PhD project

Firms' sustainable choice of energy

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November 2009

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Introduction

The concept of sustainable development is now present in every sphere of life. Firms cannot avoid this concept whatever they consider it as a threat or as an opportunity. They must take into account environmental and socio-economical impacts of their activities and proof their sustainability in order to meet stakeholders' expectations.

Fighting against climate change is part of sustainable development and imposes the mitigation of greenhouse gases (GHG) emissions, considerable efforts have to be pursued by firms, especially in the field of energy production and use.

Each energy route, composed by resource, conversion technology and end-use, presents GHG emissions but also other negative and/or positive environmental and socio-economical externalities[1]. These externalities must be assessed in order to compare one energy route to another energy route. The lack of primary and reliable data on externalities is, nevertheless, an important non-technological barrier to the choice of the best energy route(s) by firms. The aim of this PhD project is to enhance the firms' sustainable choice of energy.

The first part of this thesis is an extensive study of the literature, taking into account the existing works concerning energy externalities assessment and focusing on methods and models proposed in this field.

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[1] "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).

The second part defines a list of externalities, also called sustainability criteria, to assess energy sustainability. This list is derived from literature review and assessment of sustainability criteria initiatives and certification schemes.

These externalities or sustainability criteria are then articulated in a qualitative model 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.

These two first parts are directly tied to the TEXBIAG[2] project which aims at designing decision-making tool to support the development of bioenergy from agriculture. On the basis of the consolidated qualitative model, this project will construct a quantitative model which will enable, on the one hand, the monetization of measurable sustainability criteria, and, on the other hand, the qualitative assessment of other sustainability criteria and their potential introduction in a certification scheme. For each bioenergy route studied, monetized, quantitative and qualitative information will be gathered in a table. Comparison of tables will allow policy makers to take into account all dimensions[3] of sustainable development in their choice of the best bioenergy route(s) to support by investments, taxes, quotas, subventions…

For this thesis, and on the basis of the two first parts, we study how firms chose their energy route(s) and if they are responsive to incentives given by politics to support the best (bio)energy routes. Do firms take sustainability criteria into account? Which criteria they consider? How they integrate them in management? And if the qualitative/quantitative model we develop can be helpful for them in their energy choice?

[2] Project sponsored by the BELgian Science POlicy (BELSPO) and led by Walloon Agricultural Research Center (CRA-W), University of Namur (FUNDP), Vrije Universiteit Brussels (VUB) and Katholieke Universiteit Leuven (KUL). For more details, see www.texbiag.be

[3] Policy makers can give different weights to different dimensions (criteria, externalities) of sustainable development.

With this thesis, we will give an overview of the definition and the application of sustainability criteria in the particular context of energy choice by firms and we expect to provide relevant tool to managers in order to enhance their choice of the best energy route(s). We also hope that our conclusions can apply to other types of commodity.

The next section describes the links between the TEXBIAG project and the thesis. The three parts of the PhD project are then explained.

TEXBIAG project vs. Thesis project

Figure 1 proposes the links between the TEXBIAG deliverables and the thesis parts. Each part is then described here after.

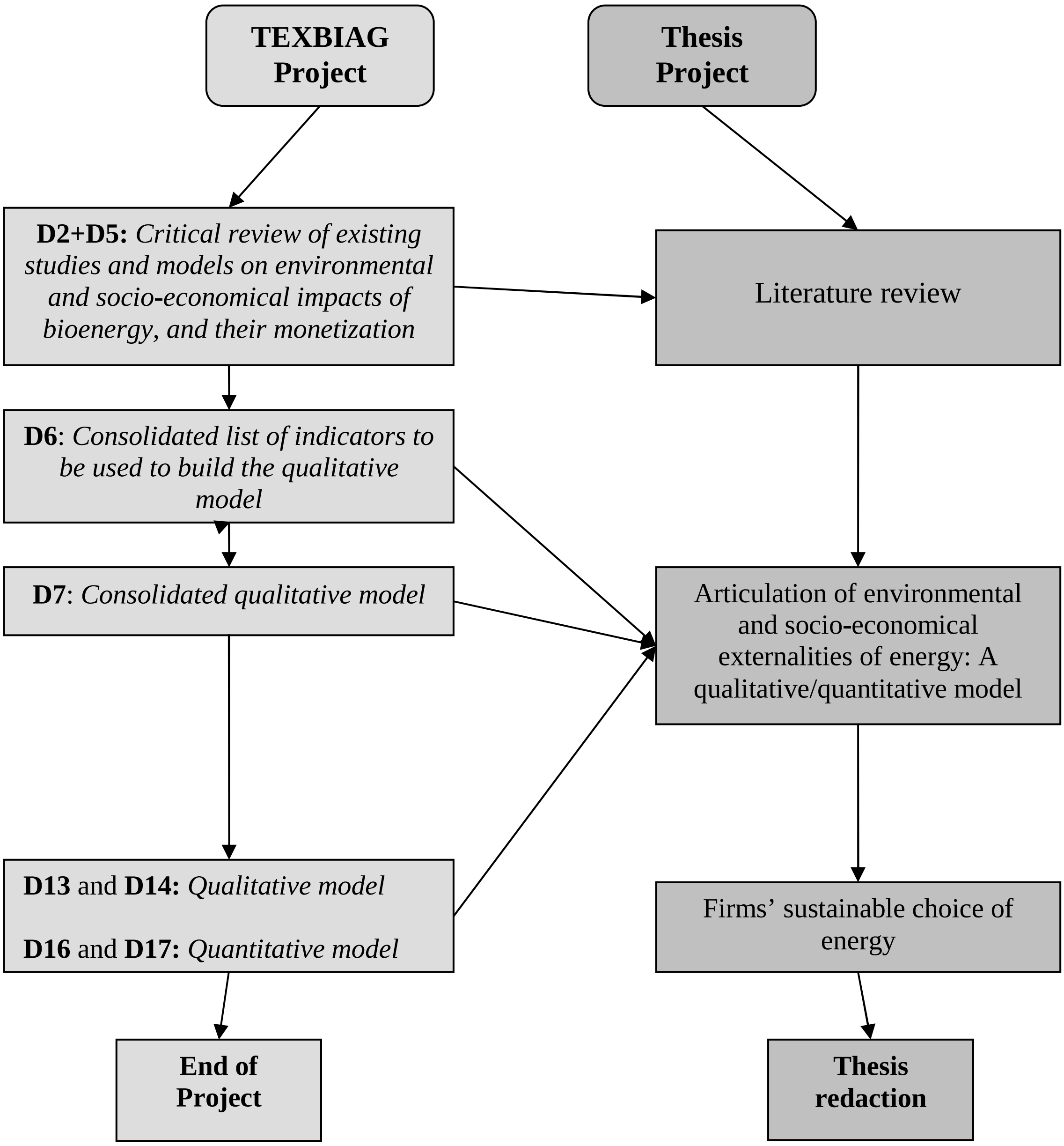

Figure 1 - Articulation of TEXBIAG and Thesis projects

Within the TEXBIAG project: "*Decision-Making Tools to Support the Development of Bioenergy in Agriculture*", another thesis is carried out by Florence Van Stappen from CRA-W and deals with the development of a certification system for the use of liquid biofuels.

1. Critical review of existing studies and models on environmental and socio-economical impacts of energy, and their monetization

This literature review is two-parts. On the one hand, an extensive study of the literature is led, taking into account the existing works concerning energy externalities and focusing on methods and models proposed in this field. On the other hand, a critical review of existing sustainability criteria initiatives and certification schemes allows the design of a list of externalities or sustainability criteria to take into account in energy routes assessment (see section 2).

Concerning energy externalities evaluation and monetization, Table 1 presents the models and methods described in the first part of this thesis.

Table 1 – Existing models and methodologies on externalities evaluation and monetization

Category	Model	
Externalities evaluation models	BIOSEM	
	RETScreen	
	ExternE	
	CASES	
	ELVIRE	
	SAFIRE	
	INSPIRE	
	RECAP	
	BEAM	
	BIOCOST	
	BEAVER	
	MULTISEES	
	ABM	
	Input-Output models	
Economic models	Energy models	PRIMES
		POLES
	CGE models	GTAP-E,
		LEITAP
		DART
		USAGE
		GOAL

	Agricultural Equilibrium models	AGLINK
		ESIM
		FAPRI
		AGMEMOD
		IMPACT
	Agricultural and Forestry Programming models	EUFASOM – ENFA
		RAUMIS
		CAPRI
Some examples of projects using the models	CASCADE MINTS	
	NaRoLa	
Existing methods to monetize externalities	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
	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 energy routes (internal costs), and by their comparison. Some environmental externalities are sometimes taken into account (especially emissions). Some socio-economical externalities are also considered (especially direct employment) but, most of the time, at local or regional level (case study of local initiative).

It also appears that externalities are sometimes quantified (tons of CO_2 emitted, number of jobs created…) but rarely monetized (cost of one ton of CO_2, benefits from job creation, etc.). Nevertheless, several relevant methods to monetize externalities exist. Finally few energy externalities are evaluated by each model. There is no model which integrates and assesses all externalities from energy.

2. Articulation of environmental and socio-economical externalities of energy: A qualitative/quantitative model

2.1 List of externalities or sustainability criteria

Concerning the definition of a list of externalities or sustainability criteria to take into account in energy routes assessment, a panel of initiatives led by different stakeholders (consultants, government representatives, distributors, social and/or environmental NGOs…) on different agricultural and/or energetic products (soy, palm oil, fruits and vegetables, coffee, wood, biomass, biofuel, electricity…) is considered:

- Cramer Commission,
- Renewable Transport Fuel Obligation (RTFO),
- Round table on Sustainable Palm Oil (RSPO),
- Round table on Sustainable Biofuels (RSB),
- Basel Criteria for Responsible Soy Production,
- Utz Codes of Conduct,
- Eurep or Global Good Agricultural Practices (EurepGAP-GlobalGAP),
- International Federation of Organic Agriculture Movements (IFOAM),
- Sustainable Agricultural Network / Rainforest Alliance (SAN/RA),
- Forest Stewardship Council (FSC),
- Pan-European Forest Council (PEFC),
- American Tree Farm System (ATFS),
- Sustainable Forestry Initiative Standard (SFIS),
- EUropean Green Electricity NEtwork (Eugene),

- Green Gold Label program (GGL),
- Öko-Institut.

From this extensive literature review and consultation of experts, a list of externalities to take into account in energy routes assessment has been defined (see Table 2).

Table 2 - Externalities and sustainability criteria selected

Externalities	**Sustainability criteria**	
Environmental externalities	Global warming	GHG emissions (CO_2, CH_4, N_2O, O_3 emissions) Carbon stocks (above- and below-ground carbon sinks) Direct land-use change
	Environment quality	Air quality (CO, NO_x, SO_2, metal, PM, NMVOC, PAH, benzene emissions) Soil quality (soil structure and fertility) Water quality (ground- and surface-water quantity and quality) Agricultural practices (use of pesticides and other agrochemicals)
	Biodiversity	Biodiversity GMO
Socio-economical externalities	Local prosperity Social well-being Working conditions Land property rights Competition with food Energy security	
Macro-level externalities	Indirect land-use change	

2.2 Indicators

If there is a consensus, among initiatives and certification systems, on a list of externalities to take into account, there is little information on indicators to measure these externalities. Several indicators and their methodologies still need to be described accurately.

Global warming (GHG emissions, carbon stocks, and direct land-use change), and air quality externalities are already measurable by well-defined indicators. They can be quantified and, probably, monetized on the basis of their impacts.

Some externalities still need good indicators to be measured:

- Indirect land-use change,
- Soil quality,
- Water quality,
- Agricultural practices,
- Biodiversity,
- Local prosperity,
- Competition with food,
- and energy security.

Other externalities as the respect of social well-being and land property rights cannot be monetized. These externalities can only be assessed through qualitative indicators.

Examples of quantitative (monetization) and qualitative indicators are given in Table 3.

Table 3 - Qualitative and quantitative indicators for environmental and socio-economical externalities

	Qualitative indicators	**Quantitative indicators**
Environmental externalities		
Global warming		
GHG		➢ Net emissions (gCO_2eq/MJ) of CO_2, CH_4, N_2O and O_3 ➢ Minimum requirement of 35% emission savings from fossil energy references ➢ Monetization (cost by gCO_2eq) of

		impacts on health, global warming and soil and water quality
Carbon stocks	➢ Evidence of no conversion of wetlands and forests ➢ Evidence of conservation compared to a reference date	➢ Considered in GHG emissions calculation
Direct land-use change		➢ Direct impacts considered in GHG emissions calculation
Environment quality		
Air quality	➢ Evidence of compliance with GAP ➢ Evidence of compliance with relevant laws and regulations ➢ Prioritization of practices and scoring of compliance	➢ Net emissions (g/MJ) of CO, NO_x, SO_2, metal, PM, NMVOC, PAH, benzene ➢ Comparison to fossil energy references ➢ Monetization (cost by g) of impacts on health and soil and water quality
Soil quality	➢ Evidence of compliance with GAP ➢ Evidence of compliance with relevant laws and regulations ➢ Prioritization of practices and scoring of compliance	➢ Monetization of health and economic impacts (yield) from acidification, eutrophication ➢ Cost of treatment to restore soil quality ➢ Cost of pollution control
Water quality	➢ Evidence of compliance with GAP ➢ Evidence of compliance with relevant laws and regulations ➢ Prioritization of practices and scoring of compliance	➢ 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
Agricultural practices	➢ Evidence of compliance with GAP ➢ Evidence of compliance with relevant laws, conventions and regulations (WHO types, Amsterdam convention, Stockholm convention on pesticides…) ➢ Prioritization of practices and scoring of compliance	➢ Quantity of agrochemicals, fertilizers and pesticides used ➢ Monetization of impacts on health ➢ Monetization of impacts on soil and water quality ➢ Cost of agrochemicals
Biodiversity		
Biodiversity	➢ Evidence of compliance with relevant rules (EU), conventions (CBD, CITES) and treaties ➢ Scoring of compliance	➢ Potentially Disappeared Fraction of species and comparison to a reference date ➢ Monetization based on Benefits transfers from Contingent valuations
GMO	➢ Reporting on use ➢ Evidence of compliance with relevant laws and regulations	

	➢ Scoring of compliance	
Socio-economical externalities		
Local prosperity		➢ 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
Land property rights	➢ Evidence of compliance with relevant local and national laws and regulations ➢ Scoring of compliance	
Social well-being	➢ 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 ➢ Evidence of initiatives that contribute to local population well-being ➢ Scoring of initiatives	
Competition with food	➢ Land availability ➢ Land price evolution ➢ Food availability (production, importations, exportations) ➢ Food prices evolution ➢ Feed prices evolution ➢ Livestock prices evolution	
Energy security	➢ Number of potential countries of origin ➢ Security of their furniture	➢ Importations ➢ Fossil energy importations replaced by bioenergy route ➢ Exportations ➢ By-products importations and exportations ➢ Storing possibilities
Indirect land-use change	➢ Reporting of indirect impacts on national level, comparison to a reference date	

2.3 Qualitative model

The qualitative model articulates externalities or sustainability criteria selected in order to identify cause-effect relationships, feedback, induced and non-linear effects between them. The general articulation of major externalities or sustainability criteria is given by Figure 2.

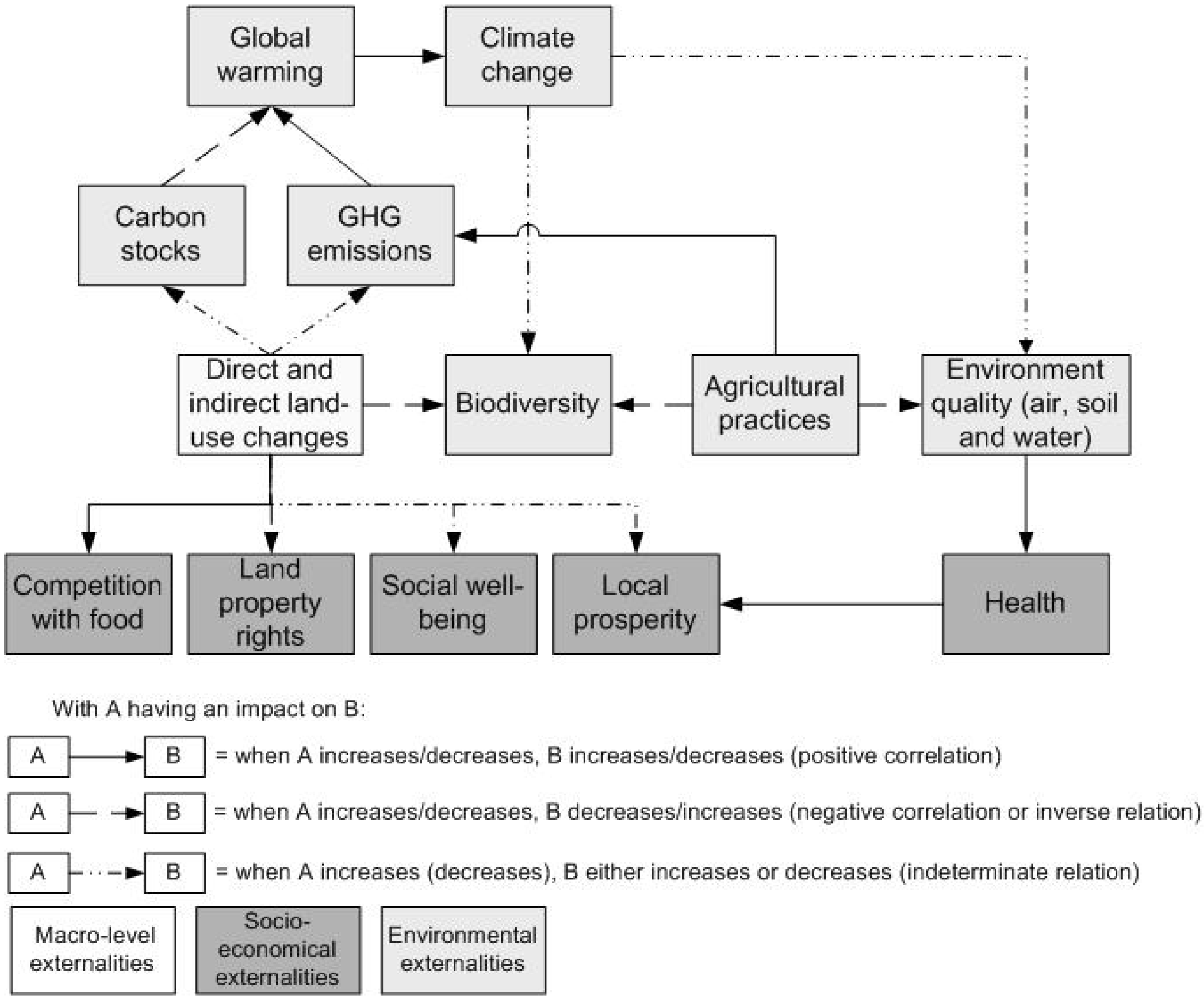

Figure 2 - Articulation of major sustainability criteria

2.4 Quantitative model

On the basis of the qualitative model, a quantitative model will be built and will enable on the one hand the monetization of measurable sustainability criteria and, on the other hand, the qualitative assessment of other sustainability criteria.

For each energy route, a table will gather quantitative (incl. monetization) and qualitative evaluation of sustainability criteria. Comparisons of energy tables will enhance the policy makers' choice of the best energy route(s).

The list of sustainability criteria, their indicators and their articulation in qualitative/quantitative model are developed in the frame of TEXBIAG project and for bioenergy routes. Nevertheless, each of these elements can be easily adapted to all types of energy route. In the third part of this thesis, we expect to apply the tool designed to firms and managers' energetic choice.

3. Firms' sustainable choice of energy

This third part aims at assessing if the tool developed in TEXBIAG project for policy makers' bioenergy choice can be applied to firms' energy choice, and if this potential application leads to managerial implications.

Today, firms must and/or want to be sustainable. Fighting against global warming and climate change is part of sustainable development and imposes the mitigation of GHG emissions. Considerable efforts have to be pursued by firms, especially in the field of energy production and use.

In order to "green" their energy consumption, firms have several possibilities which can be mixed:

- Optimizing energy use (metering/auditing of energy consumption and relevant initiatives (from few habits to isolation investments) lead to energy efficiency and savings),
- Buying green energy from suppliers (Electrabel, Luminus, Nuon, Essent),
- Producing energy on their own or in collaboration with suppliers (Combined Heat and Power (CHP), biomass, waste (Cradle to Cradle (C2C)), photovoltaic (PV), wind, hydro, oceanic, geothermic, hydrogen, but also carbon sequestration…),
- Investing in external projects with partners (for example: investing in off-shore wind energy projects).

In this thesis, we want to study how firms make their choice between these energy possibilities and if they are responsive to incentives given by politics to the best (bio)energy routes.

As the energetic choice is guided by a will to be sustainable, we want to know which sustainability criteria are taken into account by firms when they are designing their relevant energy-mix, and if they consider the sustainability criteria we retained for TEXBIAG project (see Section 2). We also want to understand how firms are measuring these criteria, which tools they are using, and if/how the decision-making tool we develop for politics in TEXBIAG project can be adapted for managers.

Some firms refer, at least partially, to Global Reporting Initiative (GRI) list of criteria to assess their sustainability. We should thus compare these criteria to our own list. We already know that GRI considers the three pillars of sustainable development and uses indicators to evaluate economical, environmental and social criteria. GRI also devotes specific criteria and indicators to energy (in)direct consumption and efficiency.

As long as GRI remains a complex tool to apply, some other firms, especially Small and Medium Enterprises (SMEs), adopt a reduced list of criteria and indicators to assess their sustainability (for example, the 15 indicators of sustainable development developed by Union Wallonne des Entreprises (UWE)). We also have to consider these smaller tools, which are quickly operational, and compare their performance to our own tool. Other initiatives and standards as ISO1400X, EMAS… should also be considered in our thesis.

This thesis doesn't focus on firms' motivations to be sustainable and to use green energy. Nevertheless, these motivations can influence firms' selection of sustainability criteria to take into account in energy-mix choice. We have thus to consider them. They are all directly or indirectly tied to firms' strategy and economical performance:

- Efficiency (firms reduce energy costs),
- Regulation (firms meet and/or anticipate rules and laws, try to get subsidies, tax reduction and/or green certificates, try to meet carbon quotas),
- Image (own values, marketing, reporting, norms, certifications, labels, meeting stakeholders' expectations, attracting investments…).

From our assessment of firms' energy choice, we would like to develop a typology of firms. This typology will categorize firms according to their energy-mix choice, their motivations, and their sustainability criteria evaluation (see Figure 3). On the basis of this typology, we hope to determine if a specific energy choice is tied to a particular group of firms, and thus if firms' characteristics influence energy choice. We also expect to identify which groups of firms can be interested by the decision-making tool we develop for TEXBIAG project

To answer these questions, we will use qualitative methodologies. We plan to lead case-studies on a panel of firms. These detailed case-studies will be supported by interviews, and observations.

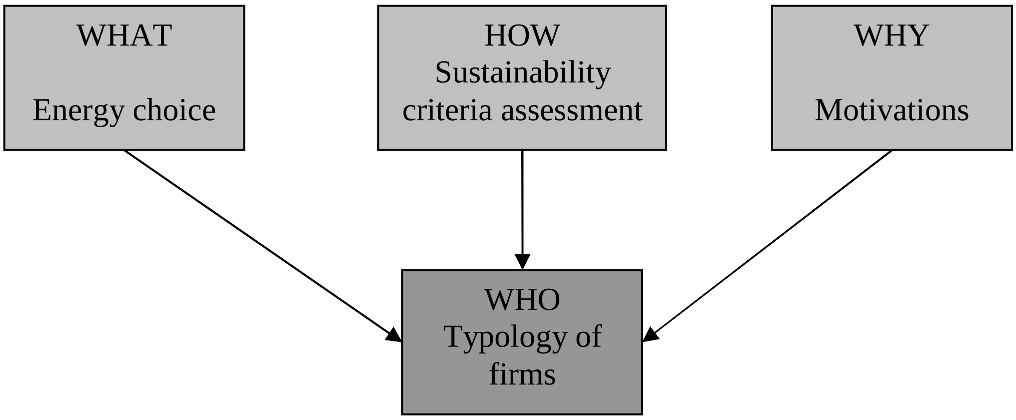

Figure 3 – Articulation of Part 3

To be sustainable, firms must be economically, socially and environmentally responsible. At first sight, our project seems to only look at environmental and economical dimensions of energy choice. Social responsibility is however also considered as the sustainability criteria we study include social impacts from energy production and use.