STUDY OF THE FINANCIAL INSTRUMENTS TO SUPPORT THE MARKET INTRODUCTION OF ADVANCED BIOFUELS AND RENEWABLE FUELS IN THE EU

[Document subtitle]

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ABSTRACT

This paper aims to gather the insights of experts in the field of Advanced biofuels and, based on their input, explore the mechanisms available for biofuels that could be effective in introducing advanced biofuels in the market. The paper will start by providing a small overview of the financial mechanisms that can be used for the market introduction of advanced biofuels. A Technology Specific Innovation Systems approach will be used to carry out a dynamic analysis of advanced biofuel's technological development by mapping the actors, networks, and institutions where development is lobbied and where actions for change are promoted. Hekkert's seven functions of innovation systems will be used to describe and explain technological change and diffusion. The role of these functions in the development of advanced biofuels will be observed and possibilities of learning by exchange will be underpinned. A cross-case study will be carried out, analyzing the functions in four countries: Sweden, Austria, France and Finland. In the seven functions, Sweden had a better performance than the other three countries overviewed. National efforts and public finance support at national level were significant in setting the direction of change in the innovation system. The analysis of function 5, Market Formation, indicates that the Swedish taxation scheme has the most lessons to learn from: it was introduced in a way that allowed adaptation and avoided secondary effects as carbon leakages. Finland and France have had similar approaches, but they have combined taxes with a quota system since an earlier stage. This shows the options and opportunities for other countries who do not want to introduce high taxation mechanisms. Lessons from Austria point to the fact that taxes should be set at a level high enough so that consumption by neighboring countries and consequent increase in CO2 emissions could be avoided.

KEYWORDS

Advanced Biofuels: Biofuels that have zero or low ILUC impact, and produce high GHG reductions or low CO2 emissions

Indirect Land Use Change (ILUC): Changes in the use of land caused by its use for growing crops for the production of (advanced) biofuels.

Renewable Energy Directive (RED): A directive of the European Parliament with an overall policy for the production of energy from renewable sources

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INTRODUCTION

Problem Statement

In 2009, the European Commission published the Renewable Energy Directive (RED), setting a minimum requirement on the consumption of renewable energy within the European Union. It was drafted with the purpose of achieving a gross final energy consumption of at least 20% from renewable sources by 2020. The Directive includes a target of 10% use of renewable sources in the transport sector, with a required greenhouse gas reduction of at least 35% resulting from the use of biofuels and bioliquids. From 2017, this target should be of at least 50%, and of 60% from 2018 for biofuels and bioliquids produced in installations which started their production on or after 1 January 2017 (RED, 2009/28/EC).

For the past years, the transport sector as a whole has had the largest share of final energy consumption in the EU, consuming as much as 352.9 Mtoe in 2014 (EEA 2017). Due to the slower pace at which this sector decreases its emissions -relative to other sectors-, this will result in the transport sector becoming the largest source of CO2 emissions after 2030 (SGAB 2017, p.40).

The Fuel Quality Directive required fuel suppliers to reduce the greenhouse gas intensity of fuels by 6% from 2010 levels by 31 December 2020 (Directive 2009/30/EC, EPRS 2015, p.2). The directives set out in RED I were meant to counter the externalities of an energy intensive transport sector by increasing the share of renewables, including, although not limited to, biofuels. In 2015, a Directive (EU/2015/1513) amending RED on these issues was adopted by the European Parliament and the Council.

REDII was then designed to set a regulating framework for the period 2021-2030 (ICCT 2017). Within this framework, sustainability criteria for biomass resources used for energy were further enhanced. The proposed directive increased the requirement on the share of renewable and low-carbon fuels to be provided by transport fuel suppliers: from 1.5% in 2021 to 6.8% in 2030. It also lowered the cap on first generation biofuels from 7% in 2020 to 3.8% in 2030 (SGAB 2017, p.49).

In assessing the effects of ILUC, the Commission concluded that first generation biofuels have a limited role in the decarbonization of the system (SGAB 2017, p.43). As first generation (1G) biofuels need to be gradually phased out, the introduction of advanced biofuels becomes ever more important. Not only do they have the potential of achieving the REDII targets while complying with sustainability standards, but in some sectors, they are the only

option for decarbonization. Henceforth, the focus that will be given to advanced biofuels and renewable fuels in this study.

In order to allow a widespread use of biofuels in the transport sector, advanced biofuels and renewable fuels need to achieve a greater market penetration. This means that they must be able to compete with fossil fuels. However, production costs for advanced biofuels are higher than for conventional biofuels, and even more so than fossil fuels. Production costs of advanced biofuels is currently estimated at 70-90 €/MWh, "50-100% higher than their crude oil based alternatives" (SGAB 2017, p.14), at 45 €/MWh. With lower prices, fossil fuels used in transportation have a competitive advantage compared to advanced biofuels (Cavka & Vahlström 2014 p.37).

Since renewable energy technologies compete with fossil fuel technologies, advanced biofuels need mechanisms that reduce their costs and emissions so that they can gain a competitive advantage. Mechanisms as quotas, blending mandates and fossil fuel taxes could be effective for shifting the demand in favour of renewable sources (EC 2017, p.98).

Gap in literature

Despite the potential for advanced biofuels to reduce the negative effects of ILUC, and of reducing GHG and CO2 emissions, these technologies are still in the early stages of development and need support to become commercially available.

Various policies can be implemented to support the development and market introduction of renewable energy technologies. These include, but are not limited to, investment subsidies and grants, risk guarantees, loans, and equity (ART Fuels, p.3, IEA Bioenergy 2009, p.65,68). However, it is not yet clear how they can be best implemented to achieve the desired CO2 reductions. Hekkert et. al (2005, p.428) have pointed out that this could be explained by analyzing system dynamics, whereby not only the policies in place are important, but also the processes that lead to their adoption and implementation. Thus, comparing the Dutch and the German cases, for instance, would explain why despite both countries having policies supporting renewables, Germany has been overall more successful.

Despite the experience with other renewable technologies, it is not yet clear what are the opportunities for advanced biofuels and renewable fuels in Europe. Since each MSs has its own action plan, it is expected that an overall assessment and comparison of the financial mechanisms in various EU MSs will allow to identify those areas where learning by exchange is possible.

Social and Scientific Relevance

Advanced biofuels, by definition[1], have zero or low ILUC impact, and produce high GHG reductions or low CO2 emissions -much lower well-to-wheel emissions than conventional fuels (EC 2017, p. 8, 13). It is estimated that "the advanced biofuel industry can contribute between 6% and 9% of total EU transport energy from sustainable biofuels" (SGAB 2017, p.27). With adequate research and investment opportunities, it is expected that almost half of the EU transport sector's needs could be satisfied by the use of biofuels. These biofuels will be produced using mainly domestic feedstocks (EC 2017, p.13), which would increase energy security.

In some sectors like aviation, maritime and heavy-duty road transport, advanced biofuels are the main alternative to fossil fuels, particularly since electrification in these sectors is not yet a viable option. These sectors also have the disadvantage that their potential for technological development is slow due to barriers to entry such as long investment cycles, a capital-intensive nature, and for the aviation sector, high fuel certification standards (EC 2017, p. 14, 127-8). This makes the incorporation of biofuels in the mix attractive. In the maritime sector, the infrastructure already built for LNG and methanol can be used for biomethane and biomethanol, facilitating the transition to biofuels without incurring in major investments (EU Science Hub 2016).

For all this to happen, advanced biofuels and renewable fuels need to be able to compete with fossil fuels and be available in the market. The current financial mechanisms available need to be revised to ensure that those financial mechanisms that guarantee the demand and supply of advanced biofuels and renewable fuels in the future are supporting these technologies.

Research aim

The aim of this proposal is to analyze what forms of support are available for advanced biofuel technologies as they try to enter the market and gain an advantage over fossil fuels. Ultimately, it aims to identify opportunities of learning by exchange where the characteristics and events leading to a country's success can be identified and applied to other EU-MSs.

[1] Defined by the European Industrial Bioenergy Initiative (EIBI) and the International Energy Agency (IEA). Also, the EC proposal assigns a value of zero to all advanced biofuels (biotechnology for Biofuels 2014, p.7).

Research Question

Which financial instruments currently exist at the EU or MS level that can support the adoption of advanced biofuels or renewable fuels in the EU transport sector?

THEORETICAL FRAMEWORK

This section provides an overview of Hekkert's functions of innovation systems and on the Technology Innovation Systems (TIS) approach that will be the base of this study.

Hekkert's seven functions of innovation systems will be used to analyze the factors and events that have been essential for four EU-MSs in their reduction of GHG and introduction of renewables in the Transport sector.

These functions of technology innovation are chosen because they can be used to map the activities that contribute to the generation and diffusion of innovation technologies (Hekkert et al. 2005, p. 415), in this particular case, of advanced biofuels. Note, that not all steps taken by the four countries under analysis has led to their current success. It is thus important to differentiate between those events and activities that could be learnt from, and those that should be avoided. In Hekkert's functions, the events recorded can be classified as positive or negative depending on their impact on the performance of the innovation system (Hekkert et al. 2005, p.428), allowing this differentiation.

Once all the events have been mapped, classified and allocated to one of the seven functions, it is possible to assess the relevance of a function in the understanding of technological change.

The seven functions of technology innovation and their main characteristics and indicators are described below (Hekkert et al. 2005, p.421-5):

1. **Entrepreneurial Activities:** They constitute actions taken to take advantage of opportunities, either by creating new opportunities or creating diversification. It can be identified by the actions taken by the entrepreneur, such as the competition for R&D sources, emphasizing the benefits of specific technologies, among others.
2. **Knowledge Development:** It constitutes all the activities intended to enlarge the knowledge pool and contribute to the development of a specific technology. Its main indicators are R&D projects, patents and investments in R&D. The degree of knowledge development can also be identified by observing at learning curves.
3. **Knowledge Diffusion through networks:** Networks are considered essential to diffuse information. It is here where 'learning by interacting' takes place. It can be identified by quantifying the number of workshops and conferences, but also their size and intensity.

4. **Guidance of the Search:** It assumes that societal preferences influence priority setting and the direction of technological change. It refers to the activities that can have a positive impact on the way a technology is observed. Therefore, the setting of ambitious targets or the way a technology is presented to the public, has a great impact on its development, its timing and its direction.
5. **Market Formation:** New technologies require protected markets or adequate support mechanisms that would allow them to compete with other technologies in the market. Financial mechanisms as taxation regimes and quota systems, are the main indicators in this function.
6. **Resources mobilization:** It observes whether access to resources is problematic and is affecting a technology's knowledge production. It is based on the perceptions by relevant actors on the ease of acquiring adequate long-term funding.
7. **Creation of legitimacy/Counteract resistance to change:** New technologies have to compete to create an image and an advantage over current technologies. This is only possible through the involvement of interest groups and their patterns of lobbying activities.

A Technology Specific Innovation Systems approach is used to analyze the development of advanced biofuels. This approach is adequate because (i) it allows to study a specific technology, (ii) it encompasses the geographical and sectoral dimensions relevant for both national and sectoral innovation systems, and (iii) its more specific focus allows to perform a dynamic analysis (Hekkert et al. 2005, p.417). The process of change can then be represented as the result of a series of interrelated activities that positively and negatively impact each other, rather than focusing simply on the present structure (Hekkert et al. 2005, p.418).

This paper applies a Technology Specific Innovation Systems approach to analyze the process of change of advanced biofuels'. Hekkert's functions of innovation systems will be used to classify the events that can describe and explain technological change and diffusion. Since the study will focus on four 'better-performing'[2] EU-MSs, it is expected that useful insights on the activities that have given them a competitive advantage can be obtained. Opportunities of learning by exchange are expected to be gathered.

[2] Although the countries chosen make the top of the group in certain criteria, there are areas in which other countries might perform better. The instances in which these countries are not at the top can thus also be insightful of the areas that need improvement.

METHODOLOGY

Four countries will be analyzed and compared in this paper. The selection of these countries is based on a combination of indicators that place them as remarkable in terms of their adoption of renewables in the transport sector, their renewable targets for 2020, and of their efforts to reduce CO2 emissions.

The first part of this paper will include a literature review on financial mechanisms for renewable energy technologies, including biofuels. This will serve as an introduction to the mechanisms available, and their potential for supporting the introduction of advanced biofuels.

After identifying the four countries to be studied, the seven Hekkert functions will be analyzed independently. Functions (1) Entrepreneurial activities and (3) Knowledge diffusion through networks, will be mapped at European level. The other five functions will be mapped at a country specific level. Information on the individual country's support mechanisms will be gathered and will be used to map functions (2) Knowledge development and (5) Market formation. Finally, information for functions (4) Guidance of the search, (6) Resource mobilization and (7) Creation of legitimacy, will be obtained partly from the answers from the questionnaire[3] sent to the members of the ART Fuels Forum[4], and partly based on available literature and newspaper articles.

In this qualitative study there are two main sources of data collection. Most of the information will be obtained through literature research and reports from organizations such as the European Commission (EC), the International Energy Agency (IEA), UPEI, the Global Subsidies Initiative (GSI), among others. A second part of this project will consist on a questionnaire for the members of the ART Fuels Forum. Their answers will be used as a general guideline throughout the study and will be used to map function (6) Resource mobilization. Insights obtained from the Third Plenary Meeting of the ART Fuels Forum in Brussels in June 4 and 5, 2018, will also be used to map function (3) Knowledge diffusion through networks.

[3] For the questionnaire, see Annex V.

[4] Financed by the European Commission, the Alternative and Renewable Transport Fuels Forum (ARTFF), aims to facilitate the "discussion and elaboration of common issues on policy and market penetration barriers for these fuels" (ARTFuels). Its objective is to enhance the understanding of the need of the ART Fuels and the main technological and market challenges it faces. It brings together relevant EU stakeholders and policy makers, international cooperation actors, and members of the transport consumption and production industry.

LITERATURE REVIEW

The financial mechanisms supporting renewable energy technologies will be reviewed in this section. These mechanisms will be briefly presented, accompanied by a small evaluation of their performance or usefulness. The mechanisms that will be the main focus of this paper, taxation schemes and quota systems, will then be presented and briefly explained.

Evaluation of the existing financial mechanisms

This section will focus on the support mechanisms available for the market introduction of advanced biofuels, including support mechanisms for First of a Kind Technologies (FOAK). In general terms, this includes instruments as investment subsidies, soft loans, grants, allowances, tax exemptions, price guarantees, Feed-in Tariffs/Fixed Premiums, Tendering schemes, obligations and certificates (IEA Bioenergy 2009, p.66, JRC 2013). These mechanisms can be combined with measures as double counting[5] which can increase the competitiveness of second generation biofuels (ELOBIO 2010, p.39).

In 2007, a Report from the Global Subsidies Initiative (GSI) published a table with an overview of the national mechanisms of EU MSs supporting ethanol and biodiesel (Table 4). The mechanisms are divided in groups for the type of support they provide. More detail on the specific fuel taxation schemes and the specific rates was obtained from ePure 2016 (Table 5), and information on specific programmes available at EU level for the implementation of FOAK technologies was obtained from a JRC Report from 2013 (Table 2).

Four support mechanisms were analyzed by a report from ELOBIO, focusing on their role in supporting advanced biofuels from obtaining investment to achieving wider market deployment (2010, p.4): investment subsidies, tax breaks, soft loans and double counting. A summary of their results will be presented as part of the review of the available support mechanisms.

[5] RED, Article 21 (2) and Annex IX, states that the contribution made by biofuels produced from waste, residues, non-food cellulosic material and lingo-cellulosic material, shall be considered twice that made by other biofuels. This means that biofuels falling under this category can contribute twice for the minimum biofuel targets of each country. Some double counting materials are Palm Oil Mill Effluent (POME), Empty Palm Fruit Bunches, straw, among others (Henke 2017, p.5).

Support Mechanisms

1. *Investment subsidies* were found to be effective in "bridging the gap to commercialization of second generation biofuels" (ELOBIO 2010, p.4) and achieving a higher market share. According to ELOBIO (2010) the higher the investment subsidy, the higher would be the production capacity on the market. However, since investments are a costly measure, they cannot be maintained forever. It was found that subsidies are more cost-effective when they are phased out gradually, which is possible thanks to learning effects.
2. Experience with first generation biofuels has shown that *Tax Breaks* can be useful in promoting the use of second generation biofuels. However, taxes alone are not "sufficient to overcome the initial investment barrier for second generation technologies" (ELOBIO 2010, p.4). It is better to combine tax differentiation mechanisms with an initial period of investment subsidies, which is discontinued once "second generation biofuels reach approximately 10% of market share" (ELOBIO 2010, p.4).
3. *Soft loans* alone are "not sufficient to achieve high market share for second generation biofuels". Instead, they should be taken as a complementary, cost-efficient option which would reduce "the need for direct investment subsidies" (ELOBIO 2010, p.4). The effectiveness of *loans, guarantees* and *equity* available at EU level is limited to either moderate risk levels or to already commercially proven projects.
4. The European Energy Programme for recovery *grant* was made available at EU level to support this stage, and although it proved useful for offshore wind projects, it was less successful for CCS where the industry is not ready and there is a lack of favorable market conditions (JRC 2016, p.16).

Incentives as subsidies, minimum use requirements, incentives on investments in production capacity, tax reliefs and taxation on carbon can help the achievement of cost-efficient production levels and thus improve the competitiveness of advanced biofuels in the market (EC R&I 2007, p. 142). However, second generation biofuels technologies are capital intensive and require long lead times, which has become one of the barriers for venture capitalists who, would otherwise be more prone to invest in these technologies (Elobio 2010, p.22-3). Furthermore, the industry is deemed too risky for private equity financing, whose lack of commitment has also hindered the co-ordination and mobilisation of resources (JRC 2013,

p.20-1). Therefore, financial tools need to be coupled with regulatory support that would bring security to investors and allow the creation of a business case. Among others, feed-in tariffs, quotas, and blending mandates are thus also necessary.

5. *Feed-in tariffs* are the best perceived by investors due to the security of a steady cash flow, even though they are not directly aimed at cost-reduction (Bürer and Wüstenhagen 2009, p.5004, IEA Bioenergy 2009, p.73) For least-cost solutions, *quotas* can be a better option (IEA Bioenergy 2009, p.73).
6. *Obligations* such as *Blending mandates* should only be applied once a mature market with stable biofuel prices has been achieved. Biofuel prices need to be able to compete with fossil fuels (IEA-RETD 2016, p.50).
7. The effectiveness of *double counting* remains unclear as it is dependent on fossil fuel prices and can add an uncertainty factor for investors and lenders, potentially creating a disadvantage for second generation biofuels as it can reduce the total size of the biofuel market (ELOBIO 2010, p.4). So far, double counting mechanisms for advanced biofuels have only favoured biofuels based on cooking oil and animal fats, leaving other technologies unaffected (Öko-Institut et al. 2017, p.148). It can achieve high market share at low costs when coupled with an initial, high investment subsidy, but also reliable financial incentives and regulatory instruments (ELOBIO 2010, p.4 & Öko-Institut et al. 2017, p.148). It should be considered as a means to overcome the investment risk to achieve "full commercialization of biofuels and support initial capacity levels until learning effects start decreasing the cost of the technology" (ELOBIO 2010, p.4).

Mechanisms to create demand

Once biofuels became a mature technology, market entry was supported by mechanisms intended to give them an advantage despite the cheaper production costs of fossil fuels. These mechanisms are reviewed to find insights on their potential effect, were they applied to support the market entry of advanced biofuels and renewable fuels. Two mechanisms are considered to be specially suited to create market demand, and thus to be adequate for supporting technologies in this stage of the development curve. The first one, a tax reduction scheme, subsidizes biofuels "to reduce the price level to that of fossil fuels (or below)" (Wiesenthal et al. 2007, p. 794). The second one, minimum biofuel mandates, set a mandatory

fixed minimum "quantity of biofuels to be supplied by fuel suppliers" (Wiesenthal et al. 2007, p. 794).

Taxation Schemes

Tax schemes for biofuels have proven successful in supporting the introduction of biofuels in the market. As a matter of fact, Sweden realized its 10% biofuel target in the transport sector based on tax exemptions only (GAIN 2017, p.13), and by 2016 it had a share of energy from renewables sources in Transport (RES-T) of 30.3% (Eurostat 2017). Its remarkable performance relative to other EU-member states might lie on the existence of adequate policies supporting the tax advantage. The governmental support package "include specific excise-tax reductions on E85 fuel, tax credits and low registration fees for flexible fuel vehicles (FFVs) owners, or free parking, among other measures" (GSI 2007, p.17). This makes it possible for FFVs to be sold and operate in the country as consumers are provided with the necessary infrastructure to switch to biofuels (GSI 2007, p.31). In Germany, Austria and France, the lack of adequate and sufficient distribution networks made the penetration of biofuels less successful than in Sweden, despite these countries adopting similar taxation schemes (GSI 2007, p.31-2).

Tax exemptions for advanced biofuels have the potential to work in a similar way that they did for biofuels. Taxes have the ability to influence the market, benefiting different fuels depending on their reduction rates (Wiesenthal et al 2007, p.790). In Germany, for instance, biofuel blends were not initially supported by the tax scheme, but once it was extended, low-blends started gaining an important market share (Wiesenthal et al. 2007, p. 795). Since the government can modify tax advantages to benefit certain fuels or blends over others, the original advantage given to first generation (1G) biofuels could be gradually switched to benefit second generation (2G) biofuels. Note however, that, as mentioned before, the benefits of a tax scheme should be coupled with other policies that would ensure that there is enough infrastructure to support the consumption of 2G biofuels.

Tax schemes can be very effective mechanisms, but they also result in high tax revenue losses for governments (Wiesenthal et al. 2007, p. 794, ELOBIO 2010, p.4). In 2006, the fiscal cost of tax exemptions for biofuels was estimated at €1.97 billion in Germany, followed by France at €334 million, and Sweden at €201 million. At a European level, only in Luxemburg revenue losses from tax exemptions did not increase (GSI 2007, p.42-3).

The high governmental costs of taxes make it necessary to combine them with other instruments. One such option could be by combining tax exemptions with fossil fuel taxes,

rendering the mechanism budget neutral (Wiesenthal et al 2007, p.795). This view was supported by the members of the ART Fuels Forum, who perceived that to promote biofuels, there should be a taxation system penalizing fossil fuels or CO2 emissions. The potential of carbon taxes as a substitute for tax exemptions will be explored in further detail, to identify how it could lead to better results.

Carbon taxes and subsidies

Carbon taxes do not only have the potential of being more cost-effective for the government than tax exemptions, but they can also be better understood and accepted by the public. Moreover, they also generate income which could either be used to compensate for the revenue losses from tax exemptions, or to support alternatives, like biofuels (Waldheim, 2018). In fact, carbon taxes by themselves do not necessarily promote biofuels. Although the exact effects vary by country and depend on the effective tax rate, there can be negative impacts whereby a reduction of total energy demand will affect the demand for fuels, including biofuels. However, with adequate taxation incentives, whereby the tax leads to a substitution effect, lower-carbon and carbon neutral biofuels will then experience a competitive advantage in the market (Andersen 2010, p.3).

The market penetration of biofuels can further increase if the tax revenue is used to subsidize them (Timilisina et al. 2011, p.2401). ELOBIO (2010, p.4) reached a similar conclusion finding that taxation mechanisms should be combined with an initial period of investment subsidies to be more effective. Timilsina et al. found that combining a carbon tax with a 25% subsidy, "would increase biofuel penetration by more than 60% from the scenarios with no subsidies" (2011, p. 2405). In Germany, a $10/tCO2 tax, with a 25% subsidy could increase penetration by 67%, while a 50% subsidy would increase penetration to as much as 222%[6] from the base scenario. Their study also shows that a high tax is not necessary, as a $10/tCO2 tax increases penetration almost as much as a $50/tCO2, for each level of subsidy (Timilisina et al. 2011, p.2405). Finally, the study suggests that if the objective is to stimulate biofuels, a more effective way of doing so would be through taxation of traditional fuels (gasoline and diesel) -this will give an extra advantage to their biofuel counterparts. Under this scenario, countries around the world will be capable of meeting their biofuel targets (Timilisina et al. 2011, p.2405).

[6] Based on scenario analyses.

Biofuel Mandates

Another method to support the introduction of biofuels in the markets are biofuel mandates. They impose an obligation on "oil companies and fuel distributors to sell a certain share or a fixed amount of biofuels" (Wiesenthal et al. 2007, p.795). Although mandates were not an EU obligation, several EU MSs had voluntarily adopted them. In 2009, the Renewable Energy Directive set a minimum mandate for all EU countries. This minimum has been increased with RED II, which mandates that a minimum of 6.8% of transportation biofuels be alternative or renewable fuels (ICCT 2017).

However, mandates can become unpopular because the costs are carried by fuel suppliers and ultimately by transport users, who would have to pay higher fuel prices (Wiesenthal et al. 2007, p. 794-5). Since taxation mechanisms are also costly, albeit for the government, some countries have opted for the adoption of a mixed scheme were mandates and taxation mechanisms are combined.

France was one of the first countries adopting a mixed scheme, through the Tax Générale sur les Activités Polluantes (TGAP), that taxes fuel suppliers who do not conform to the minimum blend required (Wiesenthal et al. 2007, p. 796). Germany, on the other hand, provided "tax exemptions only to high blends such as E85 and B100, while employing quotas to maintain production of low and medium biofuel blends" (GSI 2007, p. 31). However, mandates on their own cannot guarantee that a minimum amount of biofuels is supplied.

First of all, mandates need to be framed carefully since they could lead to fuel suppliers opting for the least cost biofuel to comply with regulations (Wiesenthal et al. 2007, p.796), thus closing the market for new or more expensive technologies. Targets differentiating between biofuels and advanced biofuels[7] are thus important to keep the market open.

Likewise, double counting was intended to incentive the consumption of waste-based biofuels, including biofuels made from cooking oil and animal fats, which are more expensive than the production of crop-based biofuels. However, it is not yet sure whether double-counting could support the introduction of new advanced biofuels[8] (Öko 2017, p.148).

Mandates also need to include compliance mechanisms. In 24 out of the 28 MSs, these mechanisms are in place with varying degrees of severity. They range from a fine calculated per liter of biofuel not sold and can be as severe as to include imprisonment of up to five years, like in Cyprus (ePure 2016).

[7] E.g. RED II minimum of 6.8% share of advanced biofuels used in transport.
[8] More specifically, of advanced biofuels that have not already been introduced to the market.

Complementary Policies

Although taxation schemes and obligations are the main mechanisms available to create market demand, they need to be complemented with both supply, and more importantly, demand side measures. Supply side measures include agricultural feedstock production support or grants to production facilities. In France and the UK, for instance, the establishment of fuel stations is supported by capital allowances or grants (GSI 2007, p. 66). Demand side measures include biofuel standards and user incentives. Standards can increase biofuel penetration at a national level, but EU wide standards would also simplify trade among MSs (Wiesenthal et al. 2007, p.796-7). As for incentives, reduced registration fees and road taxes as those implemented in Cyprus, Ireland and Sweden, are intended to promote the use of FFVs (GSI 2007, p. 66).

CROSS CASE STUDY

Countries with high renewable energy targets are expected to make use of sufficient support mechanisms that would enable them to achieve these targets. However, targets on themselves are not always indicative of the actual progress of a country. Therefore, it is important to identify those countries that have both high targets for renewable energy consumption but that have also achieved a high share of use of renewables. Since this study is focused on the transport sector, the share of renewables in the transport sector (RES-T) is of particular interest. Finally, biofuels are analyzed because of their potential for decarbonizing the transport sector. Therefore, the actual level of emissions is relevant for this study. In this case, the values for the CO2 emissions (metric ton per capita) are considered.

The share of renewables in the transport sector is not limited to the use of biofuels, as it also includes 'green electricity'. However, liquid biofuels are the most used energy source in the transport sector (Eurostat 2018) together with other biofuels as biomethane. In fact, by 2015, 88% of the renewable energy use in transport in Europe came from biofuels, specially biodiesel (T&E 2017b, p.2). Likewise, although it would have been interesting to analyze the targets on renewables along with the targets on (advanced) biofuels, this would have been inadequate. For instance, Sweden, which until recently did not have any mandates regulating the use of biofuels, is the EU country with the highest share of use of biofuels in transport. Sweden achieved and surpassed the 10% target due to tax exemptions (GAIN 2017, p.13), and it is now the EU country with the highest share of biofuels in the transport sector.

To determine how financial mechanisms can be combined to support the introduction of renewables in general and advanced biofuels in particular, a cross-case study has been carried out to compare the situations in four EU countries. The main support mechanisms in each country will be overviewed, with a focus on those mechanisms affecting directly the transport sector. This information will then be analyzed and compared in the expectation of finding important insights that could be applied in other countries for the introduction of advanced biofuels and renewable fuels.

Data Collection and Data Analysis

The data used for the individual country targets was obtained from the National Renewable Energy Action Plans[9]. From each national report, the target of energy from renewable sources in gross final consumption of energy in 2020 was obtained. For the RES-T, the information was obtained from the values for 2016 of the 'Shares' tables made available by Eurostat (2017). Finally, the levels of emissions were obtained from the World Bank World Development Indicators.

This information was plotted in various ways to try to obtain the group of countries from which more useful insights could be drawn and those from which lessons could be learned. One of these plots also excluded double counting, thus taking into account the net share of biofuels in each country. However, this did not change the overall trend by much, as most countries presented a 50% reduction in their RES-T, and those who did not, had a very small share of RES-T to begin with, and the difference was barely noticeable. Figure 1 shows the share of energy from renewables in transport (RES-T) in the *x*-axis and the 2020 renewables target on the *y*-axis. The bubble size corresponds to the RES-T for 2016. *Figure 2* shows a Bubble diagram, with the RES-T in the *x*-axis and the CO2 emission per capita on the *y*-axis. The size of the bubbles indicates each countries' 2020 target. Double counting is not included in either graph.

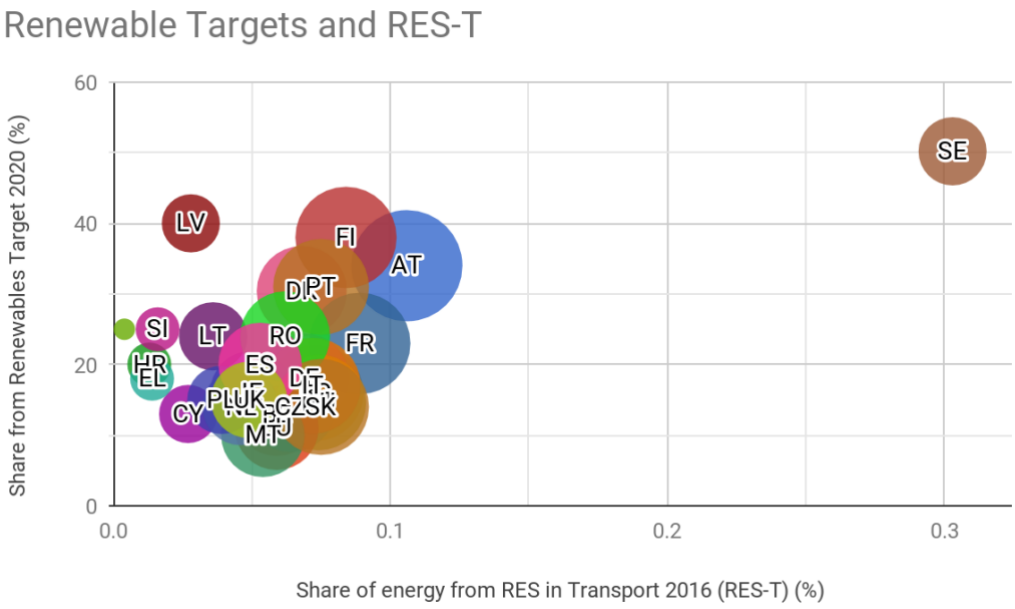

Figure 1 RES-T and 2020 targets, no multipliers. Based on data from: National Renewable Energy Action Plans and Eurostat

[9] European Commission. *National Action Plans.* Retrieved on May 17, 2018 from: https://ec.europa.eu/energy/en/topics/renewable-energy/national-action-plans

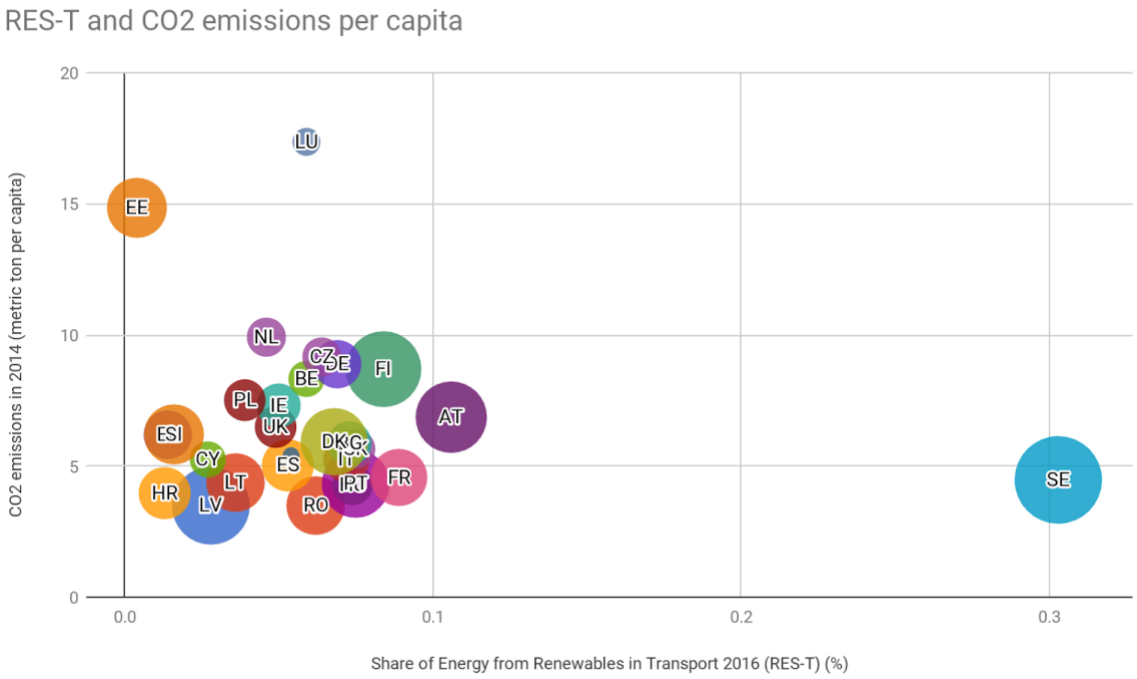

Figure 2 RES-T and CO2 emissions per capita, no multipliers. Based on data from: National Renewable Energy Action Plans, Eurostat and World Bank Development Indicators.

In all different plots, Sweden was at the top of the group. It has the highest renewable energy target for 2020, its RES-T share is significantly higher than in the rest of the MSs, and it also has one of the least CO2 emissions per capita of the EU. However, Sweden is a special case as it achieved its RES-T mainly through tax exemptions (GAIN 2017, p.13) and a gradually raised carbon tax (Raab 2017, p.2). Tax exemptions are nonetheless considered to be expensive, which makes it difficult to be applied in other countries, particularly at the same level of success. Three other countries will be studied to observe the differences in their mechanisms and how are taxation schemes combined with other policies. In most plots, Austria and France had the best values at EU level, with Finland and Denmark alternating between graphs. However, Finland's 2030 target in transport is of at least 30% renewables, to be achieved mainly by biofuel blending obligations (Huttunen 2018, p.8), which is why Finland was chosen over Denmark for this study. Although Austria's levels of emissions are not among the lowest (Figure 2), it was still included as part of this analysis for two reasons. First, the levels of emissions are still relatively low[10], especially considering the high levels from Estonia and Luxembourg. Second, it is expected that this difference provides useful insights as of (i)

[10] Austria's CO2 emissions are of 6,87 metric tons per capita, 60,43% lower than the EU country with the highest CO2 emissions, Luxembourg, with 17.36 metric tons per capita.

why the emissions per capita in Austria are not lower, and (ii) what should other countries avoid and/or improve from its financial mechanisms.

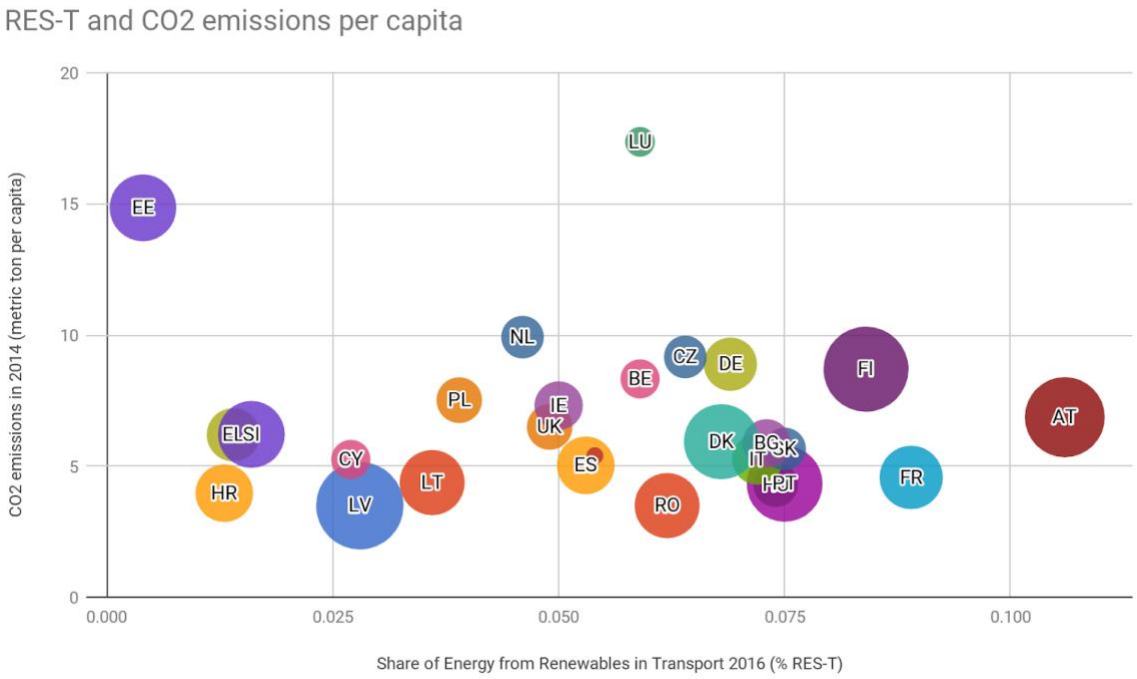

Figure 3 RES-T and CO2 emissions per capita, no multipliers, Sweden not included. Based on data from: National Renewable Energy Action Plans, Eurostat and World Bank Development Indicators.

ANALYSIS

The events, activities, institutions and networks corresponding to each of the seven functions of innovation technology will be looked at individually. This section will present an overview of the contribution of each function to the innovation system. Insights on each of the functions will be provided, highlighting the best performing countries in each of them.

Function 1: Entrepreneurial activities

Function 1, Entrepreneurial activities, constitutes those actions taken by the entrepreneur to take advantage of opportunities, such as the competition for R&D sources and research efforts.

The NER300[11] programme, for instance, is a funding programme subsidizing projects on innovative renewable energy, integration, and Carbon Capture and Storage (CCS). Of the 19 projects selected in the second call for proposals, Bioenergy was the category from which most projects were chosen, followed by Ocean Energy. From the countries studied in this paper, only Sweden got funding for a project in this area[12] (Figure 10). Most of the budget for NER300 was also assigned to projects on Bioenergy. Of the 968.3 Million Euro of maximum funding made available, 625 Million Euro was assigned for Bioenergy projects (Figure 11). The project with the second greatest awarded funding was Bio2G in Sweden, with a maximum funding of €203.7 Million (EC 2014).

Similarly, Horizon 2020, is the eight[13] Framework Programme for Research and Technological Development from the European Commission. New calls for applications for energy, low carbon energy, and transport projects have been recently opened. The latest being a call for application for seven energy related projects with a €56 Million budget (INEA 2018).

Next to the NER300 and Horizon2020, the EU has funded a number of other projects in the areas of energy, sustainability and transport (Figure 12). A great number of environmentally friendly projects have been funded, however, the number of fossil fuel

[11] The NER300 programme, is a funding programme managed by the European Commission, the European Investment Bank and EU MS. It was established to subsidize projects on innovative renewable energy, integration, and Carbon Capture and Storage (CCS). It is funded by the EU Emissions Trading System (Article 10(a) 8 of the revised Emissions Trading Directive 2009/29/EC) by the sale of 300 million allowances, raising a budget of €2.1 Billion. This money was to be made available to selected projects as they operated. 39 projects in 20 EU countries were selected for funding under this programme (NER300, n.d. & EC.c. 2017). The grant funding is receivable once the plant has been put in operation (SGAB 2016, p.5). This has resulted in some projects being cancelled and "undisbursed funds of at least €436 million" (EC n,d.)

[12] This project was intended "to demonstrate the large-scale production of synthetic natural gas (SNG) from woody biomass" through the construction of a plant of 200 MWth of SNG, using mainly biomass from forest residue (EC 2014).

[13] In 2021, it will be followed by Horizon Europe, with a budget of €100 billion (EC.b n.d.)

projects funded (258) is slightly larger than the number of projects on biofuels (212). Hopefully, this trend will be reversed in the upcoming years as a move towards a fossil-free society is taken.

In the latest years funding has been prioritized for projects focusing on biofuels, however there is still a big gap to be covered. As can be seen in Figure 12, for the last 20 years, the number of projects on biofuels has been very small compared to the projects on other energy related areas. From the EU countries under study, **Sweden** has taken the most entrepreneurial activities, as observed by the information provided above.

Besides the actions taken by individual member states to create opportunities of development for (advanced) biofuels, the support obtained for the development of the technology needs to be reliable and efficient. Although this is not dependent on the MSs themselves, this will affect the speed and quality of the innovation system under study. The need for more and better financial mechanisms is thus emphasized as new funding programmes[14] are under development within the European Commission.

The analysis of the Entrepreneurial Activities shows that more efforts are required by all MSs. There is still a clear difference between the amount of projects carried out in the area of (advanced biofuels) and renewable energy, and projects in other (fossil) sources of energy, and efforts needed to close this gap. From the 28 MSs, only 11 countries received funding under the NER300. These countries are also among those with high share for renewable targets for 2020, high shares of RES-T in 2016, and low CO2 emissions. Therefore, entrepreneurial activities seem to happen within a 'closed-circle', while it would be expected that more countries within the EU would be taking similar steps and getting involved in projects in the area of (advanced) biofuels.

Function 2: Knowledge development

Knowledge development is mapped by identifying the available R&D projects and investments, patents, subsidies, and other forms of efforts towards the production of knowledge.

The number of scientific publications on the topics of biofuels (*Figure 13*) and advanced biofuels (Figure 14) were recorded for quantifying the efforts of knowledge production in the different countries. The number of publications for the period from 2015-2018 in both topics was obtained from the search tool *Scopus*.

[14] Such as the Innovation Fund and the Strategic Energy Technology (SET) Plan

For the four countries under analysis in the cross-case study, **France** has the largest number of scientific studies on the topic of biofuels: 650. On the topic of advanced biofuels, **Sweden** has the greatest number of scientific studies for this period: 14. This goes in accordance with the insights from Function 1, Entrepreneurial Activities. As Sweden has obtained funds for the development of projects in the areas of biofuels, it makes sense that they are also developing scientific knowledge that could make these projects feasible.

Knowledge production efforts from each country have also been obtained and classified from the Policies and Mechanisms made available by the International Energy Agency (IEA). Only those efforts towards the production of knowledge for (advanced) biofuels in the transport sector have been recorded.

From the four countries under analysis, **France** has by far the greatest number of initiatives towards knowledge development[15]. Sweden and Austria follow it, and Finland lags behind with just one initiative. In France, most initiatives are presented in the form of funds for RD&D or demonstration projects, and feed-in tariffs. Details on each tool are presented in Table 1 in the Annex.

Although there are various initiatives and mechanisms available in Finland, not all of them are directed towards the development of (advanced) biofuels[16]. Likewise, most efforts in the area of (advanced) biofuels are focused on the electricity sector or the production of heat, and not so much in the transport sector. Finland's support for the development of RES and the reduction of CO2 emissions in transport is not negligible, it only does not always match both criteria.

Next to the efforts available through the IEA, support for the development of biofuels has also been made available through Business Finland in Finland, and the Swedish Energy Authority and Swedish Transport Authority in Sweden.

The countries overviewed have a significant amount of public finance at national level, which is often *complemented* by EU finance. This is not necessarily due to the lack of instruments at EU level, but due to the advantages of obtaining national finance, especially for limited size projects. National mechanisms have usually more rapid application processes, and

[15] The information on the initiatives was obtained by reading and classifying all the information available in what refers to the 'Policies and Mechanisms' as made available by the IEA website through: https://www.iea.org/policiesandmeasures/pams/**country**

[16] Some examples are: the Waste to REF & Energy, RD&D Programme, focused on solutions to waste management including the use of waste for energy production (IEA 2012). Streams was a technology programme also focused on technology related to municipal waste streams (IEA 2015). Climtech, was an RD&D programme for climate change related projects (2012).

henceforth do not delay the investment time schedule[17]. Moreover, national funding is considered easier to get, and has better success rates than financial mechanisms at EU level. Therefore, the amount and quality of these mechanisms at a national level can be a strong determinant of the success and progress of a given country in the innovation process. The actions taken by national and local authorities to promote knowledge development become key, as they are the main instrument in which investors can and will rely on.

Function 3: Diffusion through networks

There are various types of diffusion networks, all of them with different agendas, and involving different stakeholders. In this study, only the networks at EU level have been looked at. This allows to note a difference in levels of participation from the different member states. It is important to note, however, that looking at the amount of networks at national level, the frequency of their meetings, or the numbers of participants, would also be a good way of analyzing the role of function 3, Diffusion through networks.

The networks treating the topics of Advanced Biofuels include but are not limited to the ones presented in Box 1, in Annex II. From the four countries under study, **Sweden** is the one with the most participation, followed closely by Finland.

Next to these conferences, Sweden, Austria and France together with other 36 European countries have participated in the event "In town without my car! (ITWMC)[18]" and in the European Mobility Week. Austria has also organized independent information events at country level[19].

These information and communication networks are important because individual, industry and state agendas are likely to change with new norms. At the ARTFF third plenary session in Brussels, in June 2018, for instance, concerns about REDII were made evident by

[17] Insights obtained from the answers of the members of the ARTFF to Question 24 of the questionnaire send to ART Fuel Forum members in May/June 2018.

[18] This event has been held on a yearly basis in September, since 1998. Participating cities "present their urban centers in a different light for one day by restricting motorised traffic in certain areas, encouraging the use of sustainable modes of transport and raising awareness for the environmental impacts of citizens modal choice" (IEA 2017). In 2003, 126 cities and towns participated in Austria and 80 in France. Many of these cities "also conduct events on sustainable mobility as part of the associated week-long European Mobility Week" (IEA 2017).

[19] Most likely, events like the ones organized in Austria have also taken place in other countries around the globe. However, they might be smaller in scope, being this the reason why they have not been recorded by the IEA. To analyze the policies and measures in a comparable way, only the information obtained from the IEA-Policies and Measures was recorded. Not doing so would lead to differences in the accessibility to the information, one of the reasons being the language.

all its members. There was an overall feeling that not very significant actions could be taken until RED II is made official and there is certainty over the future political framework.

These networks are also important for policy makers, who need to be aware of current technological insights so that their decisions are consistent with the current state of development. As an example, in France, an inter-ministerial coordinator agency was established in 2005 by the Ministry of Agriculture to "advise the Prime Minister on biomass-centered agricultural energy and industry policy, [..and] verify sources of biomass"[20] (IEA 2012). This way, technological development is consistent with the political environment.

These conferences and events are important for the networking activities of the interested parties. They can be useful for gaining knowledge as members collaborate and interact with other participants. The countries under study seem to have understood this, as they not only engage in networks at an EU level, but also create some at national level, which can be as useful as the former for the fulfillment of function 3, diffusion through networks. Although not enough data on the topic has been obtained, it is also possible that those countries with lesser participation in conferences at EU level, have compensated this with participation in smaller multilateral or bilateral conferences. This can be equally important if policy decisions are strongly related to the actions of one other country, as is France's position towards the establishment of a carbon price together with Germany.

Diffusion networks on the topic of advanced biofuels, need to change focus and be more active. Although discussions and knowledge sharing are important, plans for action can be much more valuable.

Function 4: Guidance of the Search

For the function Guidance of the Search it is important to look at the goals set by the countries and also their discourse: how they present advanced biofuels so that they become an attractive option. Ultimately, it is societal preferences what influence priority setting. As people grow awareness of the need for protecting the environment and reducing the level of emissions, governmental agendas will also start to reflect this concern. In **Sweden**, for example, although energy taxes were introduced as a fiscal measure, societal acceptance and the creation of a 'green' consciousness has been an important factor in enabling a behavioural change.

[20] Source: https://www.iea.org/policiesandmeasures/pams/france/name-22741-en.php

Sweden's government also played a pivotal role by emphasizing the 'polluter pays' principle when introducing its taxes. This gave legitimacy to the energy tax and allowed it to be more easily accepted.

Setting high (advanced) biofuel or RES-T targets is essential for emphasizing the commitment of a government to support measures and projects that would enable their development. This is why the level of RES-T and the 2020 targets were also plotted (Figure 4 & Figure 5). Setting targets not only encourages the development of new or better technologies that would allow their achievement, it also makes people more receptive of harsher measures. This is important when unpopular measures, such as the increase in the carbon taxes in France, or a change in the threshold for the bonus-malus, are taken.

Finally, Hekkert states that "the type of wording used by scientists and policy makers is often a good indication for the expectations [regarding an energy carrier]" (2005, p. 424). Accordingly, the members of the ARTFF see the government as a relevant actor influencing the opportunities of advanced biofuels in the market, partly, because of its ability to attract private sector finance. It is perceived that (i) governments can give projects credibility and thus increase investor confidence, (ii) they can reduce lender's risk, making projects more bankable, and (iii) they can create markets that would allow an eventual scaling of the technology. Ultimately, it is the government who can establish regulations for long lasting trust on the biofuel market.

Apart from their high renewables and RES-T targets, the four countries studied have also used positive speech to influence the focus and attention given to (advanced) biofuels. Both Finland and Sweden have done so through their early tax introduction, and Sweden has enforced this by emphasizing the polluter pays principle. In Sweden, it is now widely accepted the need for CO2 taxation as a tool for environmental protection. **France**, on the other hand, has influenced the direction of technology change through policies as the bonus-malus, which have in fact resulted in the purchase of more environmentally friendly vehicles. Likewise, their unpopular decision of increasing the carbon taxes, emphasizes the priority given to CO2 emissions reductions. Finally, France has, for some time now, lobbied for the establishment of a higher carbon price[21]. These behavioral cues are important for the direction taken by technology developers, who will now see new market opportunities in the development of advanced biofuels.

[21] If a high enough price is adopted, this would make Natural Gas Combined Cycle (NGCC) plants competitive with coal plants.

Function 5: Market Formation

This function is mapped by looking at the tax regimes or quota systems in place to support advanced biofuels. The taxation schemes and quota systems are described in detail for each of the four countries under analysis in Annex III. A summary of the implementation of these mechanisms in the four countries, and its highlights, are presented below.

Taxation schemes

All four countries have similar taxation mechanisms: CO2 taxes, energy taxes and electricity taxes. In the latter, taxation takes place at the consumption side, leaving fuels used for electricity production untaxed. This has been important for ensuring industries' competitiveness in the international market and consequently for avoiding a carbon leakage, as consumption switches to foreign industries due to lower energy prices. Although this is the case in all four countries, this has been particularly important for Sweden and Finland who have had energy taxes since a relatively early date. In both these countries, the introduction of energy taxes has also been accompanied by reduction in taxes in other areas to balance the fiscal effects.

Most of the lessons can be learnt from **Sweden**'s taxation scheme. Despite initially being introduced as a fiscal measure, energy taxes were very carefully thought of, so that it could be easily adapted into the system. This required three important things. First, a gradual introduction of the taxes, which has been later followed by gradual increases in the rates. This way, people have had enough time to adapt to the new taxes and secondary effects as carbon leakages or budgetary problems could be avoided. Second, the availability of options once the taxes are introduced have to be guaranteed. This includes, but is not limited to, better and adequate infrastructure (e.g. fueling stations), adequate public transport, and (advanced) biofuel availability. The sufficient availability of distribution facilities in Sweden, compared to other countries, including France and Austria, explains why biofuels have had a higher penetration despite similar taxation schemes. Finally, the introduction of new taxes should be adhered to an already existing system of tax recollection. This way the taxes can be easy to recollect and administrative costs are reduced. A similar approach was taken in France when the carbon component was introduced and was gradually added to the existent energy tax. Moreover, taxes are calculated based on their energy content, which not only makes them neutral between fuels, but also facilitate the administration process, as actual emissions do not need to be calculated.

In **Finland**, and more recently in Sweden, the tax differentiates between 1G biofuels and advanced biofuels. In Finland, while advanced biofuels are totally exempt from the CO2 tax, 1G biofuels are liable to 50% of its value. As advanced biofuels can be consumed at a lower effective price, this measure benefits the introduction of advanced biofuels in the market, while still encouraging the consumption of 1G biofuels over fossil fuels. This option should be considered and adopted by other member states. Tax advantages can be easily modified to benefit different blends or fuels, making this support mechanism well suited to initiate the transition. Quota systems can thereafter be combined with these tax advantages, to require a minimum share of advanced biofuels as part of the minimum share of biofuels that needs to be supplied.

Finally, although a taxation scheme can be a useful mechanism for shifting the consumption of the transport sector from advanced biofuels to renewable fuels, it needs to be high enough to encourage a shift. In Austria, despite a system taxing energy, the low energy taxes have rendered fuels cheaper relative to other countries. This has caused not only increased fuel consumption in Austria from neighbouring countries, but it has also consequently resulted in higher CO2 emissions in the country. Another problem with their system is that the revenues from the taxes are high enough to enable the purchase of carbon credits, which can lead to an overall negative effect. To avoid this, an option is to allocate revenues from taxes for earmarking, that is, using the tax revenues to subsidize renewable energy in general, and potentially, advanced biofuels in particular.

Bonus-malus

Two of the four countries analyzed had in place a bonus-malus system, which can be a very effective mechanism complementing the already existing taxation schemes. Working in a carrot and stick fashion, the bonus-malus encourages the consumption of vehicles with the lowest emissions. In both countries, **France** and **Sweden**, the bonus-malus also makes a differentiation between vehicles driven by 1G biofuels and vehicles driven by advanced biofuels. This system can thus be a useful tool for introducing advanced biofuels in the market. In the French case, it was possible to see that once the bonus-malus system was introduced, there was an evident switch in consumption towards greener options. It could be expected, that eventually this will also lead to higher consumption of FFVs. It is important to note that since electric vehicles and hybrids also have less emissions, they are also benefited by this policy. Therefore, a bonus-malus will not necessarily increase the consumption of advanced biofuels

only, as they will still have to compete with electric and hybrid vehicles. This mechanism, however, should also be regarded for its high potential of reducing GHG emissions.

Quota system

Most countries have a mixed scheme where taxation is supported by an obligation under a quota system. These obligations are intended to guarantee that a minimum amount of biofuels is being used. It is also important to make sure that the specified minimum is not too low, otherwise it might not result in further introduction of advanced biofuels or might even reduce it. Double counting was introduced to balance this by allowing biofuels produced from waste to be counted twice towards a country's targets.

Moreover, a quota system can only be effective if it enforces a minimum amount of biofuel to be *supplied* and not its *availability*. This guarantees that biofuels are actually introduced in the market, and that actual CO2 emission reductions are achieved. Quota systems should also have a compliance mechanism, enforcing that the minimum amounts are achieved. In France, the obligation is enforced through the taxation system, whereby a fuel supplier is liable to pay the tax if it does not comply with the minimum obligation established. Most EU countries have penalties for non-compliance, although Sweden has not made one specific yet.

Currently, most biofuel mandates do not include a minimum amount of advanced biofuels to be included in the blend, as **Sweden** and **Finland** do. This might need to be revised in order for this mechanism to be actually supportive of advanced biofuels. Moreover, the mandates only set the minimum amount of biofuel to be supplied, without making further specifications. As they are technology neutral, they do not allow for diversification and might end up benefiting just one type of biofuel. That is why double-counting is necessary.

Function 6: Resources mobilization

The level of accessibility to financial resources will be assessed by looking at the answers of the questionnaire sent to the ARTFF members.

There is a common concern that resources are not enough and not easily available for all stages. Most respondents agreed that the main problem lies with obtaining resources to finance projects in the pilot and demonstration phases. There is the perception that investors in FOAK and demonstration projects, and technology suppliers, are lacking access to funding in most EU-MSs.

Another important concern was the need for better incentives and better market conditions. In this sense, it was frequently emphasized that a long-term stable policy

framework in which to work is needed, as well as a long-term trust in the market in order to encourage investment.

In the questionnaire the respondents were asked to assess the effectiveness of NER300[22]. The few members that have applied for funding within the NER300 indicated that none of their projects had been realized. Overall, the NER300 is considered to be a weak support instrument, that would not support the achievement of the 2030 targets. In the respondents' experience, the problem with NER300 was the way the financial support was given. The main problems enlisted were the following:

- Long periods and strict application deadlines. This is a problem since innovation and development of a technology does not necessarily adhere to strict dates. Overall, the system is considered to be too rigid.
- It is considered that the financial support should be given in proportion to the risk taken.
- The support should be given beforehand or reimbursed after the achievement of set milestones rather than being given as a bonus once the project is operational. More often than not, the ones investing in these technologies have to get the funds elsewhere in order to finance the project as it is realized, which renders the fund ineffective.
- Production based support did not encourage investments.
- Support has been targeted for energy production and technology suppliers are unable to use the mechanism to mitigate their risks.

Although access to resources is not only available at EU level, the difference between the accessibility to funding within countries can be a significant factor influencing their performance in this function. The overall feeling at EU level, including from members of the four countries under analysis, is that access to funding at EU level is not sufficient or adequate. The failure of NER300 can be taken as an example of the difficulties that have to be faced when trying to get access to funding. Accordingly, most of the respondents to the questionnaire mentioned that access to national funding is usually the preferred option. This is the case specially for limited size R&D projects which could benefit from faster application processes[23].

Table 2 in the Annex presents a small overview of available financing instruments at EU level and their adequacy or suitability for giving the intended support. As can be seen in the

[22] A funding programme for innovative low-carbon energy demonstration projects.
[23] Based on the answers to the questionnaire sent to the members of the ART Fuels Forum.

table, most of the instruments are inadequate to fulfill their purposes, or are very limited in terms of funding, scope[24], or in terms of risk taking.

Function 7: Creation of legitimacy/Counteract resistance to change:

As new technologies have to compete with traditional, often cheaper technologies, there is a need to create an image that would put them in advantage compared to these traditional technologies.

Sweden, was the first country where an airline offered its passengers the opportunity to fly with aviation biofuel. Passengers who chose to flight on aviation biofuel are thereby charged with a fee equivalent to the difference in costs between the fossil and the biofuels. This measure goes in line with Sweden's goal to fly fossil free by 2030 (Biofuels digest 2018). Besides initiatives as this one, Sweden's legitimacy is strengthened by the concept of "polluter pays", which makes the recollection of taxes and the adoption of other measures legitimate to the society.

The case in **France,** is a little more complex. France builds its legitimacy as it advocates for the establishment of a minimum price for carbon, reinforcing its commitment to take the necessary measures to achieve GHG reductions. However, it rejects to adopt a minimum price of carbon unilaterally, stating it will not adopt it unless Germany does so as well. Therefore, in France, there are both positive and negative indicators.

Currently, more efforts towards this function are required, especially since there are other interest groups whose lobbying activities might have a hampering impact on the development of advanced biofuels.

In Sweden, resistance against 2G biofuels comes from the farmer community. Farmers' interests usually align with the biofuel industry, as farmers favour any change that would lead to an increase of the value of their products and co-products. The production of 2G biofuels, on the other hand, can affect the advantage farmers have with the production of crops adequate for the production of 1G biofuels. Advanced biofuels are thus seen by the farmer community as competition.

The use of palm-oil for the creation of biofuels is also struggling to create legitimacy. An amendment made this year on RED II states that "the contribution from biofuels and bioliquids produced from palm oil shall be 0% from 2021". This amendment is considered by some as arbitrary and unjustifiable. It seems to overlook the fact that (i) palm oil can be used

[24] Countries that can benefit from it

in a sustainable and environmentally-conscious manner, and (ii) that the European Parliament has acknowledged that "other plant-based oils produced from soybeans, rapeseed and other crops have a much higher environmental footprint (Monard 2018, p.15, 18). **France** however, has decided to allow French biorefinery 'Total', to import soybean and palm oils for the production of advanced biofuels (Robert 2018).

Currently, advanced biofuels struggle to create a competitive advantage with both fossil and 1G biofuels. Their legitimacy is constantly challenged by conflicting parties, ranging from oil companies to farmers. There are many issues that seem to be misunderstood in the community at the moment, and great concerns about the secondary effects of a truly fossil free society. Issues on ILUC, for instance, need to be better addressed, since they extend to areas as governance and food security. This does not mean that there is no need to emphasize the benefits of advanced biofuels and their role in decarbonizing the transport sector, but the case needs to be as of why they are a good, viable option, and of how the main concerns of the public can be addressed. Small steps as those taken by France and Sweden need to serve as an example: they form the basis for more and better lobbying by interest groups. The option given by Sweden to fly fossil-free, for instance, can be easily adopted by other countries without damaging their market opportunities or without requiring significant infrastructure investments.

CONCLUSIONS

From the four EU MSs analyzed, Sweden's innovation system for advanced biofuels is the one from which more lessons can be learned. Although all seven functions of the innovation system are important in explaining Sweden's current success, in this paper special attention was given to function 5, Market Formation. During the literature review preceding the function analysis, it was possible to identify tax schemes and quota systems as the two best policies to support the introduction of advanced biofuels to the market.

It can be concluded that three types of taxes are important: taxes on CO2, fuel taxes, and engine-related taxes. These taxes are important because, when set at adequate levels, they can produce behavioural change and incentive the consumption of advanced biofuels. This can happen in two ways. First, by taxing emissions, more environmentally friendly products, be it automobiles or fuels, will be consumed more because they produce the least emissions. The concept of 'polluter pays' is key in the effectiveness of this tax, making the purpose of the tax clear, and identifying the specific desired behavior: emit less CO2. The same occurs with fuel taxes. However, these taxes could be improved by taxing advanced biofuels and biofuels at different rates, giving the former a competitive advantage. Henceforth, a greater consumption of biofuels will lead to lower fuel taxes, and ideally, even lower taxes for the consumption of advanced biofuels. The second way taxes can incentive the consumption of (advanced) biofuels, is by modifying behavioral choices from the beginning, when future behavior is restricted by the purchase of a certain type of vehicle. This way, engine related taxes would lead to the purchase of more and more vehicles adapted for the consumption of advanced biofuels, thus also expanding the potential consumers of advanced biofuels. The bonus-malus system and the consequential change in the purchase of automobiles in France, can illustrate the change in individual's market choices as influenced by this tax. With adequate complementary policies and conditions[25], these taxes can help other countries in the introduction of advanced biofuels in the market.

Quota systems are also important as they require a minimum amount of biofuels to be *supplied*. They are meant to ensure that these biofuels are actually entering the market. Framing of these mandates, however, needs to be done carefully so as not to lead to the consumption of the cheapest options only. The double-counting system was implemented to avoid this from

[25] i.e. availability of alternatives as adequate vehicles, or adequate infrastructure, as fueling stations.

happening by allowing biofuels from waste sources to count double towards member states' targets.

Member states that would want to support the market entry of advanced biofuels, could then make use of these mechanisms. However, in order for them to be more effective, the implementation of these financial support mechanisms needs to be accompanied by equal efforts on the other six areas covered by the functions of innovation systems.

Hekkert's Functions of Innovation Systems

The innovation system approach was used to classify the events that have characterized the technological development in four EU-MSs. Through this classification it was possible to identify which countries have performed better in each of the functions, and the reasons why this has been the case. Ultimately, this distinction allowed the identification of the factors that have given them a competitive advantage. Function (2) Knowledge Development, Function (4) Guidance of the Search, Function (5) Market Formation and Function (6) Creation of Legitimacy, have demonstrated to be the most significant in these countries' development. These functions share the quality that they are strongly dependent on national -rather than European- actions. Therefore, the government and public financial institutions have strongly set the direction of the advanced biofuels' innovation system.

The adequacy and availability of national funding, combined with a strong and stable policy framework supporting less CO2 intensive technologies is characteristic of these four countries. This, however, has been strengthened by a society that has accepted change and has adopted an environmental conscience, as in Sweden, and of stakeholders constantly getting involved in networking environments.

FINAL OBSERVATIONS AND RECOMMENDATIONS

This research was done as part of a project on financial issues for the ART Fuels Forum. Originally, it was expected that the answers to the questionnaire from the members of the forum would help set the direction and guide the research to answer two questions. First, it was expected that through their insights and knowledge, opportunities for learning by exchange could be mapped. Second, it was expected that answers to the questionnaire would help identify the requirements and opportunities for project financing. However, this was in part limited by the number and depth of the responses from the members. With only 13 responses to the questionnaire, it was not possible to generalize or draw assertive conclusions. The topic of investor finance will be dealt with instead in more depth through a workshop, and it is thus out of the scope of this paper. The workshop is expected to be carried out with investors suggested by the respondents from the ART Fuels Forum.

The methodology used in this study was a qualitative approach of cross-case study of the technology innovation systems of advanced biofuels. The analysis of some of these functions were dependent on the expected answers from the members of the ART Fuels Forum (e.g. function 6, Resource Mobilization). It is possible that with more time and/or more direct contact with the members, more answers could have been obtained. However, the internationality of the group made this difficult. Another problem was the length and scope of the questionnaire. It could be the case that with a shorter, more targeted questionnaire, more answers could have been obtained within the timeline planned.

This study can be considered an initial exploratory project, where Hekkert's functions were looked at for four different countries. However, it would be interesting to conduct a more in-depth system function analysis for each country, individually. See for example the study from the Rijksdienst voor Ondernemend Nederland: a Technology Innovation System Analysis for Advanced Biofuels in the Netherlands[26].

It would also be interesting to conduct a cross-case analysis comparing the performance of a 'better-performing' country, with a 'middle-performing' country, like Germany, Portugal, Spain or the Netherlands. This would allow to identify what conditions are present in each of these countries, and what conditions have led to their current performance levels -and not to higher ones, for the middle performing country.

[26] Rijksdienst voor Ondernemend Nederland. 2015. *TIS analyse Geavanceerde biobrandstoffen.* Ministerie van Infrastructuur en Milieu. Utrecht, the Netherlands.

ANNEX I: TARGETS

The data used for the individual country targets was obtained from the National Renewable Energy Action Plans[27]. From each national report, the target of energy from renewable sources in gross final consumption of energy in 2020 was obtained. For the RES-T, the information was obtained from the values for 2016 of the 'Shares' tables made available by Eurostat (2017). Finally, the levels of emissions were obtained from the World Bank World Development Indicators.

This information was plotted in various ways to try to obtain the group of countries from which more useful insight could be drawn and that from which lessons could be learned. One of these plots also excluded double counting, thus taking into account the net share of biofuels in each country. However, this did not change the overall trend by much, as most countries presented a 50% reduction in their RES-T, and those who did not had a very small share of RES-T to begin with that the difference was barely noticeable. The chart below shows a Bubble diagram, with the RES-T in the *x*-axis and the share from Renewables Target for 2020 on the *y*-axis. The size of the bubbles indicates each countries' 2020 target. Double counting is included in the two graphs below. Two graphs are shown, one including Sweden. Since Sweden's performance is much better than the other MSs, a second graph was plotted using the same information but excluding Sweden.

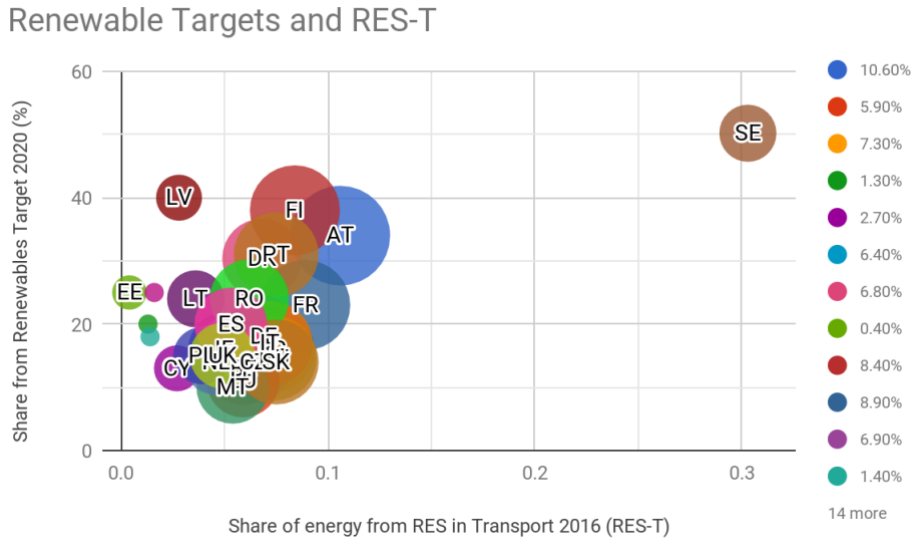

Figure 4 Renewable Targets and RES-T. Based on data from: National Renewable Energy Action Plans, Eurostat and World Bank Development Indicators

[27] European Commission. *National Action Plans*. Retrieved on May 17, 2018 from: https://ec.europa.eu/energy/en/topics/renewable-energy/national-action-plans

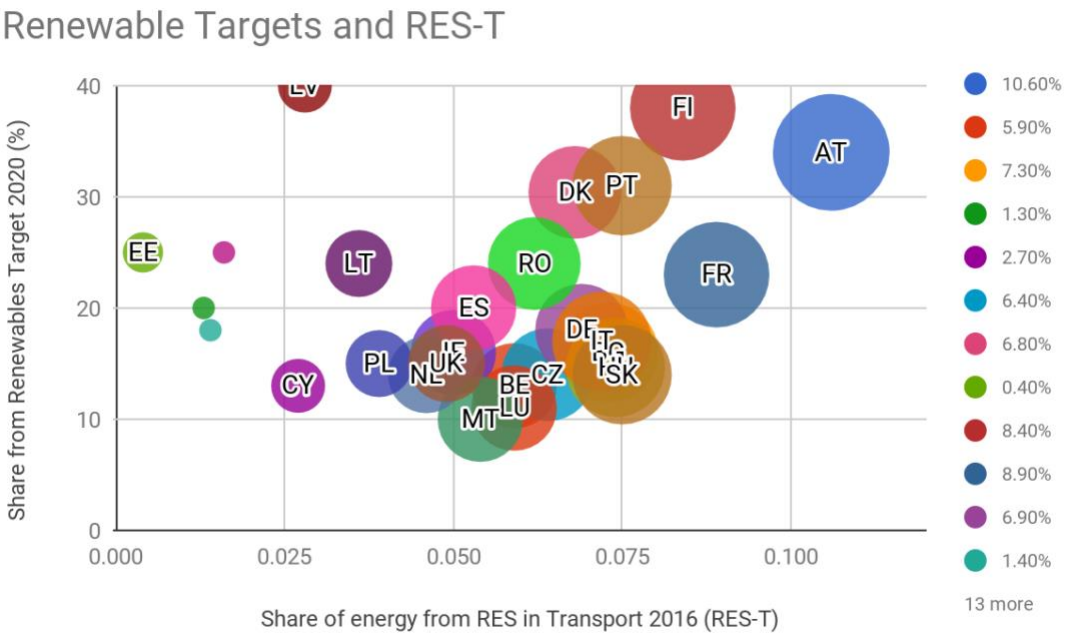

Figure 5 Renewable Targets and RES-T without Sweden. Based on data from: National Renewable Energy Action Plans, Eurostat and World Bank Development Indicators

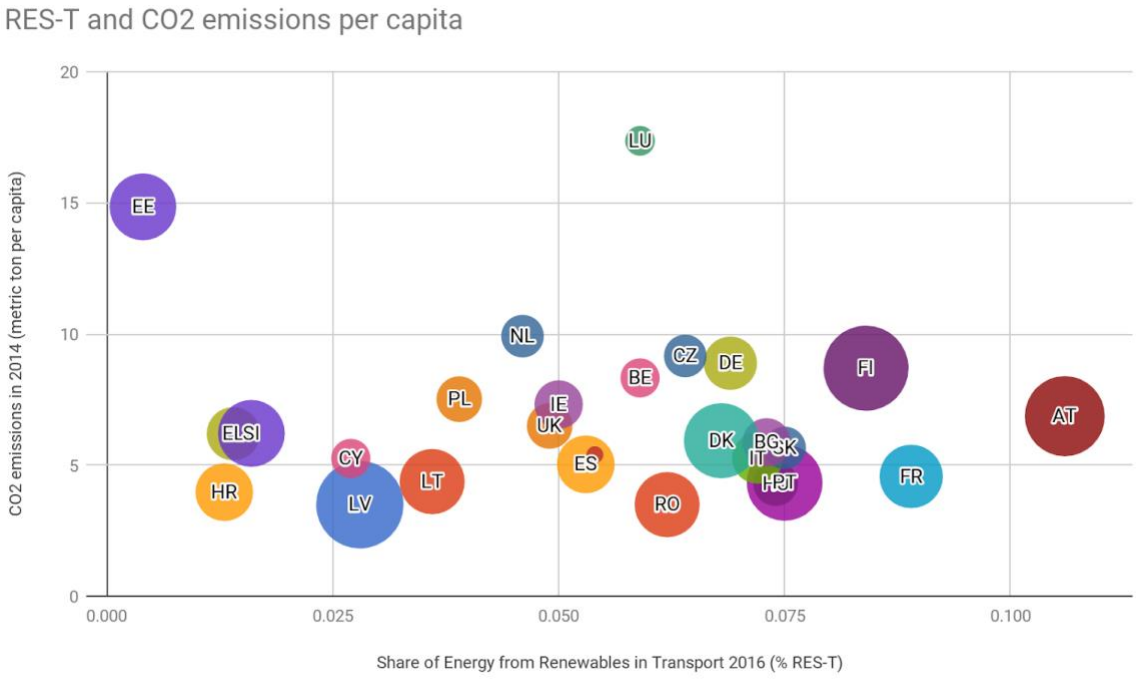

Figure 6 CO2 per capita and RES-T, no Sweden. Based on data from: National Renewable Energy Action Plans, Eurostat and World Bank Development Indicators

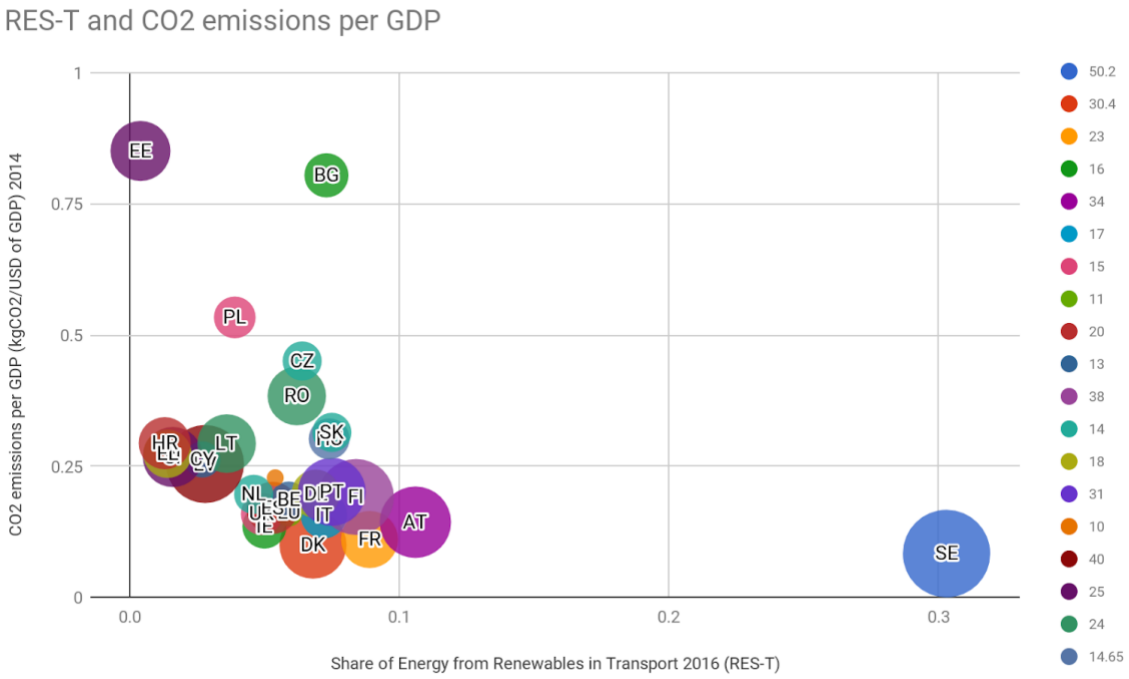

Figure 7 RES-T and CO2 emissions per GDP. Based on data from: National Renewable Energy Action Plans, Eurostat and World Bank Development Indicators

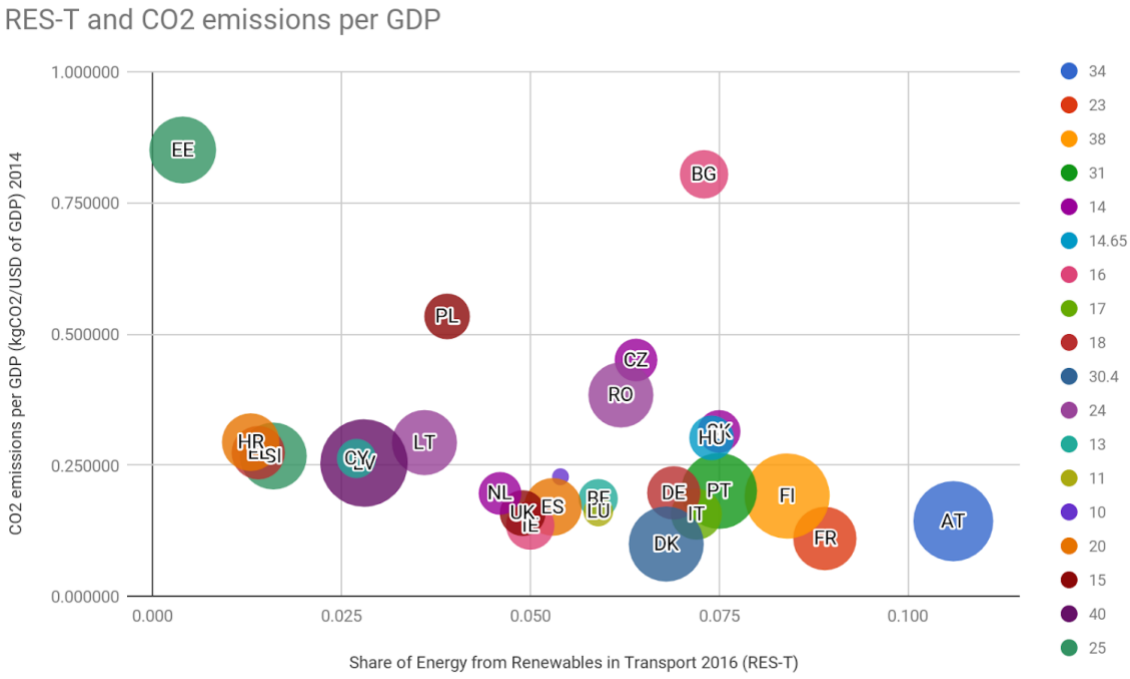

Figure 8 RES-T and CO2 emissions per GDP without Sweden. Based on data from: National Renewable Energy Action Plans, Eurostat and World Bank Development Indicators

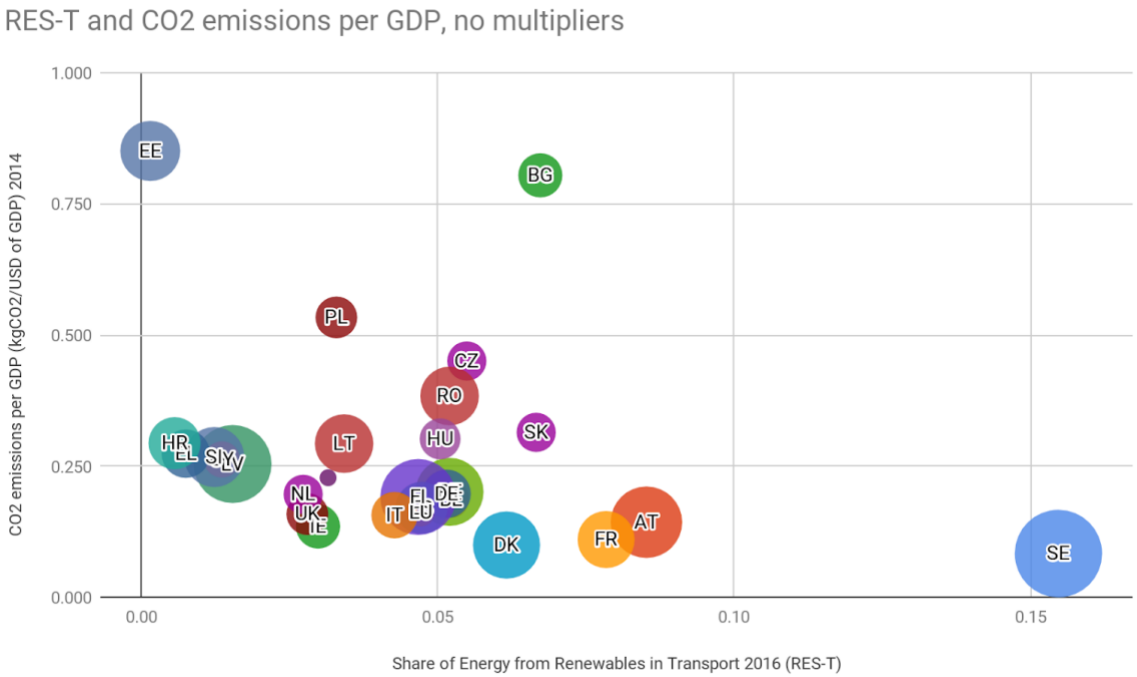

Figure 9 RES-T and CO2 emissions per GDP, no multipliers. Based on data from: National Renewable Energy Action Plans, Eurostat and World Bank Development Indicators

ANNEX II: FUNCTION ANALYSIS

This Annex contains the graphs with important information used for analyzing each of the seven functions of Hekkert.

Function 1: Entrepreneurial Activities

Figure 2 presents in the *x*-axis the number of projects selected in NER300's second call for proposals. The *y*-axis shows the topics that were to be funded by NER300 and, in colors, the countries receiving this grant. Estonia received funding for two projects on Bioenergy, and from the countries studied in this paper, only Sweden got funding for a project in this area. This project was intended "to demonstrate the large-scale production of synthetic natural gas (SNG) from woody biomass" through the construction of a plant of 200 MWth of SNG, using mainly biomass from forest residue (EC 2014).

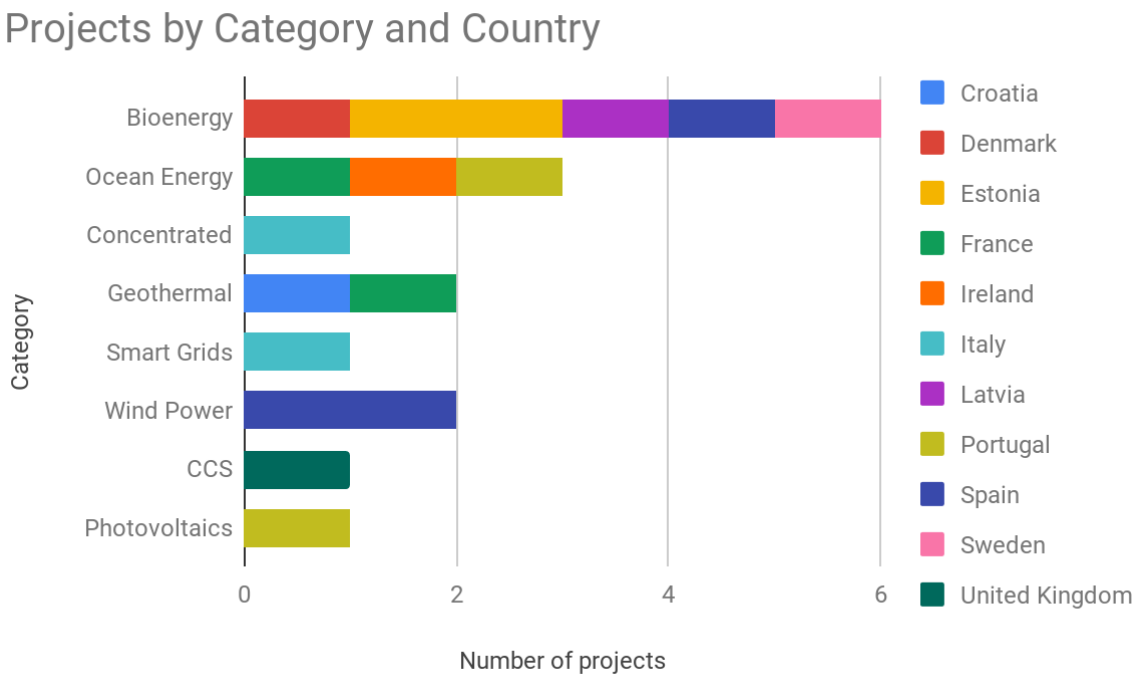

Figure 10 Projects by Category and Country. Based on data from the European Commission, 2014.

Figure 3 presents how the budget of NER300 was divided among topics. Most of the budget for this programme was also assigned to projects on Bioenergy. Of the 968.3 Million Euro of maximum funding assigned to this project, 625 Million Euro was assigned for Bioenergy projects.

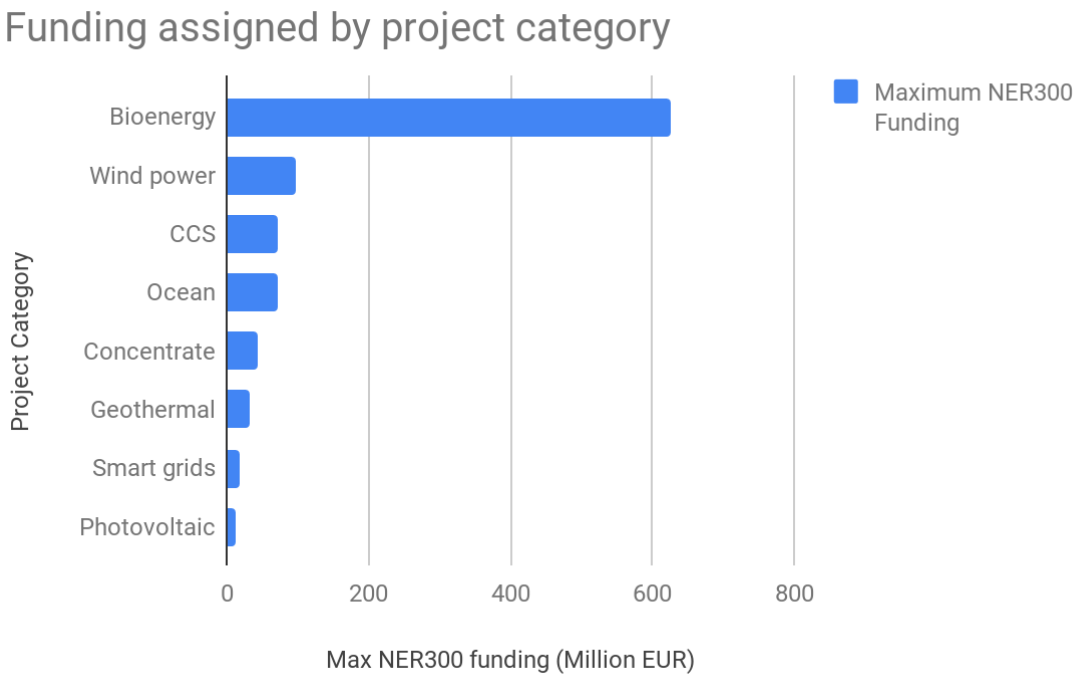

Figure 11 Funding assigned by project category. Based on data from the European Commision, 2014

Figure 4 shows the projects that have been funded by the EU since 1990 in the areas of energy, sustainability and transport.

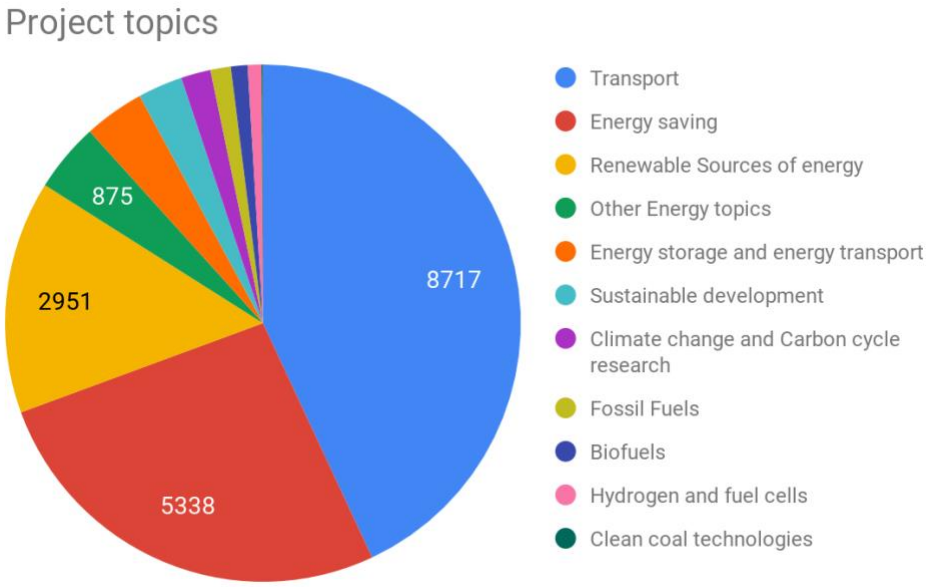

Figure 12 Project topics. Based on data from: CORDIS.

Function 2: Knowledge development

Figures 5 and 6 present the number of scientific publications on the topics of Biofuels (Figure 13) and on Advanced Biofuels (Figure 14) for the period 2015-2018.

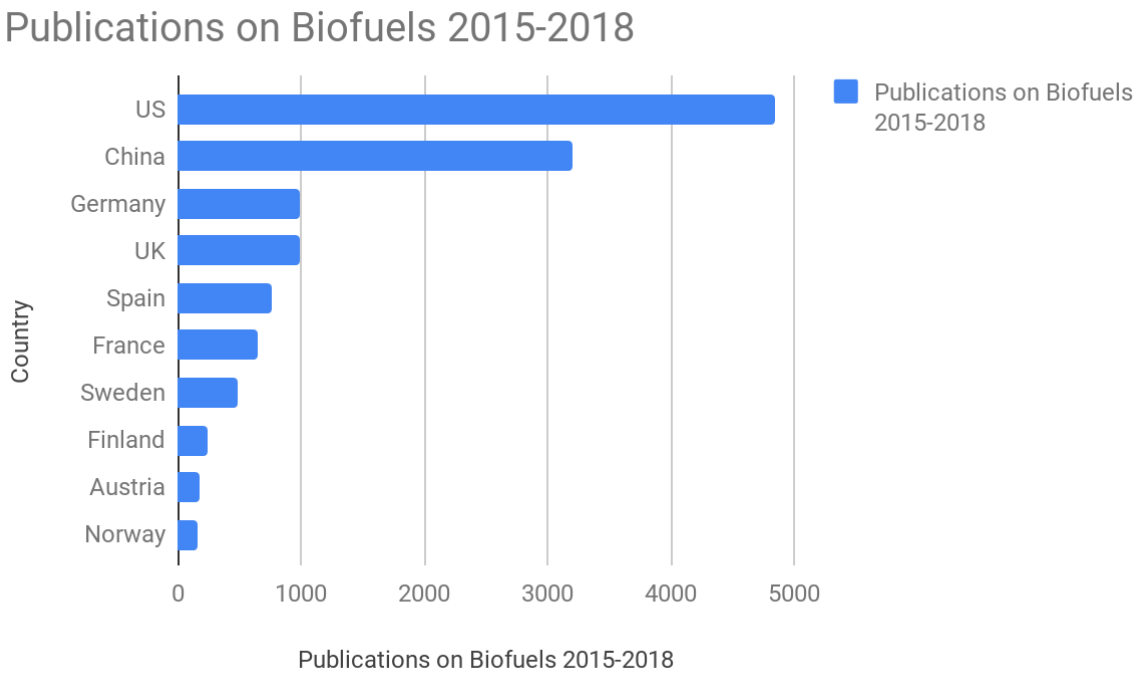

Figure 13 Publications on the topic of Biofuels, 2015-2018. Based on data from Scopus, accessed on July 2, 2018

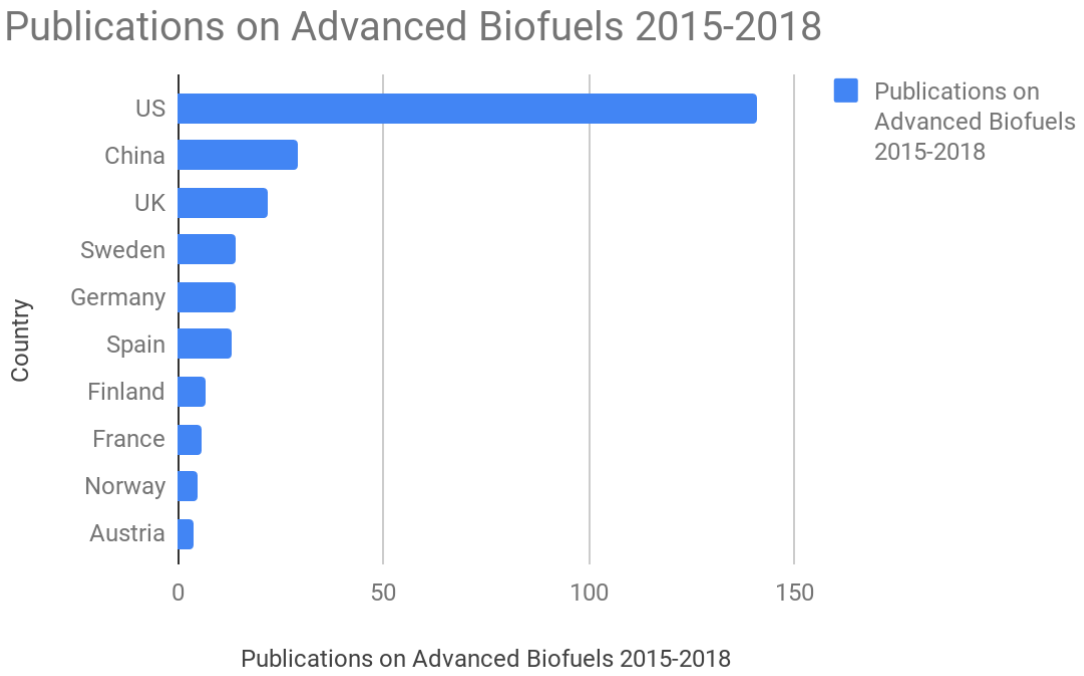

Figure 14 Publications on Advanced Biofuels, 2015-2018. Based on data from Scopus, accessed on July 2, 2018.

Function 3: Diffusion through networks

The networks treating the topics of Advanced Biofuels in particular include, but are not limited to, those presented in Box 1.

Box 1: Diffusion Network at EU level.

- Task 39, within the International Energy Agency (IEA) Technology Collaboration Programme on bioenergy (IEA Bioenergy)
- European Technology and Innovation Platform (ETIP Bioenergy)
- The Advanced Biofuels Conference: Organized for the fourth time by the Swedish Bioenergy Association (Svebio)
- The Alternative and Renewable Transport Fuels Forum (ARTFF) funded by the European Commission, and its predecessor the Sub Group of Advanced Biofuels (SGAB)
- Leaders for Sustainable Biofuels (LSB)
- Advanced Biofuels Group (LinkedIn)
- European Union Conferences like the EU Sustainable Energy Week (EUSEW), and the EU Platform for Blending in External Cooperation (EUBEC)

Information about the members or participants in these diffusion networks could be obtained for five of the above conferences/networks: IEA bioenergy Task 39, LSB, EUBEC, ETIP Bioenergy, and the ARTFF. Only for LSB, IEA Bioenergy Task 39, and the ARTFF a list of the various members could be obtained, which allowed to identify the amount of participants in each one of them. For the other two: EUBEC and ETIP Bioenergy, it was only possible to obtain a list of the member states. Although this is just indicative of a MS' participation, this kind of settings are important both for networking and obtaining important insights on the current state of technology development, and interests of the main stakeholders.

The nationalities of the members or participants were recorded with a value of 1. When the number of participants from each country was available, this number was recorded instead. The number of participants in conferences at EU level is shown in

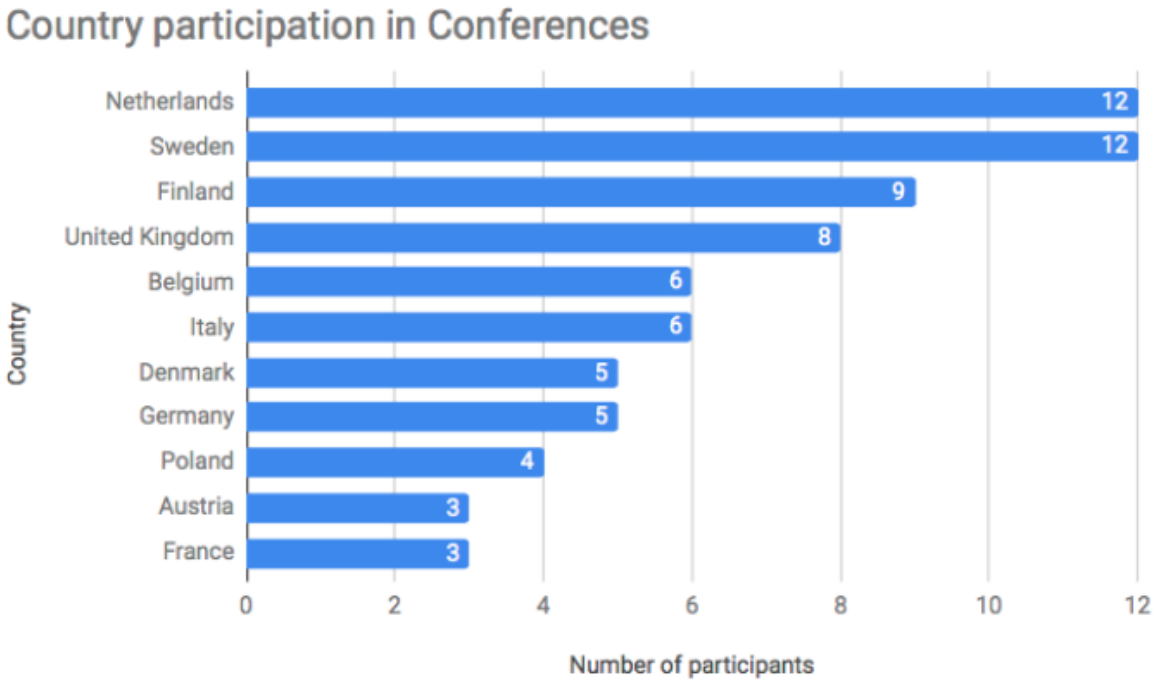

Figure 15. Note that this is just a reference number as the list of participants for all conferences were not always available.

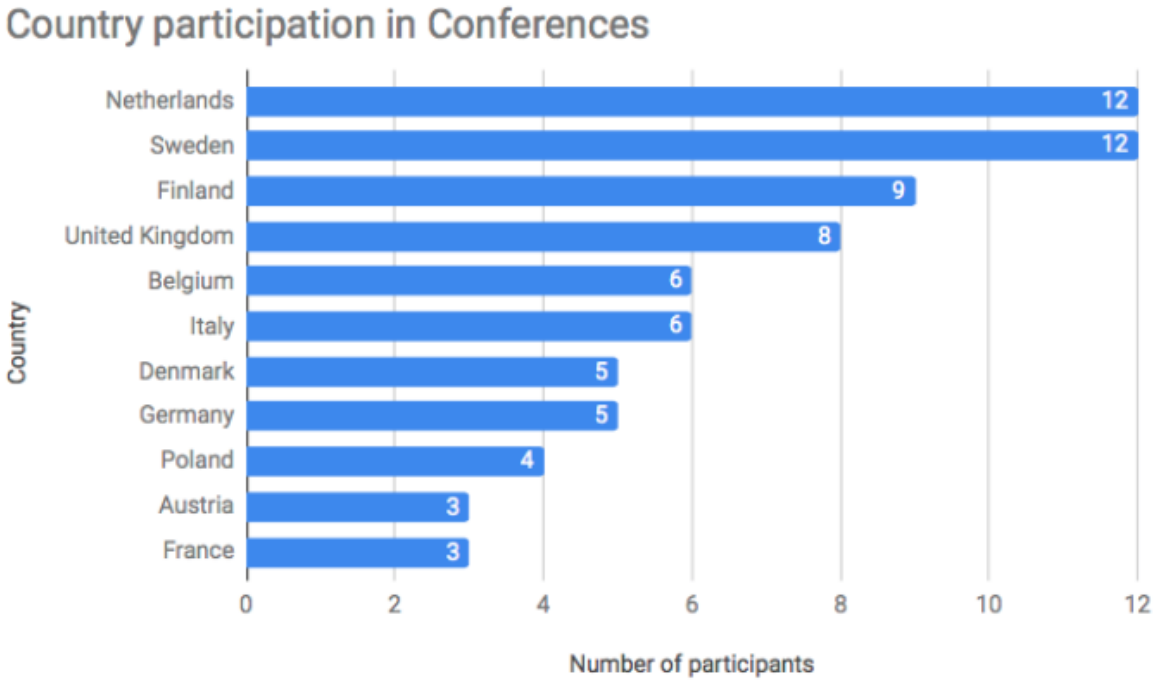

Figure 15 Country Participation in Conferences. Own source.

Together with the Netherlands, Sweden has had a very active role in diffusion networks. This can, once more, be related to its performance in Functions 1 and 2. It is also interesting to note that, although not a subject of study in this paper, the United Kingdom, and to a lesser

extent, Germany have also achieved high values in these functions, as can be seen in Figure 13 and Figure 14. The fact that these countries were not part of the four better-performing countries can be explained as follows. First, the UK and the Netherlands have average and high levels of CO2 emissions per capita, respectively, and their share of RES-T for 2016 was not as big as in other countries. Germany did slightly better on the share of RES-T, but it is still behind France, Denmark, Slovakia, Bulgaria, Czech Republic, and others. On the other hand, even when these countries seem to have a good performance in function 2, Knowledge Development, and function 3, Diffusion through networks, it is the combined performance in all the functions and the events leading and following them, what characterizes the development of a technology in the innovation system.

ANNEX III: TAXES AND QUOTAS

The details of the tax schemes and quota systems that can map function 5, market formation, are presented below for each of the four countries under analysis.

Sweden

Sweden's case is remarkable because it has achieved its targets mainly through the use of taxation schemes. At EU level, it has a significantly greater share of RES-T than other countries, with a 30,30% share compared to 10,6% of the second highest, Austria. It also has one of the lowest[28] CO2 emissions[29] of the EU: 4,478 metric tons per capita[30]. In all the three aspects considered in this study, Sweden is at the top. It's early use of taxation on energy sources can be used as an example for other EU countries, and for the EU in general if it is to apply a harmonized CO2 taxation scheme.

Taxation Schemes

Energy taxation in Sweden started as early as on 1930, for petrol and diesel, and for fossil heating fuels during the 1950's. In 1991, a CO2 taxation was introduced, which increased the overall value for all fuels despite a 50% reduction on the energy tax (Akkerfelt and Hammar 2015, p.2). Currently, the tax structure comprises (i) an energy tax, (ii) CO2 taxes, (iii) a sulphur tax and (iv) an electricity tax. Taxes are levied according to the stipends of the EU Energy Directive. Therefore, in some cases as in electricity[31], new taxes have been introduced to comply with the minimum established in this directive. Oil products, natural gas, coal and coke consumption are taxed at rates proportional to the fuels' energy and carbon content for the energy and carbon taxes respectively (OECD 2018, p.6).

Fuels used for the production of electricity are not taxed, but electricity is taxed when being delivered to consumers (OECD 2018, p.7), with biomass-based electricity being exempt from CO2, sulphur and NOx taxes (IEA 2014). Renewable sources of energy as wind, and solar energy, but also most biofuels, are tax-free under this scheme, with the exception of tall oil with an energy tax of 3.9c/KWh (Akkerfelt and Hammar 2015, p.13). Sustainable biofuels in

[28] The country with the least emissions per capita is Latvia, with 3,498 metric tons per capita.
[29] World Development Indicators, 2018
[30] It has been argued that one of the reasons why Sweden has such low emissions is because it imports carbon-intensive products from least developed countries (WWF 2008, p. 15). However, this argument takes into account the performance of the industry, which is regulated by the EU-ETS, and does not take into account the role of the transport sector. In this paper it is argued that one of the reasons for this low level is also related to the effective policies taxing emissions and incentivizing the use of low carbon vehicles, together with a collective environmental-responsibility awareness.
[31] Now taxed with the minimum of 0.5 €/MWh

blends of up to 5% are not liable for a CO2 tax and are exempt of 89% and 84% of the energy tax for biofuels in petrol and diesel respectively (IEA 2017).

The CO2 tax is considered to be the primary instrument in reducing fossil fuel consumption and CO2 emissions in Sweden. Despite taxation schemes usually being associated with high governmental revenue losses, the experience in Sweden shows that it can be easy and affordable to implement carbon taxes. CO2 taxes are based on carbon content instead than on actual emissions. This not only means that the CO2 tax is neutral between fossil fuels[32] (Akkerfelt and Hammar 2016, p.8), but it also implies that they can be easily calculated, making tax administration easier. Also, CO2 taxes are collected together with energy taxes, so the extra administrative costs of having a CO2 tax are minimal.

CO2 taxes are also accepted among households and businesses, not only out of a sense of environmental responsibility but also because the "polluter pays" principle is observed. Gradual increases in the tax levels have enhanced its acceptability, as people have time to adapt. The gradual increase also protects industries' competitiveness in the market (Akkerfelt and Hammar 2016, p.4) and avoids potential carbon leakages (Akkerfelt and Hammar 2015, p.3). At the beginning, energy intensive industries had to pay a lower CO2 tax, but since the introduction of the EU Emission Trading Scheme (EU ETS), these industries are exempt from the CO2 tax as a whole. Meanwhile, smaller industries' energy consumption is small enough that its competitiveness will not be greatly affected by the CO2 tax (IEA 2017, Akkerfelt and Hammar 2015, p.4).

The implementation of the CO2 tax was also smoothened thanks to a simultaneous reduction in capital and labour taxes (Akkerfelt and Hammar 2015, p.2) and guarantee of the availability of feasible options like district heating, adequate public transport, housing isolation, biofuel availability, and the installation of distribution facilities, among others (Raab 2017, p.8).

To support the market introduction of advanced biofuels, it is necessary to make a distinction among 1G and 2G biofuels in the taxation system (Wolthaus, 2017). Since 2014, Sweden has implemented a sub-quota for advanced biofuels (IEA 2018).

Quota System

Despite achieving its renewable energy targets solely thanks to its taxation scheme, the Swedish tax scheme is since 2014 combined with a quota system[33] (IEA 2018). The minimum

[32] There is no advantage or disadvantage given to any fuel.
[33] Source: https://www.iea.org/policiesandmeasures/pams/sweden/name-44937-en.php

obligation set for this year is of 2.6% of biofuels in gasoline and 19.3% in diesel, to be increased to a minimum of 4.2% and 21% in 2020, respectively. These values might be modified, and new targets will be set after recurring reviews by the government (IEA 2018).

Other Measures

The 'eco-car subsidy' system was established in 2007, encouraging the purchase of vehicles producing the least emissions. It benefited vehicles powered by biofuels[34] as well as electric vehicles, increasing the purchase of hybrid or electric powered vehicles by 49% (IEA 2014). From July 1, 2018, a new Bonus-Malus system will be in effect in Sweden, affecting the purchase of cars class I and II, light buses and light trucks. The tax will be charged yearly, depending on the level of CO2 emissions. The tax currently applies for vehicles with emissions over 95 grams, with a rate of 10,37[35] €/g CO2 for cars emitting more than 140g. Cars with low emissions receive a bonus ranging from €967.96[36] for cars with a 60g emission level to €5,807.79[37] for the most environmentally-friendly vehicles. Vehicles powered by alternative fuels are exempt from increased vehicle taxes (IEA 2018).

Austria

Despite being the EU country with the second highest share of renewables in transport RES-T[38], Austria is the EU country with the 10th highest CO2 emissions per capita. Moreover, emissions from the transport sector have grown in Austria by 50% since 1990 (IEA, p.11). Unlike Sweden, the main support mechanism are not taxes, but a quota system (Borek 2017), but it has been argued that a carbon tax might be necessary to reduce the emissions caused by the non-ETS sectors, including transport (CATS, n.d.). However, this responsibility relies on the government, who is in charge of regulating emissions from all sectors not covered by the EU-ETS (IEA 2014, p.11). Currently, 58% of emissions are taxed by the government, with transport being the second highest taxed sector: 94% of its emissions are taxed (OECD n.d, p.2).

Fuels for transport also have the highest tax rates in Austria (OECD 2015, p.1), higher than those for heating and electricity generation. The taxation mechanisms include the Mineral

[34] Emissions must not exceed 120 g/km during mixed driving (IEA 2014).
[35] 107 Swedish Krona
[36] 10,000 Swedish Krona
[37] 60,000 Swedish Krona
[38] In both the scenarios with and without double-counting.

Oil Tax (MÖSt), the standard fuel consumption tax (NoVa) and the engine-related insurance tax.

The engine-related insurance tax is a tax paid for every month that the car is registered to transit. It favours vehicles with lower fuel consumption (IEA, p.34). Unlike this tax, the other two taxes are consumption taxes. The MÖSt charges fuels from mineral oils, with the exemption of high blends as E85 and biofuels (Borek 2017). In 2011, the levy for this tax was increased with the aim of reducing GHG emissions from fuel export, raising the petrol and diesel prices by €0.048 and €0.05 (including VAT), respectively (Environment Agency Austria 2013, p.97). After the amendment in the Mineral Oil Act, tax concessions were provided for sulphur-free fuels with a biofuel share of 6.6% and 4.6% for diesel and petrol respectively (IEA 2013).

The NoVa is a tax to be paid at the time of purchase based on a car's fuel consumption specifications, including CO2, NOx and particulate matter (pm) emissions. In 1996, the measurement for the fuel consumption was changed, increasing the levy by 1% from the original 1992 levels. This change led to the purchase of more diesel vehicles, which now account for about 40% to 50% of the vehicle fleet in Austria (IEA 2017). Moreover, gasoline is taxed at a higher rate than diesel both in terms of TJ and CO2 (OECD 2018, p.6)

In the 2010s two important tax amendments took place. The first, allows up to a €200 tax cut for cars with lower levels of NOx and pm emissions. The second amendment benefited vehicles with eco-friendly driving motors, allowing for a reduction of the levy of up to €500 (Environment Agency Austria 2013, p.99).

Just as in Sweden, energy intensive industries benefit from tax refunds, and there is no levy charged on fuels used for the production of electricity. However, in Austria the tax on electricity output is the same for all users (OECD 2018, p.7).

Fuel taxes in Austria are not as high as in other countries, which results in overall lower fuel prices which attract consumers from neighbouring countries. In fact, foreign fuel consumption accounts for as much as 30%. More importantly, Austria's tax revenue "is several times higher than spending on carbon credits that Austria purchases to offset part of the resulting emissions" (IEA, p.11). If the revenues are not used for earmarking on renewable technologies, and it is indeed financing the purchase of carbon credits, the overall environmental print in Austria will have negative effects.

Quota System

Austria's main support mechanism for biofuels is its quota system, which establishes an obligation to substitute fossil fuels with biofuels. The obligation is technology neutral, which means that any type of biofuel might be used to achieve the minimum set target (Borek 2017b). This has resulted in biodiesel and bioethanol being the main fuels blended with diesel and petrol respectively (IEA 2013).

The mandate applies to fuels used or introduced to the country. Therefore, the substitution obligation falls on the party introducing the fuel, which must report the quantities of fossil and renewable fuels introduced or used every year (Borek 2017b). The costs of the obligation are reflected on higher fuel prices, which are ultimately borne by the consumers (Borek 2017b).

When first established, the target was set to 2.5% of the energy content of petrol or diesel (IEA 2013), and it was raised to 8.45% for 2020 (IEA Bioenergy 2016, p.12). If the blending obligation is not met, or if the biofuels used do not meet with certain specifications, the fuel "may not be released for free circulation" (Borek 2017b). Moreover, fuel suppliers are liable to pay an administrative penalty if they fail to meet with the quota obligation (ePure 2016).

France

In all the graphs plotted, France is always among the leading countries, showing its ambition to lead the energy transition. To facilitate it, France has long advocated for the need of higher carbon prices -as much as €30 per ton of CO2. This seems particularly urgent as, under the ETS system[39], it fell to as low as four euro per ton of CO2 in 2016[40], a price at which Combined Cycle Gas-Turbine (CCGT) plants are not yet competitive with hard coal plants (Morris 2017).

In 2014, France joined the Carbon Pricing Leadership Coalition (CPLC) which aims to attain a CO2 reduction by creating fiscal measures or trading systems that would send a price signal to consumers (Planete Energies 2017). On the European context, it has aimed at closer cooperation with Germany suggesting the carbon price be set at 25-30 euros. With a 75% share of nuclear power in France, compared to Germany's 40% share of coal power, it is unlikely that Germany will risk losing competitiveness with France, while France refuses to set a unilateral minimum value (Morris 2017).

[39] The transport sector is not part of the ETS system
[40] The current price is of 16 €/ton CO2

Unlike Austria, whose main support mechanism is a quota system, or Sweden, who relies mostly on tax schemes, France has adopted a combined scheme, the Tax Générale sur les Activités Polluantes (TGAP), that taxes fuel suppliers who do not conform to the minimum blend required (Wiesenthal et al. 2007, p. 796).

Next to the TGAP, France's policy includes various other support mechanisms, as those exposed in *Le Grenelle de l'Environnement*, and other energy taxes.

Taxes

France has three forms of taxation on energy use: a carbon tax, an energy tax and an electricity tax. Within the framework of *Le Grenelle de l'Environnement* a tax on polluting vehicles and on transport trucks crossing the borders is also included (IEA 2014). The inclusion of a fossil fuel tax has also been considered by both right and left-wing governments, however it has been rejected on the grounds that it does not ensure "equal rights for all citizens with regard to taxes" (Planete Energies 2017).

The energy and carbon taxes apply to the consumption of oil products, natural gas, coal and coke, the latter being dependent on the fuel's carbon content. As both in Sweden and Austria, fuels used for electricity generation are untaxed. Instead electricity output is taxed at a single rate, with electricity used in transport being exempt from this levy. Other exemptions include a reduced tax rate for biodiesel and biogasoline, and reduced rates for fuels (except diesel) used in agriculture, among others (OECD 2018, p.6-7). Finally, he Alternative Vehicle Differential Tax Exemption, grants an exemption on a portion or the total of the tax on alternative vehicles (IEA 2012).

Tax credits have also been made available, in particular, to support the acquisition of alternative vehicles, i.e. vehicles fueled by electricity, natural gas or LPG and hybrid vehicles. Already in 2002, the finance law granted one-time tax credits for the acquisition of new alternative vehicles (IEA 2013). The tax credit varies from €1,525 for natural gas vehicles, rising by €775 if the purchase of a clean-fuel vehicle was paired with the discarding of a vehicle older than 1992[41]. A tax credit was also made available for the transformation of gasoline cars into gas from liquefied petrol (GPL) (IEA 2013). Credits on the purchase of alternative vehicles were risen to €2000 by January 2006 (IEA 2012).

Carbon taxes in France are high and are set to rise further in the upcoming years. To achieve its 2020 targets, the original tax value of €39/tCO2 expected for 2018 was increased

[41] In 1992, "France began requiring the use of catalytic converters on unleaded fuel vehicles" (IEA 2013)

to €44.6/tCO2. The tax is currently expected to increase to €55 in 2019, €65.4 in 2020, €75.80 in 2021 and €86.20 in 2022. Under the original law of 2015, the tax would increase to €100 for 2030 (Fèlix and de Clerq 2017 & Planete Energies 2017).

In 2014, the carbon component was introduced as a form of a 'climate energy contribution'. It is a value gradually added to the existent energy tax (TICPE) so it does not constitute a new tax by itself. The contribution is proportional to the CO2 emissions generated by the fuel and it is applied at the same level to all types of energy, with some mandatory exclusions[42] (Croquette 2017, p.8 & Planete Energies 2017). By 2017, the carbon component was of 8.1 euro cents per liter on diesel and 7 euro cents per liter on gasoline. With the increase on diesel tax, the carbon component of diesel is expected to rise to 9 euro cents per liter by 2020, while gasoline will remain at the same rate of 7 euro cents per liter (Croquette 2017, p.6, Planete Energies 2017 & UFIP in Félix & de Clercq 2017).

Quota system-Mixed Scheme

The TGAP was created in 2005 to stimulate the inclusion of biofuels, whereby a tax reduction is granted dependent on the volume of biofuel included in petrol and diesel fuels (Bureau de l'information et de la communication 2017). Conversely, a surplus environmental tax[43] is levied on refiners or filling stations who fail to meet the minimum levels of biofuel contents (IEA 2013). Therefore, it conforms a form of mixed scheme that reinforces both minimum biofuel levels by means of a taxation scheme. As of 2017, the minimum level[44] for diesel was of 7.7%, allowing up to 0.35% to be double-counted biodiesel. For petrol, the minimum was 7.5% of bioethanol, of which up to 0.3% could be double counted (GAIN 2017).

Other measures

The bonus-malus is a system that incentives the purchase of vehicles that produce the least CO2 emissions, whereby a bonus is given for vehicles that produce below a given threshold, and a tax is charged to vehicles whose emissions are above it (IEA 2015). As of 2018, only the vehicles emitting less than 20g CO2/km could benefit from a bonus of €6,000 (Le Portail 2018). Conversely, as of 2018, vehicles emitting more than 120 gCO2/km will be subject to a tax that can range from €50 to €10,500 (Carte Grise 2017). With this system,

[42] Exclusions result from international or European rules, like in international aviation. There are also exceptions in agriculture and freight transport, and for energy intensive business within and outside of the EU-ETS (Croquette 2017, p.8).
[43] This tax is meant to be raised progressively (IEA 2013).
[44] Indicated as % of energy value.

vehicle registration within the groups eligible for the bonus saw an increase, while there was a decrease in the registration of vehicles subject to the malus[45] (IEA 2015).

Finland

With the first ever carbon tax on fossil fuels, Finland's efforts towards the energy transition could be exemplary for the EU. Along taxes, a quota system is also in place, which is considered to be the most effective mechanism supporting the introduction of renewables in the transport sector (Siniloo 2017). It's minimum overall biofuel target for 2016 is the highest from all EU countries from which information is available: a 10% share in energy content. Failure to comply with the established minimum results in a penalty of €0.84/l and €1.32/l for ethanol and biodiesel respectively (ePure 2016, p.26). For 2020 the target is established at 20%, with a 7.5% share of double-counted biofuels (IEA 2015). However, by 2014, Finland had already reached and surpassed this minimum, having achieved a total share of 23.5% (ePure 2016, p.26).

Taxes

There are four main taxation mechanisms in effect in Finland: an energy content tax, a CO2 tax, an electricity consumption tax, and the Strategic Stockpile Fee. The last one applies to most fuels across sectors, albeit at lower rates than the energy and CO2 taxes. As in all other countries overviewed in this study, fuels used for electricity production are untaxed. The electricity tax charges a levy on consumption, with different rates depending on the sector. The residential, commercial and agriculture sectors are taxed at higher rates than the industry sector (OECD 2018, p.6). Since 2011, the effective rates are calculated based on the fuels' energy content, CO2 emissions, and the health effects of particle emissions (IEA 2015).

The carbon tax was introduced in Finland as early as in 1990 (IEA 2015), originally with fiscal rather than environmental purposes. This changed in 1995, after Finland joined the EU and taxation was modified to conform EU directives on mineral oils. Peat was temporarily exempted from the CO2 tax and natural gas had a 50% relief (Prime Minister's Office 2000, p.36). Currently, all biofuels that meet the sustainability criteria, as established in the RES directive, receive a 50% exemption, while 2G biofuels, wood and other types of biomass receive a full exemption (IEA 2015). Tax reductions are also granted based on the level of

[45] An increase of 75% and a decrease of 28% was observed for 2012 (IEA 2015).

particle emissions for second generation diesel, and the emission benefits to the environment for natural gas and biogas (IEA 2015).

In addition to the fuel tax, an energy tax has been collected since 1994, taxing all energy sources except for wood, wind power and waste fuel (Prime Minister's Office 2000, p.35). Currently, it is calculated based on the volumetric energy content of the fuel, at the same rates for both fossil and biofuels (IEA 2015). A special feature of the Finish model is that a differentiation between 1G biofuels and advanced biofuels is made, whereby conventional biofuels are liable for a percentage of the CO2 tax while advanced biofuels are exempt from it (Wolthaus, 2017).

The introduction of an energy tax in Finland, however, meant two problems. First, production based on renewable sources got affected, as it was no longer tax-free. Second, Finland saw in it a threat to its production competitiveness, as with higher energy prices, energy-intensive industries would have higher costs. Therefore, as in the other countries overviewed, the energy tax is levied to the consumer, leaving fuels used for electricity production exempt from the tax. Also, since 1997, the levy is based solely on the CO2 content of the fuels used (Prime Minister's Office 2000, p.36), which favours electricity produced from renewable sources. Finally, the electricity tax is levied at a lower rate for industries, which can also, under certain conditions, claim a rebate (Prime Minister's Office 2000, p.36).

To balance the impacts of the energy tax, a number of tax subsidies have also been introduced gradually. Since 2003, nearly all energy produced from renewables receive a tax subsidy, with recycled fuels, biogas and forest chips, being eligible since 2007. A different rate applies for production from different sources, ranging from 0.25 €/kWh for production from recycled fuels, to 0.69 €/kWh for production from wind power and forest chips in 2015 (IEA 2015).

Finally, there are three taxes on motor vehicles in Finland: (i) a tax levied at the moment of purchase, (ii) an annual vehicle tax, and (iii) an annual motor tax applied to vehicles not powered by petrol to compensate for the lower excise tax on diesel (Prime Minister's Office 2000, p.38-9). Since 2008, the tax has been calculated based on emissions (CO2/g/km), ranging from 5% for cars with no emissions, to 50% for cars that emit more than 360 g/km. The tax is technology neutral (IEA 2010), benefitting all low emission vehicles.

ANNEX IV: TABLES

Table 1 Knowledge Development Instruments by country. Source: IEA Policies and Measures, own recollection.

Country	Type	Name	Organization	Amount	Area
Sweden			Swedish Energy Agency	€140 M	Six sectors including transport
Sweden	Subsidy				Electric bicycles
Sweden	Subsidy	Eco-car		SEK 10,000	Vehicles powered by biofuels and hybrids
Sweden	Subsidy	Long Term Energy Policy Programme		€36 M/y	Biomass research, development and demonstration
Sweden	Grant			SEK 21M/y	Wind, Bioenergy, Bioenergy, Biomass for heat, Bioenergy, Biomass for power, Hydropower, Multiple RE Source
Sweden	R&D		Swedish Government and vehicle manufacturing companies	SEK 1800M/5y	Several subprogrammes, including on advanced combustion technology, fuel-cell technology and electric-hybrid vehicles.
Austria	Premiums		The Federal Ministry of Economic Affairs and Labour	€37M for 2004	For electricity output from renewables
Austria	RD&D			€3M in 1996 (50M ATS)	Projects on the direct use of biomass (e.g., by improving wood-burning stoves), as well as the production of liquid biofuels
Austria	RD&D	Austrian Programme for Technologies for Sustainable Development	Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT)	€7M	Spent in the new A3-Technology Programme (Austrian Advanced Automotive Technology) for new propulsion systems, energy efficient auxiliary devices and alternative fuels.

Austria	RD&D	MOVE -- Mobility and Transport Technology	Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT)	€2.9 M/y	Projects in the field of transport and mobility by funding demonstration projects capable to trigger innovation in the transport system.
Austria	Subsidy	Federal Environment Fund		€25.5 M in 2003	Renewable Energy
France	Tender		Ministry of Environment, Energy and the Sea		In 2016, a new tender has been launched to cover period of three years to acquire following volumes: 10 MW/year for biogas projects and 50 MW/year for biomass projects – of which 10 MW of capacity are dedicated for small projects with individual capacity up to 3 MW each
France	Feed-in Tariff		Ministry of Environment, Energy and the Sea	EUR cents 4.34/kWh	For electricity produced from biomass. FIT support was (until 2016) open for vegetable and animal agricultural waste, algae and some industrial biomass waste (pulp and paper, wood industries) projects.
France	R&I		Ministries of Ecology, Industry and Research; National Research Agency (ANR), Environment and Energy Management Agency (ADEME), SME innovation Agency (OSEO)	€145 M in 2012	To finance projects that reduce CO2 emissions, improve data on pollution and its effects, and in the longer term coordinate research into very energy-efficient, low- or zero-carbon dioxide emitting vehicles, particularly trucks.

France	Demonstration fund		Ministry of Ecology, Energy, Sustainable Development and Territorial Planning; the Ministry of Higher Education and Research; the Ministry of Economy, Industry and Employment, and is managed by the French Environment and Energy Management Agency, ADEME	€400 M over four years	For 2008, the fund will have three calls for proposals in following areas: -Carbon capture and storage - Renewable energy (2nd generation biofuels) - Innovative transport systems, with low energy consumption and/or reduced greenhouse gas emissions. Eligible technologies are: production by thermochemical means, essentially based on pyrolysis gasification, and production by biological means, based on enzyme hydrolysis and/or fermentation.
France	R&D			€100 M over five years	To further promote vehicles powered by electricity, natural gas and hybrid fuels
France	Demonstration projects			up to 30% of costs	The programme covers wood-energy for industrial boilers, collective and individual household heating; biogas recovery for energy production, electricity from renewables, geothermal heat and ground source heat pumps as well as solar energy.
France	R&D	Clean Vehicles plan		€40 M	To accelerate the commercial viability of less polluting and more energy efficient vehicle; - Provide an additional incentive to encourage the promoting of alternative energy vehicles.
France	Fund			20M francs a year	new technologies and processes to convert biomass to fine chemicals to substitute fossil fuels.

France	Feed-in Tariff			between EUR cents 5/kWh EUR cents 14/kWh is offered for a period of 15 years (since 2011)	for biomethane injection into the natural gas grid
Finland	RD&D				The main objective of the BIOENERGY programme was to develop new technology solutions for biomass fuels. The BIOENERGY research programme resulted in three new final harvest methods already in commercial usage: the MOHA chipper lorry, CHIPSET chipharvester and EVOLUTION multi-purpose chipharvester

Table 2 Financing Instruments at EU level. Source: JRC 2013.

Instruments	**Organisations**	**Type**	**Suitable?**
Loans and Guarantees	European Investment Bank (EIB)	Standard or RDI Investment loans	Yes, in principle, but limited to moderate risk levels
Loans and Guarantees	European Investment Bank (EIB)	Intermediate loans	Limited
Loans and Guarantees	European Investment Bank (EIB)	Guarantees	Limited
Loans and Guarantees	Joint European Commission/EIB	Project bonds initiative	No, because focus is on commercially proven projects
Loans and Guarantees	Joint European Commission/EIB	Risk sharing Financing Facility	Limited
Loans and Guarantees	Joint European Commission/EIB	Connecting Europe Facility	Limited
Loans and Guarantees	Joint European Commission/EIB	EURATOM loans	Limited to nuclear fission
Loans and Guarantees	European Bank for Reconstruction and Development (EBRD)		Limited to Central and Eastern Europe and with moderate risk level only
Equity	Marguerite Fund		Very limited, financing usually only available for commercially viable projects

Equity	Venture Capital		No, investment amounts too low
Insurance/ reinsurance products			Very limited in terms of risk taking. Potentially as a long term investor
Grants	EU	European Energy Programme for Recovery	While for innovative offshore wind technology projects EEPR grants managed to mobilise additional capital, for CCS, this was not the case , notably due to that industry not being ready, the absence of favourable market conditions (low carbon emission rights prices), and a regulatory framework which would have allowed building a business case, EEPR in CCS particularly illustrates the lack of co-ordination and mobilisation of private sector resources .
Allowances	EU Emission Trading Directive	NER300 programme	

Table 3 Support Mechanisms. Sources: EC 2013, UPEI Biofuel Matrix 2018, and GSI 2007

Country/ Mechanism	R&D subsidy	Tax Exemption	Feed-in tariffs/ fixed Premiums	Tendering schemes	Obligations (certificates)/ Mandatory supply	Mandatory Advanced Biofuel Targets	Quotas/ TGC	Support to consumption
Austria	✓	✓	✓		✓			
Finland	✓	✓			✓	✓		
France	✓		✓	✓	✓			✓
Sweden	✓	✓			✓	✓	✓	✓
✓ Source: EC 2013, p.24								
✓ Sources: Biofuel Matrix from UPEI and GSI 2007								

Table 4 Financial Mechanism in different stages up to 2007. Source: GSI 2007

Country	**Description**	**Fuels**	**Category**	**Limitations/Other eligibility criteria**	**Subsidy Rate**
Assistance to outputs (excise-tax exemptions)					

Sweden	(i) Tax exemption to 2013. The exemption is applicable to biofuels in pure form or on the biofuel portionof blended fuels. (ii) Tax exemption, 2003 to 2007, for fuels produced by pilot plants aimed ar promoting the development of environmentally friendly fuels. The annual cost to the government is estimated to be about €16.5 million (SEK 150). In 2005, this scheme was granted a one-year extension, until end 2008.	(i) All CO2-neutral fuels (ii) Biofuels	Fiscal measure	(ii)Ethanol related projects must be approved by the European Commission	(i) Biodiesel: €390 per 1,000 litres. Ethanol: €530 per 1,000 litres. (ii) Biofuels replacing petrol: a maximum of €470 per 1,000 litres. Biofuels replacing diesel: a maximum of €320 per 1,000 litres
Finland	A tax reduction was provided to two demonstration projects in 2004	Ethanol	(i) Fiscal measure. (ii) Direct payment		Tax on the ethanol component in blends of ethanol and petrol was reduced by 30cts per litre.
Austria	Tax exemption for pure biofuels until 2011. E85 exempt from mineral oil tax.	Biodiesel, ethanol, vegetable oil	Fiscal measure	(ii) 2005 quota (litres) Ethanol: 11,392,000, Biodiesel 12,500,000	Biodiesel: €325 per 1,000 litres. Ethanol €445 per 1,000 litres

France	(i) Partial tax exemptions are applied to quantities of biofuels within a production quota (ii) The distributors are required to pay the General Tax on Distribution Activities (TGAP) if they fail to comply with biofuel incorporation objectives (iii) A reduced excise tax is applied on the biodiesel component of B30 (note: B30 is authorized only for use by public and commercial fleets) (iv) The ethanol component of E85 is exempt from the excise tax, and the gasoline component benefits from a reduced excise tax.	Biodiesel, ethanol, ETBE	Fiscal measure	(i) 2007 quota (tones): Biodiesel: 1,342,503. Ethanol: 337,147. ETBE: 224,648 (ii) Within quota biofuels must be produced by government-designated operators, allocated by public tender.	(i) As of 2007 within-quota production: Biodiesel €250 per 1,000 liters. Ethanol: €330 per 1,000 liters. ETBE: €330 per 1,000 liters. (ii) TGAP rate increases each year, from 1.2 percent in 2005 to 5.75 percent in 2010 (iii) Biodiesel component of B30: €25 per 1,000 liters. (iv) E85: Zero tax on ethanol component, €33,43 per 1,000 liters in gasoline component (compared with €60,69 on regular gasoline)
Finland	A tax reduction was provided to two demonstration projects in 2004	Ethanol	Output payment		Tax on the ethanol component in blends of ethanol and petrol was reduced by 30cts per litre.
Assistance to value-adding factors (capital, land, labour)					

Austria	(i) Biofuel production facilities can receive support under the Austrian Rural Development Programme, where farmers own at least 51 percent of the facility in question. (ii) Investment support is also available through domestic environmental support measures, applicable where farmers do not have majority ownership.	Biodiesel, ethanol	Capital grants	(i) At least 75% of the biomass must be derived from the local region	(i) A maximum of 55% of the total investment for private or community facilities can be subsidised. (ii) A maximum of 30% of the investment costs can be subsidised.
Finland	The ministry of Trade and Industry may grant investment aid (energy aid) to businesses and the non-corporate sector to promote the use of renewable energy sources, including biofuels.	Renewable fuels	Capital grants		
Sweden	Investments in renewable fuels, in response to Swedish biofuel obligations, can receive a subsidy.			The subsidy may not exceed the investment cost minus the lowest cost needed to fulfil the requirement.	Up to 30% of the total investment cost can be financed.
Support for intermediate inputs (feedstocks)					

EU-15	(i) Since 2005, producers of oilseeds and cereals have received support through the Single Farm Payment system, through oayments decoupled from production. Farmers can also grow oilseed crops on land that cannot be used for food crops (set aside land). New EU members do not benefit until 2013. (ii) The Energy Crop Scheme offers producers incentives to grow crops for energy use, including biofuel production. The scheme was introduced in 2003 for the EU-15 but was extended to all EU members in 2006. (iii) Since 1999, 'crisis distillation of wine' has been used to dispose of wine surpluses. The alcohol must be disposed of outside the potable alcphol market, either for industrial or energy uses. In 2005, 7.8 million hectoliters were removed via this mechanism. Approximately 30 percent was dedicated to ethanol fuel, which increased to 50 percent in 2006.	(i) Biofuels (ii) Biofuels (iii) Ethanol	Feedstock subsidy	(ii) The maximum elegible area is 2 hectares.	(i) Because payments are decoupled from production, these subsidies cannot be quantified. (ii) €45 per hectare (iii) €13 per hectolitre of wine, paid to distillers. €11 per hectoliter of win for storage and disposal costs.

General services (Research and Development)					
EU	The EU Framework Programmes define the Commission's activities in the field of research, technological development and demonstration. The total budget of the Sixth Framework Programme (2002-2006) was €17.5 billion and €53.2 billion for the Seventh Framework Programme (2007-2013)	Biofuels	R&D		(i) Sixth Framework Programme: €72.5 million for biofuel related projects (ii) Seventh Framework Programme: amounts for biofuel projects not yet available
Austria	Research funding is provided both at state and federal levels. More than half of the funds were provided by the government and various funding organisations. Universities and research insitutes (which are partly publicly financed) accounted for the remainder.	Biofuels	R&D		Research spending on liquid biofuels was approximately €253,000 in 2003 and €186,500 in 2004

Finland	(i) The technology Development Centre provides funds for R&D through Technology Programmes and selective project financing. (ii) The Finnish Parliament approved €9 million for 2006, for Biofuels the development of novel second generation production technologies	(ii) Biofuels	R&D		
France	(i) The government sponsored scientific interest group *Agriculture for Chemicals and Energy* (AGRICE) funds and monitors research and development in the area of biofuels and bio-additivities. (ii) Since 2005, the National Program for Research on Bioenergies has funded 23 projects on biofuels.	Biofuels	R&D		(i) Public funds allocated to biofuels during AGRICE's initial eleven years of activity, 1994 to 2005, amounts to over €7.2 million (ii) Public funding dupport totalled €16.5 million

Sweden	The Swedish government supports research, development and demonstration measures for developing more energy-efficient and more cost-effective processes for the production of biofuels.	Biofuels	R&D		Funds provided vary from year to year, but are estimated to amount to at least €5.5 million a year.
Support to consumption (distribution infrastructure, biofuel vehicles, biofuel use)					
France	(i) Favourable tax measures are in place since 2006 to support ownership of FFVs. (ii) The government created an enhanced capital allowance for investments in fuels stations and deposits.	(ii) Biofuels	(i) Alternative fuel vehicles (ii) Distribution infrastructure		(i) Full exemption from the vehicle tax on FFVs for business use for 2 years, enhanced capital allowance over a 12-month period, relief of between 50 to 100 percent of the proportional tax on registration certificates; relief of 50 percent of the additional tax on registration certificates.

Sweden	(i) From 2002 until 2008, company cars powered by alcohol or gas other than diesel qualify for a tax reduction. (ii) "Clean cars" enjoy free parking in several cities and are also exempted from the recently introduced congestion charge in Stockholm. (iii) From 2006 onwards, the largest petrol stations must sell renewable fuels, a requirement that will be extended to additional petrol stations in 2009	(iii) Renewable fuels	(i) Alternative fuel vehicles (iii) Mandatory supply, capital grants		(i) 80%reduction tax reduction relative to that for the most closely comparable conventional cars. (iii) Operators investing in the distribution of renewable fuels can receive a 30% subsidy on investments
Mandatory supply requirements					
Austria	2.5% in 2006, rising to 5.75% by 2010	Biofuels	Mandatory supply		
Finland	2% in 2008, rising to 5.75% by 2010	Biofuels	Mandatory supply		

Table 5 Excise duty values per country. Source: ePure 2016

Country	**Excise duty EUR/1000 litres**							
	Unleaded Petrol	**Diesel**	**Ethanol (1G)**	**Ethanol (2G)**	**FAME (1G)**	**FAME (2G)**	**HVO (1G)**	**HVO (2G)**
Austria	<=10mg/kg (sulphur content): 482, >10 mg/kg: 515	(i) with a minimum biofuel content of 66 l and sulphur content <=10mg/kg: 397. (ii) otherwise: 425						
Belgium	95 oct: 619.1026 >=98 oct low sulphur level: 619.1026. <=98 oct high sulphur level 634.2379	>10 mg/kg: 479.9698. <=10 mg/kg						

Bulgaria	363.02	330.29	More specific on mixes					
Croatia	505.25	400.52						
Cyprus	479	450						
Czech Republic	472.53	402.97						
Denmark	547.3	354.9	More data on Tax on CO2 and VAT for unleaded petrol and diesel					
Estonia	465	448					340.3	252.4
Finland	681.3	506.1	396.1	342.8	378.9	293.6		
France	<95 oct: 641.20	498.1						
Germany	654.5	470.4						
Greece	670	330						
Hungary	383.63	352.78						
Ireland	587.71	479.02						
Italy	728.4	617.4						
Latvia	436	341						
Lithuania	434.43	330.17						
Luxembourg	<=10mg/kg: 462.09, <10mg/kg 464.58	<=10mg/kg 335, <10mg/kg 338.3548						
Malta	549.38	472.4						
Netherlands	769.9	484.47						
Poland	393.18	343.64						
Portugal	617.51	402.01						
Romania	461.92	429.6						
Slovakia	514.5-550.52	368-368.4						
Slovenia	545.25	462.4						
Spain	<98 octane: 424.69 (+ an additional duty of up to 48€ as regional charge) >=98: 455.92 (+ an additional duty of 48€ as regional charge)	331 (+ an additional duty of up to €48 as regional charge)						
Sweden	1a: 482.11, 1b: 673.04, 2: 676.24	1:592.93, 2: 622.69, 3: 638.16						
United Kingdom	674.15	674.15						

ANNEX V: QUESTIONNAIRE

ART Fuels Form Project for issues on Financing and Taxation

Questionnaire prepared by Sofia Rosero, Eric van den Heuvel, studio Gear Up,

24 May 2018

This is a questionnaire created as part of the ART Fuels Forum project for Financing and Taxation issues. It is part of the activities Eric van den Heuvel presented at the October 2017 ART Fuels Forum meeting in Brussels.

We would highly appreciate receiving your insights. The information obtained from your answers to this questionnaire will be used as input for a report on Financing and Taxation issues. In this way your input serves the building up of the collective intelligence of the ART Fuels Forum community.

Preliminary outcomes, based on responses received before May 31st, will be presented at the Third Plenary Meeting of the ART Fuels Forum in Brussels, in June 2018.

The report will be finalised before the ART Fuels Forum meeting in the second half of this year.

Besides the responses to this questionnaire we also would like to ask if you could provide us up to three names of representatives of financing organisation, whom we would like to send some questions on their view on various risk issues related to advanced biofuels and renewable fuels (risks associated with political, economic, social, technological, environmental and legal issues).

Please provide your responses to sofia.rosero@studiogearup.com and eric.vandenheuvel@studiogearup.com

Many thanks in advance!

Foreword

At the beginning of the S-curve, where the technology requires support for research development and deployment, innovation support instruments and R&D subsidies are necessary. As the technology develops and enters the upper-part of the S-curve, different financial support is needed if the technology is about to enter the market or has entered the market with first-of-a-kind facilities and aims to acquire economies of scale for further deployment.

The purpose of this questionnaire is to collect your insights on existence, and experience with regards to the financing and taxation tools available for the support of advanced biofuels and renewable fuels in the EU. Furthermore, we would like to identify the potential of learning by exchange among sectors and to identify the risks and opportunities for project financing in the upper part of the S-curve.

Questionnaire

0. What is the country in which you operate?

Please provide your opinion on the financial support instruments providing a feedback for the following questions.

Introduction

1. Which financial support instruments are known to you in the road, railway, aviation and maritime sectors for renewable technologies in the country you operate? Could you specify which stage of development do they support? (**1.** R&D, **2.** Early Market/Start up, **3.** Mass Market/Competition) Please add rows if needed.

no.	Description of Mechanism/ instrument	Please indicate sector (one or more if applicable): **RD** = Road **RW** = Railway **A** = Aviation **S** = Shipping	Indicate stage: **1** = R&D **2** = Early Market/Start up **3** = Mass Market / Competition
1.			
2.			
3.			
4.			

2. For which of the above mentioned instruments have you applied to obtain financial support? Please specify, add rows if needed.

Mechanism (Please refer to the mechanisms using the numbers from the table in question 1 above)

3. Are you aware of instruments used in certain transport or other sectors (e.g. biomass for electricity generation) that could be applicable for scaling up biofuel projects? Please answer for the country you operate and at EU level, if any.

Mechanism	Sector

Mechanisms

4. What mechanisms do you think are necessary to bridge the cost-price difference between fossil fuels and advanced biofuels?

Your input/remark:

5. What mechanism(s) do you think are better suited to overcome the investment barrier and introduce advanced biofuel/renewable fuels capacity in the market?

Your input/remark:

6. How would you rate the following mechanisms for their effectiveness as a support instrument in each stage? Please evaluate each instrument for its own merits. (1= not valuable, 5=very valuable; more than one mechanism can have the same rating):

Mechanism	Stage		
	R&D	Early Market/Scale up	Mass Market/Competition
R&D subsidy			
Investment Subsidy			
Soft loans			
Loan (guarantee)			
Tax Exemptions			
Price Guarantees			
Feed-in tariffs/fixed Premiums			
Tendering schemes			
Public procurement[46]			
Obligations (certificates)			
Environmental Standards[47]			
Emission Trading			
Other, please specify			

7. Taxation advantages are national policy measures that have sometimes been used to give an incentive to the use of biofuels. At what stage of development do you think a taxation advantage should be introduced?

Your input/remark:

8. What do you think are the characteristics that a taxation regime should have to be able to bring renewable fuels and advanced biofuels to the market? and to compete with fossil fuels? Which elements do you think should be included in an adjusted taxation regime?

Your input/remark:

9. When do you think it can be reasonably assumed that advanced biofuels and renewable fuels' technologies will have reached full commercialization (from the point of view of finance providers) and what kind of policy support is best suited to achieve it?

Your input/remark:

[46] This option refers to offtake-contracts for biofuels by (semi-)public organisations, e.g. municipalities
[47] This mechanism refers to either (i) quotas for production of biofuels, or (ii) for performance indicators, e.g. setting a cap on the allowed carbon intensity of fuels provided to the market, thus creating a market for biofuels with a low Well-to-Wheel carbon intensity

Current Situation

10. Do you think there are enough support mechanisms for the different stages of the S-curve? (R&D, Scale-up/Early Market, Mass Market/Competition). Please indicate whether your answer refers to advanced biofuels and/or to renewable fuels.

Your input/remark:

11. Some perceive that there is a gap for support mechanisms for scale-up of advanced biofuels and renewable fuels. Do you agree? If yes, how do you think it could be overcome?

Your input/remark:

Investment

12. To what extent do you think policy instruments for the later part of the S-curve enable investors to create 'bankable' projects, i.e. projects that meet the requirements for project financing?

Your input/remark:

13. How do you think the different financial mechanisms inspire or affect investor confidence?

Your input/remark:

14. What do you think is required to open the investment window for new biofuel and low-carbon facilities?

Your input/remark:

Risk

15. How do you assess *systemic* risks for investment (i.e. future crude oil prices, raw material prices, future uncertainties on policies, stakeholder loyalty)?

Your input/remark:

16. How do you assess *internal* risk (levels of profitability, access to liquidity reservoirs, diversification or specialisation of the business)?

Your input/remark:

17. In your opinion, are *systemic* or *internal* risks more influential when deciding whether to invest or not?

Your input/remark:

18. How do you think the development of other fuel sources (fossil fuels, electricity) affect the investment on biofuels? What are the actors involved in this "trend"? (e.g. oil companies?)

Your input/remark:

19. How does the opinion of other stakeholders (e.g. farmers, NGO's) affect the possibilities for investment on advanced biofuels?

Your input/remark:

Lessons Learned

20. Have you been involved in the NER300 application project? What can you learn from the NER300 facility? Many viewed the NER300 facility as failed. Do you agree, and if so what in your view caused its failure?

Your input/remark:

21. Which countries can learn from? Why? What are the conditions that made its success remarkable?

Your input/remark:

Financing

22. Do you think that governmental support affects the ability to attract private sector financing? If so, how?

Your input/remark:

23. What is the future outlook for conversion technologies associated with biofuels? Which conversion technologies do you see entering the market in the next 10 years?

Your input/remark:

24. If you were involved in a project at the moment that would require financial support, which instrument(s) would you expect to get finance from?

Your input/remark:

This is the end of the questionnaire.

We thank you very much for completing the questionnaire and will provide you with the insights as soon as possible.

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