the network operators should study thoroughly different operation modes and capacity for different load profiles in a particular distribution network. Furthermore, the starting-up of DG units, especially induction machines, must not harm other sensitive loads due to voltage dip problems.

To investigate the impact on the transmission system a unit commitment model, from which the operation schedule of the present power plants is derived, with a simplified representation of the Belgian high voltage grid is used. This unit commitment model takes into account:

- Rise in electricity consumption;
- Change in generation park, due to the introduction of biomass and other planned investments;
- Planned reinforcements of the high voltage grid;
- Evolution of fuel and CO₂ prices.

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).

5.3.4. Food Market Modelling

VUB (2008b) developed a mass balance 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.

The international market for cereals, sugar crops and oil crops is studied:

- Cereal crops: Annually, about 2154 million tons of cereals are produced worldwide, mainly maize (31%), wheat (28%) and rice (28%). The United States of America are the biggest producer and exporter of both maize and wheat. China and India also produce large volumes of wheat but use it mainly for domestic consumption.
- Sugar crops: Most of the sugar cane world production (1300 million tons per year) comes from India and Brazil, also being the largest exporter. Sugar beets (240 million tons per year) are mainly produced and traded in Europe.
- Oil crops: The world production for oil crops is about 647 million tons per year. Soybeans have the largest share (30%) and are mainly produced in North and South America. Rapeseed, being a feedstock for biodiesel, has a 6% share and is mostly produced in China.

Looking at the Belgian market for cereals, sugar beets and rapeseed, the main conclusions are:

- Cereal crops: In Belgium, $\frac{3}{4}$ of the cereal supply is imported and $\frac{1}{4}$ is domestically produced. The largest part of these cereals is exported again (after being processed) or ends up in animal feed. Only 11% of the cereals are consumed in the form of food. Wheat is by far the most important cereal crop for Belgium.
- Sugar beet: The position of sugar cane in Belgium is negligible compared to sugar beets. Sugar supply is spread over Belgian sugar beet production (57%) and processed import (43%). The large sugar beet production combined with a large processed export indicates that the sugar beet processing industry plays an important role in Belgium.
- Oil crops: The supply of oil crops in Belgium completely import dependant. The combination of a large import and a large export shows the presence of an important oil crop processing industry. In general, soybeans are the most important oil crop.

In the modelling, the Belgian markets for wheat, sugar beet and rapeseed are considered to be separate entities being indifferent for interactions with other crops, resulting in three separate food crop models. Each model starts from a food crop balance containing the crop's supply and demand volumes, including subcategories. A connection matrix forms the link between supply and demand: the different supply volumes are allocated to the demand volumes proportional to the relative weight of the demands.

In VUB (2008b), 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.

6. Preliminary conclusions and recommendations

6.1. Bioenergy database construction

Now that the structure of the TEXBIAG database has been agreed with all partners, data is filled in, firstly based on Ecolnvent, which is the most comprehensive database currently available. This database is however often related to the Swiss situation, or is a European average. 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.

6.2. 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). These recommendations can be summarised as following:

- Scope of sustainability criteria and certification system: it seems preferable that Belgium implements a system considering all bioenergy uses and not only biofuels, especially since biomass feedstocks can usually be used indifferently for several purposes (biofuels, bioelectricity or bioheat) and their production is the step where the major sustainability risks occur;
- Certification system implementation: a mandatory scheme seems the most appropriate solution in order to guarantee sustainable bioenergy production and use but in order to prevent WTO conflicts, some criteria should perhaps be part of a mandatory scheme, while others could be part of a voluntary system;
- Sustainability criteria can be based on the following topics:
 - Greenhouse gas balance (GHG saving target and above- and below-ground carbon sinks conservation);
 - Biodiversity protection;
 - Environment protection (soil, water and air quality conservation, sound use of pesticides);
 - Social well-being (good working conditions and human rights respect);
 - Land property rights;
 - Local prosperity;
 - Transparent GHG calculation methodology with:
 - Bioenergy chains according to the Belgian market;
 - Default values proposition;
 - Direct land-use change calculation;
 - Indirect land-use changes monitored by the Government;
 - Co-product allocation;
- Certification system: for the time being, it seems that there is no preferable option between the three most common systems (track & trace, mass balance and book & claim) for biomass and bioenergy certification. Further research (surveys and field tests) should enable grasping better the pros and cons of the three systems and possibly selecting the most suitable for biomass and bioenergy certification in the Belgian context.

Because bioenergy sustainability is a hot topic, regular updates will help this publication becoming a useful document for Belgian decision-makers.

6.3. Bioenergy externalities monetization

Among the large number of models which evaluate bioenergy externalities and internal costs, few are relevant for the TEXBIAG project: INPUT-OUTPUT models can be used to assess employment externality, ECOINVENT will be used as a database, and information can be found in ExternE and CASES projects.

Existing models can be useful as a tool-box to assess different bioenergy externalities in the TEXBIAG project, which needs to construct its own integrated model to monetize environmental and socio-economic externalities from bioenergy at a national level.

Monetization methods are more relevant for the project and several of them will be used to assess bioenergy externalities. For example, Cost Of Illness can be used to assess the impacts of emissions on health, Averting behaviour or defensive expenses to assess the impacts of emissions on soil and water quality, and Benefits transfers to monetize the impacts of emissions on global warming.

For each bioenergy route considered by the TEXBIAG project, a table will be fulfilled (see example below). 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.

Table 4 - Qualitative and quantitative indicators for environmental and socio-economic externalities (FUNDP & CRAW, 2008b)

	Qualitative indicators	Quantitative indicators
Environmental externalities		
Global warming		
<i>GHG</i>		<ul style="list-style-type: none"> ▪ Net emissions (gCO₂eq/MJ) of CO₂, CH₄, N₂O and O₃ ▪ Minimum requirement of 35% emission savings from fossil energy references ▪ Monetization (cost by gCO₂eq) of impacts on health, global warming and soil and water quality
<i>Carbon stocks</i>	<ul style="list-style-type: none"> ▪ Evidence of no conversion of wetlands and forests ▪ Evidence of conservation compared to a reference date 	<ul style="list-style-type: none"> ▪ Considered in GHG emissions calculation
<i>Direct land-use change</i>		<ul style="list-style-type: none"> ▪ Direct impacts considered in GHG emissions calculation
Environment quality		
<i>Air quality</i>	<ul style="list-style-type: none"> ▪ Evidence of compliance with GAP ▪ Evidence of compliance with relevant laws and regulations ▪ Prioritization of practices and scoring of compliance 	<ul style="list-style-type: none"> ▪ Net emissions (g/MJ) of CO, NO_x, SO₂, metal, PM (NMVOC, PAH, benzene) ▪ Comparison to fossil energy references ▪ Monetization (cost by g) of impacts on health and soil and water quality
<i>Soil quality</i>	<ul style="list-style-type: none"> ▪ Evidence of compliance with GAP ▪ Evidence of compliance with relevant laws and regulations ▪ Prioritization of practices and scoring of compliance 	<ul style="list-style-type: none"> ▪ Monetization of health and economic impacts (yield) from acidification, eutrophication ▪ Cost of treatment to restore soil quality ▪ Cost of pollution control
<i>Water quality</i>	<ul style="list-style-type: none"> ▪ Evidence of compliance with GAP ▪ Evidence of compliance with relevant laws and regulations ▪ Prioritization of practices and scoring of compliance 	<ul style="list-style-type: none"> ▪ Water quantity needed ▪ Monetization of health and economic impacts from acidification, eutrophication ▪ Cost of making water drinkable (contamination categories and cost classes) ▪ Financial penalties for surface and non-exploited ground water not cleaned

<i>Agrochemicals</i>	<ul style="list-style-type: none"> ▪ Evidence of compliance with GAP ▪ Evidence of compliance with relevant laws, conventions and regulations (WHO, Amsterdam convention, Stockholm convention on pesticides...) ▪ Prioritization of practices and scoring of compliance 	<ul style="list-style-type: none"> ▪ Quantity of agrochemicals, fertilizers and pesticides used ▪ Monetization of impacts on health ▪ Monetization of impacts on soil and water quality ▪ Cost of agrochemicals
Biodiversity		
<i>Biodiversity</i>	<ul style="list-style-type: none"> ▪ Evidence of compliance with relevant rules (EU), conventions (CBD, CITES) and treaties ▪ Scoring of compliance 	<ul style="list-style-type: none"> ▪ Potentially Disappeared Fraction of species and comparison to a reference date ▪ Monetization based on Benefits transfers from Contingent valuations
<i>GMO</i>	<ul style="list-style-type: none"> ▪ Reporting on use ▪ Evidence of compliance with relevant laws and regulations ▪ Scoring of compliance 	
Socio-economic externalities		
Local prosperity		<ul style="list-style-type: none"> ▪ Number of net direct, indirect and induced jobs created (full-time equivalent) ▪ Part of jobs created for local staff ▪ Monetization of jobs ▪ Rural value-added ▪ Local expenses
Working conditions	<ul style="list-style-type: none"> ▪ Evidence of compliance with local and national laws and regulations; with Human rights and ILO conventions (29, 87, 98, 100, 105, 111, 138, 182) ▪ Scoring of compliance 	
Property rights	<ul style="list-style-type: none"> ▪ Evidence of compliance with relevant local and national laws and regulations ▪ Scoring of compliance 	
Local well-being	<ul style="list-style-type: none"> ▪ Evidence of initiatives that contribute to local population well-being ▪ Scoring of initiatives 	
Competition with food	<ul style="list-style-type: none"> ▪ Land availability ▪ Land price evolution ▪ Food availability (production, importations, exportations) ▪ Food prices evolution ▪ Feed prices evolution ▪ Livestock prices evolution 	
Energy security	<ul style="list-style-type: none"> ▪ Number of potential countries of origin ▪ Security of their furniture 	<ul style="list-style-type: none"> ▪ Importations ▪ Fossil energy importations replaced by bioenergy route ▪ Exportations ▪ By-products importations and exportations ▪ Storing possibilities
Indirect effects		
Indirect land-use change	<ul style="list-style-type: none"> ▪ Reporting of indirect impacts on national level, comparison to a reference date 	

6.4. 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. Especially for animal feed, more efforts will be needed to get reliable input information.

The introduction of bio-energy 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, photovoltaics) 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).

7. 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 this integrated tool.

7.1. Database Construction

7.1.1. Sustainability criteria and certification systems for biomass and bioenergy

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.

7.1.2. Environmental and socio-economic impacts data collection

A survey to collect data on missing environmental and socio-economic impacts and on logistics will be prepared and conducted by the project partners.

From the results of the first phase of the project as well as with the inputs of FUNDP, VUB and KUL, 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).

If primary data on environmental impacts are expected to be satisfactorily found in the literature and existing databases, there is a need for more accurate and reliable data on socio-economic impacts (jobs creation, economic-side effects, technology development) and on logistics of bioenergy from agriculture according to the biomass fuel type and to the size and type of the energy conversion technology. To collect reliable and accurate data, a survey has to be conducted to obtain homogenous results.

This survey is structured around three major themes:

1. Agriculture: energy crops (ex: short rotation forestry, miscanthus), by-products; the survey will address issues related to all operations of biomass mobilisation and conditioning (harvest, comminution, storage, handling), the type of jobs created by these operations, salaries, side-effects, etc.
2. Energy conversion technologies: for the different conversion chains (heat/cooling, electricity, liquid biofuels), the survey will address:
 - Equipment necessary according to biomass fuel type and plant size (silos, feeding system, reactor, peripheral equipment, operation, maintenance, transport and distribution to the end-user);
 - Erection and commissioning of the installation;
 - Type of jobs created, salaries, side effects.
3. Fuel oil and gas equipment: with the objective of reducing greenhouse gas emissions from fossil fuels, bioenergy production plants must be installed in place of fossil fuel-based ones. However, this means that jobs will be cut in the fossil fuel energy plants sectors (supply, construction, operation, maintenance) while more new jobs will be created in the bioenergy sectors. In order to determine the quantities of net jobs created through the substitution of fuel

oil or gas plants by bioenergy systems from agriculture, the survey will also address the same issues for fuel oil and gas equipment as for bioenergy from agriculture.

The operation of the database is be ensured by the means of two actions:

- The tests that will be conducted on the two decision-making tools (externalities monetary value model and policy prediction tool) are also used to evaluate the performances and the reliability of the database. Adaptations, corrections, improvement are applied to the database according to an evaluation carried out on the basis of the tests on the decision-making tools.
- The database is continuously updated thanks to a permanent monitoring of the different sectors concerned (energy, agriculture, environment, socio-economics, and logistics).

7.2. Externalities monetary value model

7.2.1. Validation of valuation indicators and consolidation of the qualitative 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 during the first semester of 2009.

Brainstorming sessions will also contribute to articulate environmental and socio-economic externalities in order to design the qualitative model.

The qualitative model designed at the end of phase 1 and that will have received approval from partners will be submitted to experts. Various stakeholders (policy makers, experts in agriculture, and experts in energy) will be invited to one or several brainstorming sessions that should help to propose a consensual model to which all concerned stakeholders adhere. This approval is necessary before beginning the quantitative approach.

Moreover, the project partners will check the possible innovations in the field through a continuous analysis of literature.

7.2.2. Quantification of the effects through a cost/revenue analysis

This part is perhaps the most delicate of the modelling approach. 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. Some of these quantitative data will be available in the database built by CRAW. Other data will require an in-depth evaluation.

7.2.3. Consolidation of the quantitative model

As the qualitative model, the quantitative model should be approved by consortium partners and fit with their own conclusions and objectives. Moreover, it would be interesting to come back to (some of) the experts that were consulted previously in order to check if the evolution of the model meets their considerations. A way to communicate with partners and experts would be to build some test simulations in order to give an explicit image of the model. The model will be then be consolidated on this basis.

7.3. Policy prediction tool

Because of its complexity, special attention is paid to the modelling of the animal feed market: the modelling itself is finished but still appropriate inputs for the model are needed. VUB will collect more reliable inputs trough external expertise: follow-up committee members, CRAW, ILVO, BEMEFA and compound feed producers. The other model components are also open for additional inputs and comments of follow-up committee members.

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.

7.3.1. Introduction of new externalities in the System Perturbation Analysis

SPA so far calculates the system balances of fossil energy, renewable energy, GHG emissions and limited costs when introducing any perturbation such as for example replacing a hectare of set aside land by growing rapeseed for RME production to replace diesel in the transport sector. Some 60 of such scenarios have been introduced in the Libiofuels project.

In the present project other numerical impacts will be computed, such as job creation (direct and indirect employment), rural development, energy supply security, etc. The corresponding software extension will be introduced.

Usage of commodities, which are relevant for determining the externalities (e.g. water usage) of bioenergy and not yet included in the data, will be searched for.

7.4. Results dissemination and valorisation

7.4.1. Programming a user friendly interface of the three tools

So far the data for the SPA and the running of the software are not designed for general use, but based on intervention at programming level. The purpose of this task is to make the SPA tool more versatile and exportable for users other than VUB. This will be made in the MATLAB programming environment and in conjunction with the data structures developed in subtask 1.1. A 'user friendly' interface tool will be programmed where access to and update of the basic data (Task 1), monetary models (Task 2) and SPA (Task 3) will be prepared.

At this stage all software adaptations and data for externalities are available and introduced in the database. The SPA will be conducted for a given number of scenarios with sensitivity analysis wherever possible. Inputs for task 4.2 and 4.3 will be prepared.

7.4.2. Performance of the decision-making tools and awareness campaign

Thanks to a thorough dissemination of the results and deliverables of the project towards its target groups. The three main target groups that will benefit from the project are: the government officials and policy makers in the field of agriculture, energy and environment in Belgium and its two main regions, the small, medium and large energy companies and the agricultural sector. Through the performance of the decision-making tools and awareness campaign, it is expected that the project will:

1. Improve the understanding of government officials and policy makers on the barriers towards implementation of bioenergy from agriculture and the measures to improve these policies and their implementation;
2. Enhance the capacity of policy makers and public administrations in setting up adequate policy and policy implementation guidelines that could promote bioenergy from agriculture;
3. Enhance the capacity of small, medium and large energy companies as well as the agricultural sector in implementing bioenergy from agriculture by developing strategic know-how and approaches towards bioenergy from agriculture development and implementation;
4. Demonstrate to government officials and policy makers, small, medium and large energy companies, agricultural sector the benefits of bioenergy from agriculture, in terms of environmental and health protection, potential energy supply security, jobs creation and economic development;
5. Encourage government officials and policy makers, small, medium and large energy companies, agricultural sector to develop bioenergy projects from agriculture.

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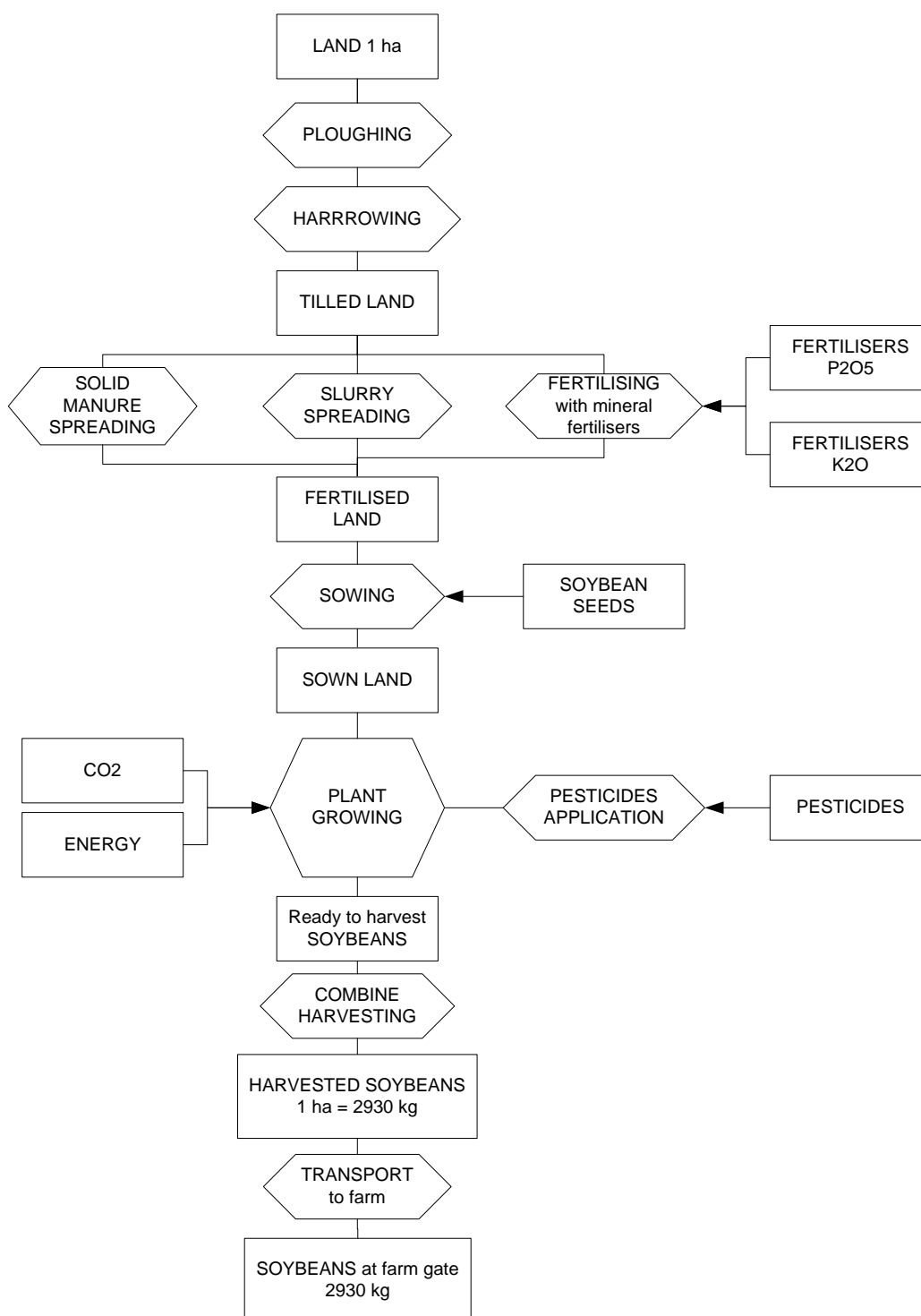
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Annex 1 Typical flow chart used in the TEXBIAG database

This example comprises the cultivation of 1 ha of soybean from the preparation of the soil until the beans reach the farm. Each of these steps comes along with inputs (machinery, diesel fuel, electricity, pesticides, etc.) and outputs (products, emissions in soil, air, water, etc.) that are detailed in Excel sheets, readily available for processing by partners at VUB and FUNDP in their models.

For instance, in the flow chart below, the step "ploughing" represents the action of preparing 1 ha of land with a plough. It requires a tractor, pieces of machinery, diesel (inputs) and emits substances in the air (due to fuel combustion) and in the soil (due to tyre abrasion) (outputs).



Annex 2 Summary of main initiatives regarding sustainability criteria for biomass and bioenergy

The table below summarizes the characteristics of the most advanced initiatives studied in CRAW & FUNDP (2008).

Characteristics	NL : Cramer Commission	DE : German Biofuel Quota Act	UK : Renewable Transportation Fuels Obligation	RSPO : Sustainable Palm Oil Scheme	EC: Proposal for new RES Directive and FQD
Scope	Bioenergy	Biofuels	Transport fuels	Palm oil (food, feed, material and energy uses)	Biofuels and bioliquids used in heating and electricity sectors
System implementation	Minimum requirements to be implemented (and made stricter) by authorities as a mandatory scheme	Law = mandatory	Carbon & Sustainability Reporting Scheme: <ul style="list-style-type: none"> ▪ Step towards assurance scheme ▪ Legal reporting obligation in order to claim certificates (RTFCs) ▪ Not mandatory targets ▪ Report compliance with benchmarked standards or RTFO meta-standard ▪ Possible to claim "unknown" in reports 	Voluntary scheme	<ul style="list-style-type: none"> ▪ Proposal for a new Directive on Renewable sources ▪ Amendment of Fuel Quality Directive ▪ New Directives to be transposed by Member States into National Actions Plans
Sustainability criteria definition	<ul style="list-style-type: none"> ▪ Hierarchised themes (6) ▪ Principles (9) ▪ Criteria ▪ Indicators or reporting requirements 	<ul style="list-style-type: none"> ▪ Themes (3) ▪ Criteria & requirements 	RTFO sustainability meta-standard: <ul style="list-style-type: none"> ▪ Principles (7) ▪ Criteria 	<ul style="list-style-type: none"> ▪ Principles (8) ▪ Criteria ▪ Indicators and guidance ▪ Possible national interpretations 	<ul style="list-style-type: none"> ▪ Environmental sustainability criteria (3) in Proposal for new RES Directive ▪ Sustainability requirements (11) in Amendment 48 of the EU Parliament
Sustainability criteria quality	<ul style="list-style-type: none"> ▪ Based on existing initiatives ▪ Improved by stakeholders' consultation, workshops & web survey ▪ Smallholders taken into 	No detailed principles and indicators	<ul style="list-style-type: none"> ▪ Sustainability principles & criteria so far relate only to biomass cultivation steps (others steps to be included later) ▪ Not applicable for by-products representing < 	<ul style="list-style-type: none"> ▪ Very detailed indicators and guidance ▪ Long-term (oldest) initiative (2004), developed by working group and improved through public consultations 	<ul style="list-style-type: none"> ▪ Environmental sustainability criteria in Proposal for new RES Directive perceived as insufficient ▪ Socio-economic sustainability only suggested in

	account (simplification) <ul style="list-style-type: none"> Continuous improvement (revision in 2011) 		10% of the product value and for labour intensity < 5 man days/ha		Amendment 48 <ul style="list-style-type: none"> Other criteria by other initiatives excluded at present
Indirect land-use change effects	<ul style="list-style-type: none"> To be monitored by Dutch Government List of data to be monitored included 	?	Monitoring by UK Government through RFA	?	? (default values assume no net change in land-use)
GHG calculation methodology	<ul style="list-style-type: none"> To be integrated in tool Compares bioenergy with fossil reference Biofuels: well-to-wheel Bioelectricity: chain till consumer 	<ul style="list-style-type: none"> Aims at introducing a quota multiplication factor depending on GHG savings in the Biofuel Quota Law Compares biofuel with fossil reference 	<ul style="list-style-type: none"> Compares biofuel with fossil reference Flexible method from default to actual data Well-to-wheel Technical guidance available Biofuel GHG calculator available 	GHG calculation methodology lacking	Compares biofuel with fossil reference
GHG emission reduction target(s)	Minimum requirements: <ul style="list-style-type: none"> 50-70% for electricity 30% for biofuels 	Mandatory targets: <ul style="list-style-type: none"> 30% in 2008 40% from 2011 	Expected targets: <ul style="list-style-type: none"> 40% in 2008-2009 45% in 2009-2010 50% in 2010-2011 		Proposal: <ul style="list-style-type: none"> 35%
Selected chains	According to Dutch market	According to German market	According to UK market		According to EU market
Default values for bioenergy systems	To be set	Set (based on IFEU, IPCC & others)	Set (based on UK actual data)		<ul style="list-style-type: none"> Set (based on?) Available both for commercially available and future technologies
Reference fossil systems	To be set	Set (based on Concawe)	Set (based on Concawe)		Set (based on?)
Direct land-use change effects	<ul style="list-style-type: none"> Based on IPCC Guidelines 'Tier 1' Base year = 2005 	Calculation methodology included, time span = 20 years	<ul style="list-style-type: none"> Based on IPCC Guidelines Base year = 2005 Possibility to report "unknown" to avoid discrimination by default values application 		<ul style="list-style-type: none"> Calculation methodology included Base year = January 2008 Time span = 20 years Some default values available if actual values lacking
Co-products allocation	On energy content	On energy content	<ul style="list-style-type: none"> Substitution is 1st choice Allocation by mass or 		On energy content

			energy if risk of double accounting <ul style="list-style-type: none"> Allocation by market value as a fall back option 		
Certification system	<ul style="list-style-type: none"> Not yet chosen 3 main existing systems (Track&Trace, Mass balance and Book&Claim) described and compared 	<ul style="list-style-type: none"> Based on Track&Trace and Mass Balance systems Execution & monitoring drafted Verification by third party Proposed fees for certification application 	<ul style="list-style-type: none"> Verification of reports through chain-of-custody from feedstock supplier to fuel supplier Failing that, mass balance approach is operated Independent verification by auditors Reports publicly available 	<ul style="list-style-type: none"> Three main existing systems (Track&Trace, Mass balance and Book&Claim) have been tested (stakeholders' consultation and field testing) All 3 systems considered viable and acceptable Accreditation and certification process requirements already set (validity of certificates, non-conformities resolving, etc.) Mechanism for certification bodies approval set 	No proposition yet
Conclusions	NL : Cramer Commission	DE : German Biofuel Quota Act	UK : Renewable Transportation Fuels Obligation	RSPO : Sustainable Palm Oil Scheme	EC: Proposal for new RES Directive and FQD
Advantages (strong points)	<ul style="list-style-type: none"> Not limited to biofuels Most complete initiative Stakeholders involved Smallholders considered Well-developed GHG methodology 	<ul style="list-style-type: none"> Own direct LUC assessment method Well-developed GHG methodology Certification process well developed 	<ul style="list-style-type: none"> Well-developed GHG methodology Certification process well developed 	<ul style="list-style-type: none"> Very complete set of criteria, indicators and guidance 	<ul style="list-style-type: none"> Well-developed GHG methodology
Drawbacks (weaknesses)	<ul style="list-style-type: none"> Lacks own direct LUC assessment (uses IPCC's) Lacks certification system (but probably under development) 	<ul style="list-style-type: none"> Vague and not detailed criteria 	<ul style="list-style-type: none"> Reporting scheme with possibility just to claim "unknown" is weak 	<ul style="list-style-type: none"> GHG methodology is very much lacking 	<ul style="list-style-type: none"> Insufficient criteria Certification system not yet developed