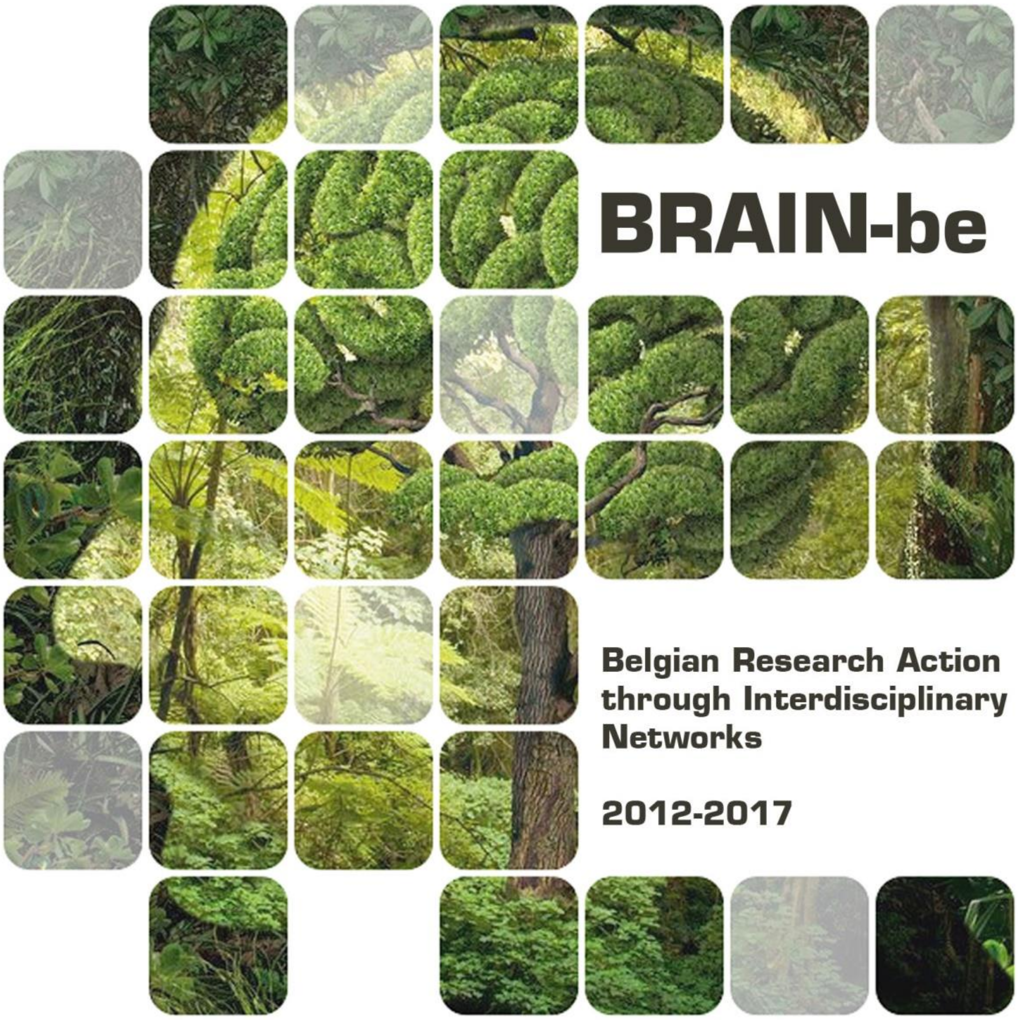

ALPI

Assessment of Low Carbon Policy Instruments

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Axis 5: Major societal challenges

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NETWORK PROJECT

ALPI

Assessment of Low Carbon Policy Instruments

Contract - BR/143/A5/ALPI

FINAL REPORT

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ABSTRACT

The Paris Agreement, adopted in Paris on 12 December 2015, aims to accelerate and intensify the actions and investment needed for the transition to a low carbon society. In this context, the work made by the ALPI project constitute a relevant and current issue for policy makers. The main objective of the ALPI project is to promote relevant instruments to accelerate the transition towards a low-carbon society by comparing the efficiency and/or effectiveness of different policy instruments from a socio-economic and legal point of view. Focusing on a set of case studies corresponding to different belgian economic sectors, relevant conclusions and policy recommendations have been derived from our project. First of all, results of all study cases reveal the importance of investment support in front of operational support. Operational supports are more profitable or more economically effective in the short term but investment supports are more efficient in the long term. Next, the lack of private consumers awareness of information about possible energy savings is showed as an important cause of unsuccessful policy measures, especially for energy efficiency in buildings and green public procurement. Finally, the concern about policy uncertainty is identified as a major obstacle in the investment in renewable technologies and supply energy security.

Keywords: renewable energy, low-carbon society, policy instruments, socio-economic evaluation, legal feasibility

1. INTRODUCTION

The Paris Agreement, adopted in Paris on 12 December 2015, aims to accelerate and intensify the actions and investment needed for the transition to a low carbon society. Indeed, EU's members have specific targets to reach on renewable energy generation. Concerning 2020 binding targets, most of the EU members, as is the case of Belgium, are well on track to reach the objectives (Spitzley et al., 2015). In particular, Belgium will normally achieve the 2020 target of 13% for the electricity, the transport and the heating&cooling sectors. However, European authorities claim that additional investments will be needed in order to ensure the compliance of current and future more ambitious targets.

In this context, finance is one of the main critical issues for the development of a low-carbon society especially during times of economic recession. The ALPI project will concentrate on promoting relevant instruments to accelerate the transition towards a low-carbon society by comparing the efficiency and/or effectiveness of different policy instruments from a socio-economic and legal point of view.

As to tackle this issue is a complex problem, the ALPI project will therefore focus on a set of case studies corresponding to different belgian economic sectors. The cases studies corresponds to working packages (WP) 2-6: Energy efficiency in residential buildings; Geothermal technology as case for "new" technologies; Electricity: financing models for biomass based electricity production; Transport: how to shift to a more sustainable fuel mix?; Green public procurement: the government as sustainable consumer. First and last working packages will be in charge of the exploration of current measures (WP1), integration of different working packages (WP7) and respectively valorisation of project results (WP8).

Each case-study have run through the same subtasks:

-**Stakeholder consultation**: Workshops/interviews have been organized to discuss and select the instruments that have been tested.

- Different policy instruments have been compared through an independent and case-study **economic evaluation**;

-**The legal context**: A review of the existing and/or innovative policy measures has be performed (i.e. WP1), followed by a discussion on legal feasibility of new instruments proposed (i.e. WP7).

This report describes the work realized during the two-years projects and is organized in different sections. Section 2 state the objectives of the different WP of the project, as well as their contribution with respect to the literature. Section 3 and 4 describe the methodology used and results and recommendations derived per case of study. Finally, dissemination and valorization activities are summarized in sections 5 and 6.

2. STATE OF THE ART AND OBJECTIVES

WP1 Exploration

The two objectives of this first work package were a review on policy instruments, taking into account the legal distribution of competences, particularly focusing on taxation instruments as well as the fine-tuning of the scope and methodology of the case studies, that consisted mainly on the design of the stakeholder consultation protocol.

Review of policy instruments: focus on tax instruments

This task was to explore existing Belgian and international/ European measures in the environmental and energy context, as well as to provide proposals to transpose particular regulations from other contexts into policies of an environmental focus. Providing a review of existing instruments for each working package required to examine measures adopted at each level of power: international/supranational, federal, regional and local. It was decided to mainly focus on national instruments as the European Union and international organization have little competences in tax matters. Taxation remains indeed a symbol of sovereignty and States are reluctant to abandon this power. However, a thorough understanding of these instruments implied to analyse constraints at the European level, since certain rules such as the freedoms of movement and the prohibition of State aids have a great influence on the implementation of domestic instruments. In order to study proposals to improve the current system, it was necessary to consider different stimuli to the adoption of instruments: *institutional* barriers (e.g. rules on the distribution of competences), *material* barriers (e.g. principle of equality and non-discrimination, prohibition of State aids, etc.), and *budgetary* barriers. Belgian law requires indeed complying with the distribution of regulatory, spending and tax competences enshrined in the domestic institutional context and to take into account possible differences between the distribution of regulatory c.q. spending competences and tax competences. Furthermore, when providing legal stimuli or barriers, one has to take into account the constraints resulting from the European Union law, interacting on all competence levels. Finally, qualification of operations has consequences from a budgetary perspective. In particular, the European system of accounts (ESA 2010) can influence political choices.

Legal literature has partly addressed questions regarding legal constraints but few of them have been properly studied from an environmental perspective, especially at the national level. In addition, the cases studies were so specific that sometimes, no particular literature was available. Many authors have examined the rules on the distribution of competences both between the European Union and Member States on the one hand and between Belgian entities on the other hand. Energy, environmental and tax competences of the European Union have been analyzed in great depth (Maitrot de la Motte 2016; Terra 2012; Traversa 2010). From a Belgian perspective, Lavrysen, Tulkens and Neuray have provided an overview of the distribution of competences in environmental matters (Lavrysen 2016, 2009; Neuray 2009, Tulkens 1999) while authors like Traversa and Bourgeois have examined the distribution of spending and tax competences in the context of the Belgian federalism (Traversa 2010; Bourgeois 2017, 2014). Regarding material constraints, prohibition of State aids and the environment has been widely discussed, notably by Peiffert (Peiffert 2015). Environmental taxes and expenditures have also been considered, especially at the European and international level (Milne & Andersen 2012) In Belgium, a part of the doctrine has studied financial instruments for a low carbon society (Sepulchre 2007; Foulon & Kerckhove 2013; Astaes & al. 2013). However, these contributions have approached environmental taxes and expenditures from a rather general perspective, too broad to fit with the specific features of the different working packages. In addition, financial instruments are subject to frequent changes and most of the contributions were thus – at least partly – outdated.

Stakeholder consultation protocol

Moreover, in the framework of WP1, an stakeholder consultation protocol was designed. All case studies started with this stakeholder consultation. The objectives of the consultation were multiple:

- Create awareness about the ALPI-project
- Complete the list of possible policy instruments or policy interventions
- Discuss about ad- and disadvantages of the different (categories) of instruments
- Select the most relevant instruments to be tested in the further process
- Results of these consultations are described in section 3 and 4 in the work realized per WP.

WP2 Energy efficiency in residential buildings

Energy efficiency is central for climate policies and every country possesses this resource in abundance (International Energy Agency, 2016). Alongside with renewables, energy efficiency is expected to contribute to achieving the EU proposed target of 40% reduction of CO2 emissions by 2030 compared to 1990 levels and energy savings of at least 27% (EC, 2016). The residential sector is an important share and accounted for 25% of the final energy consumption in the EU, according to 2014 data (Bertoldi, Lorente, & Labanca, 2016). Multiple policy instruments exist already that aim to reduce the greenhouse gas emissions by improving the energy efficiency of residential buildings. Some are command-and-control measures, such as the Energy Performance of Buildings regulations in the three Regions, while others are merely incentives, such as tax rebate or subsidies. The minimum requirements of 2010/31/EU Directives (EC, 2010) have been translated into substantial improvements for the new construction of dwellings. Yet the existing building stock still has a considerable untapped potential, with 75% of the existing buildings being inefficient and the availability of cost effective renovation measures (EC, 2016).

However, despite the high potential for energy savings in the Belgian residential sector, the renovation rate remains low (Verbeeck & Housmans, forthcoming 2017), thus meaning that convincing private house owners to invest in energy efficient measures requires more convincing parameters than are currently present in existing policy instruments. Even if the financial benefit of the measure is often positive in the long term, the perceived risk and effort can still block the home owner from investing in energy efficiency. Therefore not only the impact of financial support in the cost benefit balance, but also behavioural aspects of the decision making process towards deep energy renovation and the impact of policy instruments on these behavioural aspects have to be taken into account in the development of policy actions to incite the uptake of deep energy renovation. In this context, the case study of energy efficiency in residential buildings has been focusing mainly on the effectiveness of policy instruments to increase the energy efficiency of existing dwellings through deep energy renovation.

Since Europe is characterized by a 50% rate of owner-occupied dwellings (Belgium even over 70%) (BPIE, 2011), it is important to understand the mechanisms behind individual dwellers' behaviour. So the main objective of WP2 was to investigate the decision making aspects of private owners regarding deep energy renovation. These one-off decisions, that imply decisions on investments in insulation, energy efficient HVAC systems and systems on renewable energy, differ from daily energy use, where habits and curtailment prevail. The existing approaches for uptake of energy renovation can be divided in two main categories: one based on neo-classical assumptions and one based on environmental consciousness. The first approach has the limitation of considering individuals as 'computers' with unlimited cognitive abilities and complete emotional self-control (Thaler & Sunstein, 2008), whereas the second approach, that addresses the environmental consciousness of individuals (intrinsic motivation) is challenged by the widely documented intention-action gap (Bartiaux, et al., 2006), (Ceulemans & Verbeeck, 2015). Both approaches are based on the assumption that dwellers are exclusively rational in their reasoning. In reality decisions are systematically affected by the *"self-control problems, unrealistic optimism, and limited attention"* characteristic to humans (Sunstein, 2014). So people tend to escape the slow and cognitive processing of the information with the use of a shortcut called heuristic or bias (Darnton, 2008). These two routes (slow and deliberative versus fast, automatic and intuitive) process the information concurrently, hence the models are called Dual Process Models (DPMs).

In order to contribute to the main objective of understanding the decision making process of home-owners regarding deep energy renovation, two sub-objectives have been defined:

A first sub-objective was to investigate the theory of DPMs, from the perspective of their implications to energy renovation, in order to understand both deliberative and heuristic thinking of house owners. Unlike previous research, the research in WP2 did not limit to testing biases in isolation, but explored the balance between deliberative/heuristic thinking to verify if dwellers' arguments regarding energy renovation are mostly rational or heuristic;

A second sub-objective was to apply the insights on DPMs in the context of energy renovation onto existing policy instruments, such as the Energy Performance Certificate (EPC) and financial support instruments, as both the EPC and the financial support instruments are key policy instruments for promoting energy efficiency in the building sector.

The EPC was introduced first with the Directive 2002/91/EC (EC, 2002) that stipulated that member states should ensure the certificate *"is made available to the owner or the prospective buyer or tenant when the building is constructed, sold or rested out"*. Various EU reports have been investigating the implementation and impact of the EPC on the uptake of energy efficient measures (Christensen, Gram-Hanssen, de Best-Waldhober, & Adjei, 2014; Harsman, Daghbashyan, & Chaudhary, 2016; Mudgal, Lyons, Cohen, Lyons, & Fedrigo-Fazio, 2013; Wahlstrom, 2016), but most reports focus on quality assurance of the calculation method and the energy experts that establish the EPCs (Arcipowska, Anagnostopoulos, Mariottini, & Kunkel, 2014; Harsman et al., 2016; Maivel, Kuusk, Simson, & Kurn, 2016). Very few consider the quality of the EPC as communication tool and focus on the framing of the information (Backhaus, Tigchelaar, & de Best-Waldhober, 2011; "IDEAL EPBD Project Improving Dwellings by Enhancing Actions on Labelling for the EPBD,") (Sutherland, Audi, & Lacourt, 2015). Therefore within WP2 the information framing of the two key messages of the EPC (energy performance indicator and recommendations) have been analysed by means of a theoretical framework that was deduced from the analysis of DPMs. With information framing is meant the content, the wording and the lay-out.

With regard to the financial support instruments, an analysis of which households make use of subsidies and tax rebate for energy efficient measures in the Flemish Region (Verbeeck, 2016) that revealed that a very high share of the financial support goes to higher income groups, gave rise to the hypothesis that financial support might mainly act as a psychological trigger for these groups, rather than as an essential, indispensable financial factor without which renovation would not have been possible. So therefore WP2 analysed the importance of financial support in the renovation decision making process.

WP3 Geothermal technology as case for "new" technologies

As a showcase of emerging technologies in Belgium, the Hasselt and Antwerp Universities and the Geological Survey of Belgium are investigating the regional potential for geothermal electricity and heat production.

The Belgian subsurface presents an exceptional geological diversity resulting from tectonic events and evolution of different sedimentary basins over a period of 550 million years. The sedimentary basins in the northeast (Campine basin) and south (Namur-Dinant basin) of Belgium provide the largest potential for deep geothermal energy (see belowFigure 1). The recognized geothermal resources and hydrothermal processes observed in Belgium are localized in the thick sequences (up to 500 m) of Devonian-Carboniferous platform carbonates.

However, the basins differ in structure and characteristics. This case study focuses on the Campine basin, which is an intermediate basin between the Brabant Massif and the Roer Valley Graben (itself an extension of the active Lower Rhine Graben) primarily within the Netherlands. A great deal of uncertainty remains due to the lack of deep exploration boreholes, leading to high risk (e.g. the Meer project in the 1980s). This has led to a bottleneck for geothermal projects during several decades. However, recent projects (Balmatt wells) will improve geological understanding.

EU best practices

A standard geothermal project development is divided into 4 key phases: exploration, resource development, construction, and commissioning, operation and maintenance. A geothermal project is a capital-intensive technology that needs 5-7 years to become operational from the start of the permitting process until commissioning. The significant upfront investment is related to the drilling and to the need to cover the geological risk at the beginning of the exploration.

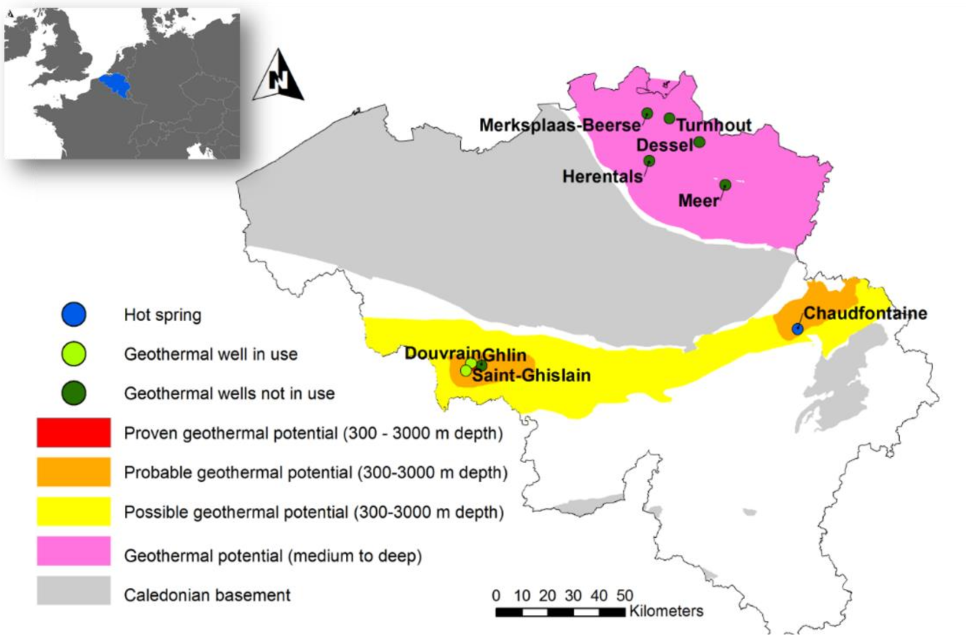


Figure 1 : Mapped medium-deep geothermal potential and geothermal wells Belgium (Loveless, 2015).

Objectives

The main aim of the WP3 is to find appropriate instruments to foster the geothermal sector development in Belgium. For that the objective was to develop a methodology to refine the probability of success for a geothermal investment. This methodology also forms the first step in integrating geological modelling in techno-economic simulations. Fully accounting for geological uncertainties in the overall economic evaluation allows for directly linking the level of geological knowledge to the economic viability of potential future projects

WP4 Electricity: financing models for biomass based electricity production

In view of the EU's Renewable Energy Directive, ensuring security of supply and a stable investment climate has become an important challenge for decision makers. In this context, Biomass-based conversion systems, which currently deals with a decrease in support, offer technical alternatives for flexible power generation to compensate for fluctuations and the resulting residual load, in comparison with non-flexible renewables (solar PV and wind).

The general **objective** of this working package was to compare the efficiency of different renewable policy instruments, and their effect on operational and investment decisions,, in the electricity sector.

To this goal, we analyze different case studies involving electricity generation by different energy sources in Belgium. In a first study, we analyze the effect of **operational versus investment support** as policy instruments **for the development of biogas plants** in Flanders (Belgium).

In this context, different types of subsidies exist and are currently being used to promote the production of renewables in Europe. The main market based instruments applied in Europe are the feed-in tariffs and feed-in Premia (FIP) and the green certificates (GC), also known as quotas or portfolio standards (Eurostat - Statistical Office of the European Communities, 2009). In Flanders, the latter is implemented. A lot of research has been done to evaluate the effects of FIP and GC on society's welfare, on the increase in overall renewable energy production, and their economic efficiency (Aune et al. (2012); Couture and Gagnon (2010); Del Río (2012); Drechsler et al. (2012); Eyre (2013); Kim and Lee (2012); Schallenberg-Rodriguez and Haas (2012)). However, research has been focused mainly on high-efficient renewable energy sources (RES) such as wind power or solar energy. Currently, interest has risen on the use of biomass for energy production as a sustainable policy option. Verbruggen (2004) provides an analysis of Tradable Green Certificate systems in Belgium. They argue that Green Certificates may become an effective instrument, but also efficient if the different physical, technological and economic characteristics of the different renewables are considered. Moreover, they recommend that Green Certificates must be matched to the impact of other instruments such as direct feed in support and capital subsidies (i.e. investment support). More research is then necessary concerning this topic, what motivates the work realized in our first study case.

However, other important factors of the current Belgian situation are not taken into account in the previous study, as for example policy uncertainty. Indeed, the absence of long term vision, makes very difficult for private investors to encourage the development of the biogas sector. In our second study, we analyze **how** policy uncertainty, and in particular, **uncertainty about a nuclear phase out in Belgium**, coupled with the implementation of renewable energy subsidies and nuclear taxes, **affects investment capacity and productivity decisions** by Belgian electricity suppliers. Finally in a third study case, the analysis is implemented for different types of market structure in order to understand how the **level of competition in the market influence firm's decisions** and market efficiency.

Indeed, the consideration of the uncertainty about a nuclear phase out is particularly important in Belgium where the electricity market is characterized by a high dependence on nuclear energy and a dominant market position by one of the market players that operates all the nuclear plants in Belgium. Since 2003, the Belgian government seems committed to a nuclear phase-out. However, recently, the government extended the operational license permits of the three oldest nuclear power plant units from 2015 to 2025 because of a highly likely shortage of electricity supply.

In this context, a number of studies have already analyzed the future of Belgian power generation and the optimal electricity mix (see Albrecht and Laleman (2014), Van Wortswinkel and Lodewijks (2012)). Van Wortswinkel and Lodewijks (2012) applied a partial equilibrium model of the energy system to the case of Flanders., in order to support decision-making. Albrecht and Laleman (2014) used however a more complex general equilibrium model in order to investigate policy trade-offs for the Belgian electricity system. They concluded that (i) market participation by renewables is essential for an affordable and sustainable energy mix in the future, (ii) a higher share of renewables will result in higher overall system costs in future decades, and (iii) the feedstock costs of biomass will be the main driver in the overall costs of any energy mix involving a high share of renewable energy (RE) technologies.

As we have advanced in the previous paragraph, most of the economic literature about optimal investment and production decisions on electricity market is based on perfect competition markets, in which the main model assumption is that individual suppliers of the electricity market assume that no single firm can influence the market price. However, since the liberalisation of the european electricity markets at the turn of the millennium, proper market models must deal with imperfectly competitive markets (see Ventosa et al., (2005) for a review) in which single firms can take a strategic position in order to influence market price (see next section for modelling details). From then on, several authors have focused on analyzing strategic long-term capacity investments under imperfect market using the concept of Nash-Cournot equilibrium (Filomena et al. (2014); Genc and Sen (2008); Leibowicz (2015); Murphy and Smeers (2005). To the best of our knowledge, this equilibrium concept has not so far been introduced in the current models of electricity mix forecast for the Belgian case. This motivates our second study case in the scope of this WP.

Finally, Kettunen et al. (2011) argue that "apart from the level of carbon prices, the associated policy uncertainty will have an effect on market structure evolution through a tendency for investments to be led by dominant incumbents rather than smaller independent power producers, leading to a more concentrated and hence less competitive market." . The same argument could be then used to study how policy uncertainty associated to nuclear phase-out influence investments depending on the level of competition on the market in our third study case.

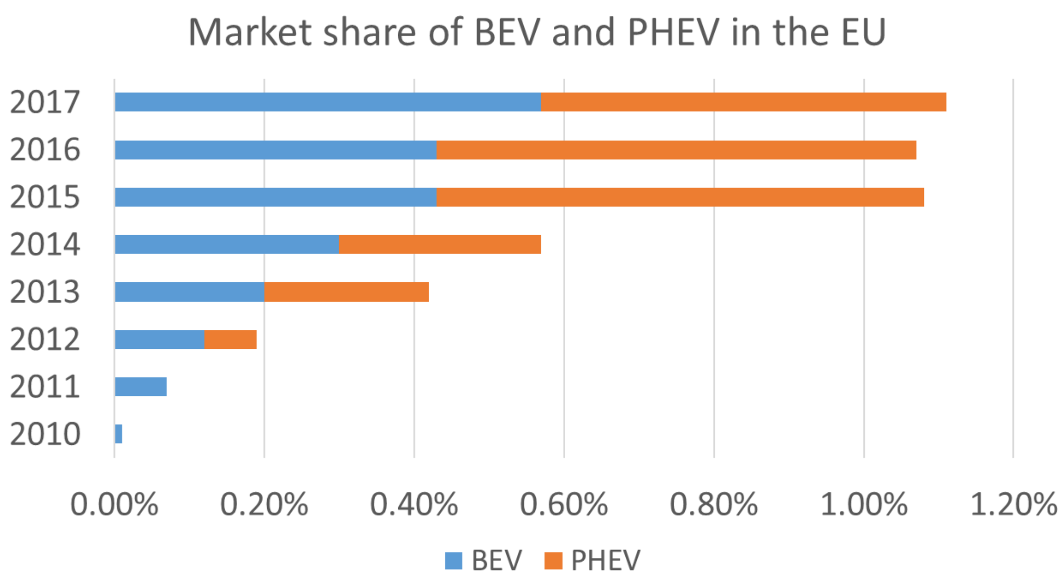
In this context, some studies have already been conducted on the optimal capacity investments for different level of market competition, or in other words, for different types of market structure. The vast majorities of these models consider uncertainty on demand (e.g Genc and Sen (2008); Grimm and Zoettl (2013); Murphy and Smeers (2005)). However, little attention is paid to the lack of stability of investments caused by policy uncertainty, in particular uncertainty about the future of nuclear power. To the best of our knowledge, just recent studies have analyzed the impact of the nuclear phase-out on Europe's electricity generation (eg. Bruninx et al. (2013) and electricity prices (eg. Nestle, 2012). The second and third study cases of this WP are then especially relevant and innovative from a methodological and practical point of view.

WP5 Transport: how to shift to a more sustainable fuel mix

Transport is the second most important sector in terms of greenhouse gas (GHG) emissions in the European Union. Most transport currently happens using vehicle with internal combustion engines based on fuels: diesel and gasoline mostly produced using fossil energy sources. As these fossil energy sources will run out, alternative need to be provided. A first approach is to change is to make the currently used combustion fuel more sustainable by stimulating the production of biofuels.

However, research has shown that the first generation biofuels are not very efficient in combatting climate change and it takes more time then expected to develop the second generation biofuel. Therefore, there is more and more a consensus that other energy carriers need to be considered for the transition towards a more sustainable fuel mix. Possible alternatives are compressed natural gas or electricity. In the long run compressed natural gas could be produced by upgrading biogas and biogas can be produced from waste stream of biomass residues. The gains for climate change are larger than with the traditional biofuels. Electricity stored in batteries is currently considered to be the most promising alternative energy carrier and can also be produced in a renewable way.

Therefore Plug-In Electrical Vehicles (PEVs) play a principal role in diminishing the dependence on liquid fossil fuels and decreasing GHG emissions of the transport sector. The deployment of PEVs is gaining momentum in the EU as show in next figure. Plug-in hybrid electric vehicles (PHEVs) are similar to conventional hybrids because they have both an electric motor and internal combustion engine, except PHEV batteries can be charged by plugging into an outlet. PHEVs can substitute electricity from the grid for gasoline. The rate of using gasoline as electricity depends on the type of use of the car. Therefore, BEV are considered to be more sustainable because they run exclusively on electricity via on-board batteries that are charged by plugging into an outlet or charging station.



BEVs have no gasoline engine but have larger batteries than PHEV and therefore longer electric driving ranges compared to PHEVs and never produce direct emissions. The BEVs on the market today have a driving range of around 100 to 150 km per charge, though some models go well beyond this.

There are two obstacles to the breakthrough of electric vehicles. First, as indicated in previous paragraph, it is difficult to travel longer distances if there is insufficient charging infrastructure.

The presence of this charging infrastructure is therefore considered indispensable to boost sales of electric vehicles. The challenge is that private investors might also not set up these charging stations unless there is a promising growth in demand from the increased sales of electric vehicles. Second, electric vehicles are currently often more expensive in total cost of ownership. In the absence of incentives, the electric vehicles are currently not cost-competitive. Fiscal incentives are important measures as they influence directly the vehicle purchase decision of individuals or companies. They can be total or partial tax exemptions, or direct subsidies.

The research questions that are analysed are thus the following.

1. Has the total cost of ownership an impact on the sales of electric vehicles in Europe?
2. Which countries have a total cost of ownership that would induce more sales of battery electric vehicles and plugin electric vehicles?

To what extent can the presence of fast and slow charging stations impact the sales of electric vehicles?

WP6 Green Public Procurement: the government as sustainable consumer

The FAO (2017) identified four major roles for forests in climate change:

1. Forests can potentially absorb one-tenth of the global carbon emissions projected for the first half century into their biomass, soils, and products 'and store them in perpetuity'. Research presented by Global Footprint Network (2016) finds that forests can store up to 31% of annual emissions;

2. In contrast, forests contribute about one-sixth of global carbon emissions when cleared, overused or degraded. Simultaneously, The Global Footprint Network (2016) reports that deforestation (not including forest degradation) accounts for 9% of global emissions;

3. Forests react sensitively to climate change;

4. Sustainably managed forests produce fuel wood as a less harmful alternative to fossil fuels.

Tropical forests are particularly important in this respect, as they account for 55% of the global forest stock. In addition, the Amazon basin and the Congo basin are the largest contiguous blocks (Pan, Birdsey et al. 2011, Hansen, Potapov et al. 2013, Doetterl, Kearsley et al. 2015). For this reason, sustainable forest management became a crucial element in combating climate change.

Eco-certification of forest and wood products became an important tool to improve producers' environmental performance (Blackman and Naranjo 2012, Jaung, Putzel et al. 2016). Eco-certified producers must comply with various sustainability standards which aim for more sustainable forest management (Cashore, Gale et al. 2006). Those standards include both environmental and social guidelines (Murray and Abt 2001).

The Forest Stewardship Council (FSC) and the Programme for Endorsement of Forest Certification Schemes (PEFC) dominate the international certified wood market (FAO 2014).

They reported a combined global total of 462 million hectares of certified forests in May 2016 (UNECE 2016). This includes (an estimated) 29.5 million hectares of double certified forest area. Excluding the double certified forest area, FSC and PEFC together certify 10.9% of the global forest area. According to UNECE (2016), 29% of global industrial roundwood production originates from the certified forest area. However, the regional distribution of the certified forest area is apparent. The Northern hemisphere accounts for 87% of the global certified forest area, while the Southern hemisphere only accounts for 13% (UNECE (2016).

Governments can considerably support eco-certification since they are an important consumer of wood (products): according to EUROSTAT all EU's governments account for 26.88% of final wood consumption. Consequently, government procurement is gaining momentum as a tool to foster the production and consumption of environmentally-sustainable goods and services (Amann, K. Roehrich et al. 2014). Once governments take environmental and societal criteria into account, in addition to purely economic criteria, when procuring goods and services, this is referred to as Green Public Procurement (GPP). On the supply side of the market, GPP must spur the introduction of innovations involving sustainable techniques and practices. On the demand side of the market, GPP must reduce the transaction costs for adapting to new products and stimulate the uptake of innovations (Edler, Georghiou et al. 2015).

An increasing number of governments at national, European, and international level, explicitly refer to the two main certification schemes: FSC and PEFC. Those governments recognize certificates as sufficient proof of compliance with the green criteria for wood. More details on GPP and its link with eco-certification are provided in chapter two.

According to Gulbrandsen (2014), governments must not only support (non-governmental) eco-certification schemes by purchasing eco-certified wood themselves. In addition, they can also support eco-certification by providing additional services to the producers (e.g. expertise and technical advice, as well administrative or financial support.

WP6 aims to quantify the economic and environmental impact of Green Public Procurement by making use of a Spatial Equilibrium Model. The environmental impact is analysed by quantifying the eco-certified production. This production is assumed to be positively related to the eco-certified forested area.

As an alternative to Green Public Procurement, this WP also assesses the impact of legality verification. An increasing number of developed countries (including the EU, USA, Australia) are making it unlawful to import or trade illegal wood (products). Illegal wood in this narrative is harvested, processed, transported, bought, or sold in contravention of national and international laws (European Commission 2017). In this rationale, the prohibition of illegal wood must contribute to the illegal felling of trees and as such indirectly contribute to more sustainable forest management. Within the EU, legality verification is part of the EU Timber Regulation. This regulation is a core element of the "Forest Law Enforcement, Governance and Trade Programme" (FLEGT) which aims to stimulate 'both legal wood production and good forest governance' at global level, and particularly in tropical countries (Wan and Toppinen 2016, Wodschow, Nathan et al. 2016).

WP7 Integration

The objectives of this WP consisted of:

- the comparison of the different instruments taking into account their specific context
- summarizing the lessons learnt per study case, and for the overall project
- giving policy recommendations based on the instruments implemented in each specific case study, and for the overall economy
- analyzing how to tackle the implementation of recommended policy instruments from a legal point of view.

WP8 Valorization and communication

The general objective of this WP were to disseminate project results to meet user needs through conference and workshops presentations and publications in peer-reviewed journals, and to communicate the outcome to potential next users. The latter mainly consisted in the organization and development of the final conference of the project. The work realized in this WP is described in section 5 and 6.

3. METHODOLOGY

WP1 Exploration

The exploration part, mainly conducted by the Tax Institute, followed a methodology based on a two steps analysis:

- a descriptive analysis (*de lege lata*), which aimed to describe, understand an assess the existing framework. Its objective was to comment law as it is.
- an explorative analysis (*de lege ferenda*) with the purpose of exploring possible instruments based on the input given by partners of the other working packages. The explorative analysis described law, as it should be, by making or by suggesting changes in case law or in legislation. In this context, it was notably necessary to take into account the institutional rules having respect to each government's competence.

For both phases, we used the traditional method applied in legal studies:

- the identification of the facts;
- the identification of the norms that apply to the facts;
- the identification of the barriers to the implementation of measures.

To do so, we made a review of the relevant *primary* legal sources and *secondary* legal sources. Primary sources on the on hand include statutes at levels of power (local, regional, federal, supranational), texts of legislative bills, court decisions, advices of Council of State (legislative section). Secondary sources on the other hand encompasse materials that discuss, explain, interpret, and analyse what the law is or what it should be, including treaties, law reviews, encyclopaedias, legal newspapers.

The originality of our methodology consisted of the use of an *interdisciplinary* approach. It raised important challenges as to timing and communication. The exploration phase helped highlighting institutional rules pertaining to the implementation of instruments and providing an overview of measures adopted in this context. A central issue was to explain legal concepts and to popularize them to be understood by partners of a non-legal background. This first step enabled partners of the other working packages to understand existing measures and to figure out which constraints applied to the adoption of instrument they were willing to propose. In other words, it helped them to fine-tune their proposals to be legally feasible and not repetitive with existing measures. The description of this legal framework annexed in the deliverable 1.1. Another aspect of the work consisted of permanent support activities, under a dynamic form of questions and answers. The objective of this support activity was to enable the partners of other working packages providing deliverables with a thorough understanding of the legal context surrounding the financial instruments they were studying and limiting the proposals they made. For this part, no specific deliverable has been written but this was a demanding aspect of the research.

One of the main difficulties of the project touched upon timing. The work of the Tax institute was all at once *before*, *during* and *after* the one of the partners. Making a legal analysis based on the inputs of partners of other working packages was particularly challenging, due to the limited delays between the moment when the results were provided and the deadline of the research. In addition, we were working on the legal aspects of *each* working package. For these reasons, it was not always possible to analyse the proposed measures *ex post*. In addition, although the scope of the cases was well determined and specific, each working package raised distinct and various questions from a legal perspective. The fields covered for each working package were exceptionally broad, and often surpassed tax matters. As a consequence, it was necessary to set limits up, and some field, such as green public procurement, were studied to a lesser extent. On the contrary, other fields were analysed more in depth, like the prohibition of State aids and the taxation of nuclear energy. We also decided to put some efforts in the analysis of budgetary constraints, which were not mentioned in the initial project. Finally, although common work has been done, it must be noted that common publications were hard to consider, as expectations and ratings differ from one discipline to the other.

WP2 Energy efficiency in residential buildings

At first a stakeholder consultation of a wide range of experts related to the domain of energy renovation of houses was hold by means of a focus group. Aim was to discuss in an interactive way some proposals for innovative measures to respond better to house owners' aspirations. A large and diverse group of stakeholders was invited with 23 representatives from policy makers, researchers, sector organizations, industry, financial sector and social actors, in order to gather stakeholders with a different background, vision and interest in the topic of energy renovation from the three Regions: 10 actually participated, 4 expressed their interest, but could not attend, 2 were not interested and 7 did not respond to the invitation. The need for energy renovation of the residential building stock was widely accepted as an important problem to be tackled and as such not a point of discussion. What still are points of discussion are the degree to which houses should be renovated and the reasons why it is so difficult to motivate house owners to actually renovate their house. From an ecological point of view (to reduce the $CO2$ emissions by buildings to a great extent), a very deep energy renovation of the whole residential building stock should be aimed for, but from an economic point of view this is often considered as not feasible or realistic.

From the discussion among the stakeholders on the degree of and the barriers for energy renovation, it could be concluded that there is more or less a consensus on setting requirements for the degree of renovation that are strict enough and mandatory in the long term, but with the implementation of a roadmap for a transition period towards this final goal. With regards to the barriers (financial, technical, practical, informational, motivational), there was a consensus on the existence of all these barriers, but there was not a consensus on their order of importance.

So in order to understand both deliberative and heuristic thinking of house owners, starting from the general literature on the theory of Dual Process Models (DPMs) a classification of models was made, detailing heuristics and biases that might be applicable in the context of energy renovation. Unlike previous research, the research in WP2 did not limit to testing biases in isolation, but explored the balance between deliberative/heuristic thinking by means of a questionnaire to verify if dwellers' arguments regarding energy renovation are mostly rational or heuristic. The survey (n = 178) was collected using computer-assisted personal interviews by trained surveyors using random intercept sampling at the largest construction fair in Belgium and consisted of three main sections: socio-demographics and housing conditions (to profile the respondents and their living situation), a ranking exercise and a labelled choice experiment (CE). The ranking exercise allows finding out whether deliberative or heuristic reasoning is behind arguments in favour of or opposing renovation. It regarded five renovation measures: wall insulation, energy efficient windows, energy efficient boiler, solar panels and solar water heater. For each measure a set of two questions was presented to respondents with argument in favour and against the uptake. These were based on the most frequently cited reasons by Flemish private owners in large scale surveys. The goal of the choice experiment was to find out the preferences of people interested in placing energy efficient renovation measures and their attributes. Moreover we aimed to verify whether deliberative or heuristic arguments were the stronger factor in influencing renovation choices. The experiment was presented to owners and renters by means of detailed stylized hypothetical renovation scenarios for an average Belgian dwelling. This simultaneously avoided unrealistic values to be presented. In choice experiments, respondents are typically presented with several choice sets consisting of multiple alternatives from which they are asked to choose their most preferred alternative. To fill out a choice set, respondents were required to choose their single, most preferred renovation measure. Each choice set contained the following four labelled alternatives: energy efficient windows; roof and wall insulation; geothermal heat pumps and PV panels. Each alternative was described by varying levels of the following characteristics: the degree of visual changes, the thermal comfort obtained, the CO_2 reduction, the investment cost, the hassle during renovation and the source of advice. By capturing which alternatives have been chosen, the relative importance of the different attributes and levels can be estimated. Compared to other preference elicitation mechanisms, a choice based elicitation format has the advantage of resembling an actual (purchasing) decision. The choice experiment further explores the features that stimulate or discourage undertaking renovation measures.

For the analysis of the effectiveness of energy performance certificates as information tool in the decision process of purchasing and renovating a house, the certificates of nine European countries/regions were analysed through a qualitative inquiry based on a theoretical framework of deliberative and heuristic thinking. The inquiry was undertaken in two phases: 1) a comparative analysis of the key information they contain, followed by an analysis of the framing of the information and the nudges used; 2) a focus group with seven experts with technical or social background from Flanders that analysed and discussed the findings of the comparative analysis and selected the information framing and nudges to be tested in a later stage with dwellers in a quantitative way.

For the analysis of the importance of financial support instruments in the renovation decision process, a survey was hold among households. Since at this moment, also other financial and non-financial support instruments are being developed to stimulate energy renovation, the interest of the households in these instruments was investigated simultaneously. In order to survey households that might have given thoughts about constructing or renovating a house, the survey was held among visitors (N = 401) of the construction fairs of Bouwinnovatie (Hasselt) and Batibouw (Brussels). At the first weekend, some of the questions in the survey were asked as open questions (N = 99), in order to cluster the answers into multiple choice questions for the next survey (N = 302). This way, the multiple choices were based on actual arguments given by homeowners themselves. Both samples have been used in the analysis. The survey consisted of three parts: socio-demographics and housing condition (including the nature of the construction intentions), questions on the financial support measures: knowledge, use in the past, importance of financial support to actually renovate, and question on interest in other financial and non-financial support measures that have been developed recently (BENOVEREN brochure, subsidy for advice in case of collective renovation) or that might become available in the near future (renovation loan that is paid back by the energy savings, checklist to help consider the necessary/possible renovation steps and the option to demolish and rebuild).

WP3 Geothermal technology as case for "new" technologies

In this case study, we decided to consult stakeholders in private interviews instead of workshops to facilitate exchange due to a certain reluctance to speak freely (confidential data). The stakeholders were classified in 4 groups (A, B, C, D) in function of the objectives of the consultation: the group A (practitioners, researchers) was dedicated to refine the structure of the case study, the group B represent the geological experts involved in the assessment of the reservoir parameters, the group C involved policy makers for policy instruments and mid-long-term strategies evaluation, the group D was set up to take into account the point of view of private investors (investment heuristics).

A full presentation of the methodology and its application to test the impact of different policy measures, can be found in Petitclerc et al. (2017). The methodology used allowed to fully describe the 2 reservoirs and incorporate the full current state of knowledge including all uncertainties. The findings of e.g. Lin & Bier (2008), Bier (2004), or Henrion & Fishoff (1986) were put into geological context for CO_2 geological storage by Welkenhuysen et al. (2013). This approach was extended to describe geothermal projects in Belgium for the first time in the ALPI project.

The data were collected for two reservoirs: the Carboniferous Limestone Group of the Campine basin and the Upper and Middle Devonian limestones and shaly limestones of the Givetian and Early Frasnian of the Mons basin. The data collected of the Campine basin were mainly used for the next steps. The Balmatt wells (drilled during the project) allowed better understanding of the reservoir.

Techno-economic evaluation WP3

The probability of success of a deep geothermal project is low, especially when this is executed in regions where only little information is available on characteristics of the deep subsurface. In order to investigate the success rate, and the influence of governmental instruments, the point of view of a private investor is taken. This investor analyses one single case study to be executed in a defined region, and has to optimise the outcome in terms of return on invested capital. Policy instruments are considered as external factors that change the investment conditions. During the elaboration of such a project, the investors and the project team go through several stages. Each stage is based on the information gained from the previous stage, and each stage contains the risk that the project fails or is abandoned.

In order to simulate this process of knowledge growth, a decision tree procedure is optimal. That's why we chose to do the techno-economic evaluation by a decision tree (Figure 2). A decision tree distinguishes a development in distinct steps. . That's why we chose to do the techno-economic evaluation by a decision tree. New pathways are chosen, based on the results of the previous step. It is important to maintain the detailed step sequence in the simulation and not to calculate the expected profitability of the geothermal project for all situations in exactly the same fashion. The main advantage of the decision tree is to incorporate the liberty that the investor has to redirect or abandon the project during the execution stage. This liberty allows to avoid costly mistakes, and increases the overall value of the project. If the results are disappointing – for instance of the seismic survey - the investor can stop the project, and take the expenses of the preparation as sunk costs. This prevents much higher losses in case the project would proceed. The simulation method has to incorporate these discrete decisions.

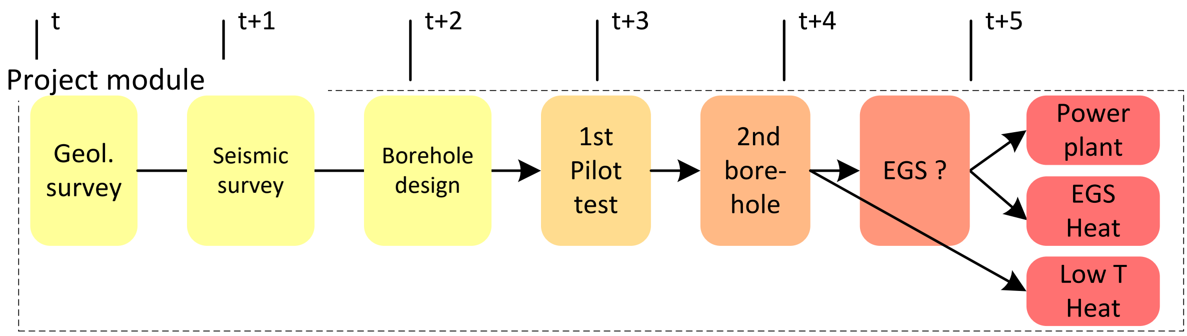


Figure 2 Decision model for the generic deep geothermal project

This decision tree gives a link between technological and economic evaluation. It gives a statistical analysis of value of these investments on a certain time. This decision tree approach is in this case combined with Monte Carlo simulation (Figure 3). This numerical stochastic uses random sampling to approximate distributions of the outcome. The probability distributions, as designed during the stakeholder involvement, reveal highly irregular distributions of the expected groundwater temperatures, flows, and reservoirs characteristics. These probability distributions cannot be simulated with analytic density functions. The Monte Carlo approach takes a random point within each distribution, and calculates the complete decision tree of the geothermal project development. This process is repeated for a sufficiently large number of times until the full distribution of probable outcomes is generated, and the total final density of outcomes can be approximated.

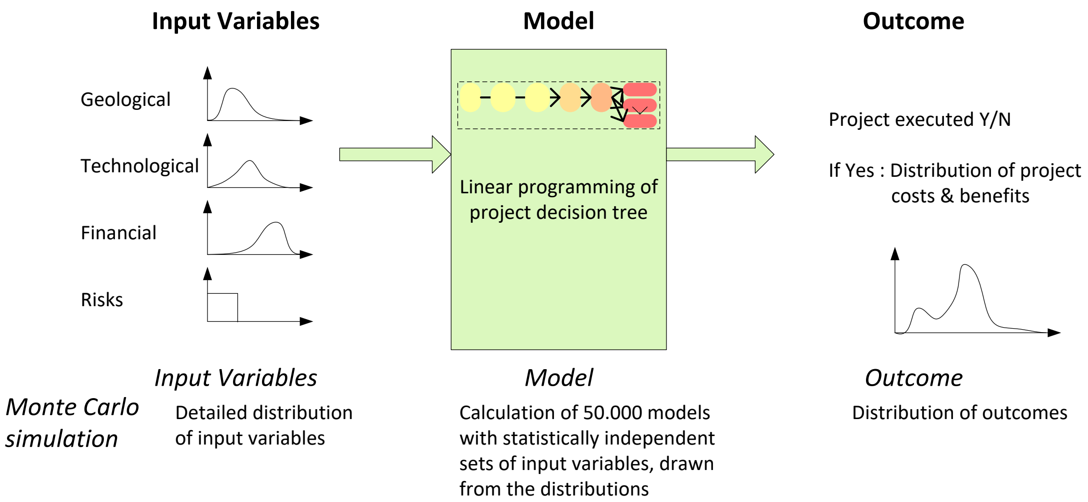


Figure 3 Schematic representation of the Monte Carlo method

The effect of support mechanisms were included in a second step. This real option models are optimisation models that give an indication on when is the best time to invest (depending on complexity of the decision tree). As it includes private and public investments this model gives an idea on when private investors will take over the technology and how and what measures/instruments can speed up this take-over. Based on data provided by the stakeholder consultations, the methodology of the techno-economic simulation was discussed and defined between the partners. All steps on the realistic decision tree and the different input parameters were assessed.

WP4 Electricity: financing models for biomass based electricity production

Stakeholder consultation

First of all, a stakeholder consultation was realized in the framework of this WP in order to derive relevant policy instruments. In particular, these consultations consist of personal interviews to members of different national research organizations (VEA, ODE, BBL, WWF, OVAM etc..). General questions as well as specific questions about policy instruments were designed and used as basis for the interviews.

Economic Evaluation

In order to answer to the different research questions corresponding to the three study cases, we developed decision support models that can be classified in two groups following the classification described in Ventosa et al. (2005):

- optimization problem for one firm (Case studies 1 and 3)
- market equilibrium considering all firms (Case studies 2 and 3)

Single-firm optimization models are based in a profit maximization problem for one of the firms in the market. They allow to consider operational constraints of the single firm problem as well as a more detailed representation of the price process. **In the first study case**, we build this type of model for a representative biogas plant in Flanders. Moreover, this type of model is able to represent quasi-perfect markets because the modelling does not consider the influence of the different firms on the market price, and then the interactions between the different firms.

In contrast, **market equilibrium models** are more suitable to represent imperfect electricity markets such as observed in real markets. In other words, the fact that suppliers can take a strategic position to influence the market price and, thereby, the total electricity generation capacity in the market, is taking into account within the modelling. In particular, we have developed a Nash-Cournot Equilibrium model. This is a concept of game theory in which players (in this case, electricity suppliers) choose their optimal decision strategies based on the strategies of all the other players. Thus, players are in Nash equilibrium when each firm strategy is the best response to the strategies employed by the other players. This type of model is used in our **second study case** in order to represent the belgian electricity market as an oligopolistic market in which a finite number of non-cooperative firms maximize their profits, taking into account the decisions of the other firms.

Finally, both types of models are used in our **third study case** in order to compare investment and operational decisions by assuming different degrees of market competition, that is perfect and imperfect market structure. In this case, we extend the analysis made previously for different levels of market competition, namely monopoly and perfect competition (see main differences in Table I). In Figure 4 , you can see a more extended classification of electricity market models with respect to the degree of competition and the time scope modelled. In particular, as described in Table I, in perfect competition an external regulator maximize the total expected welfare while in an imperfect monopolistic setting, the monopolistic firm aims to maximize his own profits. In both cases, decision-makers are considered price-takers, that is they cannot influence market price. In contrast, an oligopoly model is characterized by several decision makers who are also price-makers.

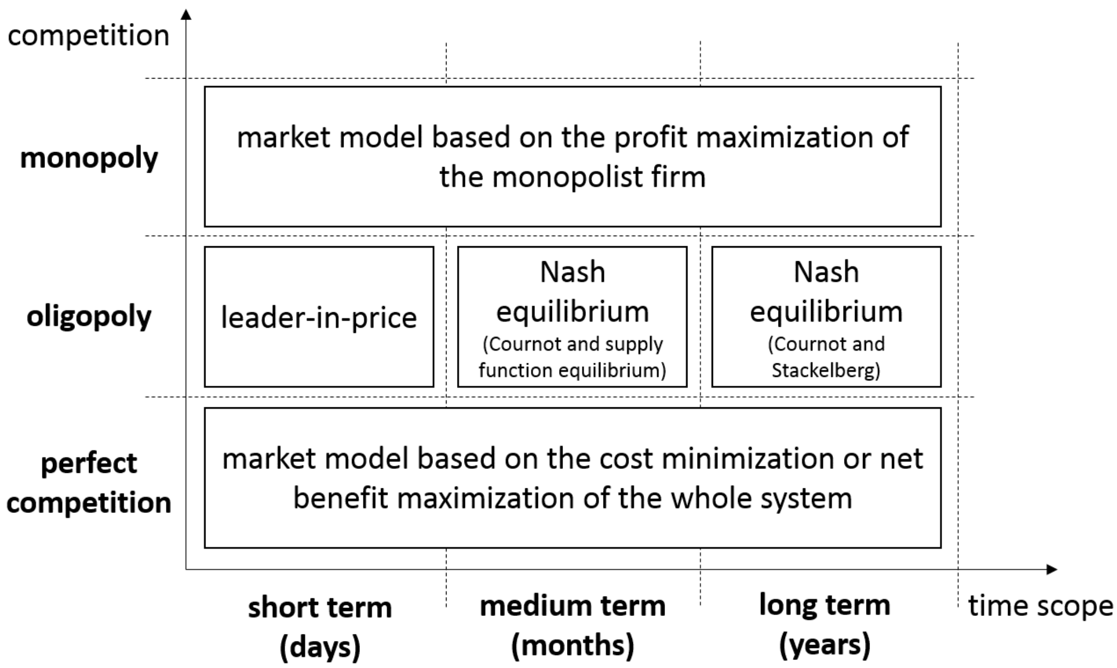


Figure 4 Schematic representation of the electricity market modelling trends, adapted from Ventosa et al. (2005)

Table I Summary of main differences between market structures.

	Perfect Competition	Oligopoly	Monopoly
Number of decision makers	one (external regulator)	all firms	one (the monopolistic firm)
Price-setting of the decision maker	price-taker	price-takers	price-maker

WP5 Transport: how to shift to a more sustainable fuel mix

The three research questions are dealt with through the collection of data on sales of electric and other vehicles, the number of electric charging stations, the share of fast charging stations for the years 2009 to 2016 in 13 different European countries (Austria, Belgium, Denmark, France, Germany, Iceland, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, UK). This panel data set allows to perform a panel data regression to quantify the impact of the number of charging stations and the share fast charging stations separately on the sales of electric vehicles.

Theoretically, many variables play, next to the charging stations, a role in the sales of electric vehicles:

- consumer purchasing power
- geography of a country because it affects the mobility systems
- alternatives in mobility
- congestion
- fiscal regimes on car mobility
- fiscal and other incentives to buy electric vehicles

It was however impossible to collect this information in a panel dataset because the data is not always available and the data collection would be very time consuming. Most of the information is also constant over time and therefore perfectly correlated with the country variable. Instead of trying to obtain all the additional data, we have chosen to run a panel regression that captures the information of the missing variables in the countries specific fixed effects. A fixed effect specification is preferred because of the correlation between the case and the error term.

Some other variables that determine sales would not be country specific but vary of time such as the development of the electric vehicle technology, fossil fuel prices, expectations of fossil fuel prices. The information of these variables can be captured either in the country specific time variables and a trend variable that we have added to the model.

The following econometric model can test the impact of the presence of charging stations and the share of fast charging stations on the sales of electric vehicles.

$$Plugin\_electric\_vehicles\_sales_{it} = \mathbf{Countrydummy}_i + \mathbf{Yeardummy}_t + \boldsymbol{\beta}\,Conventional\ chargers + \boldsymbol{\beta}\,High\text{-}Power\ chargers + \boldsymbol{\beta}\,trend_i + \boldsymbol{\varepsilon}_t$$

An ordinary least square estimation determines the model parameters indicated in bold symbols.

In addition to the panel regression, we have collected data to determine the total cost of ownership in 2016 of Austria, Belgium, Denmark, France, Germany, Iceland, Italy, Netherlands, Norway, Spain, Sweden, Switzerland and the UK to see in which countries the fiscal regime is sufficiently beneficial to increase sales of electric vehicles. In the two countries that stand out we have in addition the evolution of sales of plugin hybrid vehicles compared with the evolution of the battery electric vehicles. The asymmetric evolution of the sales of these two types of vehicles can illustrate the relevance of differentiated support mechanisms for both in comparison with the support or tax for battery electric vehicles.

WP6 Green Public Procurement: the government as sustainable consumer

The impact of Green Public Procurement and Legality verification is analysed by using a Spatial Equilibrium Model (SEM). For both policy options we assume that they are implemented at EU-level, hence all governments within the EU adhere and perfectly implement the policy.

It would be incorrect to analyze the impact GPP in Europe in an autarky situation. Our research needs to take into account the international dimension of wood markets. Forest industries in different regions are 'increasingly linked through international trade and global environmental policies' (Buongiorno, Zhu et al. 2003). Consequently, demand and supply shocks in one region can impact on other regions' wood markets. In addition, forest conservation policies – such as certification – in one region can lead to deforestation in other regions (Gan and McCarl 2007, Sedjo and Sohngen 2013).

For this reason, this research presents a novel Spatial and temporal price allocation Equilibrium Model (SEM) to analyze the impact of GPP in Europe. This implies that we adhere a strictly economic approach in this chapter, based on perfect competition. A SEM will allow interaction between spatially separated regional wood markets. The novelty of this research is found in the modifications made to the standard SEMs maximization framework. A first modification distinguishes conventional products from certified products in each regions' production and consumption. Albeit both types of wood are substitutes, the traditional multi-product models cannot be used. The price mechanisms between both products is not based upon substitutability, but on the price premium. A second modification permits the analysis of the impact of government spending by distinguishing the governments' share of final consumption from the households' share.

The traditional SEM had to be adapted because the price mechanism in the traditional multi-product SEM is not appropriate for markets characterized by the presence of certified (either eco-certified or legality verified) products alongside conventional ones. The standard price mechanism for substitute products assumes a positive (negative) cross-price elasticity for demand (supply) for substitute goods (Takayama and Judge 1970, O'sullivan and Sheffrin 2008). A price increase of one substitute good makes the substitute relatively cheaper.

However, the certified and conventional wood prices are directly linked to each other. The certified wood price consists of the conventional wood price with the addition of a price premium. and are expressed as a percentage increase to the conventional price. Hence, a price increase for conventional wood increases the certified wood price by the same percentage and both wood types remain equally expensive in relative terms. As a consequence, the multi-product SEM's price mechanisms does not hold in this situation: the demanded (supplied) quantity of the certified good is not positively (negatively) related to the conventional wood price per se. Instead, the new price mechanism is built into the single-product SEM.

The novel SEM incorporates the production costs related to eco-certification or providing a proof of legality, and the consumer valuation of the credence qualities of eco-certified or legal wood by introducing a price premium at the demand and supply side of the wood market. The required equations and mechanisms to do so are explained in the paper by Brusselaers et al. published in Ecological Economics (2017).

The modified SEM's objective function maximizes global quasi-welfare (Swoboda 1972) through the simultaneous solution of all regions' equilibria under the assumption of bilateral trade costs. The equilibrium state of the model will however also provide in-depth information on each region's welfare level, equilibrium price and equilibrium quantity. Due to the modifications, the model also determines an equilibrium price premium and the equilibrium share of certified wood within a region's total wood consumption and production.

The difference between 'quasi-welfare' and 'welfare' relates to the solution of the applied equilibrium model. 'Welfare' is used when a full equilibrium is attained. This requires an equilibrium in each separate market in the economy. In a full equilibrium, excess demand in one economy is compensated by excess supply in another economy. Swoboda (1972) describe how in stable economic systems, 'forces that will eliminate any disequilibrium and return the system to its equilibrium position are automatically set in motion'. 'Quasi-welfare' relates to a quasi-equilibrium position in which a disequilibrium in (at least) one market is consistently prevented from spreading to other markets and from returning the system (assumed to be stable) to equilibrium. Those economic indicators can be transformed into proxy indicators for the environmental impact. The eco-certified or legal production provides an indication of the sustainably managed forest area.

In addition to the economic and related environmental analysis, this WP also analyses the support for GPP, and drivers for eco-certified consumption among private consumers. This is imported since GPP also aims to foster private demand for eco-certified consumption. Therefore, the third paper empirically investigates to what extent consumers of eco-certified wood are driven by self-interest instead of environmental or altruistic concerns. This is done by making use of a cross-sectional survey data collected through questionnaires in May 2016 and January 2017 in Belgium. The questionnaire allows to establish distinct consumer profiles in terms of demographics, attitudinal and behavioral characteristics. The profiles are formed using a two-step segmentation process combining hierarchical and K-means segmentation.

This research applies segmentation analysis in order to separate the respondents into different groups based on their characteristics. The segmentation process aims for a high degree of similarity among respondents within a segment, and a high degree of dissimilarity between the segments. The reason to apply segmentation analysis is twofold. First, this research aims to check whether the identified determinants of sustainable consumption also apply to wood consumption. Those explanatory variables are the respondents' environmental concern, Perceived Consumer Effectiveness, subjective norm, and attitude towards eco-certified purchases. In addition, this research also takes explanatory variables into account which specifically link to eco-certified wood consumption: trust in the certificate's positive impact and income level (Aguilar and Vlosky 2007) in addition to the socio-demographic variables. The segmentation analysis is conducted by making use of the respondents' score for these explanatory variables, on the condition that these variables significantly impact on the intention to buy eco-certified wood. The latter is checked using Ordinary Least Squares (OLS) regression analysis and analysis of the Pearson correlation coefficient. This allows us to check for the presence of segments with a significantly different intention to buy eco-certified wood. Second, the consumer segmentation provides a solid framework for the comparison of attitudes by different consumer types towards government purchases of eco-certified wood (given specific scenarios).

Segmentation analysis is only useful if the segmentation process is sufficiently efficient to result in stable segment solutions. This chapter applies the two-step procedure, as described by (Yedla, Pathakota et al. 2010). The first step consists of hierarchical segmentation in order to determine the optimal number of segments, and the position of each segment's centroid. The second step introduces those centroids as the initial points for a K-means segmentation. The quality of this solution is double-checked by analysis of the within group sum of squares for the resulting number of segments. Finally, ANOVA must indicate significantly different attitudes or characteristics between the segments.

4. SCIENTIFIC RESULTS AND RECOMMENDATIONS

WP1 Exploration

Scientific results of the WP1 can be divided in two parts: a first one that presents the legal constraints to the adoption of economic instruments and a second one that provides, generally and then specifically for each working package, an overview of financial instruments for a low-carbon society. The same structure is followed in the deliverable 1.1.

Legal constraints to the adoption of economic instruments

To understand the existing policy framework of an environmental focus, it is necessary to analyse the legal stimuli – or constraints – that have influenced the adoption of such measures. These are of three types: institutional, material and budgetary.

Institutional constraints: Institutional constraints notably pertain to the distribution of competences. It asks the question "Who can do what", or in other words, "Which authority has the power to adopt which instrument". The issue is central as it conditions the validity of the instrument. Distribution of competences has been studied between the European Union (EU) and Member States and, within Belgium, between entities of different level. In this regard, one must distinguish tax competences from material competences.

As to the distribution of competences between the EU and Member States, it must be noted that environmental (art. 192 TFEU) and energy (art. 194 TFEU) matters constitute a shared competence. Goals of the EU energy policy include the development of renewable energy. Member States remain nevertheless exclusively competent to determine the conditions for exploiting their energy resources, their choice between different energy sources and the general structure of their energy supply. Tax competences, on the contrary, remain to a large extent an exclusive competence of Member States, especially in matters of direct taxation. Indirect taxes, such as VAT and excises have been harmonized to a large extent, especially with respect to the tax base and the minimum rate. In addition, provisions on the approximation of law (art. 114-118 TFEU), free movement (art. 45-66 TFEU) and competition (art. 107-109 TFEU), and general principles such as non-discrimination have led to a certain level of harmonisation in matters of direct taxation.

At the national level, the different State reforms have increased the complexity of the State structure and decentralized major competences to the federated entities, and notably the Regions. A key principle that needs to be considered is that in Belgium, the rules governing tax competences distribution and those pertaining to material competences greatly differ, both as to the principles and the sources they are governed by. From a material perspective, the Regions have received key competences in environmental and energy matters. These include areas such as agriculture, land management, new sources of energy, rational use of energy and distribution network tariffs for gas and electricity. The federal authority has remained competent in matters of product standards, nuclear energy, electricity transmission, transmission and distribution tariffs, and on the territory of the North Sea. The Regions have also received important taxing power but are limited by a central rule known as "*non bis in idem*" which implies that the Regions may not levy taxes in areas that are already subject to federal taxation. It must be noted that the Belgian system of distribution of competences allows taxes to strive for other objectives than purely budgetary (e.g. the protection of the environment). This statement is limited by the proportionality principle, which implies that the entities may not, in the exercise of their tax competences, make the exercise of competences granted to other entities impossible or unreasonably difficult. Finally, it must be noted that local authorities also have material and tax competences, provided that their action strives for local interest. All of these rules are particularly complex and judgements of the Constitutional court and advisory opinions of the Council of State show the difficulty to apply them in practise.

Material constraints: Material constrains concern the compatibility with norms that set substantial rules, and in particular: the principles of equality and non-discrimination, the European freedom of movement and fundamental freedom, the European prohibition of State aids. The principle of equality and non-discrimination commit public authorities to treat Belgian citizens equally and ensure their rights and freedoms without discrimination. These are central principles of national and international law, which find a specific application at article 172 of the Constitution. At the European level, certain rights and freedoms with respect to the movement of goods (art. 28-32 TFEU), movement of workers (art. 45-48 TFEU), right of establishment (art. 49-54 TFEU), services (art. 56-62 TFEU) and capital and payments (art. 63-66 and 75 TFEU) are guaranteed. In addition, in tax matters articles 110 to 113 of the TFEU prohibit the imposition of any internal taxation of any kind, directly or indirectly, on the products of other Member States in excess of that imposed directly or indirectly on similar domestic products. Finally, assuming that economic support can be economically harmful, since such instruments can generate distortions of competition and jeopardise the internal market, European law generally prohibits state aids (art. 107 & f. TFEU). Exceptions have been provided regarding State aids that aim to protect the environment. However, their compatibility depend on a number of very specific and well-determined criteria that make the task of public authorities very complex.

Budgetary constraints: Members of the Euro zone have committed to limit they public debt and their annual deficit. The European system of accounts (ESA 2010) enables the European Commission to monitor whether they respect these commitments. ESA 2010 is characterized by the prevalence of economic aspects on the legal reality. The way operations are classified is central as it determines whether they should be recorded as an expense of the State or not. This has constituted an important issue regarding the implementation of measures like the Walloon Ecopack. Qualification is also particularly significant when organising public-private partnership.

Overview of financial instruments for a low-carbon society

Various instruments can be used in order to achieve a low-carbon society. These include regulations – or command and control mechanisms – social instruments and economic instruments. Regulations can take the form of licenses, prohibitions, standards, quotas, etc. In the sector of transportation for instance, the European directive 70/220/CEE of 20 March 1970 on measures to be taken against air pollution by emissions from motor vehicles and the federal statute of 17 July 2013 on incorporation of biofuels are good examples of this first category. Social instruments encompass sensitisation, self-regulation, voluntary labelling, etc., while economic instruments can concern taxes, tax-incentives, subsidies, loans, market-based mechanisms, etc. As regulations often lack flexibility, the last two categories are gaining more and more importance. This research has focused on economic instruments.

Two approaches have been distinguished: a deterrent or detrimental approach that discourages environmentally harmful behaviours and an incentive-based approach that financially rewards environmentally positive behaviours. Environmental taxes and fees follow the first approach while subsidies and tax incentives fall within the second approach.

In a first time, these instruments have been presented generally, highlighting their pros and cons. Environmental taxation allows for a greater flexibility than pure regulation, by authorizing the use of dynamic and adaptable thresholds depending on the projected period and the type of addressee (enterprises and/or private individuals). However, this approach also entails a number of disadvantages relating to the unpopularity of tax levies, or the general incompatibility between budgetary and environmental aims. In response, earmarking can be used, which is the tax income appropriation to a budgetary fund whose purpose is environmental. Regarding environmental fees, they may only be used if the public authority's objective is to internalise external environmental costs, that they support and that are caused by citizens' behaviour. They cannot be used to change citizens' behaviour or to empower it, without considering the real environmental cost caused by the behaviour in question. Then, the distinction between the legal concepts of environmental tax and environmental fee is not perfectly clear in the Belgian legal order and is subject to dissension.

Incentives, which are widely used by Belgian public authorities, also have a number of disadvantages. They only enable focusing on positive actions and not on negative behaviours (to restrain from doing something). In addition, their budgetary impact is hard to predict. Their cost-efficiency is also questioned as they often generate a deadweight effect for citizens who have already adopted the desired behaviours. From a legal point of view, such measures face constraints of the European State aid prohibition, which imposes strict rules on Member states to be able implementing financial advantages (art. 107 and f. TFEU). Finally, there is currently no mechanism of *a posteriori* assessment of the existing incentives, which reduces their cost-efficiency.

Finally, market-based mechanisms enable flexibility within the determined group and integration of marginal costs of pollution reduction, as well as insuring that public authorities achieve emissions reduction targets. They also help avoiding the issue of setting a pollution price, as the market determines it. However, this system also has downsides including the impossibility of applying it to all pollutants (private individuals and enterprises), due to its complexity and the administrative cost of such a mechanism. Irrespective of these reasons, another question is whether a market-based mechanism is a suitable instrument regarding private individuals.

In a second time, a list of existing instruments applicable to each working package has been made. These instruments usually differ as to their addressees, their goal and their main features, except between instruments of the WP 3 and 4, since they both concern the development of renewable energy. They also greatly differ depending on the entity adopting them (Flemish Region, Walloon Region, the Region of Brussels-capital and the federal authority). Taxation of energy and of nuclear operators has also been studied as it may influence to some extent energy consumers and investors in renewable energy.

The incentives studied are summarized in the table below:

Working Package 2	• Federal tax credit for expenses made in order to save energy in housings • Federal tax credit for low energy, passive and zero energy housings federal tax credit and interest subsidy for loan contract interests in order to finance expenses made in order to save energy; • Federal tax credit for roof insulation, property tax deduction (Flanders) • Walloon energy premium • Walloon renovation premium • Walloon Qualiwatt premium (photovoltaic installation) • MEBAR II (Wallonia) • ECOPACK (and RENOPACK and ACCESSPACK) (Wallonia) • PIVERT (Wallonia) • Energy Premium (Brussels) • Renovation Premium (Brussels) • Brussels green loan • Renovation premium (Flanders) • Improvement Premium (Flanders) • Totaalrenovatiebonus (Flanders) • Energy loans (Flanders)
Working Package 3	• Investment deduction (federal) • Tax credit for research & development (federal)

	- Green certificates - Reimbursable advances for experimental research and development projects (Wallonia) - Investment support (Wallonia) - Novalia financial support (Wallonia) - Ecology premium (Flanders) - Energy premium (Brussels)
Working Package 4	Same instrument as *working package* 3.

Working Package 5	- Registration tax
	- Circulation tax
	- Premium – zero emissions (Flanders)
	- Company car taxation including
	  o the solidarity CO2 contribution to the ONSS (employer)
	  o Taxable benefit in kind (employees and business leader)
	  o Non accepted expenses (employer)
	  o VAT aspects.

Working Package 6	Legal analysis of the *Working Package* 6 has been subcontracted to a lawyer (Christophe Dubois from the law firm Equal), due to the specificities of the rules on public procurement. In particular, he has studied how European rules on public procurement take into account environmental considerations. Five key moments have been identified: - the definition of the subject of the contract - the redaction of technical specifications - the selection of the firm (exclusion causes or selection criteria) - choice of the most interesting offer - execution of the public procurement (conditions of execution)

The main conclusions of the working package 1 (exploration phase) are the following:

- <u>A greater level of coordination between authorities is necessary</u>: Without coordination, federalism can lead to contrary policies (e.g. nuclear vs. renewable energy), as autonomous measures at different levels often interact. In the context of the federalisation of the State, cooperation authority (such as the National Climate Commission) have been created in order to compensate inconsistencies arising from autonomous policies but their efficiency is questioned. Therefore, we recommend to create a *new organisation* or to *reform current structures* in order to enhance the cooperation of the different levels of power. In addition, article 92*bis* of the special law on institutional reforms should be modified in order to include climate change policy, or at least specific aspects of it, in the list of issue for which *cooperation agreements* are required.

- Distribution of competences rules need to be reformed: As taxes often pursue goals other than purely budgetary, and are therefore often used as a policy instrument, the distinction between tax competences and material competences seems out-dated to a large extent. In the current system of distribution of competences, although Regions have most of the environmental competences they have limited tax instruments to achieve their objectives. From an institutional point of view, it is easier for them to implement non-tax incentives to achieve objectives for which they are materially competent, rather than tax incentives, as they must link the objective to a tax for which they are competent, based on the distribution of tax competences. In addition, it is easier for them to implement tax incentives than deterrent taxes, since the *non bis in idem* principle limits their power to introduce new (deterrent) taxes. Therefore, shifting towards greener system taxation will require a modification on the rules on the distribution of competences. The general framework should be subject to re-thinking process.
- Incentives vs. deterrent approach: Belgian authorities mostly use an incentive approach in order to protect the environment, which takes the form of tax and non-tax incentives, rather than deterrent approach, based on deterrent taxes. This is partly due, as noted, to the rules on the distribution of competences. Nevertheless differences between the Regions can be observed. In contrast to the other Regions, the Flemish Region has partly greened its tax system in order to introduce more environmental taxation (e.g. property tax, gift duties, annual circulation tax and car registration tax). In order to be in line with international and European recommendations, public authorities should nevertheless prefer *environmental taxes*.
- Efficient tax system would require periodic assessment of measures: A periodic *ex post* assessment of existing measures would enable to quickly modify those that do not achieve effectively their goals. Report of these measures should be compulsory to some extent. In this context, one of the major issues would be to establish criterions of evaluation.
- Financial instruments need to pursue only one objective: Financial instruments often pursue different objectives at the same time. These may counteract themselves and ultimately miss their goal. Tax system in Belgium has been implemented in this sense. Moreover, newly adopted instruments may pursue contrary goals to existing instruments, within the legal policy of one entity. Policymaker need to determine clearly their objective and pursue only one goal per instrument. In addition, budgetary and environmental objectives are incompatible, as the desired change of comportment will make the tax revenues void, or at least reduce them. This will need to be taken into account when implementing environmental taxes.

WP2 Energy efficiency in residential buildings

The traditional policy measures have proven to have a low impact in the uptake of deep energy renovation. One of the causes is that human limitations are not or too little taken into account in the development of policy instruments. Therefore when developing new policy instruments or improving existing ones, human limitations should be taken into account during development, but the effectiveness should also be tested through field tests and focus groups much more than is the case now. The research in WP2 has resulted mainly in recommendations for improvement of existing policy instruments. Since most policy actions related to energy efficiency in buildings are developed at regional level, most recommendations can be applied at this level. The most important are listed here below.

Applying behavioural insights from the dual process models to energy renovation

The main feature of Dual process models (DPMs) is the concurrent possibility of processing certain information in a slow rational way (System 2) or in a fast, intuitive, heuristic way (System 1). Understanding the factors influencing this delicate balance is rather significant for policy making. If the arguments of an informational campaign are exclusively rational, it is important to verify if the target processes the information in a cognitive way. While System 2 thinking implies slow and deliberative thinking, System 1 is characterized by shortcuts: heuristics and biases. These are intuitive estimations of probability of the outcome that allow taking fast decisions. While in everyday practice these intuitive shortcuts might be useful in increasing the efficiency of small decisions, they can be dangerous in taking important decisions such as the ones regarding energy renovation. A summary of heuristics and biases that are relevant in the context of deep energy renovation decisions are presented, with an example for renovation. These can be used as criteria of attention in a first evaluation of policy instruments.

Availability heuristic: the probability of an event or the frequency of an object is assessed by the ease with which it can be, recalled (Kahneman, Slovic, & Tversky, 1982). If the event is present in the memory, the bias is due to '*retrievability*' (Tversky & Kahneman, 1974). Often the choice of a certain renovation measure is based exclusively on its familiarity (already known information or singular cases from friends) or on its salience (PV panels have high visual impact, certain technologies have more coverage in media, etc.). The bias of '*imaginability*' regards the objects and events that are not present in the memory. For example, the aesthetical advantages of the refurbishments the architect describes are easier imagined than the energy efficiency measures' benefits such as thermal comfort, humidity control, etc.

Representativeness heuristic explains how people assess the probability of events merely based on the "*degree to which A resembles B*" (Tversky & Kahneman, 1974). An example of representativeness heuristic is the way dwellers assess what is responsible for a high energy consumption (and respectively a high energy bill). They might overestimate the impact of their occupancy patterns and underestimate the importance of the characteristics of the dwelling. Everyday actions such as heating, cooking and showering resemble other activities such as buying groceries or dining out. All these actions are regarded as expenses depending mostly on the dweller's lifestyle. This way, the bill on the heating is associated more with the temperature chosen and less with the insulation of the dwelling. This perception is often reinforced in information flyers with suggestions on how to save energy. The characteristics of the dwelling are perceived as external factors such as prices on the menu that you have to accept if you opt to dine out. This heuristic might be an explanation for the distrust in the energy performance certificate of the dwelling. It is calculated for standard occupancy, while people expect the certificate to reflect their actual energy consumption.

Adjustment and anchoring: in order to estimate a certain value, people start from an initial value called 'anchor' and try to adjust it accordingly (Kahneman, Slovic, & Tversky, 1982). This is one of the reasons why framing of the message is highly influential. Another anchor is related to the way probabilities are estimated. The overall probability of a series of events is different from the probability of the elementary events of which it consists. However, the latter works as an anchor and people "tend to overestimate the probability of conjunctive events and underestimate the probability of disjunctive events" (Tversky & Kahneman, 1974). The renovation process is a concatenation of '*conjunctive*' events. In order to achieve the final result, all the elementary events have to take place, such as obtaining the renovation permit, etc. The success rate of each phase is very high, but the overall probability of the sequence is much lower. Often dwellers overestimate the overall success rate and underestimate the difficulty of the renovation process. It may lead to excess of optimism in initial planning and disappointment during the process. On the contrary perform the disjunctive series of events, such as the risk of malfunctioning of the building' systems. In this case it is enough that one of the indispensable elements of the chain breaks in order to block the entire system. The probability that each element will malfunction is very low, the overall probability is higher but once again, the initial low probability works as an '*anchor*'. Therefore people underestimate the risk of malfunctioning of the systems and neglect their duly inspection and maintenance.

<u>Satisfice bias:</u> people aim for a satisfactory result, rather than an optimal resultInvalid source specified.. When confronted with too many options and too complex information, often people rush for the 'good enough' renovation measure and avoid seeking 'the best' option (Frederiks, Stenner, & Hobman, 2014). People with a high level of need for closure are more likely to incline for the first 'satisficing' option that is encountered. Moreover, satisfice bias might be related to status quo bias if the existing state of the dwelling is perceived as '*good enough'* and, as a consequence, renovation is discarded altogether.

<u>Social norms:</u> the decisions are heavily influenced by others' opinions or others' undertaken decisions (Frederiks, Stenner, & Hobman, 2014), (Ariely, 2008), (Behavioral Insights Team, 2011). Social norms might explain the choice for under optimal, lock-in technologies. These solutions give the confirmation, recognition that these are the best technical, ecological solutions ("there must be a reason why everybody chooses it"). Besides it spares the hassle to compare multitude of available solutions in order to find the solution that best fits your particular dwelling.

<u>Discount the future:</u> smaller benefits in the present overweight bigger benefits in the future (Behavioral Insights Team, 2011). Time affects as a dimmer thus future savings on the utility bills resulting from energy efficiency investments are less appealing.

<u>Endowment effect:</u> people value more the things they own, not due to their characteristics, but merely because they own them (Ariely, 2008). This bias might be the explanation why people resist to change old appliances and boilers with energy efficient ones.

Deliberative versus heuristic arguments in favour of or opposing energy renovation

The hypothesis of the ranking exercise was that the dwellers are mainly deliberative in their positive arguments and are mostly heuristic in their negative arguments:

Hypothesis 1: Arguments in favour are mostly deliberative $\Sigma(D+) > \Sigma(H+)$

Hypothesis 2: Arguments against are mostly heuristic Σ(H–) > Σ(D–)

Table II Results of the ranking exercise

	EXPERIENCES arguments in favour (mean of) ΣR–ΣH	EXPERIENCES arguments against (mean of) ΣR–ΣH	N	INTENTIONS arguments in favour (mean of) ΣR–ΣH	INTENTIONS arguments against (mean of) ΣR–ΣH	N
Wall insulation	1.19***	0.13	76	1.05***	0.93**	98
EE windows	2.63***	0.39	95	2.89***	0.56*	78
EE boiler	2.25***	-0.11	70	2.90***	0.08	104
PV	-	-	34	1.96***	1.84***	140
Solar water heater	-	-	8	1.84***	1.62***	166

Student's t-test for paired sample

significance level * p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001

For all the measures the first hypothesis was confirmed (*Table II*): the dwellers are more deliberative in their positive arguments. This is common for both house owners who installed the measure (EXPERIENCES) and the ones who did not or who are renters (INTENTIONS). These deliberative arguments in favour are based mainly on monetary motivations ("I want to save money on heating") or environmental motivations ("It is good for environment to save energy"). Therefore, independently whether they installed the measures or not, dwellers are equally aware of the monetary and CO2 savings and they prevail over heuristics. Regarding the negative arguments the second hypothesis was not confirmed: the heuristic arguments do not prevail. It is important to remark that here the responses between house owners who have undertaken the measure (EXPERIENCES) differ from ones who did not (INTENTIONS). The former show a balanced deliberative and heuristic thinking, whilst for the latter group deliberative thinking still prevails for all the measures except for EE boiler. A possible explanation of the different reasoning between EXPERIENCES and INTENTIONS in terms of obstacles might be the investment cost. While both groups are aware of the monetary and environmental savings as main motivations, the respondents who did not install the measures are more concerned about the investment cost. Another possible explanation of this finding is that the house owners who installed the measure (EXPERIENCES) are more self-aware of their own biases, since the responses are self-reported preferences.

Preferences for energy saving measures

The results of the choice experiment showed that despite the information provided by the attributes in the choice experiment, respondents still largely base their choices on associations with the chosen alternative which are already present in their minds at the time of surveying seeing that the alternative specific constants (ASCs) have the largest impact on utility. Furthermore, the finding that the ASC for geothermal heat pumps is not significantly different from that of PV panels reflects that both of these options are less chosen independently of their characteristics compared to the other alternatives. This might reflect a more averse attitude towards these technologies. On average the respondents were found to be influenced strongly in making the (positive) choice to renovate by deliberative arguments, i.e. investment cost, reduction in CO2. It is important to note that findings from the ranking exercise show that deliberative arguments prevail for motivations. Therefore, even though monetary and environmental factors play an important role in the decision making, these are already perceived in a positive way. At the same time, the dwellers who installed the measure and those who did not show different reasoning in terms of barriers. Only for the latter group investment costs and other deliberative arguments prevail over heuristics. For these reasons, providing information on financing schemes might be more effective than underlining monetary savings during information campaigns. Another possible explanation of this finding is that the house owners who placed the measure are more self-aware of their own biases. An example of availability heuristic, "A friend has a bad experience installing/ using solar heaters" could be debunked with statistical data. An alternative to avoiding biases is to use them in the right direction. For example, Living Lab Housing Renovation programmes can set up new, positive, retrievable in the memory examples.

The energy performance certificate and behavioral insights

Up to now, it was assumed that people are able and willing to process the technical information of the EPC in a rational way. The EPC, similarly to the other labels, gather technical concepts and translates them into accessible terms. Therefore their impact and understanding of information presented might be different than expected. An illustrative example is the misinterpretation of the fuel efficiency expressed in MPG, previously used for the car label (Larrick & Soll, 2008). Experimental studies on energy-efficiency labels of cars, heating systems and appliances provide evidence of cognitive biases (Larrick & Soll, 2008; Newell & Siikamaki, 2013; Waechter, Sütterlin, Borghoff, & Siegrist, 2016; Waechter, Sutterlin, & Siegrist, 2015; Waechter, Sütterlin, & Siegrist, 2015). Instead of processing the information in a rational, deliberative way, people make use of a shortcut.

Under this perspective, the certificates of nine European countries/regions were analysed based on a theoretical framework of deliberative and heuristic thinking. The comparative analysis revealed a wide range of possibilities in communicating the energy performance and the recommendations for improving the energy efficiency. An important aspect is the choice of the units for the energy performance indicator, as well as for the recommendations. These can be expressed in energy consumption, energy efficiency, CO2 emissions, monetary savings or even unitless. The choice of monetary or environmental metrics can play a role in decision making (Schwartz, Bruine de Bruin, Fischhoff, & Lave, 2015), these can contribute to extrinsic or intrinsic motivations to undertake the recommended energy efficiency measures.

Many countries have applied behavioural insights and potential nudges either in an explicit or an implicit way, see *Table III*.

Table III Comparative analysis EPCs - potential nudges

	DE	NL	UK	ES	RO	DK	FR	Lombardy	Flanders
Make it easy	-	✓	✓	-	-	✓	✓	✓	-
Make it salient	✓	-	✓	-	✓	✓	✓	✓	-
Social norm	✓	✓	-	-	-	✓	-	-	-
Temporal discounting	✓	-	✓	✓	-	-	✓	✓	-
Default	-	✓	✓	-	-	✓	-	-	-
Anchoring	✓	✓	✓	-	-	✓	-	✓	✓

The **focus group** with experts aimed to gain additional insights regarding the existing version of the Flemish EPC and to analyse which insights from the comparative analysis could apply to the Flemish context. The certificates can be divided in two categories: a **first insight** on the energy performance as in the Netherlands or a **detailed energy advice** as in Denmark. As other reports point out, there is a trade-off between the quality and the cost of the certificate (Sutherland et al., 2015). Thus there is the need for a better definition of the purpose of the Flemish EPC. For now, many EPCs, including the Flemish, are half way between the two models and delude the expectations of both dwellers and policy makers. The paper version of the Flemish EPC presents a limited number of generic recommendations that could be complemented with an **online tool**. A new voluntary policy tool is under development, the building passport (Fabbri, Groote, & Rapf, 2016). Since the EPC is compulsory, it should work as a 'bridge' towards the building passport. The online tool could be accessed via a QR or bar code directly from the paper version of the EPC. This nudge, **'make it easy'**, reduces the frictional, extra hassle of undertaking an action (Hallsworth et al., 2014).

During the focus group it was pointed out that the energy performance score is the main information that dwellers consider and remember. Therefore, the perception of the energy performance indicator is crucial. According to the Flemish EPC, a dwelling with the energy score of 235 kWh/m2 per year of primary energy is on the green-yellow part of the scale, while on the German EPC it is on red part of the scale (***Figure 5***). Besides, the scale of the German EPC range from 0 to 250 kWh/m2 per year, while the Flemish from 0 to 700 kWh/m2 per year. These ranges might act as **references**, the so called anchoring bias. Therefore, these anchors might contribute to an **over-optimism** in assessing the EPC score of a particular dwelling due to an underestimation of the rest of the Flemish buildings on the market.

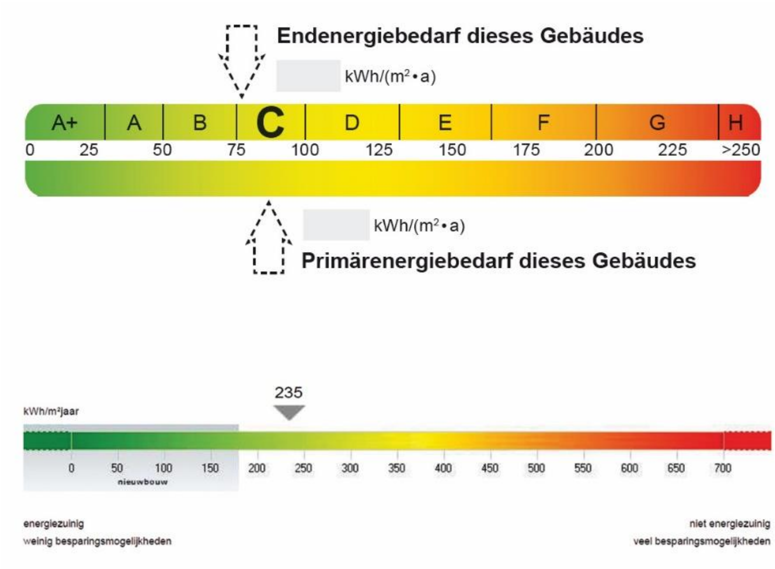


Figure 5 The scales of the energy performance certificates. Upper - EPC of Germany, lower - EPC of Flanders

These ranges of the colour gradients must be adjusted for each member state according to:

- the energy performance of the existing building stock
- the minimum requirements for the new construction
- the policy targets

Alternative to rescaling are nudges such as **anchoring** and **social norm** – the median, that is considerably lower than the mean and the percentage of house-owners who renovated within the next five years with a similar EPC score. The qualitative study, based on the framework from literature review and the focus group allows to tackle the issue in depth. Nevertheless, the hypotheses need to be further on tested in a quantitative way.

The undertaken qualitative analysis points out that **information framing** is an important aspect in the implementation of the EPC, alongside quality control in the calculation software and training of the energy experts. If up to now behavioural insights were mostly associated to **nudging and libertarian paternalism** (BIT, 2011; Corrales & Jurčys, 2016; Thaler & Sunstein, 2009), their implications to **traditional policy measures** are yet to be explored. The EPC is a mandatory scheme, yet the implications of heuristic thinking should be considered in its elaboration and implementation. Many public institutions and governments have set up behavioural research units in order to develop behaviourally informed policies (Lourenço, Ciriolo, Almeida, & Troussard, 2016; OECD, 2017; Samson & Sunstein, 2017). Even if nudging is not the purpose, no message is neutral and the information framing might play an important role in the impact of the provided information on the purchase and renovation decisions of the dwellings.

Importance of financial support for different household types

Financial support instruments have been used by policy makers for many years to incite energy efficient investments in residential buildings. However, as the analysis of the use and distribution of instruments as subsidies and tax rebate has shown (Verbeeck, 2016), most financial support goes to the higher income groups leading to the hypothesis that subsidies and tax rebate have mainly a sensitizing and mobilizing effect for theses households and thus act more as a psychological trigger than as an essential, indispensable financial factor without which renovation should not have been possible.

Although it is very difficult to prove this hypothesis, especially with a survey that only captivates stated preferences, the survey among households visiting the construction fairs Bouwinnovatie 2017 and Batibouw 2017 has given new insights in the importance of financial and other support in the renovation decision process, also with distinction among different socio-demographic groups.

According to socio-demographics and based on the answers to the survey, the respondents can mainly be divided into:

a large group of young people with higher education, but currently with a limited budget because of their age and life stage, but with a high chance to have a higher budget in the future because of their education level. They have plans to build a new house or want to renovate a recently purchased house. Most of them did not undertake any energy efficient action and therefore did not make use of financial support up to now. They are in general quite well informed or do not experience many difficulties in finding the information they need. The support they are mainly interested in, is financial support in order to be able to do more than what is possible with their available budget. They know in general quite well what they want, but financial support can also help them to prioritize or to investment in more expensive measures, under the condition that they are convinced of the surplus value of these measures. Because of their knowledge and/or ease of finding information, they are less interested in a brochure, a calculator or a checklist and because of the loan they have they are less interested in an additional loan. From all groups, they are most interested in subsidies from a purely financial point of view, because for them it is an indispensable financial factor in the renovation process. For the same reason, they are most open to collective renovation as they see it as a way to reduce the investment cost, but under the condition of clear rules. Since this group is only starting its living and housing trajectory, it is important to support them to do it properly and profoundly enough. So for this group, financial support is essential to make a renovation possible, but attention should also be paid to easy access to online accurate and practical information in order to incite them to undertake a deep energy renovation, because there might be the risk of overconfidence about their knowledge, which in combination with a limited budget might lead to renovations that lead to lock-in of future energy saving potential.

a large group of middle age (35-64) with higher or university education and especially the group of 45-64 with much more budget available. They own the house they live in and most of these houses are built before any energy-related regulation became into force. Because of the age and condition of their house, they have already undertaken energy efficient actions and/or are interested in extra energy efficient actions, but profitability is quite important for them. Although their housing situation might be more difficult for a renovation from a practical point of view (since they already live in it), they might be more easily be convinced because of the (perceived) profitability and savings an energy renovation might achieve. Some of them are well informed, others are less informed, but most of them are interested in extra information under the form of a brochure, a calculator and/or a checklist to get more insights in the conditions and the possibilities of their house and of renovations. From all groups they are most open to an additional loan to renovate that can be paid back with the original energy bill (many of them do not have a loan anymore), although some of them are not willing to lend money under any condition. They are least interested in collective renovation, because they fear the lack of freedom, the administration and problems this can give. They might also be negatively biased towards certain, newer technology, so good information or advice from a reliable party with enough attention for the financial consequences is crucial. For this group, especially 45+, experiencing difficulties with getting information or with the execution of the renovation might be a higher threshold, even when the investment is profitable. So enough attention should be paid to non-financial support.

a small group of 65+, both with and without budget, most of them owners of the house they live in, a house that might need adaptations for lifelong living. Although the budget will be often a crucial element in the decision process, especially for energy efficient measures that risk to be profitable on a longer term, the non-financial aspects might be a higher threshold, such as lack of knowledge, fear for the efforts a renovation will take, difficulties in finding a reliable party, in finding information, in getting financial support. So advice and support tailored to this group can be crucial.

a very small group of people from the lower income groups (with a higher risk to remain in this income group in the future because of their education level and/or household group). Some are owners, others are tenants. For this group often the combination of overcoming problems of pre-financing and of lack of knowledge and fear for all the difficulties and efforts a renovation process can give, has to be tackled. The existing financial support is often too low or too difficult to get, loans can create a too high risk and the information is often too difficult to get or to understand. So for this group really personalized support is crucial.

WP3 Geothermal technology as case for “new” technologies

The key step is the analysis of individual policy instruments applicable for geothermal energy. Geothermal energy projects are large projects with substantial risks, and therefore not viable without strong support systems.

The particular structure of individual support instruments can strongly influence the applicability and effectiveness of the instrument in its capacity to stimulate geothermal projects. This analysis looks at individual support instruments applied to single projects. The effectiveness or impact of the instruments is controlled by looking at its capacity to increase the probability of success of the project, at the total public cost it entails, and the impact it has on the profitability during the lifetime of the geothermal project.

The different public instruments that are included in this analysis are described in Box 1. The calculation model determines the Net Present Value (NPV) of the geothermal project, over the lifetime of the project, including 5 years of construction and 35 years of operation.

All private costs and benefits are calculated on an annual basis, and the value is actualised taken a weight average capital cost into account. Details of all elements that are included in the calculation are described below.

Box 1 : Description of the different policy instruments that are considered in the analysis

Policy instruments

1. Recoverable advance

The recoverable advance is an advantageous loan that is provided by public institutions. The advantage of the loan is that capital reimbursements can be reduced when the project does not earn enough to pay for its monthly capital reimbursements. In that case the specific reimbursement is pardoned. In this analysis, three levels of recoverable advances are analysed: recoverable advances for 30%, 50% and 80% of the total investment, including survey expenses.

2. Federal tax rebate

The federal tax rebate is a system that is currently available for investments in sustainable energy production and consumption. With this system, the company can claim a percentage of the sustainable investment cost in the annual tax declaration on top of the declared investment cost, and thereby reduce the taxable income. As the tax rate in Belgium is currently 33.99%, this system is equivalent to a reduction in the total investment of 33.99% of the part of the investment cost that can be booked additionally. In this analysis, three levels of federal tax rebate are analysed: a tax rebate for 30%, 50%, and 80% of the total investment cost, including survey expenses.

3. Energy production subsidies

Most European countries provide subsidies for the production of renewable electricity. This can be done in the form of green electricity certificates, of feed-in premiums. Other countries foresee a fixed advantages feed-in price for electricity that is fed into the grid. This system is also available in Belgium with the provision of green electricity certificates. This system provides an additional benefit of approximately 88 EUR/MWh_{el}. This price depends on fluctuations on the green electricity certificate market, but has stagnated around this price for the last months.

A similar system can be designed for the production of green heat. As the majority of the energy produced by geothermal plants is in the form of heat, this type is the only system that can provide an adequate stimulus for deep geothermal projects. In this analysis, three levels of green heat certificates are analysed: 30 EUR/MWh_{th}, 50 EUR/MWh_{th}, and 80 EUR/MWh_{th}.

4. Public insurance

Because the risks of a geothermal project remain very high, insurance companies are not likely to provide standard insurance services for geothermal projects. The operational expenses for an insurance of a large deep geothermal plant are impossible to obtain or very expensive, given the fact that very few installations of this type have already been created.

In France, public institutions and private operators of geothermal systems have created a shared fund, “Geodeep”, that is designed to provide advantageous insurance for new geothermal projects. Following this examples, we analyse three levels geothermal insurance: reductions of 30%, 50% and 80% compared to the cost of a private insurance.

Technical and financial details of the NPV calculation

Investment costs

Geological survey	500 000 €
Seismic survey	2 000 000 €
Borehole design	500 000 €
First drilling	1 800 €/m *
Second drilling	1 800 €/m *
Power plant (Only for electricity production)	16 000 000 €

* : Drilling risks are accounted for as a potential additional cost of $C^S$of the total borehole cost. C^S [€/m] is drawn randomly from N(1000,200). This appearance of this risk is modelled as a Poisson process with 30% chance of occurring.

Operational costs

Operational costs	2.5% of investment costs
Insurance	10% of structural investments

Benefits

Market price are modelled as

$$p_{kt} = p_k^S(1 + t^S)^t \qquad \text{for } k = LT, HT, and\ El$$

Here, p_{kt} is the price per MWh produced of the energy stream k in year t. p_k^S is the randomly drawn market fluctuation, drawn from N(p_k^{ref}, 0.3 p_k^{ref}). t^S is the long-term price trend on the market, drawn from N(t^{ref}, 0.1%). This approach allows to account for short-term fluctuations, and long-term trends divergent from standard inflation.

	p_k^{ref} [EUR/MWh]	t^{ref} [%]
Low Temperature heat (<90°C)	20	0.0
High Temperature heat (>90°C)	30	0.0
Electricity	140	0.0

Table 4: Parameters for market price estimations

Electricity is produced by ORC with an estimated net efficiency of 11%. Annual net benefits are actualised based on a WACC of 4.6%.

Results without support instruments

The probabilities of success of a geothermal project (Figure 6) are small without any support system. If all investments and risks are borne by the private investor, only 20.5% of all projects are attempted, and only 16.6% of the projects are successful in the sense that they obtain an NPV that is equal to or larger than zero. This means a geothermal project that is started, has a chance of 79.5% to be abandoned after the survey stage. This entails an irrecoverable sunk investment cost for the investor of 2.5 M€. There is a 20.5% chance that the boreholes are created, but of these attempts one on five of the drillings cannot be transformed in a profitable operational project.

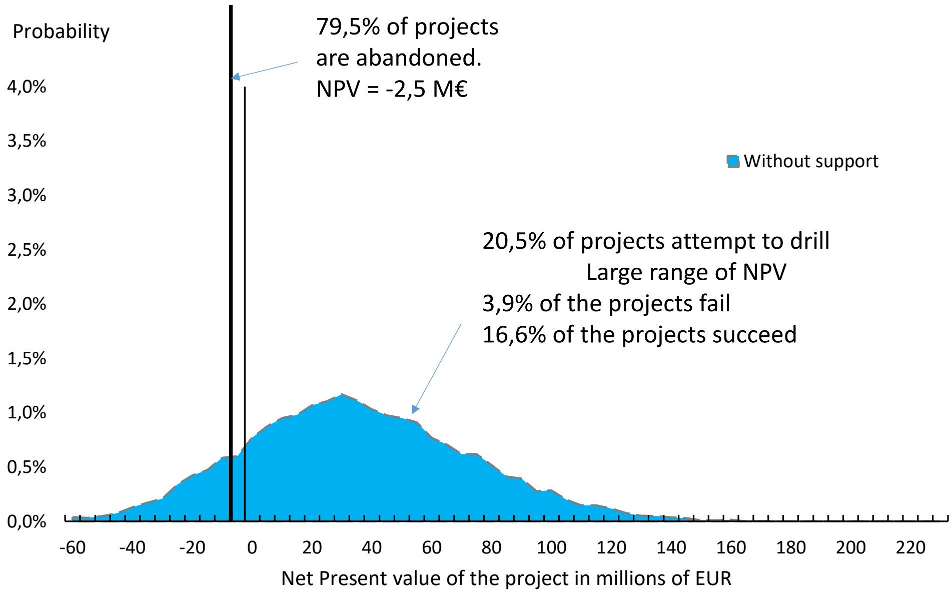


Figure 6: Schematic representation of the probability distribution of the NPV of a geothermal project without any support instruments.

Results for the different support instruments

For every support instrument, three levels of support have been evaluated. For each evaluation, the analysis looks at the average NPV for all cases, this can be interpreted as an option value for the project before starting. The analysis indicates the chance that the project will be abandoned after the survey stage, or inversely the chance the drilling will be attempted. And of the attempted drillings, the chance that the project is profitable is also deducted. To illustrate the effort for the public institutions, the average investment through the use of public support instruments is shown for projects where drilling is attempted. In all of the analysed cases the choices where mostly between the abandonment after the survey stage, or the construction of a high temperature heat plant. The probabilities of construction a low temperature heat plant, or a binary electricity and heat plant, were always less than 0.1%. Therefore, the results for these scenarios are not included.

The current institutional structure of Belgium allows the stimulation instruments to be proposed by different levels of government. Table IV presents an overview of different instruments that are currently proposed. In this research generic forms of these instruments have been investigated, regardless of the level of government that proposes them, and allowing for simultaneous application to the same project.

Table V: Categorisation of policy instruments according to the development stage of the innovation

Development stage	Basic research	Applied research	Development	Engineering	Market development
Federal Authority		Tax credit for R&D activities			Green investment tax deduction
Walloon region			Advantageous deposit for investments		Green investment premium

				Novallia	Green electricity certificates
Flemish region			Strategic industry research collaboration	Environmental research projects (MIP)	Ecology premium
				Public venture capital (GIMV, PMV)	Green electricity certificates
Brussels region					Energy premium
					Green certificates

A proposal for appropriate policy combinations has been designed for the geothermal sector by the European Geothermal Energy Council (EGEC, 2013). This proposal distinguishes between three stages of sector development. For colleagues of EGEC (European Geothermal Energy Council), policy instruments/incentives have to be adapted in function of the level of the market development (juvenile (0-6 geothermal wells), intermediate (6-60 wells), or mature market (>60 installed wells in the country). Financial support should firstly aim at the take-off of the first deep geothermal projects for a juvenile market (state of the Belgium market).

The individual analysis of the different instruments yields the following results:

- The recoverable advances are very effective instruments to increase the success rate of the projects. The risk of inflating excessively the profit of the private investor is reduced.
- The federal tax rebate only has a limited effect on the projects;
- The Green heat certificates have a significant effect on the success rate of the projects, but to a high cost for the public authorities. The green heat certificates lead to excessive profits for the most effective projects, being the projects that do not need support instruments. The risk for important costs for the government is present.
- The public insurance mechanism has a similar effect as the recoverable advance. The entailed costs for the government are higher than for the recoverable advances, and the risk of excessive private profits are higher.

Based on these individual instrument analyses, an adapted set of support instruments is proposed in Table V, according to the following principles: (i) juvenile markets are best served with recoverable advances, as these are instruments that are directed towards individual projects, or can be set up with an innovative procurement mechanism, (ii) any application of green heat certificates has to include a maximum amount of certificates that can be obtained by one project per year. This is to avoid excessive profits.

When these instruments are applied to the development of projects, this leads to the following results for the benefits and success rates of individual geothermal projects, as presented in Table V and Figure 5.

Table VI: Proposal of policy instrument combinations for different stages in the development of the geothermal sector.

Development stage	Juvenile market	Intermediate market	Mature market
Stage description	0-6 geothermal wells Less than 3 power plants are operational	About 6-60 geothermal wells Less than 10 power plants are operational	Over 60 geothermal wells Geo-electricity and geothermal heat plants developed all over the country.
Combination of policy instruments	Recoverable advance for 50% of the investment cost Green electricity certificates (88 €/MWh_{el}) Green heat certificates capped at 40 GWh/year (20 €/MWh_{th})	Public Risk insurance Green electricity certificates (88 €/MWh_{el}) Green heat certificate capped at 25 GWh/year (10 €/MWh_{th})	Public Risk insurance Green electricity certificates (88 €/MWh_{el})

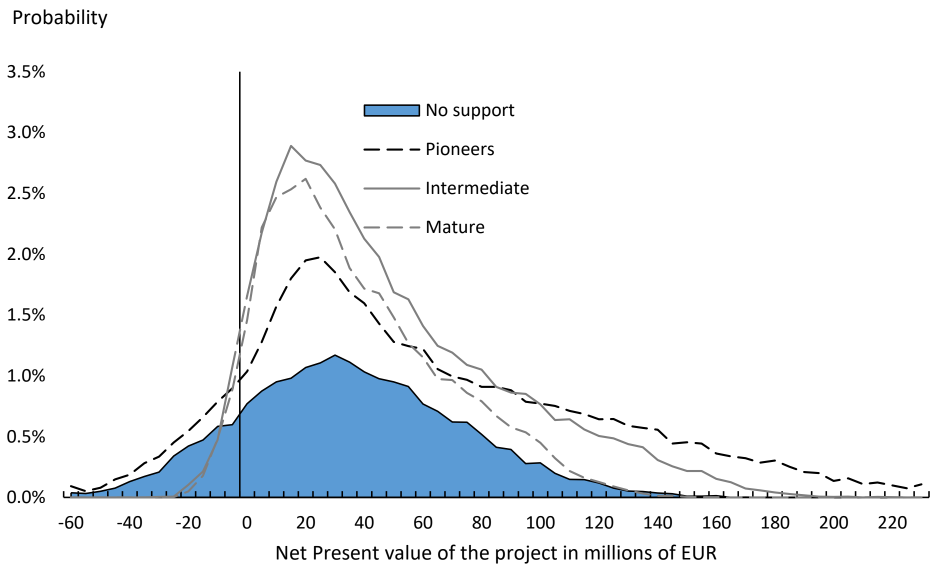


Figure 7: Probability distributions of the NPV of an attempted project for the policy sets in different sector maturity levels

Table VII: Results for policy sets in different levels of market maturity

	Without support	Juvenile market	Inter-mediate market	Mature market
Option value of the project	4 757 179	24 037 367	19 553 611	11 264 048
Average private investment	5 214 010	8 015 186	6 213 892	4 892 940
Abandoning the project after the survey				
Probability	79.5%	58.3%	56.4%	66.5%
Average NPV	-2 535 000	-1 267 500	-500 000	-500 000
Construction of a High Temperature heat plant				
Probability	20.5%	41.7%	43.6%	33.5%
Chance of success	16.6%	36.1%	40.1%	30.5%
Average NPV	33 019 261	59 465 152	45 480 649	34 583 049
Average cost of the public support instrument for operational projects				
Average cost	0	14 201 060	11 372 318	7 805 312

Geothermal market emergence in Belgium

From a policy perspective, it is equally important to analyse the impact of the support measure on the entire sector. To this effect, the policy measures have been applied to an evolutionary model to investigate the gradual growth of the geothermal sector under influence of the support emasures. A generic emergence simulation of the geothermal sector was realized (Figure 8). The influence of policies, timing, company profits, and market stages are all accounted for.

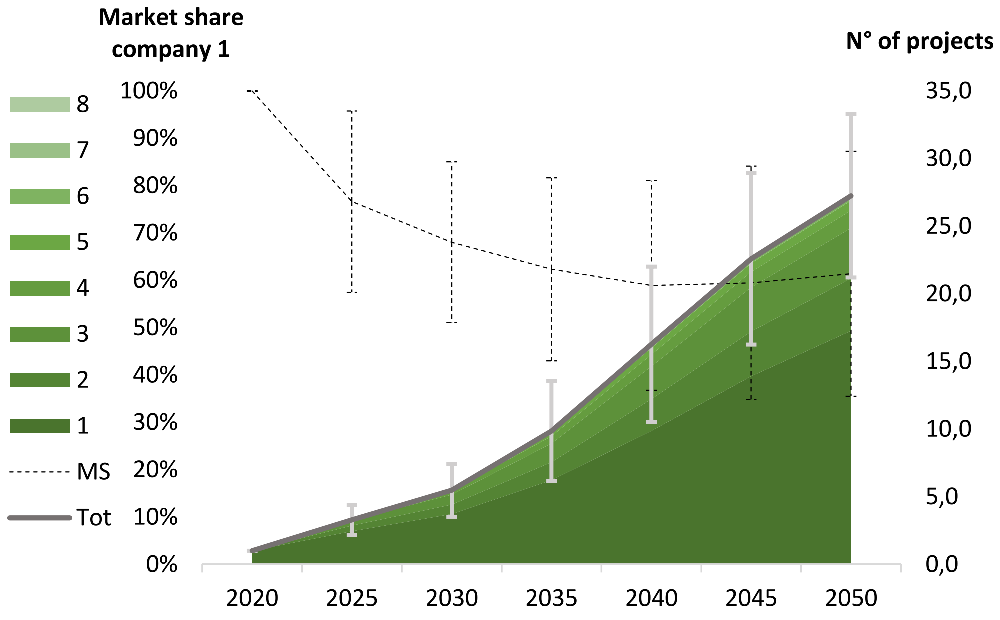


Figure 8 Geothermal sector emergence to 2050 when policies are present

The supported evolution sees a development of several geothermal projects over different basins in Belgium during the next three decades. If no policy are present, the results in Figure 9 show a low number of geothermal projects (9 instead of 29), a low number of companies and a very low success rate of projects and slow growth.

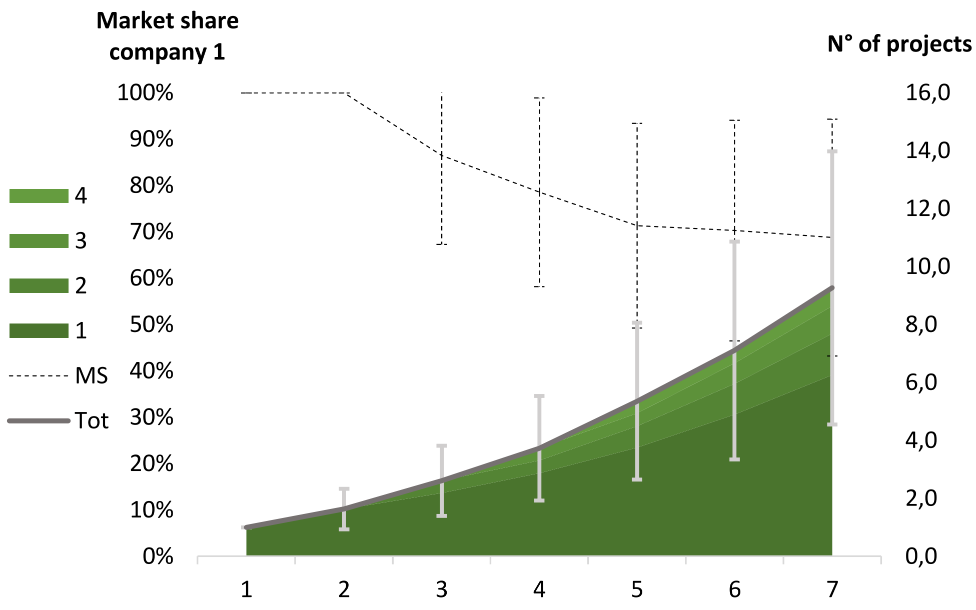


Figure 9 Geothermal sector emergence without policy

When no support measures are present (Figure 9), the exchange of (geo-)data has a positive impact of the success rate and attractiveness of the sector. With knowledge exchange and open access to geological data, the number of companies and projects increase compared to the situation without any support.

Recommendations on appropriate policy sets for Geothermal Energy sector development in Belgium

Following the results of the analysis, a more detailed set of policy instruments is proposed. This is based on the following considerations:

- Recoverable advance is very effective in raising success rates at low cost.
- Investment support via tax rebate is relatively inefficient.
- Green heat premiums of heat certificates are very expensive and support the most successful projects rather than the projects that need most support. Low price levels of green heat certificates and capping per project can reduce negative effects
- The impact of a public insurance scheme is similar to the impact of the recoverable advance, even if it is slightly less effective.

It appears that pioneer markets are best supported with contracts, not with legal instruments, certainly during the juvenile market stages, when only few projects are attempted. PPP is more certain and flexible for this small number of projects. Intermediate markets can be supported with a limited set of instruments. Mature markets are not easy to reach in Belgium.

Concerning the long-term evolution, the continuity of support is important. If no budget is available, geological data exchange of the conditions of the underground as a public resource, can support a more diversified sector to a limited extent.

WP4 Electricity: financing models for biomass based electricity production

Stakeholder consultation

Some interesting outputs came from stakeholder consultation, which can be summarized around two relevant topics: long-term policy vision and level playing field between energy resources. First of all, they claim the necessity to develop a clear long-term policy vision. In fact, the absence of long term vision in Belgium (e.g. the support period in Flanders is 10 years) makes it very difficult for investors to participate in the development of new technologies such as biomass. Next, to develop biomass based electricity, it is important to have a level playing field between the different energy sources. Currently, fossil fuels still receive higher amounts of support while biomass-based fuels had to deal with a decrease in support during the last years. The solution should consist of supporting renewable energy technologies while at the same time, support for fossil fuels should be phased out progressively. Moreover, a worldwide CO2 tax could be an incentive to decrease the use of fossil fuels.

Economic evaluation: Conclusions and recommendations per case study

- First Study case

In our first case of study, we study the effect of the implementation of different support mechanisms and different levels of these supports on the production of a biogas plant. As we can see in Figure 10 and Figure 11, we show that high levels of support involves a decrease on the efficiency of support, nonetheless, resulting in higher installed capacities.

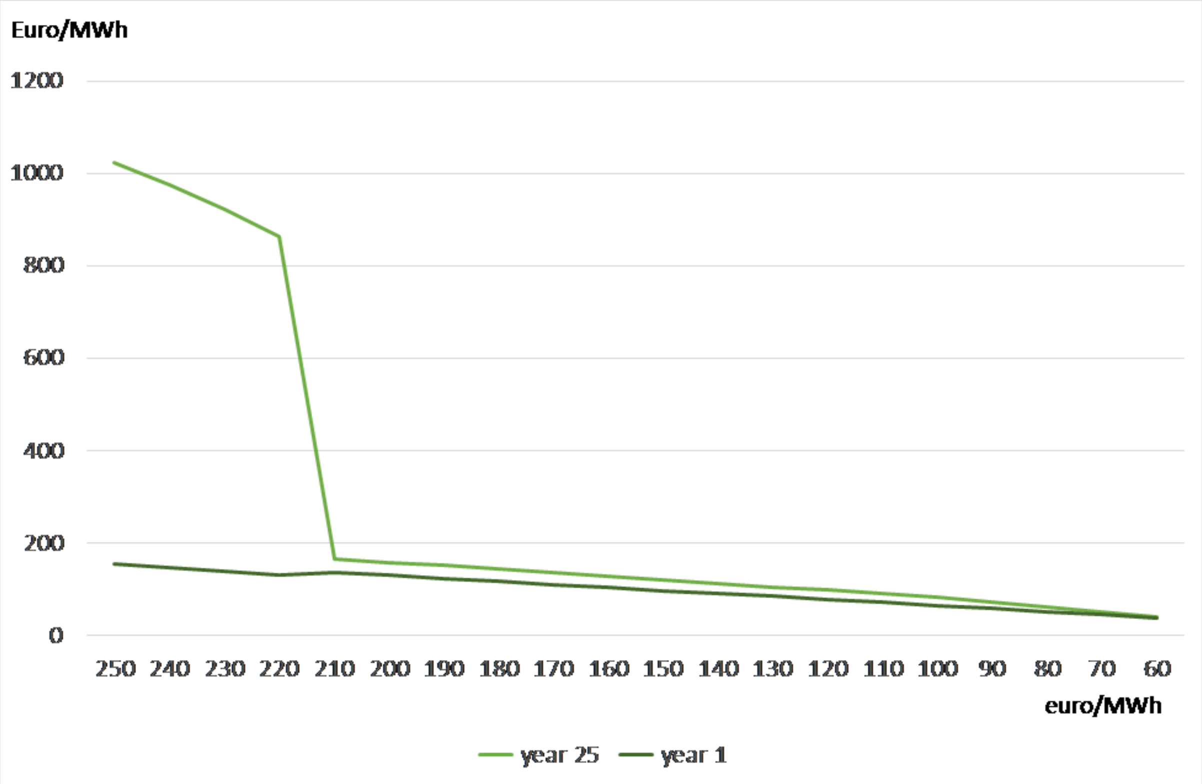


Figure 10 Effect of different feed-in premia on the subsidy efficiency (= amount of subsidies per year during 20 years divided by the electricity production on that year)

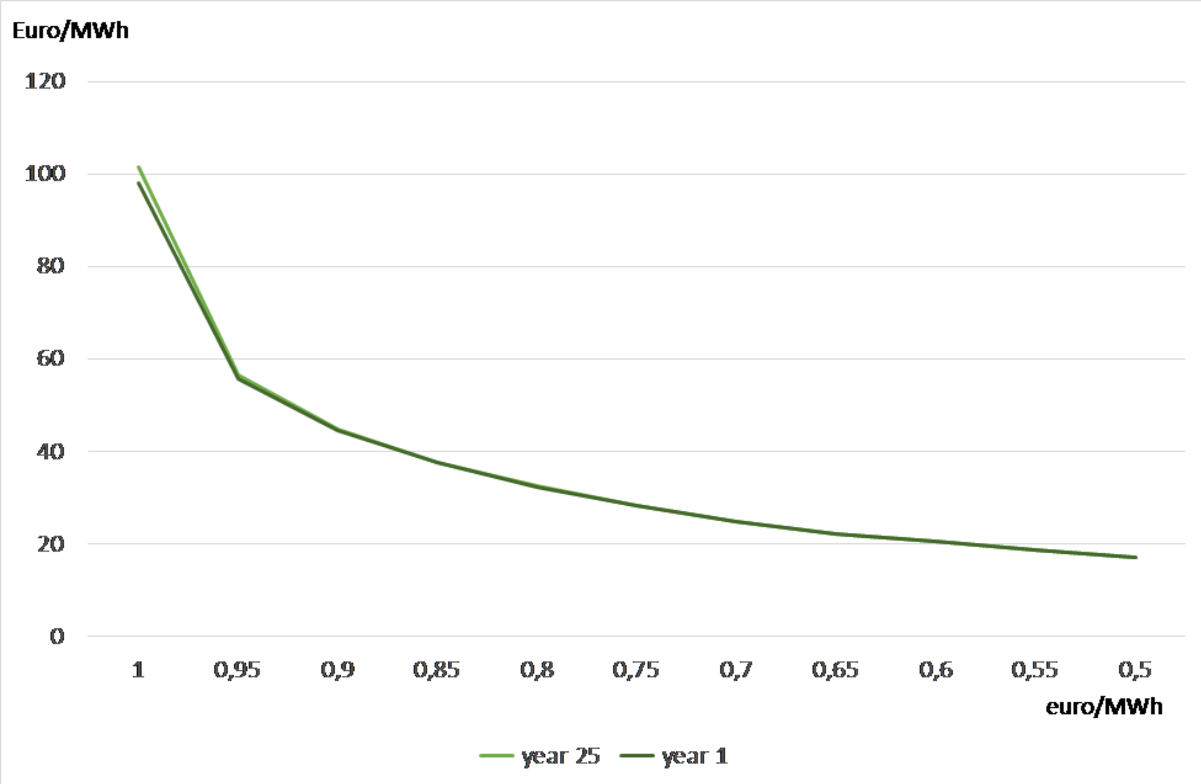


Figure 11 Effect of different levels of shares of investment costs covered by subsidies on the subsidy efficiency (= amount of subsidies per year during 20 years divided by the electricity production on that year)

Also the importance in the operational decisions is to be greatly dependent in the type of support.

The results of the model show that the long run sustainability and policy efficiency is higher with investment support than with feed-in premia. An additional advantage is that this type of policy does not interfere with electricity prices and gives operator the full responsibility to react on output and input price volatility. A disadvantage of the investment support is that it puts a higher burden on government budgets in the short run. Sometimes, it is politically easier to postpone coping with the cost of policies to next governing periods.

The European Commission have recently decided to redefine their ambitious targets and financial instruments in RE, due to the high pressure on the budgets and the overstimulation of some of the renewable energies. Certainly in some member states, the specific policy instruments have been one of the main drivers for the development of the biogas sector. Given the influence of the different support systems on operational decisions and pricing mechanisms it is likely that the new policy setting will affect the development of the biogas sector. A long term analysis on the role of biogas sector and its objectives in the context of Renewable energies is the key challenge for policy makers in order to redefine sustainable and efficient support mechanisms.

- Second and third study cases: the Belgian electricity market

The second and third study cases are set in the context of the belgian electricity market. Overall, the Belgian power sector currently finds itself in a state of uncertainty regarding the nuclear phase-out. Until now, the government's official position has been that the remaining four nuclear reactors will be shut down in 2022-2025 without license extension. However, seeing that a permit extension was granted for the oldest reactors in 2015 and taking into account the shortage of electricity supply, opinions are divided about whether or not the current permits should be extended, creating an uncertain investment climate.

In this context, the goal of these study cases was to analyze how, for the Belgian electricity market, uncertainty about nuclear phase-out, coupled with the implementation of renewable (RE) subsidies and nuclear taxes, affects investment capacity and productivity decisions by electricity suppliers. This analysis was conducted in detail for an oligopolistic imperfect market in our second case of study " Strategic investment decisions under the nuclear power debate in Belgium", and was extended to other type of perfect and imperfect market structure namely monopoly and perfect competition in our third study case.

First of all, in the context of an olipolistic market, a Nash-Cournot equilibrium model was developed that allows suppliers to take a strategic position to influence the market price and, then, the total electricity generation in the market. Four different scenarios were defined to analyze (i) the effect of implementing nuclear tax and RE subsidies, (ii) the effect of an increase in the probability of extending the nuclear license, or equivalently, an increase in uncertainty about nuclear phase out, and (iii) the effect of the interaction between both (i) and (ii) on additional investment capacity and productivity decisions, in particular, the annual quantity of full load hours for each technology.

An overview of the results for the different model scenarios assuming an oligopolistic market can be seen in Table VIII. They show that, in the framework of decarbonization of the energy sector, there should be continued support for renewable energy in the form of subsidies, as these help to secure supply and diversify the energy mix. Indeed, RE subsidies promote new investments in renewable technologies (e.g. see column 3 and compare model scenarios without and with subsidies) and a level playing field between suppliers, hence reducing Electrabel's dominance in the market and promoting innovation.

Table VIII Overview of results for the different model scenarios in case of an oligopolistic market (The probability scenario (s = 1) assumes the presence of nuclear production, while the scenario (s = 2) assumes the absence of nuclear production.)

Model scenarios	Probability of extending nuclear permits (γ)	Total additional investment capacity (in MW)	Total expected profit (in million €)	Probability scenario (s)	Total profit (in million €)	Total production (in GWh)	Electricity price (in €/MWh)
	γ= 1	1 033	2 053	s = 1	2 053	70 130	53
	γ= 0.9	1 074	1 767	s = 1	1 819	72 749	51

				s = 2	1 301	30 612	82
No subsidies and no taxes	γ= 0.5	1 968	1 371	s = 1	1 451	76 363	48
				s = 2	1 290	37 946	77
	γ= 0.1	2 352	1 091	s = 1	943	77 530	47
				s = 2	1 107	50 612	67
	γ= 0	2 387	1 037	s = 2	1 037	53 404	65
Subsidies and taxes	γ= 1	5 905	3 255	s = 1	3 255	78 491	47
	γ= 0.9	6 093	3 259	s = 1	3 221	78 889	46
				s = 2	3 598	46 256	71
	γ= 0.5	6 648	3 176	s = 1	2 882	82 187	44
				s = 2	3 469	53 588	65
	γ= 0.1	6 946	3 139	s = 1	2 464	85 953	41
				s = 2	3 214	61 511	59
	γ= 0	7 098	3 177	s = 2	3 177	62 411	59

Moreover, our analysis indicates that, regardless of subsidies, an increase in uncertainty about nuclear phase-out, or equivalently an increase on the probability of nuclear license extension **γ** (see column 2), results in lower levels of investment - primarily in renewable energy - (see column 3), lower levels of total production (see column 7) and a higher electricity price (see column 8). In absence of renewable subsidies and nuclear taxes, this increase in uncertainty leads to an increase in total expected profits (see column 4), due to the increase in profits of the dominant player in the market, Electrabel, while expected profits for the other players are reduced. However, we show that the implementation of renewable subsidies and nuclear taxes reduces the effect of the increase in uncertainty on total expansion capacity decisions, and slows the increase in profits of Electrabel and, then, of the overall expected profits, as we can see in Figure 12.

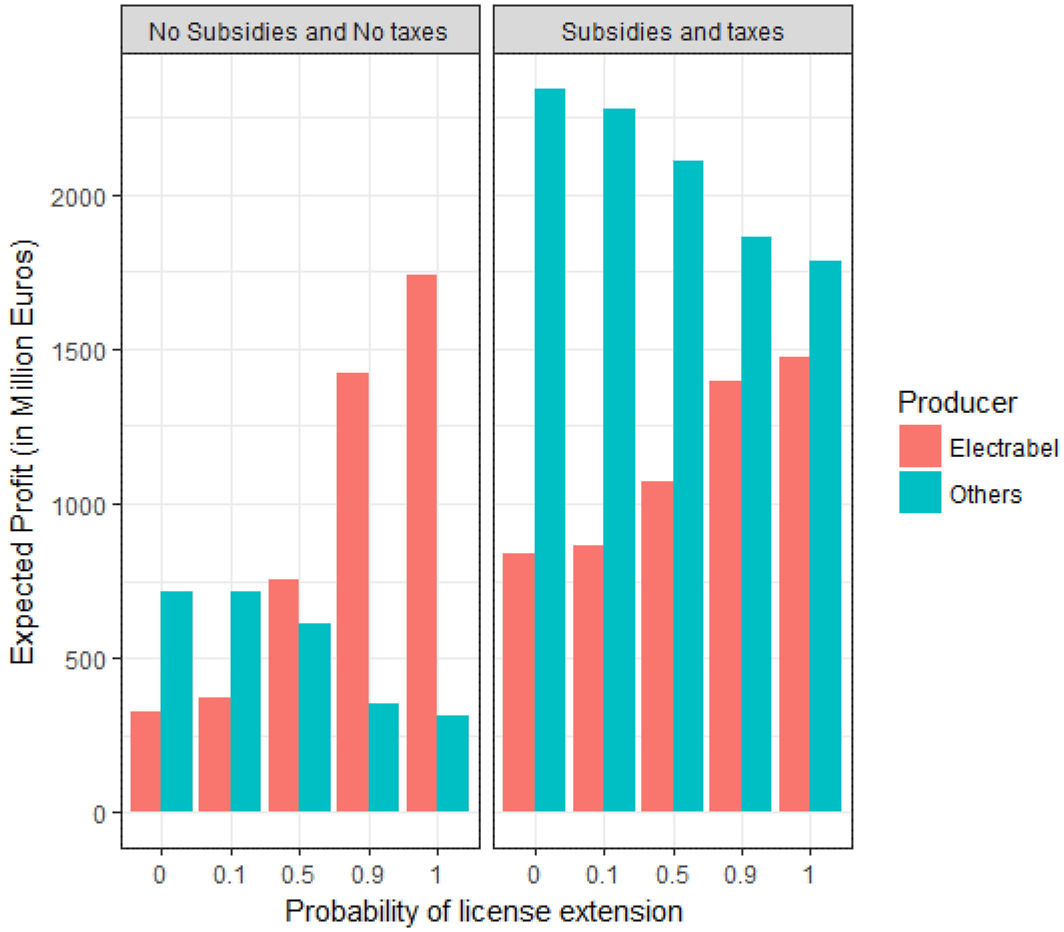


Figure 12 Expected profit of Electrabel and the sum of the other producers for different probabilities of nuclear license extension, in absence and presence of RE subsidies and nuclear taxes.

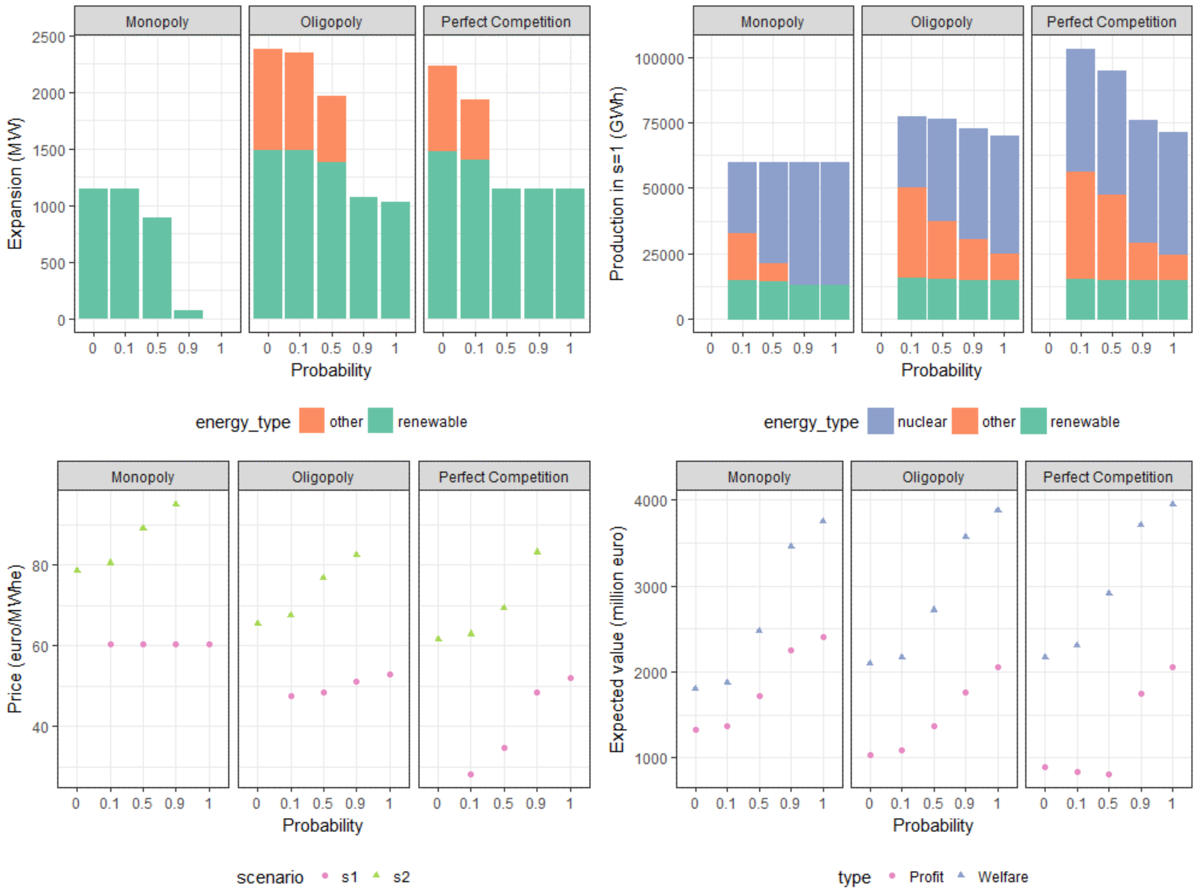


Figure 13 Result overview for the different degrees of market competition.

Next, Figure 13 provides an overview of the results for different market structures, and more specifically, the effect of the degree of market competition on expansion in capacity, electricity production, electricity price, expected producer profits and expected welfare. We showed that imperfect, oligopolistic markets offer more possibilities for increased expansion in renewable energy as compared to extreme perfect and imperfect monopolistic markets (see upper left corner). This is due to the effect of higher prices in oligopolistic markets as compared to perfectly competitive markets. In practice, this means that producers decide to produce less with CCGT installations because the profits on electricity generated with CCGT are sometimes too low. The higher price allows investment in technologies with a higher investment cost, such as wind and solar PV, and lower operational costs. Oligopolistic markets are, however, more influenced by an increase in the probability of nuclear license extension as compared to monopolies, and need to expand in non-renewable technologies (i.e. CCGT) in order to secure supply when a nuclear phase-out is highly likely.

The production and price results for the different types of markets (upper and lower right corner of Figure 13 respectively) are in line with the existing literature (Kalvelagen (2015)). The less perfect the market is (i.e. monopoly), the less production and the higher the prices will be. Moreover, we observe that the effect of an increase in the probability of license extension on total production is lower in less perfect markets.

If we now look at the expected welfare and producer profits (see lower right corner). The more perfect the market, the greater the welfare and the lower the profits will be, as is stated in the literature. Logically, the welfare is the highest in the case of perfect competition (socially optimal solution) and the lowest in the case of monopoly. However, we can also see that the inefficiency of imperfect market structures (monopoly and oligopoly), that is the difference in welfare between these market types and perfect competition, is the highest for a 0.5 probability of permit extension, or, equivalently, for a 0.5 probability of nuclear phase-out, that is, in an overall uncertain climate.

Finally, our studies derives relevant policy implications regarding the debate on nuclear energy. While the Belgian government currently seems committed to a nuclear phase-out, as is the case in many other European countries ((Aune et al. (2015)), most scientific reports recommend extending the nuclear license in order to reduce the current pressure on supply uncertainty, on the condition that the safety of the plants can be ensured (D' haeseleer et al. (2007); Febeliec (2017); Groep GEMIX (2009); International Energy Agency (2016)). In this study, we show that, in the absence of uncertainty about future nuclear energy production, i.e. when nuclear license extension or nuclear phase-out is guaranteed, the demand for electricity can be fulfilled by investing in renewable energy. In particular, in the case of permit extensions, results show that electricity prices will be around 18% lower, but there will be around 57% less investment in additional RE capacity as compared to the case of total absence of nuclear production. At any rate, these installations will be necessary in the future in order to fulfil demand. Therefore, extending the nuclear license would only postpone the problem of security of supply. A long-term energy strategy without uncertainty regarding nuclear phase-out and taking into account the future environmental benefits of RE technologies becomes necessary in order to ensure a stable investment climate.

There are possible extensions of our paper. First of all, we could improve our static model by using a multi-period dynamic model in order to analyze the effect of uncertainty about nuclear phase-out on the evolution of investment capacity decisions over time. Also, a more complex demand-price function could be considered in the modeling - for example a constant elasticity demand function. We make the implicit assumption that electricity demand is the same throughout the year. However, demand is usually higher at night time as compared to day time, and in winter as compared to summer. This can be incorporated in the model by splitting the year into different periods, and estimating different demand price functions for each of these periods. Moreover, we could also analyze the results for an endogenously determined probability as compared to a exogenously determined and fixed probability in the current model. Finally, we made the assumption that Belgian electricity supply equals Belgian demand. In reality, however, Belgium imports a net amount of electricity from abroad. In 2014, this net import amounted to 17 508 GWh from France, the Netherlands and Luxembourg (ENTSO-E (2016)). An alternative to increasing local generation capacity is to increase the transmission capacity from neighboring countries. In order to incorporate this aspect in our model, we could consider neighboring countries as additional players in the Belgian electricity market, which could strategically influence local suppliers' decisions.

General Conclusions and recommendations

The goal of this WP was to study the efficiency and sustainability of biomass based electricity production systems in Belgium, through different economic models and different study cases. In our first study case, we investigate the influence of the type of support on the type of technology and feedstock used. In particular, we analyze the effect of operational versus investment support as policy instruments for the development of biogas plants in Belgium. We conclude that operational support is more profitable than investment support in the short term but less efficient and sustainable in the long term. Moreover, investment supports promote bigger installations and the use of low-inputs energy contents as for example manure. This is particularly interesting in Flanders which is characterized by an excess of manure. As for operational supports, they encourage the development of smaller installations with high inputs-energy content feedstocks as for example energy maize. It is particularly important the use of maize as a feedstock because it can produce competition for food products. In our second study case, we investigate how uncertainty about a nuclear phase-out coupled with the implementation of renewable subsidies and nuclear tax affects new investment in renewable energy in Belgium. We conclude that, regardless of subsidies, an increase of uncertainty about nuclear phase out results in lower levels investments, particularly in renewables, lower production and a higher prices. We also show that the implementation of renewable subsidies and nuclear taxes reduces the 'uncertainty' effect on overall producer's decisions and total expected profits and promotes the diversification of renewable (RE) technologies, in particular biomass based technologies enter the electricity mix. Finally, in the third study case, we extend the work made previously by analysing how the level of competition in the market coupled with uncertainty about a nuclear phase-out influence investment capacity and production decisions. We show that although imperfect oligopolistic markets are less efficient (in terms of social welfare) than perfect competition markets, they offer slightly more possibilities for increased expansion in renewable energy as compared to extreme perfect and monopoly markets. They are, however, more influenced by an increase in the probability of nuclear license extension as compared to monopolies, and need to expand in non-renewable technologies as well in order to secure supply when a nuclear phase-out is highly likely.

General policy recommendations can be drawn from this WP. First of all, it's important to follow the trend of promoting Investment support rather than Operational support in order to ensure sustainability of biomass systems and in particular the biogas sector. Moreover, extra support would be needed if the goal is the use of sustainable inputs. Next, primate investors and citizens need a certainty environment regarding policy intervention and a long term vision in order to promote new investments. The role of the government is to promote a level playing field between technologies, that is an increase in support for renewables while decreasing support for non-renewables technologies and continue to work towards a worldwide CO2 tax. Finally, policy uncertainty can lead to changes in market structures due to an increase of investments for dominant firms. Policy implementation should then consider the specific characteristics of the market such as the degree of competition between stakeholders because significant differences on investment long-term planning are observed among the different market structure.

WP5 Transport: how to shift to a more sustainable fuel mix

With the collected data we have estimated following fixed effect panel regression using ordinary least squares:

$$\mathit{Plugin\_electric\_vehicles\_sales}_{it} = \boldsymbol{Countrydummy}_i + \boldsymbol{Yeardummy}_t + \boldsymbol{\beta}\,\mathit{Conventional\ chargers}_{it} + \boldsymbol{\beta}\,\mathit{High\text{-}Power\ chargers}_{it} + \boldsymbol{\beta}\,\mathit{trend}_i + \boldsymbol{\varepsilon}_t$$

The results of the estimated parameters of the model are shown in the table below.

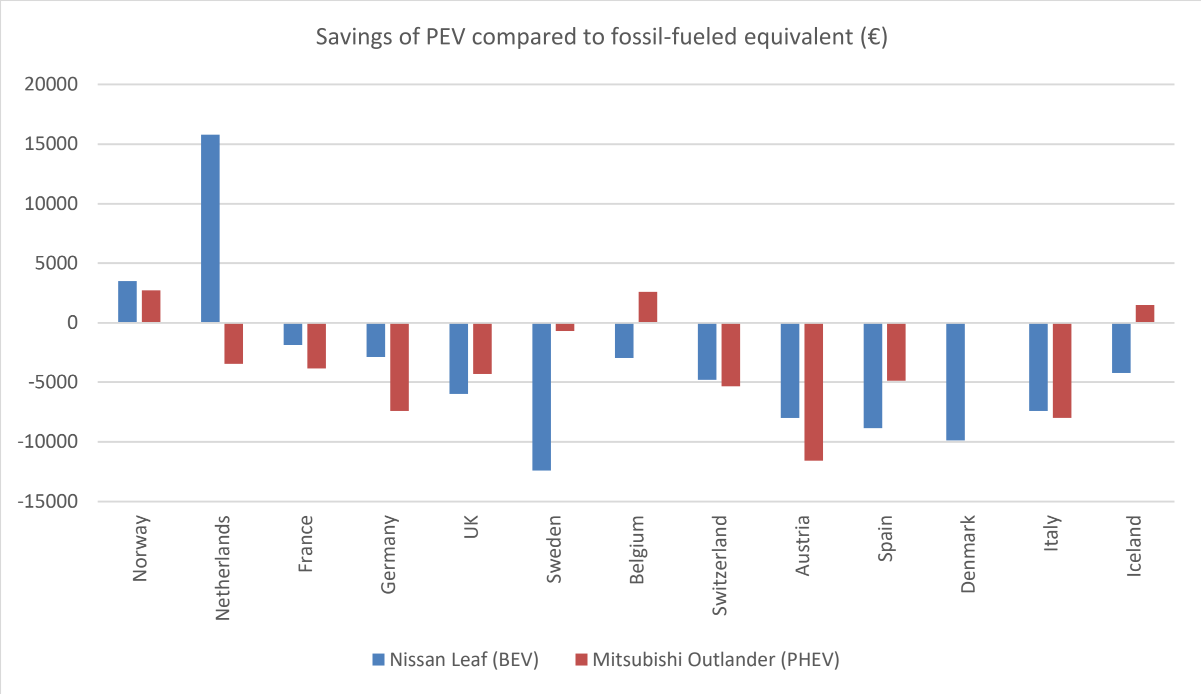
Variable	Estimate	Std. Error	t-value	p-value
β (conventional chargers)	0.581	0.240	2.420	0.018*
β (High-Power chargers)	13.687	2.369	5.778	1.123e-07***
β (trend)	478.848	344.064	1.392	0.168
R^2	0.66			

These results show that the presence of charging infrastructure has a positive and significant impact on the sales of electric vehicles in the studies European countries. For every high power charger the sales of electric vehicles increases on average with 14 while it is less than one car per year for a conventional charging station. Both variables are significant, the high power charging stations with a p-value of less than 0.001 and the conventional less than 0.05.

Assuming an additional investment cost of a high power charging station compared to a conventional one and counting a payback period of ten year, the investment in high power charging stations would result in 130 additional bought electric vehicles over a period of 10 years. The public policy cost to generate sales of additional electric vehicles is lower than the tax incentives used in the countries that have a significant amount of sales: Norway and The Netherlands.

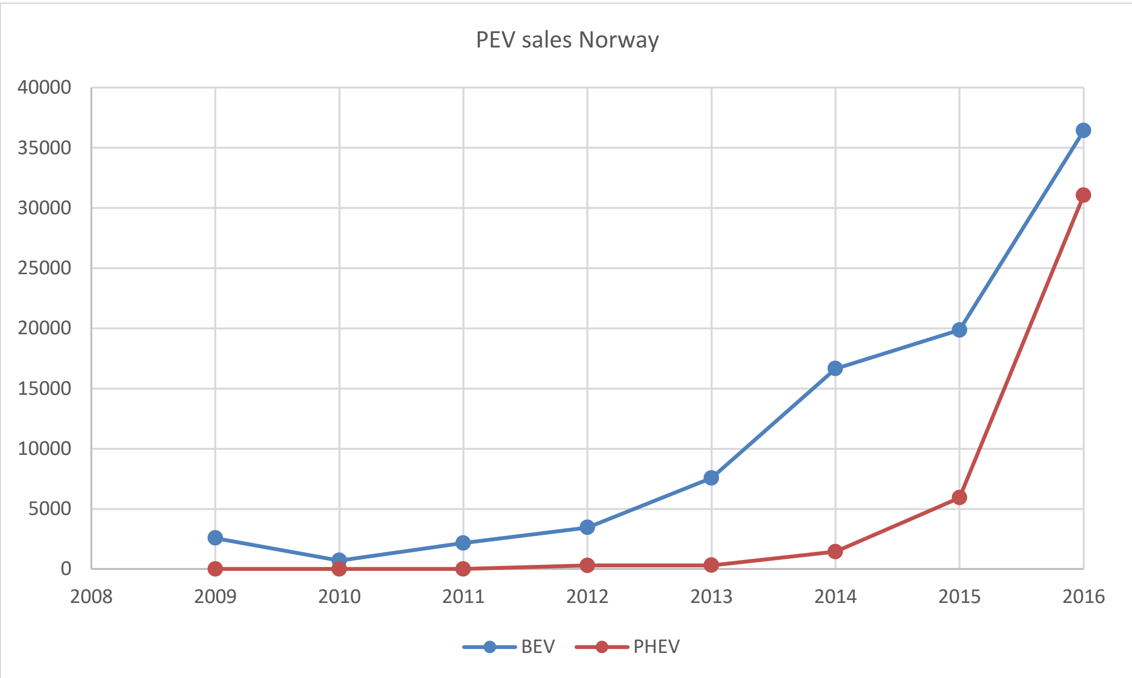
A second element of the research is to investigate more in detail the total cost of ownership because the PEV are usually more expensive than fossil-fueled alternatives. The total cost of ownership can be lowered by purchase subsidies and tax benefits. We have made the analysis of two types of cars with an electric and an internal combustion engine equivalent: Nissan Leaf (BEV) versus Nissan Pulsar DCI (Diesel) and Mitsubishi Outlander Hybrid (PHEV) versus Mitsubishi Outlander 2.2 DID 4WD (Diesel). The net saving of using the vehicles are driven by differences in purchase price (including subsidies), 4 years ownership tax savings, Fuel cost savings assuming total mileage of 80000 km.

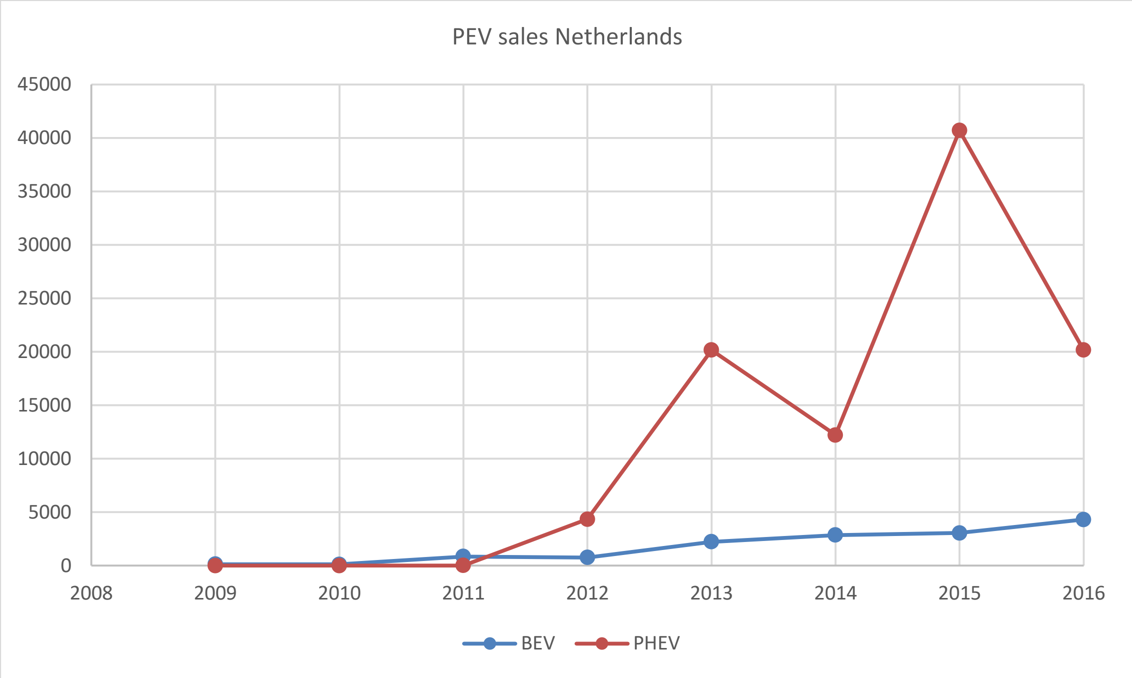
The results are shown in the figure below.



The figure clearly shows that in only two countries, Norway and The Netherlands, the net saving in total cost of ownership of battery electric vehicles is positive.

The evolution of the sales of these countries is investigated more in detail in the two following figures. The most remarkable difference between The Netherlands and Norway is the evolution of the PHEV sales in 2015. In Norway, the PHEV sales increase with a sixfold in 2015 compared to 2014 while in The Netherlands the PHEV sales reduces the same year with 50%. These opposite evolutions can be explained by the fact that PHEV have been excluded from the support measures in 2015 in The Netherland and not in Norway. The clearly illustrates that support measures can have a big impact on the relative sales changes in a country.





WP6 Green Public Procurement: the government as sustainable consumer

Non-inclusive policies towards wood producers

At present, both eco-certification and FLEGT-licensing are not inclusive towards producers in the Southern hemisphere. In the context of eco-certification, the southern hemisphere only accounts for 13% of the globally certified forest area. In the context of FLEGT, only six wood-producing countries have managed to conclude a VPA with the EU. At present, only one of these six countries – Indonesia – has managed to issue FLEGT-licenses. Hence, neither GPP, nor FLEGT, is fully inclusive towards all regions' producers. Consequently, neither of the policies increases the uptake of the sustainability or legality standards in forest management and wood production in the South.

Paper 1 and 2 describe how the EU-wide implementation of, respectively, GPP and FLEGT does not promote the uptake of, respectively, certification and legality criteria in each region's wood market. In the GPP scenario, certified production manages an increase at global level. However, certified production decreases in North America and Africa. In the FLEGT scenario, certified production decreases at global level, and notably in North America and the EU. In addition, neither policy succeeds in increasing the share of certified production in the South above 5% of the SEM's global certified production. In particular situations conventional wood production is even stimulated. This is observed in the volume of conventional wood produced in the SEMs in Paper 1 and 2.

The interaction between transport costs and the compliance costs for eco-certification, or legality criteria are held responsible for these observations. The transport costs separate the different regions' wood markets. This reduces competition between the different regions' producers. In addition, the high compliance costs in the South explain the limited importance of the South in global certified wood production. These high costs are insufficiently compensated by a price premium. The explanation for the insufficient price premium is based on the assumption of perfect competition. The use of this approach is justified by other authors who state that without tangible benefits, the uptake of certification will remain limited. Note that in the case of FLEGT, not only do the high compliance costs impede trade, but also the non-operative FLEGT-licensing system neglects access to the EU's wood market.

Comparison of both policies demonstrates that GPP provides a better stimulus for sustainable wood production. GPP is more positive in nature as it tends to activate a latent demand for wood products. This still allows each region to specialize in the wood type for which they have a comparative advantage. In contrast, FLEGT is more negative in nature, as it restricts trade in conventional wood. In this case, comparative advantages do not determine the production choices.

Non-inclusive policy towards wood consumers

GPP aims to increase the consumption of sustainable wood. The findings in Paper 1 demonstrate that GPP can indeed stimulate private consumption of certified wood, both in Europe and in other regions. Private consumption of certified wood, however, decreases in Asia and North America. Paper 2 indicates that FLEGT has a more negative impact on private consumption of certified (legal) wood compared to GPP. Private consumption of certified wood decreases in all regions, except Latin America, due to FLEGT requirements for legality.

The findings in Paper 3 provide also useful insights in this respect. In general, private consumers indicate support for GPP. However, this support significantly decreases when GPP entails negative consequences (i.e. increased price, crowding-out of private consumption). Hence, the reductions in private consumption, as observed in the SEMs in Paper 1 and 2, are likely to provoke some resistance.

Interaction between non-governmental and governmental initiatives

Eco-certification is defined as a transnational, non-governmental approach to environmental regulation and development. Although non-governmental in nature, Paper 1 and 2 describe the strong interlinkages between eco-certification and government policies (notably GPP and FLEGT).

GPP for wood relies on eco-certification for a number of reasons. The main reason is the issue of limited availability of universal environmental criteria for products/services (European Commission 2016). In addition, the use of certification can make public procurement decisions more consistent. Finally, governments are increasingly interested in socially responsive forestry administration, next to transparency in trade. Eco-certification complies with these concerns. Besides GPP, FLEGT also interacts with eco-certification. FLEGT acknowledges the full compliance of the two main eco-certification schemes – FSC and PEFC – with the EUTR requirements.

Hence, some government policies rely on eco-certification, but their interest in eco-certification can also push the certification schemes to improve their standards. The latter is explained in Paper 5 and confirmed by Gulbrandsen (2014), who noticed that 'several certification schemes are developing legality assurance standards in response to the EU FLEGT and Timber Regulation, as well as member-state procurement policies'. Hence, government policies and non-governmental eco-certification mutually reinforce each other. In addition, Paper 1 and 2 describe how the approval of eco-certification schemes by government policies can enhance the rulemaking authority and signal the credibility of the schemes to procurers and buyers. This could provide an important contribution to the uptake of private consumption of eco-certified wood, since a lack of trust prevents this uptake.

Welfare and economic implication GPP

Applying GPP increases global welfare in Paper 1's SEM. If governments opt for the lowest bid, they cannot tap into all potential quasi-welfare. However, applying GPP allows them to take other dimensions of (e.g. environmental) quality into account and purchase eco-certified wood at a price premium. Paying the price premium taps into previously unused quasi-welfare.

However, increased global welfare is not a Pareto efficient improvement. Whether or not an individual region increases its quasi-welfare due to GPP in Europe mainly depends on the evolution of its consumer surplus. Europe, Africa, and Latin America managed to increase their consumer surplus and regional quasi-welfare, mainly due to increased certified purchases. However, quasi-welfare decreased in North America and Asia.

Welfare and economic implication legality verification

In contrast to GPP, the implementation of FLEGT reduces global welfare. Again, some regions manage to increase their individual quasi-welfare (Europe, Africa) while some regions experience a decrease in individual quasi-welfare (North America, Latin America, Asia). More apparent is the observation that the consumer surplus decreased in each single region. In contrast, the producer surplus increased in each region, except North America.

This is due to the restrictive nature of the legality requirements in FLEGT. These requirements prevent conventional wood trade to Europe. This further separates the regional wood markets, which allows most regions' producers to increase their prices. As such, FLEGT has elements in common with protectionist trade policies. Protectionism generally tends to reduce global welfare. Note that, in the latter situation, a region's comparative advantage is no longer indicative of production decisions.

Private consumers' position on GPP

Paper 3 analyses private consumers' intentions to buy eco-certified wood in combination with their support for GPP. In relation to the intention to buy, Paper 3 confirms the significance of environmental concern, subjective norm, and attitude towards eco-certified purchases as drivers for eco-certified wood consumption. However, contrary to expectations, perceived consumer effectiveness does not impact on intention to buy eco-certified wood. This is explained by the low frequency of wood purchases which reduces the perceived consumer effectiveness of wood compared to the perceived consumer effectiveness of products and services that are purchased more regularly.

Private consumers, in general, support government purchases of eco-certified wood. Their level of support is positively correlated to attitude towards eco-certified purchases and environmental concern. However, the level of support significantly decreases when GPP entails negative consequences (i.e. increased prices, crowding-out of private consumption). This decrease in support for GPP is significantly and positively correlated to environmental concern.

Environmental concern (measured as the score on the NEP) is traditionally labelled as an altruistic driver for sustainable consumption. This chapter's analysis demonstrates that the score on the NEP also captures an element of self-interest. This self-interest is explained by the high level of involvement of the private consumers.

Policy recommendation targeted at sustainable wood production

The economic approach applied by this thesis implies that producers will only switch to certified, or FLEGT-licensed, wood production once the compliance costs are compensated by a price premium. The validity of this approach is confirmed by numerous authors and fellow researchers. Since the uptake of eco-certification and FLEGT-licensed production in the Southern hemisphere remains marginal, this suggests that inclusive policies should also aim to reduce compliance costs. Numerous policies that aim to reduce compliance costs are listed throughout this thesis.

At individual producer level, a cost reduction can be effected by improving: the legislative framework in support of certification, weak land tenure rights, the distance and convenience of transporting wood, the bureaucratic requirements for eco-certification and legality assurance, and the available financial means (Paper 1 and 2). Addressing these issues requires a comprehensive strategy in which certification or FLEGT licensing plays a complementary role to sustainable forest management. This type of strategy requires a phased approach. An important part of this comprehensive approach should focus on the simplification of the criteria and indicators. This would allow less costly monitoring and auditing systems.

Instead of focusing at the individual producer level, cooperative initiatives can address the same issues for four reasons. First, cooperative initiatives can reduce the direct costs of certification by distributing these costs over a higher number of producers. This could be especially beneficial for the small-scale producers in the Southern hemisphere. At present, the South's large-scale forest enterprises, rather than small-scale concession holders, particularly benefit from export opportunities to the North. Second, the demand for eco-certified wood is mainly driven by retail, which demands large volumes, consistent quality, and low prices (Paper 1). Cooperative initiatives better allow these requirements to be met. Third, a high level of vertical integration along the production chain reduces certification costs (Paper 2). In addition, cooperative initiatives might reverse the trend of power concentration in the large concession groupings. That international forest policies such as FLEGT (and its VPAs) may cause further expansion of this power concentration and lead to fragmentation of smaller forestry enterprises in the Congo Basin. Fourth, giving voice to the small and medium forest enterprises reinforces the integrity of the proposed legality assurance system (and eco-certification) and allows those enterprises to reap benefits from the schemes' implementation.

Numerous authors have investigated obstacles for cooperatives, both in the context of eco-certification and FLEGT-licensing. Future policies should avoid these pitfalls. The main obstacles are potential conflicts between centralized forestland ownership and decentralized forest tenure, identification of plantation or natural forest, monitoring of potential effects of forest management, decreases in cost efficiency, weak legitimation, and identification and conservation of high conservation value forests.

Policy recommendation targeted at sustainable wood consumption

In addition to addressing the compliance costs, policies can stimulate demand and WTP for sustainable wood. The lack of demand for certified wood in the South is a considerable constraint for certified production, and hard to address given the positive correlation between the WTP and income (Paper 1). However, the WTP by consumers in the North also insufficiently compensates the compliance costs. Paper 3 identifies three drivers for a (European, Belgian) private consumer's intention to buy eco-certified wood: environmental concern, subjective norm, and attitude towards eco-certified purchases. A government can try to increase environmental concern, by, for example, improving knowledge of environmental issues and trust in eco-certification and FLEGT-licensing. Note that Paper 3 also stresses the importance of trust in eco-certification schemes for the intention to buy eco-certified wood.

Finally, Paper 3 identifies different segments of private consumers. These insights can be used to develop specific communication strategies for the distinct segments in order to encourage the consumption of sustainable wood (e.g. focus on knowledge transfer to the least interested segment, and focus on attitude towards eco-certified consumption for the more interested segments).

Policy recommendation on GPP

The EU set an indicative target that, by 2010, 50% of all public tendering should be green (Paper 1). However, the uptake of GPP has been estimated once in 2011, and is not systematically monitored. Better monitoring would allow a trustworthy assessment of the importance of GPP across the EU. The European Commission stresses the importance of trustworthy monitoring of GPP because this allows the improvement of GPP activities. Standard points of attention are the training of staff, development of practical tools and information, a more systematic implementation and integration of GPP into management systems and cooperation between authorities to foster the uptake of GPP.

Ideally, GPP enjoys ample support by private consumers. Paper 3 described how this support tends to decrease when GPP entails negative consequences. The policy recommendations on the uptake of eco-certification can avoid the emergence of these negative consequences. The issue of building trust in eco-certification and FLEGT-licensing among private consumers, as described above, is crucial in reversing this negative trend.

In addition, the results of this WP have been discussed with numerous stakeholders. This stakeholder consultation did not solely confirm this research's approach. In addition, the stakeholder consultation identifies some flaws in current GPP implementation, points for attention and points for improvement.

Points for improvement:

- Guidelines and initiatives at high level are clear, implementable, and continuously being improved. Nevertheless, the implementation of the policy at local level remains inadequate. The governments' purchasing staff lacks **technical knowledge** (e.g. if a wood species is not available eco-certified, the purchaser must not opt for conventional wood of that particular wood species but can instead switch to eco-certified wood of another comparable species). This flexibility would provide a stimulus for eco-certification. An overview of alternative wood types for non-certified wood types would provide additional support for the procurers. This would also require a sense of flexibility in the mind-set of all parties involved (e.g. architects). Hence also these (externally) involved parties need to be persuaded of the need to switch to eco-certification. If the flexibility to switch between different wood types is not allowed, it is also possible to ensure that the desired wood type is available with an eco-certificate.

This has happened in the Netherlands. In Belgium, the demand for a parallel policy aimed at assisting wood operators and producers towards eco-certification is occasionally raised but at present not an issue. (This also links to '3.4. Vulnerable regions')

- Nobody can enforce the application of GPP guidelines at local level. There is a solid policy at national level, but it is rarely translated to local level governments. This requires a **pro-active attitude** which probably relates to the purchaser's **motivation** to purchase eco-certified instead of conventional wood. For this reason, the product sheets for procurers should be dispered more efficiently as well.

An obvious recommendation would be to oblige the uptake of the eco-certification criterion for all government purchases. However, this is hard to achieve as not all type of wood products are continuously available with an eco-certificate. Hence, this again stresses the importance of motivation and technical knowledges of the individual procurers.

- The legal framework for GPP of eco-certified wood is improving, and in addition also social clauses are increasingly added to tenders. However, the **conservative clauses (e.g. price)** remain present and important. GPP comes with a cost, but an important lobby in favour of the price criteria remains present in order to safeguard the interest of public finance. Nevertheless, higher prices should be paid for more environmentally-friendly products. This is also acknowledged in the GPP toolkit which provides product group information for the procurers.
- Eco-certification's standards and legislation can **mutually reinforce each other**. Nevertheless, governments' representatives have never been present during the multi-stakeholder process which leads to the final eco-certification standards.
- **Heterogeneity in GPP implementation** across different regions and countries. The heterogeneity makes it difficult for the industry to comply to all stipulations and participate on different markets. This advocates for a top-down approach at EU-level. **One important example in this respect concerns the presence of two eco-certificates.** Although the national government lists all recognised eco-labels, nobody can ensure that a local government will indeed allow all listed eco-labels. In Ghent for example, FSC was for a long time the only allowed option while PEFC was not considered as an option. This is problematic for wood suppliers if they are for example solely PEFC eco-certified. In this case they would not be eligible for this call.

Point of attention

- In Belgium, it is recommended that tenders request wood which has an eco-certificate by "FSC, PEFC, **or equivalent**". The "or equivalent" is necessary in order to comply with stipulations guaranteeing fair competition. In Legal terms, the "or equivalent" is correct and sufficient. However, it has not been clarified what "or equivalent" exactly stands for, and how this can be checked. Hence, a problem arises once an eco-certification scheme indeed claims it is equivalent. No procedures are available to deal with this kind of situations The Institute for Sustainable Development is aware of this unclear situation.

- The **different regions' stipulations and criteria** for GPP can differ. E.g. the Flemish product sheets are more technical in nature, more tailor-made for the procurer. The Flemish rationale is to reduce the conflict between FSC and PEFC. Current Flemish minister Schauvliege acknowledged the sustainable nature of both eco-certification schemes (albeit some differences). The Walloon criteria emphasize the societal aspects more. This makes it more complicated for wood producers and operators to comply to the criteria of each regional (and local) government.
- The uptake of **GPP is not monitored** (nor the prices paid, nor the purchased sustainable volumes). A vast volume is purchased by local governments. Therefore the monitoring is crucial as it would allow to identify shortcomings in the implementation of the policy. Both the EU and Belgium have set ambitious targets for GPP. Flanders is developing a monitoring system at present which would require over 70 entities to register their data in one central system.At present, there is a pilot project running which scans for 'sustainability' in public procurement documents in addition to queries for 'FSC' and 'PEFC' (for example). The local level's practices remain crucial for the success of GPP.

The lack of monitoring also prevents an analysis of the cost price of GPP. It is assume that governments are not paying a higher price for eco-certified coniferous wood, but higher prices are paid for eco-certified tropical wood. In addition to higher prices for the products, the cost of GPP also includes the administrative costs related to GPP (as it creates additional administrative burden through for example the implementation and application of product sheets). The administrative cost will be less important (less restrictive) when larger quantities are purchased by a government.

Policy recommendations on trade barrier

Both Paper 1 and 2 introduce transport costs in the modified SEM. The transport costs consist of per unit shipment costs and an ad-valorem tariff. Both chapters' analyses demonstrate how the transport costs further separate the different regions' wood markets. This leads to a non-optimal solution for the SEMs in terms of global welfare maximization. Lower ad-valorem tariffs allow an increase in global welfare.

WP7 Integration

Results of this WP can be summarized in the following points:

- The classification of the different types of policy instruments that were tested in the framework of the ALPI project, on the basis of different socio-economic criteria
- The summary of the lessons learnt and the general policy recommendation derived from the project results
- A discussion about how to tackle policy recommendations from a legal point of view

First of all, we classify the different types of policy instruments that were tested in the framework of the ALPI project, on the basis of different socio-economic criteria. In particular, we follow the main classification that is described in the literature, which takes into account the specific goal of the policy instruments, that is, if they directly or indirectly promote renewable investments and energy production.

Next, we classify them according to their target group in the society. Thanks to this classification, we observe that geothermal (WP3) and biomass electricity (WP4) cases mainly focus on different direct incentives for private firms and public bodies, while buildings (WP2) and electric cars (WP5) analyze efficiency or effectiveness of direct fiscal and financial incentives targeted for private consumers. Indirect incentives are studied in the WP4 and WP5, when studying different models to finance renewable electricity production and respectively, the shift to the use of more sustainable cars, and in a deeper way in the WP6 (Green Public procurement). Even if they are mostly designed for private firms as in WP4, this project also considers novel policy designs for public entities (governments, cities) as in WP5 and 6.

Next, after analyzing and classifying the different policy instruments that were studied, we made a summary of the lessons learnt from the comparison on efficiency and/or effectiveness of policy instruments tested per case of study. Common lessons can be drawn from these specific conclusions. First of all, results of all study cases, in particular WP2, 3 and 4, reveal the **importance of investment support in front of operational support**. In most of the cases, operational supports are more profitable or more economically effective in the short term but investment supports are more efficient, in terms of success rate, sustainability and diversification of low carbon technologies in the long term. Next, the **lack of private consumers awareness of information** about possible energy savings is showed as an important cause of unsuccess policy measures in WP2 and WP6. For example, in WP2 dwellers are aware about energy renovation measures but more information is still required about technical knowledge aspects concerning optimal energy private consumption. Finally, the concern about **policy uncertainty** is identified **as a major obstacle** in the investment in renewable technologies and supply energy security.

Results about lessons learnt and policy recommendations described per WP allowed us to draw common policy recommendations that could be useful for the development and sustainability of low carbon emission technologies and for the overall economy. Main recommendations can be summarized around the following points:

1- Investment support vs. operational support

Operational support given in the form of feed in tariffs for renewable electricity or heat certificates for combined heat and power generation are less efficient in dealing with the capital needs that are required for the investments in low carbon emission technologies. In addition, operational support can have an impact on the way technologies are implemented and therefore negatively influence the sustainability of it.

2- Public information from public money

Currently, in the European Union, there is a trend towards open access to research that is publicly funded. Investing in new technologies such as geothermal energy (WP3) can also be considered to be applied research. The same argumentation of having open access to the results should therefore also apply here.

The benefits of this recommendation are quite evident in the sense that providing more information involves providing more data, which would stimulate a more transparent and thus more efficient market for geothermal energy.

This idea is also observed in WP4 in the electricity market where a monopoly market structure leads to lower amounts of investment in new technologies.

3- Awareness about information

Both in the case of sustainable wood consumption (WP6) and deep energy renovation of houses (WP2) a lack of knowledge and awareness is observed amongst citizen.

Even though information campaigns have been done, it seems that even more information is needed concerning technical other monetary saving.

4- Loans rather than subsidies

In the case of energy renovation (WP2), it is observed that subsidies provide only a small incentive to people to start an renovation.

Lack of capital is, however, a major obstacle for less resourceful people. Loans are therefore a more efficient policy instrument to give incentives to people to renovate their houses.

5- Certainty : contractualisation

Policy uncertainty is a major obstacle in the investment in renewable technologies. The profitability of projects often depend on the existing policy framework that can completely be changed by new elections or a new government.

Private investors would benefit from having more certainty on a longer term which is sometimes not guaranteed by a framework arranged by intermittent laws. As an example, the work realized in WP4 shows how uncertainty about a nuclear phase-out has a negative impact on new investments in clean energy technologies in Belgium. A contractual arrangement could provide a better legal setting for certainty to private investors.

How to tackle these issues from a legal point of view?

1- Investment support vs. operational support

Currently, both operational and investment supports have been implemented to promote renewable energy. It would be possible to increase the level of investment support on the one hand and to decrease operational support on the other hand.

Increasing investment support could imply an augmentation of the level of support of existing instruments or the adoption of new instruments. When implementing these measures, public authorities must respect several substantial obligations including the principle of equality and non-discrimination (art. 10 and 11 of the Constitution), freedom of movement and the prohibition of State aids (art. 107 and f. TFEU). From an institutional point of view, the Regions could implement subsidies, market-based mechanism and loans on the basis of their material competence in “new sources of energy”. Tax incentives could also be introduced but they could concern regional taxes, such as property tax, registration fees, gift and inheritance taxes (art. 3 SLF), which are not particularly adapted in this matter but also personal income taxes (art. 5/5, §2 and 3 SLF).

As to operational support, the main instrument is the green certificates mechanism. To decrease this support scheme, a transition period should be set up, considering principles of trust and of legal certainty, and to a certain extent the right of property (1st additional protocol to the ECHR). These principles are conditional upon proportionality. In this regard, modification of existing support shall imply a transition period for existing beneficiaries.

2- Public information from public money

Although open access can raise several legal questions, they surpass the field of expertise of the Tax Institute Ulg and will require further research.

3- Awareness about information

Prima facie, it seems that there is no legal issue on this matter.

4- Loans rather than subsidies

Such as subsidies, loan schemes can be implemented in the exercise of material competences. Therefore, the Region could introduce loans, instead of using subsidies, on the basis of their competences in “new sources of energy” and “energy efficiency”. As mentioned as to investment support, one should have regard to the principles of trust and legal certainty, the principle of equality and non-discrimination (art. 10 and 11 of the Constitution), freedom of movement and the prohibition of State aids (art. 107 and f. TFEU). From a budgetary point of view, important differences can emerge and loans could be more advantageous in this regard. European System of Accounts does not record loans and subsidies on the same way. This situation may have a direct influence on the choice of public authorities.

5- Certainty : contractualisation

Use of contracts by the administration is a tricky question from a legal point of view. Contracts, on the contrary of unilateral acts of the administration, imply rights and obligations for each party. In addition, they are harder to modify or to revoke as they are based on consent. In this sense, they bring greater level of certainty than unilateral acts of the administration and legislative acts. Therefore, these could be used to prevent budget arbitration to negate promises that have been made. However, it must be noted that there is an increased tendency of the judge to appreciate the principles of trust and legal certainty as well as the right to property (additional protocol to the ECHR) in favor of the administered. The principle is that administration can enter into contract. Certain fields are generally excluded from such a possibility. These include taxes, subventions and police. However, the issue is still subject to debate and opinions vary within the doctrine and the jurisprudence. For instance the Council of State constantly considers subvention unilateral and add that all essential elements of a convention must be set in a law. On the contrary, the Court of Appeal of Brussels has considered a convention that granted subsidy a real convention, which would supersede the unilateral decision of granting subsidy.

5. DISSEMINATION AND VALORISATION

In this section, we firstly describe the work of dissemination and valorisation made by each independent WP. Next, we focus on the organization and development of the final conference of the project.

WP1 Exploration

Results were disseminated at the occasion of the participation to several international and national conferences:

- 17th Global Conference on Environmental Taxation (GCET): Two presentations were prepared and presented in collaboration with partners of working packages 3 and 4. The first one concerned « Policy combinations to navigate between private and public monopolies in emerging technological sectors ». In this context, the Tax Institute gave an overview of the existing financial instruments supporting the development of geothermal energy and presented some legal issues with respect to public access to information of geothermal projects. The second one was about the « impact of interacting energy policies on power generation in Belgium ». The Tax institute presented the existing financial instruments promoting renewable energy and taxing nuclear power generation in Belgium.
- The Classes of Excellence of the Francqui Chair, 2017: Presentation on « sustainable transport through taxation » to the Director of the Max Planck, Department tax law and public finance (W. Schön), and to academics, whom field of expertise is tax law.
- 21st EMAN conference on Sustainability Accounting and Control for Smart Cities : Presentation on transport and taxation in the context of the Smart Cities.
- Conference of the assistants (ACCA)

These presentations have PowerPoint support and some of them text attached.

Oral presentations in Conferences

- Maes, D., Petticlerc, E., Vanrykel, F., Defoy, X., Bourgeois, M., Peeters, B., « Policy combinations to navigate between private and public monopolies in emerging technological sectors », 17th Global Conference on Environmental Taxation (GCET), 2016, Groningen, Pays- Bas.
- De Frutos Cachorro, J., Willeghems, G., Vanrykel, F., Defoy, X., Bourgeois, , M., Buysse, J., « Impact of interacting energy policies on power generation in Belgium », 17th Global Conference on Environmental Taxation (GCET), 2016, Groningen, Pays-Bas.

- Vanrykel, F., « Sustainable Transport through Taxation. Analysis of Road Passenger Transport: Constraints, Limits and Prospects », Classes of Excellence of the Francqui Chair, 2017, Liège, Belgique.
- Vanrykel, F., « Transport and Energy Taxation: Legal Prospects on the Transition towards Sustainable Road Passenger Mobility in Belgium », 21st EMAN conference on Sustainability Accounting and Control for Smart Cities, 2017, Liège, Belgique.
- Vanrykel, F., « Environmental Protection and Tax Law: Belgian approach to the development of renewable energy and sustainable transport », Conférence des Assistants (ACCA), 2017, Liège, Belgique.

As previously noted, part of the work consisted of support activities and, as such, was not subject to dissemination and valorisation.

In addition, several articles will be sent soon for publication.

Finally, it must be noted that the main researcher of the Tax Institute on the ALPI project (Fanny Vanrykel) obtained a first ranking from the FRNS for her PhD project on « Sustainable Transport through Taxation. Analysis of Road Passenger Transport: Constraints, Limits and Prospects », which will be the continuation of the working package 5. Moreover, thanks to the expertise gained from his work on the ALPI project, Pr. Marc Bourgeois was designated for a public procurement of the Walloon Region on the reform of the annual circulation tax and of the car registration tax and was appointed expert by the Region of Brussels-capital in the context of reform of above-mentioned taxes.

WP2 Energy efficiency in residential buildings

In this WP several stakeholders from governmental institutions or strongly linked to policy making have been involved through the stakeholder consultation: VEA, IBGE-BIM, CEDER, BBRI, Infrax.

Results from our work in WP2 also have been integrated in a recently finished study for VEA on motivations and barriers for energy renovation:

- Griet Verbeeck, Kathleine Housmans, Victoria Taranu (2017) Motivatoren voor bewoners om over te gaan tot diepgaande renovatie. Eindrapport juni 2017 (will come publicly available soon).

Next, with respect to dissemination, the parts of our work have been presented in international conferences:

- Taranu V., Verbeeck G. 2015. Nudging and domestic energy use. Its potential for the EPC. Irish Economics and Psychology Annual Workshop, November 27 2015, Dublin. (oral presentation)
- Taranu V., Verbeeck G., (2016), Overview of dual process behavioural models and their implications on decision making of private dwellers regarding deep energy renovation. CIB World Building Congress 2016, May 30-June 3, Tampere, Finland. (oral presentation)

- Taranu V., Verbeeck G. (2016) Qualitative analysis of energy performance certificates across EU countries under the lenses of behavioural insights. BEHAVE 2016. 4th European Conference on Behaviour and Energy Efficiency, Coimbra, Portugal, 8-9 September. (oral presentation)
- Taranu V., Lizin S., Verbeeck G. (2017) Are dwellers deliberative or heuristic in their decisions to invest in energy efficient renovation measures? ECEEE Summer Study Proceedings, Consumption, Efficiency & Limits, May 29 – June 3, Hyères, France. (oral presentation)

The research on the Energy Performance Certificate will be continued in the near future: there is a collaboration agreement with VEA to contribute to the ongoing improvement of the Flemish Energy Performance Certificate and a collaboration is being established with prof. Pete Lunn from the University College Dublin for the experimental study on alternative information framings for the Flemish EPC:

- Taranu V., Verbeeck G. 2017. Experimental study on alternative information framings of the Flemish Energy Performance Certificate. PhD Conference in Behavioural Science, November 30 2017, Dublin. (abstract for oral presentation submitted)

Presentation of the research on the importance of financial support on an international conference is planned for 2018.

Finally, a journal paper has been submitted in a peer reviewed international journal Energy Efficiency (final stage of acceptance: minor revisions needed after 2nd review round)

- Taranu V., Verbeeck G. (2018) A closer look into the European Energy Performance Certificates under the lenses of behavioural insights – a comparative analysis.

WP3 Geothermal Energy as case for "new" technologies

In this WP, we decided to consult the stakeholders in interviews instead of focus groups to facilitate exchange. Four groups (see the definitions of the groups A, B, C, D in the Table IX: The fourth groups of stakeholder consultation for the WP3 below) of stakeholders were consulted for the methodological framework, the generic case study approval and the policy instruments to be evaluated in the WP3.

Table IX: The fourth groups of stakeholder consultation for the WP3

Group A	Structure of the generic case	Practitioner/researcher
Group B	Probabilities geological parameters	Geological experts
Group C	Policy instruments/scenarios	Policy makers
Group D	Investment heuristics	Private investors

Table X: List of stakeholders consulted, the geological experts belong to the group B

Names	**Affiliation**	**Group**
Roland de Shaetzen	Earthsolutions	A
David Charlet, Axelle Dinant	IDEA	A
Sonya Chaoui	SPW DGO4	C
Luciane Licour, Alain Rorive, Nicolas Dupont, Olivier Kaufmann	UMons	A,B
Ben Laenen, David Lagrou	VITO	A,B
Michiel Dusar, Yves Vanbrabant	SGB	B
Helga Ferket, Jan Van Roo, Timothy Debacker	ALBON	C
Daniel Drimmer	Tractebel Engeneering	D
Delphine Rensonnet, Theunissen Pierre, Vael Frederik, Van Hooydonk Dries	EDF Luminus	D
Luca Angelino, Philippe Dumas	EGEC	A,C
Gregor Götzl	GBA (Geological Survey of Austria)	A,C
Dezayes Christel, Philippe Calcagno	BRGM (Bureau de Recherches Geologiques et minières), France	A,C
Serge Van Gessel	TNO (Netherlands)	A,C

Part of the WP3 results were presented at international conferences:

- Maes D., Petitclerc E., Vanrykel, F., Defoy, X., Bourgeois, M., Peeters, B. (2016) Policy combinations to navigate between private and public monopolies in emerging technological sectors, 17th Global Conference on Environmental Taxation, Groningen, the Netherlands, 22-23/9/2016 (oral presentation)
- Petitclerc, E., Welkenhuysen, K., Piessens, K. & Maes, D. (2016) Impact of policy instruments on the development of the Belgian geothermal energy sector (ALPI project). European Geothermal Congress 2016, Strasbourg, France, 19-24/09/2016, 9p. EGC2016 (oral presentation + full paper)

Other disseminations activities are also planned for the coming months.

WP4 Electricity: financing models for biomass based electricity production

First of all, this WP has involved several stakeholders, through the stakeholder consultation, in particular members of the Belgian organizations VEA, ODE, BBL, WWF and OVAM. Moreover, we assisted to the "Stakeholder workshop EU project 'Biomass Policies'" in which we discuss with numerous stakeholders from which important information about the new targets 2030 as well as new ideas of policy instrument implementation (incentives or taxes) to promote the use of biomass based electricity were derived.

Next, with respect to dissemination, part of our work made in the WP, has been presented in international conferences:

- de Frutos Cachorro, J., Willeghems, G., Vanrykel, F., Defoy, X., Bourgeois, M., Peeters, B., Buysse, J., (2016) Impact of interacting energy policies on power generation in

Belgium, *17th Global Conference on Environmental Taxation*, Groningen, 22-23/9/2016 (oral presentation)

Other disseminations activities are planned for the coming months, in particular, oral presentations in other international conferences:

- de Frutos Cachorro, J., Willeghems, G., Buysse, J., Strategic investment decisions under the nuclear power debate in Belgium, *14th Symposium of the spanish economic association*, Barcelona, December 2017.

Finally, the latter paper has been submitted in a peer reviewed international journal in Economics as Energy Economics (JCR Q1).

WP5 Transport: how to shift to a more sustainable fuel mix
This WP has also involved several stakeholders through the stakeholder consultation. In addition the results have been presented on the final conference and in detail discussed with the European Association of Electromobility.

The results are currently in preparation for a scientific journal paper.

WP6 Green Public Procurement: the government as sustainable consumer
At first, this WP's results have been discussed with numerous stakeholders (including representatives from the private, public, and non-profit sector). This allowed to cross-check the validity of the WP's approach. In addition the stakeholder consultation created awareness among the involved parties in Belgium on the research project. Finally, the stakeholder consultation allowed to gather information and data on the concerned topics, which in the end strengthened the conclusion of this research project.

In addition we also paid attention to dissemination of our results within the academic world. This allowed us to check to what extent fellow-researchers approve the applied methodology. As such, this research has been presented at numerous international academic conferences and congresses:

- Brusselaers, J., Buysse, J. Introducing (eco-)certification in spatial equilibrium modelling: EUTR trade barrier or leverage. *17th Annual Conference European Trade Study Group,* September 8 to 10, 2016, Helsinki, Finland.
- Brusselaers, J., Buysse, J. The Due Diligence System in the EU's Timber Regulation: non-tariff trade barrier or leverage effect?. *European Association of Environmental and Resource Economists, 22nd annual conference, Papers*, June 22 to 25, 2016, Zurich, Switzerland.
- Brusselaers, J., Buysse, J. Procurement policies in Europe: leverage- and welfare-effect in Africa. *Ghent Africa Platform GAPSYM 9,* December 17, 2015, Ghent, Belgium.
- Brusselaers, J., Van Huylenbroeck, G., Buysse, J., GPP of wood: alternative global welfare calculation. *ICAE 2015 Congress 'Agriculture in an interconnected world',* August 8 to 14, 2015, Milan, Italy.
- Brusselaers, J., Buysse, J., GPP of Certified Wood: pass-through effect on the International Markets and Global Welfare. *European Association of Environmental and*

Resource Economists, 21st annual conference, Papers, June 24 to 27, 2015, Helsinki, Finland.

- Brusselaers, J., Van Huylenbroeck, G., Buysse, J. Green public procurement of certified wood: The impact on the international market, global welfare and welfare analysis. *20th Spring Meeting of Young Economists*, May 21 to 23, 2015, Ghent, Belgium.

In addition the research results have been presented at the high-level FAO World forestry Congress. This congress was organized prior to the Paris Climate Change negotiations. The congress came up with a vision text on forestry which was presented in Paris:

- Brusselaers, J., Van Huylenbroeck, G., Buysse, J. Green public procurement of certified wood: impact on international trade and global welfare. *XIV FAO World Forestry Congress, Papers*, September 7 to 11, 2015, Durban, South Africa.

Note as well that the model applied in Paper 1 and 2 was fully described in a peer-reviewed paper published in Ecological Economics (2017), see '6. Publications'.

Finally, our research was found interesting by the Belgian press as both De Standaard (26/6/2017) and VILT (26/06/2017) reported on our research findings. This initiated interest among certain Belgian politicians, and eventually resulted in an official question by Johan Danen (Groen) on the monitoring of the uptake of GPP to Flemish minister Schauvliege. This question will be answered early September, and we will be informed on the answer and following actions.

Final Conference

A final conference was organized the 8th June 2017 at IRSNB (Institut Royal des Sciences Naturelles de Belgique) in order to present and discuss the results of the ALPI project. The conference was very successful with 85 participants registered who were members of different public and private institution at national and international levels.

The conference started with a welcome speech by Camille Pisani (General Director, RBINS) and introductory speeches by Jeroen Buysse (UGent), promotor and coordinator of the project as well Marc Bourgeois (Tax Institute, Ulg). This was followed by two keynote speakers presentations:

- Peter Wittoeck (FPS Health, Food Chain Safety and Environment)
  The Paris Agreement: implications for the low carbon transition of Belgium
- Arnaud Collignon (Inter Environnement Wallonie)
  Low carbon policy instruments, uncivil society perspective...

Next a morning roundtable took place with four discussant from European and National institutions: Anneleen Van Bossuyt (EU deputy, N-VA), Peter Wittoeck (FPS Health, Food Chain Safety and Environment), Bob Nieuwejaers (Ministerie an de Vlaamse Gemeenschap, LNE Department), Arnaud Collignon (Inter Environement Wallonie) and with Jeroen Buysse as moderator. It was structured according to several questions discussed by the panelists and followed a vote of the public.

In the afternoon, 4 parallel sessions were organized corresponding to the 4 study cases of the project. Each WP invite a number of experts in the specific topics in order to discuss about the work made and presented by each WP. This was followed by a final panel discussion which was intended to summarize the preliminary conclusion of the ALPI project as well as the reflections of the audience. With the goal to increase the impact, the discussion was organized by emphasizing pro and contra arguments. The appreciation of this approach was tested by means of a post-conference questionnaire.

Finally, Dries Maes summarized the conclusions of the project. The conference was followed by a cocktail reception.

6. PUBLICATIONS

Peer reviewed:

- Taranu V., Verbeeck G. (2016) Overview of dual process behavioural models and their implications on decision making of private dwellers regarding deep energy renovation. In: Prins, Matthijs; Wamelink, Hans; Giddings, Bob; Ku, Kihong; Feenstra, Manon (Ed.). WBC16 Proceedings : Volume II Environmental Opportunities and challenges Constructing Commitment and Acknowledging Human Experiences, p. 591-603.
- Brusselaers, J., Van Huylenbroeck, G., Buysse, J. (2017) Green Public Procurement of Certified Wood: Spatial Leverage Effect and Welfare Implications, *Ecological Economics 135 (May),* pp. 91-102. DOI: 10.1016/j.ecolecon.2017.01.012.
- Taranu V., Lizin S., Verbeeck G. (2017) Are dwellers deliberative or heuristic in their decisions to invest in energy efficient renovation measures? In: Lindström, Therese Laitinen; Blume, Ylva; Regebro, Margareta (Ed.). Consumption, Efficiency & Limits. ECEEE Summer Study Proceedings, ABA Intercopy,p. 1979-1988. (ECEEE Summer Study proceedings)
- Taranu V., Verbeeck G. (2018) A closer look into the European Energy Performance Certificates under the lenses of behavioural insights – a comparative analysis, Journal of Energy Efficiency (final stage of acceptance after 2nd peer review round)
- de Frutos Cachorro, J., Willeghems, G., Buysse, J. (2017), Strategic investment decisions under the nuclear power debate in Belgium, Working paper (Submitted in Energy Economics).

Other:

- Petitclerc, E., Welkenhuysen, K., Van Passel, S., Piessens, K., Maes, D., Compernolle, T. (2017). Towards geological-economic modelling to improve evaluating policy instruments for geothermal energy – Case study for Belgium (Campine Basin). European Geologist Journal, 43, pp. 10-15.
- De Standaard, 26 juli 2017, Labels duurzaam hout schieten doel voorbij.

Upcoming articles:

- Vanrykel F., Sustainable mobility and taxation: an overview of the distribution of competences between relevant actors. This article will be sent for publication and to participate to the FSR Climate Annual Conference 2017.
- Other articles are expected on green certificates, on nuclear power taxation and on the judgement n° 83/2017 of the Constitutional court.

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