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The Potential of Biofuels Corridors on the Trans-European Transport Network Roads

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Executive Summary

The European Union (EU) transport sector and its policymakers are presently being confronted with two crises: fossil-fuel dependency and environmental degradation. The EU has introduced the two Directives 2003/30/EC and 2009/28/EC to increase the sustainability of the transport sector in relation to these issues. The directives require Member States (MSs) to set targets for the share of renewable energy in transport which is to replace petroleum-based fuels, and thus help to reach the mandatory level of ten percent by 2020. Biofuels are considered to be the most viable option to meet these targets. This research outlines the issues to be tackled when considering increases in biofuel usage and examines a potential scheme with the objective of achieving an increase in the use of biofuels in the road transport sector; the development of EU biofuels corridors. An EU biofuels corridor is defined as a long-distance and cross-border route on the Trans-European Transport (TEN-T) Network roads on which blends with a high biofuel content (referred to as high-blends) are offered regularly along the entire length of the route.

The study begins with an overall examination of the future potential of biofuels in the EU. Then, the potential and feasibility of EU biofuels corridors is assessed by means of a case study for one specific corridor on the TEN-T Network roads: the Rotterdam-Constanta route. Stakeholder interviews serve as input for these analyses. Subsequently, the outcomes of this case study are generalised to other corridors to determine their potential at the EU level.

Key findings of this research are:

- The potential of biofuels to reduce greenhouse gas emissions and fossil-fuel dependency is high, yet the growth of biofuels use in transport will presumably occur gradually as it follows the targets set in the Renewable Energy Directive 2009/28/EC (RED). This restricted growth is due to the economic, environmental and social barriers present-day biofuels raise and which need to be overcome before their use can be widespread.

- The scope of biofuels corridors will presumably be limited to future scenarios in which high-blends become an important part of MS strategies for achieving the RED targets. Many alternatives exist for achieving these targets and national action plans, due in mid-2010, are expected to provide more certainty regarding the future role of high-blends.

- The expected displacement of conventional fuels by biofuels on the Rotterdam-Constanta route as a percentage of the total fuel use on this route by means of biofuels corridors is limited, because only a small share of road users actually refuels at corridor fuel stations (14 percent). Instead, most refuelling takes place at local stations. Besides, the speed at which the share of biofuel-compatible vehicles can be increased, is limited.

- Major economic and policy barriers need to be overcome if high-blends are to be focussed upon. Economic barriers mainly include increasing the share of biofuel-compatible vehicles and securing competitive prices for high-blends. This, in turn, requires a robust policy to encourage their promotion.

Based on the results, it can be concluded that the extent to which biofuels corridors can increase the use of biofuels is limited, as, even if biofuels corridors were to be implemented on the entire TEN-T Network, estimations point to a maximum contribution to the RED targets of just one or two percent. The limited contribution is due to the fact that the enormous transport flows are not representative of the actual fuel sales at stations on the network; most corridor users refuel locally. Besides relatively low demand, the viability of biofuels corridors for an open market seems to depend on a future public policy focus on high-blends, which, according to the analyses, would be rather ambitious. There are many other alternatives available to stimulate the use of biofuels, including increasing the allowable percentage of biofuels to be blended in conventional fuels. These would, from the perspectives of various stakeholders, be more favourable than focussing on high-blends alone. The future role of high-blends, however, will presumably become clearer when national RED action plans are presented. In these scenarios, biofuels corridors could be implemented and would mainly serve to increase the awareness of biofuels among road users. Furthermore, they could encourage international cooperation in fuel standards and taxation.

A scenario in which only a small share of the RED targets is to be achieved by high-blends is, however, more realistic. The most promising *corridor* scenario to accommodate these would be one which incorporates a focus on a captive freight transport fleet (i.e. Corridor Scenario 1). Aside from being more realistic than the others, Corridor Scenario 1 would also be more cost-effective in terms of vehicle costs and easier to develop than corridor scenarios for the open market. Furthermore, the results of this study indicate that, particularly for the freight truck market, it may not be too difficult to increase demand further. Trucks mainly refuel at predefined truck stops or have their own fuelling infrastructure, and the fuel used by the sector is sufficiently high to warrant dedicated logistics. By focussing on these market segments as well, preferably located close to the main corridors, the measure could become more effective in contributing to the EU targets. The main challenges in ensuring the success of this extended corridor scenario lie within the cooperation of the various stakeholders that are involved.

Several recommendations can be made. First among these recommendations is to reconsider the implementation of biofuels corridors for the open market once there is more certainty regarding the future role of high-blends. Secondly, the conclusions show that biofuels corridors, including other market segments than corridor stations alone, for the freight truck market could be promising and it is thus recommended that further research be conducted into realising this concept. Thirdly, the corridor approach could be transferred to other modes of transport, as well as to other sustainable transport alternatives.

Summary

Introduction

The European Union (EU) transport sector and its policymakers are presently being confronted with two crises: fossil-fuel dependency and environmental degradation. Well over 95 percent of transport relies on crude oil and the process of burning these oil products in combustion engines is a key contributor to global greenhouse gas (GHG) emissions. EU transport accounts for approximately 21 percent of GHG emissions and this percentage is rising (EC, 2006). Awareness of the consequences of using petroleum-based fuels in transport is increasing rapidly: oil prices are expected to increase significantly over the coming decades; over 80 percent of the oil used within the EU is imported from politically unstable regions; and, the negative environmental and health effects of using petroleum-based fuels are becoming more visible.

The EU has applied several measures to increase the sustainability of the transport sector in relation to fuel dependency and environmental effects. They originate from the common transport policy, documented in the 2001 EU White Paper – 'European Transport Policy for 2010: Time to Decide' – and its 2006 Mid-Term Review. Furthermore, the 2003/30/EC and 2009/28/EC Directives (accompanied with a comprehensive strategy) were introduced, and are now the key pieces of EU legislation regarding the use of renewable energy in transport. The directives require Member States (MSs) to set targets for the share of renewable energy in transport which is to replace petroleum-based fuels, and thus help to reach the mandatory level of ten percent by 2020. Biofuels are considered to be the most viable option for meeting these targets and, nowadays, they account for almost three percent of total EU fuel consumption. This share is growing, but the implementation progress of the directive must be accelerated in order to meet the EU targets.

Most biofuels are now blended with petroleum-based fuels. One way to stimulate and achieve an increased use of blends with a high biofuel content or pure biofuels (referred to as high-blends) is to offer them on EU long-distance road routes on the Trans-European Transport (TEN-T) Network roads. One may refer to such routes as 'biofuels corridors'.

The idea of implementing high-blends by means of biofuels corridors has not yet been adopted in the EU, which gives rise to the central research question of this thesis: *To what extent can biofuels corridors on the Trans-European Transport Network roads increase biofuels usage in the EU and is their implementation viable from a technical, economic and policy perspective?*

Methodology

The potential and feasibility of EU biofuels corridors is assessed by means of a case study for one specific corridor on the TEN-T Network roads; the Rotterdam-Constanta route. Subsequently, the outcomes of this case study are generalised to other corridors to determine their potential at the EU level.

The study begins with an overall examination of the future potential of biofuels in the EU. With this information, the future role of EU biofuels is determined and a solid background for further analyses is created. To design biofuels corridors, various design parameters of biofuels corridors are identified and inserted into four future scenarios in which high-blends will play a prominent role in achieving the EU renewable energy targets. Subsequently, a specific corridor is selected based on various criteria and the characteristics of this corridor are identified. The predefined parameters (based on the scenarios) are then applied to this corridor, which results in the creation of four biofuels corridor designs. The potential and feasibility of these corridor designs is assessed by means of a SWOT analysis, as well as market, technical, economic and policy options analyses. Information for these analyses was obtained from interviews with various stakeholders closely associated with the concept of biofuels corridors (e.g. the European Commission (EC), oil companies, ministries and road transport companies). The case study results are then transferred to the wider TEN-T Network and the potential contribution and feasibility of EU biofuels corridors is determined, providing an answer to the central research question.

Transport Biofuels: The State of Play

Owing to strong government support, the share of biofuels in EU road transport, predominantly ethanol and biodiesel, has grown rapidly in recent years. The emerging biofuel incentives, mandates and barriers, which have come about as a direct result of the EU Directives, have strengthened the market. Moreover, the future potential of EU biofuels, in terms of reducing GHG emissions and providing energy-security, is far from being reached.

Despite these advantages, the use of transport biofuels is currently surrounded by global controversy. There is an ongoing discussion on the extent to which biofuels, in particular so-called first generation biofuels, are sustainable, from an economic, environmental and societal perspective.

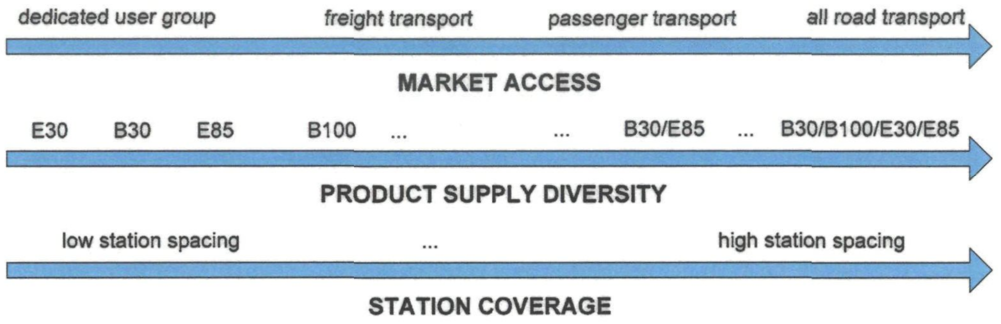
The potential role of biofuels in contributing to the EU sustainable transport policy objectives depends, therefore, on the development of crucial factors which have been identified. These factors determine the sustainability of biofuels and include market drivers, developments and research into the production technology of next generation biofuels, and developments in other renewable energy sources for transport. They are also relevant to the feasibility of biofuels corridors. If support for biofuels were to be withdrawn, biofuels corridors would no longer be feasible.

Assumptions are made regarding the developments of these crucial factors in a way that the future role of biofuels is determined by the Renewable Energy Directive 2009/28/EC (RED) targets. These assumptions are strengthened by various measures which have also been introduced in the RED, such as the EC's sustainability criteria for biofuels, for example. Thereby, a plausible framework for further (national) biofuel policy and practical implementation is created, which biofuels corridors could serve to consolidate.

Design of Biofuels Corridors

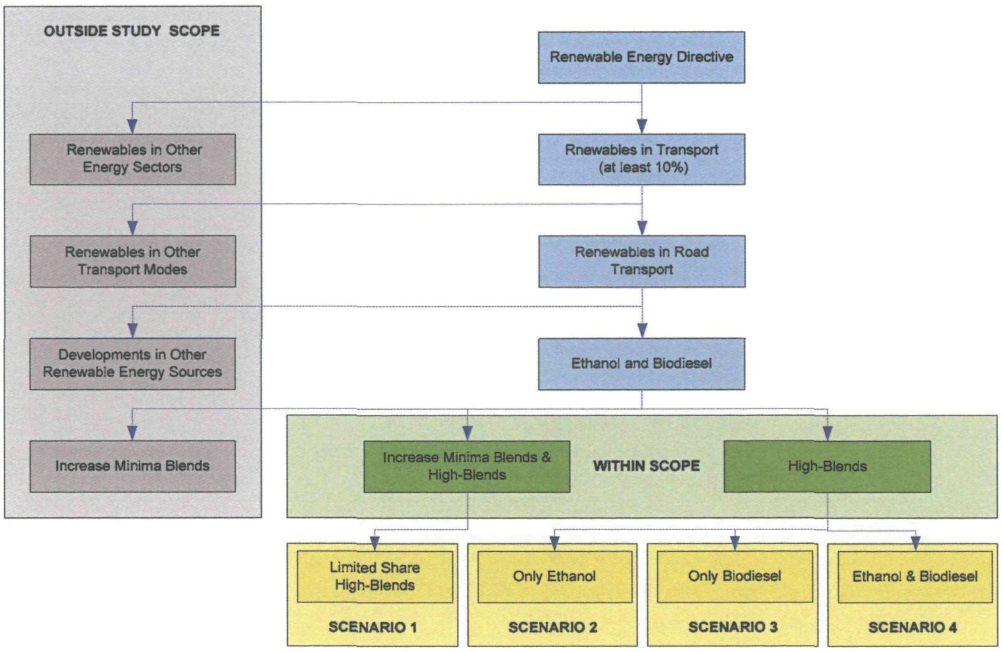
One can systematically create and distinguish between different biofuels corridor designs by changing the input value of three design parameters: market access, product supply diversity, and station coverage (see Figure 0.1). Market access represents the percentage of corridor users that is permitted or able to refuel with biofuels on the corridor; product supply diversity represents the different biofuel types and corresponding blends offered on the biofuels corridor; and station coverage defines the intensity of stations that offer biofuels on the corridor.

Figure 0.1 Three Design Parameters for the Creation of Biofuels Corridors



A scenario analysis is used to narrow down the amount of possible design configurations with regards to their future viability (see Figure 0.2). The analysis anticipates the interpretation of the RED and defines four policy scenarios which would be conducive to the development of biofuels corridors.

Figure 0.2 Scenario Analysis for the Promotion of High-Blends



The input values of the design parameters are chosen in such a way that they are able to accommodate each of the future scenarios. This results in the definition of so-called 'corridor scenarios' (see Table 0.1). These values can be applied to any TEN-T Network road corridor to develop EU biofuels corridor designs. This has been done for the corridor selected for the case study; from Rotterdam to Constanta. In addition, fuel use by corridor users, biofuels policy in the MSs involved, and this corridor's refuelling infrastructure are examined.

Table 0.1 Definition of Corridor Scenarios

Parameter	*Corridor Scenario 1*	*Corridor Scenario 2*	*Corridor Scenario 3*	*Corridor Scenario 4*
Product Supply Diversity	B100 Biodiesel	E85 Ethanol	B30 Biodiesel	E85 Ethanol B30 Biodiesel
Market Access	Restricted Freight	All Gasoline	All Diesel	All Transport
Station Coverage	Low coverage	High coverage	High coverage	High coverage

Feasibility Study: Rotterdam to Constanta

A SWOT analysis based on stakeholder interviews is conducted for EU biofuels corridors. The factors which are identified include potential positive aspects (e.g. increase of the use of biofuels) and aspects which could hamper the introduction of biofuels corridors (e.g. developing a biofuel-compatible vehicle fleet and public support policy). The SWOT leads to several other analyses being conducted in order to assess the potential and feasibility of each of the Rotterdam-Constanta biofuels corridor designs. Moreover, a stakeholder analysis has also been carried out to supplement the quantitative analyses with qualitative data in order to ascertain how likely it is that certain measures or policies will be adopted or accepted.

Firstly, the market analysis shows that demand for high-blends on the corridor, as a percentage of total fuel use by corridor users, is limited to a maximum of approximately four percent. The main reason is that corridor users mostly refuel at local fuel stations instead. Secondly, the technical analysis indicates that the vehicle and infrastructure technology required for the use of high-blends is available, but their large-scale implementation would face (economic-related) barriers. Thirdly, the economic analysis indicates that a single biofuels corridor for an open market (i.e. Corridor Designs 2, 3, and 4) would not be cost-effective, because of high vehicle-related costs. A low share of biofuel-compatible vehicles would reduce demand, which, in turn, would be insufficient to make fuel companies offer high-blends. Fourthly, the policy options analysis shows that several policy options exist to create a policy environment which is conducive to the development of high-blends and thereby of the biofuels corridor. A biofuel-compatible vehicle fleet could be established by subsidies or using regulatory methods. Furthermore, at the initial development phase, there would be a role for public policy to make the supply of high-blends on the corridor attractive. These policy measures would, however, involve a robust public policy which would potentially require high amounts of public money being spent.

Based on these analyses, it is concluded that the effectiveness of the Rotterdam-Constanta biofuels corridor as a way to increase the use of biofuels is limited. The main reason is that corridor users rarely refuel at stations on the corridor (approximately 14 percent), which reduces potential biofuels sales. The market analysis therefore implies that, if high-blends are to be focussed upon, a large market penetration would also involve other stations, away from the corridor, to offer biofuels. Besides, Corridor Designs 2, 3, and 4 present economic and policy barriers, which require a strong vision and policy towards the use of high-blends. Several options could help to overcome these barriers, but, due to the fact that these would require large amounts of public money, their actual implementation is less realistic. Moreover, several experts have indicated that the use of high-blends on a large scale to meet RED targets is a rather sub-optimal solution, as many other alternatives would be easier to achieve. Only if high-blends were to be marketed en masse, could the biofuels corridor for the open market be implemented. The main barrier to creating a significant market of biofuel-compatible vehicles would then be reduced. The primary advantages of the corridor approach would lie in the externalities such as making biofuels more recognisable among road users and promoting them, rather than in a significant increase in biofuels use.

Corridor Design 1, however, which focuses on a captive freight fleet, would be easier to implement and its corresponding scenario more realistic. Although the concept would still require additional policies and certain conditions to be met (wider coverage of the network and incentives for high-blends, for example), the implementation would be more cost-effective as opposed to the open market designs. Moreover, the biofuels demand could rise if the number of participating haulage companies were to be increased or if the focus were on other market segments than corridor stations alone (e.g. business stations).

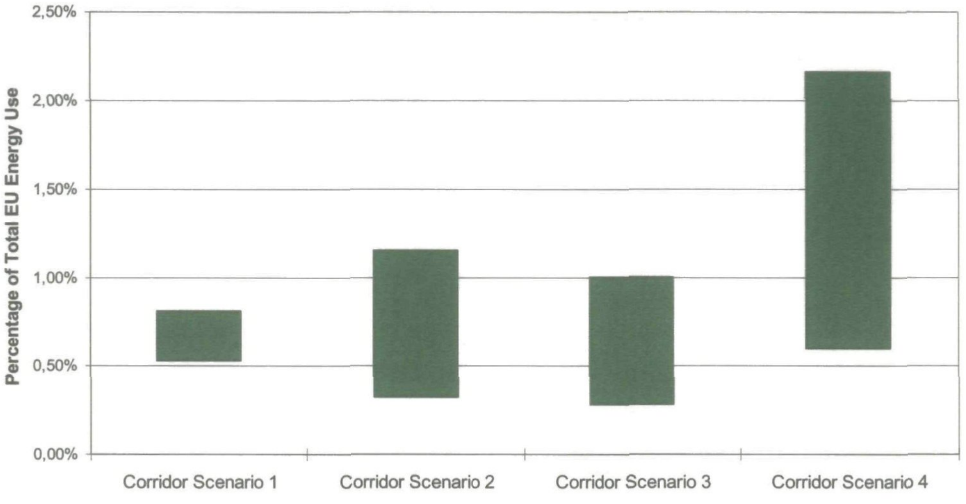
Results

The results of the Rotterdam-Constanta corridor can be transferred to other corridors on the TEN-T Network roads when taking the following factors into account. First among these factors is that transport flows and refuelling behaviour could be corridor-specific. However, it is argued that extrapolating the results of the case study, accompanied by deviation intervals, would be suitable to provide a first indication of the effects of biofuels corridors at the EU level. Furthermore, vast differences in technology and infrastructure costs are not expected. The introduction of biofuel-compatible vehicles will become easier and more cost-effective, due to economies of scale. In addition, it is likely that oil companies will show more interest if biofuels corridors are implemented on a large scale, as this would provide more certainty that a substantial vehicle fleet for biofuels will develop.

The maximum contribution of EU biofuels corridors (if these were to be implemented on the entire TEN-T Network) to the RED targets is estimated by transferring the case study results to this network. The fact that biofuels use on the Rotterdam-Constanta corridor could be different than on other TEN-T corridors has been taken into account by means of deviation intervals regarding transport flows and refuelling behaviour.

Figure 0.3 presents an estimate of the maximum contribution of EU biofuels corridors in 2020 under each of the four corridor scenarios. The green bars represent the sensitivity of the calculations, i.e. the contribution of Corridor Scenario 4 is estimated to be between 0.5 and just over 2 percent. These estimates indicate that the measure would be unable to complement low-blends entirely, in the corresponding scenarios.

Figure 0.3 Estimation of the Maximum Contribution of Biofuels Corridors to the RED Targets in 2020



Conclusions

Based on the results, it can be concluded that the extent to which biofuels corridors can increase the use of biofuels is limited, as, even if biofuels corridors were to be implemented on the entire TEN-T Network, estimations point to a maximum contribution to the RED targets of just one or two percent. The limited contribution is due to the fact that the enormous transport flows are not representative of the actual fuel sales at stations on the network; corridor users refuel locally. Besides relatively low demand, the viability of biofuels corridors for an open market seems to depend on a future public policy focus on high-blends, which, according to the analyses, would be rather ambitious. There are many other alternatives available to stimulate the use of biofuels, including increasing the allowable percentage of biofuels to be blended in conventional fuels. These would, from the perspectives of various stakeholders, be more favourable than focussing on high-blends alone. The future role of high-blends, however, will presumably become clearer when national RED action plans are presented. In these scenarios, biofuels corridors could be implemented and would mainly serve to increase the awareness of biofuels among road users. Furthermore, they could encourage international cooperation in fuel standards and taxation.

A scenario in which only a small share of the RED targets is to be achieved by high-blends is, however, more realistic. The most promising *corridor* scenario to accommodate these would be one which incorporates a focus on a captive freight transport fleet (i.e. Corridor Scenario 1). Aside from being more realistic, Corridor Scenario 1 would also be more cost-effective in terms of vehicle costs and easier to develop than corridor scenarios for the open market. Furthermore, the results of this study indicate that, particularly for the freight truck market, it may not be too challenging to increase demand further. The main challenges in ensuring the success of this corridor scenario lie in the cooperation of the various stakeholders that are involved.

Several recommendations can be made. First among these recommendations is to reconsider the implementation of biofuels corridors for the open market once there is more certainty regarding the future role of high-blends. Secondly, the conclusions show that biofuels corridors, including other market segments than corridor stations alone, for the freight truck market could be promising and it is thus recommended that further research be conducted into realising this concept. Thirdly, the corridor approach could be transferred to other modes of transport as well as to other sustainable transport alternatives.

Contents

Acknowledgements

Several academics, government officials and industry experts kindly agreed to be interviewed as part of this research. Although some of them remain anonymous, their contributions were extremely helpful and I am grateful for their time and comments. I also gratefully acknowledge the help and input of several of my colleagues at NEA Transport Research and Training, and of Thomas Coskeran for his academic advice at the start of the project. Furthermore, I want to thank Professor Bert van Wee, Pieter Schrijnen, Hans van Ham, and Jarl Schoemaker for their supervision. Their interest and enthusiasm for every aspect of my work contributed significantly to its creation. I am grateful as ever to my parents Thijs and Jacqui for their moral support throughout this year. My thanks go to other family members and friends who provided encouragement in various ways, and especially to Helen Coskeran for her constant support.

Preface

This document presents a Masters research thesis, and is submitted as part of the Transport, Infrastructure and Logistics (TIL) Masters Programme at Delft University of Technology. The project has been carried out in line with an assignment given by NEA Transport Research and Training, and contributes to the broader perspective of sustainable mobility.

List of Tables

List of Figures

Abbreviations

AEM	Agro-Economic Modelling
BtL	Biomass-to-Liquid (a second generation biofuel)
CAP	Common Agricultural Policy
EC	European Commission
EU	European Union
FAME	Fatty Acid Methyl Ester
GHG	Greenhouse Gas
GJ	Gigajoule(s)
IEA	International Energy Agency
km	kilometre(s)
Ktoe	Thousands tonnes oil equivalent
LCA	Life Cycle Assessment
MS(s)	European Union Member State(s)
MT	Metric ton (1000kg)
Mtoe	Million tonnes of oil equivalent
OECD	Organisation for Economic Co-operation and Development
RED	EU Renewable Energy Directive 2009/28/EC
TEN-T	Trans-European Transport Network

1 Introduction

This research focuses on ways to increase the use of biofuels in road transport within the European Union (EU). Road transport accounts for well over 80 percent of total energy use in EU transport as a whole and its demand is growing much faster than for other transport modes (EC, 2009). Traffic intensity is highly concentrated on the main European highways which, in most cases, are part of the pan-European transport network, referred to as the Trans-European Transport (TEN-T) Network roads. This chapter outlines the issues to be tackled when considering increases in biofuel usage and outlines a potential scheme with the objective of achieving an increase in the use of biofuels in the road transport sector; the development of biofuels corridors.

Section 1.1 provides the project context. Sections 1.2 and 1.3 define the problem outlined above in further detail and outline biofuels corridors as a potential measure for contributing to increased biofuel use, a solution which this thesis will analyse using the proposed research questions and objectives formulated in Section 1.4. Section 1.5 elaborates further upon the research methodology used in this thesis, and finally, the structure of the study is given in Section 1.6.

1.1 Overall Project Context

The EU transport sector and its policymakers are presently being confronted with two crises: fossil-fuel dependency and environmental degradation. Well over 95 percent of transport relies on crude oil and the process of burning these oil products in combustion engines is a key contributor to global greenhouse gas (GHG) emissions. These GHG emissions are widely believed to be the main cause of global warming (Gilbert and Perl, 2008). EU transport accounts for approximately 21 percent of GHG emissions and this percentage is rising (EC, 2006). In addition, other emissions, such as nitrogen oxides, sulphur dioxides and particle matter, cause air pollution which is in turn associated with negative effects on public health.

Awareness of the consequences of using petroleum-based fuels in transport is increasing rapidly for various reasons. Firstly, oil prices are expected to increase significantly over the next decades, because of a predicted gap between supply and demand. Gilbert and Perl (2008) point to a peak in oil production in the near future, which would simply not facilitate the enormous growth in overall energy consumption, predicted in various energy forecasts (see, for example, IEA, 2007). The evidence for this theory, also referred to as 'peak oil', is 'inevitable and imminent', and is widely supported in the literature (see, for example, Hirsch et al, 2005 and Hanlon and McCartney, 2008: 649). The fact that energy demand in the transport sector is increasing rapidly would only serve to intensify the problem. Secondly, many EU Member States (MSs) are highly dependent on crude oil originating from regions which are often politically unstable, such as the Middle East. Currently, well over 80 percent of the oil used within the EU is imported and 70 percent of that is used to power transport (EC, 2009). This makes the EU transport sector vulnerable. Thirdly, the negative environmental and health effects of using petroleum-based fuels are becoming more visible. The theory that GHG emissions cause climate change is now widely accepted, and has resulted in (inter)national emission targets, such as the Kyoto Protocol, being established and the negative impact of increased air pollution on human health has been corroborated by substantial amounts of research (Pope and Dockery, 2006). The debate on how to overcome these negative impacts most efficiently is ongoing and currently ranks high on the policymaking agenda.

The EU has applied several measures to increase the sustainability of the transport sector in relation to fuel dependency and environmental effects. These measures include regulatory and economic policy instruments, as well as research investments. They originate from the common transport policy, documented in the 2001 EU White Paper – 'European Transport Policy for 2010: Time to Decide' – and its 2006 Mid-Term Review. Ensuring energy security and environmental sustainability are listed among the key objectives, along with increasing safety, strengthening international competition and providing high-quality international transport connections. To achieve increased sustainability, several recommendations were made in the reports: stimulating co-modality (combining the respective energy advantages of various transport modes), improving logistics, promoting environmentally friendly innovation and shifting towards renewable and sustainable energy sources (EC, 2001 and EC, 2006a). The first three recommendations are based on saving energy and using energy more efficiently, but given that fossil fuel dependency and negative environmental effects remain, their contribution to overall sustainability will be limited. A shift towards renewable and more sustainable energy sources such as hydrogen, electricity and biofuels, is therefore key to securing the future sustainability of the transport sector, and, in turn, indicates the start of a transition away from petroleum-based fuels.

The 2003/30/EC and 2009/28/EC Directives are the key pieces of EU legislation regarding the use of renewable energy in transport and fall under the broader EU policy which aims to increase the overall share of renewable energy used in the region to 20 percent in 2020 (EC, 2008). The Directives require MSs to set targets for the share of renewable energy in transport which is to replace petroleum-based fuels, and are also referred to as the 'Biofuels Directives', as biofuels are expected to be the most viable solution to meet these targets in the short-term. The 2003/30/EC Directive was accompanied by a comprehensive EU strategy to develop the biofuels sector (EC, 2006).

Biofuels produced from plant material are renewable and offer various advantages compared to other sustainable energy sources. First among these advantages is that they generally burn more cleanly than petroleum-based fuels in terms of air pollutants. In addition, most 'well-to-wheel' studies indicate that GHG emissions are significantly reduced when biofuels are used (Worldwatch Institute, 2007). Secondly, compared to other sustainable transport options, such as electrical or hydrogen-powered vehicles, biofuels can be implemented without major changes to the current methods used for distributing and consuming petroleum-based fuels. Moreover, they can easily be blended with gasoline or diesel, making the transition easier. Finally, the production of biofuels may stimulate rural development in terms of income and employment, as it will lead to more demand for the plants needed to create it and therefore offering new activity to developing country farmers (Gilbert and Perl, 2008 and EC, 2009a). Despite these advantages, however, criticism of biofuels is increasing, mainly in relation to the manufacture of so-called first generation biofuels. This requires the harvesting of crops such as sugar, oil and starch, and there are concerns that the secondary effects of this process could be to drive up food prices, ruin biodiversity and increase soil erosion. In addition, there is controversy surrounding the extent to which biofuels are energy efficient and the reductions in GHG emissions they could stimulate. It is expected that most of these problems will be solved when second generation biofuels, made from cellulosic biomass, such as wood and grasses, become commercially viable, since the production of these products will not have the same effects as those mentioned above (see, for example, CE, 2006a and Refuel, 2008).

The biofuels industry is booming and biofuels are widely supported by governmental bodies and international organisations as a means to replace petroleum-based fuels. Two types of biofuels dominate the global market: bioethanol and biodiesel, representing approximately 85 and 15 percent of the global market, respectively (EuropaBio, 2007). Ethanol production is mainly concentrated in Brazil and the United States as a replacement for gasoline, and biodiesel is mostly produced in Europe to replace diesel. The International Energy Agency (IEA) forecasts that the industry as a whole will have doubled its 2006 production levels by 2012 (Biopact, 2007). The EU is rapidly expanding production capacity to increase the biofuel supply, and, especially in Central and Eastern European Countries, the potential for biofuel production, due to land availability, is high (see, for example, Van Dam et al, 2007). Moreover, international trade in biofuels may grow, due to the comparative advantage of biomass production in tropical areas, such as Brazil, leading to more exports from these areas to the EU. Currently, just under 10 percent of all biofuels are traded internationally, which is rather a low figure compared to the trade in conventional fuels (Worldwatch Institute, 2007).

1.2 Problem Definition

Biofuels are more costly than conventional fuels, hence the EU support of the use of biofuels in the transport sector by way of the 2003/30/EC and 2009/28/EC Directives. The Directives aim to promote the use of biofuels in order to contribute to "...meeting climate change commitments, environmentally friendly security and promoting renewable energy sources" (EC 2003: 3). Individual MSs are required to set targets for the use of biofuels. These targets, indicating the minimum share of biofuels replacing petroleum-based transport fuels, are set at 5.75 percent in 2010 and 10 percent in 2020 (EC, 2003 and CEU, 2007). The latter target is binding and was approved by the EU Council just after the 2007 progress report of the 2003/30/EC Directive. Along with the first Directive, the EU has created a strategy for stimulating the development of the biofuels sector (EC, 2006). To stimulate the demand of biofuels, MSs use various support systems and incentives which mostly involve tax reductions or exemptions and biofuel obligations.

The 2003/30/EC Directive has led to an increase in biofuel use and according to the European Commission (EC), the impacts of this growth have been positive. Biofuels account for almost 3 percent of EU total fuel consumption, and this share is growing. It has resulted in increased security in transport fuel supply and GHG savings, as well as additional jobs and added value to the agricultural sector (EU, 2009a).

However, the implementation progress of the Directive must be accelerated in order to meet the EU targets. Progress among the various MSs differs significantly. Despite the fact that some countries are well underway to meeting these targets, the average share of biofuels replacing petroleum-based fuels is low. The EU targets are deemed to be very ambitious, and, in a 2007 progress report, the Commission stated that the 2010 target was 'not likely to be achieved' (EC 2007a: 6). Lucia et al (2007: 538) point to various arguments which have been presented by national authorities to the EU for failing to meet the targets, such as limited production potential in the respective MSs, 'fundamental disagreements' regarding the use of first generation biofuels, and organisational problems related to the implementation of the Directive. Since then, a more rigorous EU framework has been adopted regarding biofuels. This has led to further recommendations, legislation and even legal proceedings against several MSs, but despite these efforts, the rate of growth remains slow (EC, 2009a).

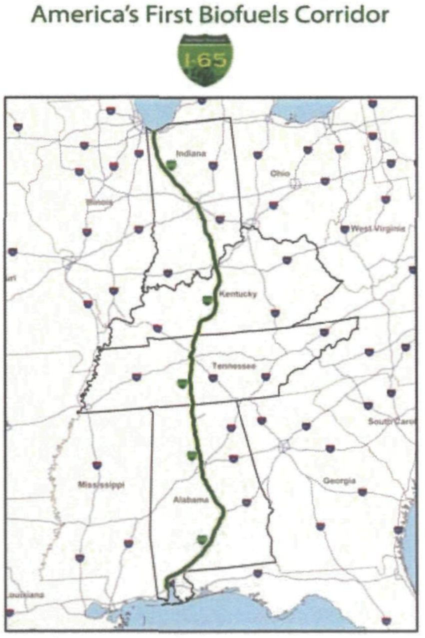
At present, most biofuels are blended with petroleum-based fuels. In Europe, blends up to 5 percent of bioethanol or biodiesel are covered under warranty by vehicle manufacturers, as they do not influence drivability and maintenance (Worldwatch Institute, 2007). This can be seen as an easy way to contribute to the early EU target, which is set at 5.75 percent. Blends with a higher biofuel content (at least 20 percent) or pure biofuels, henceforth referred to as 'high-blends', often require adaptations to vehicle engines and only a very small amount of refuelling stations offer these biofuels. Examples include the commonly used E85 (85 percent ethanol, 15 percent gasoline) and B100 (100 percent biodiesel). However, it is obvious that the mandatory 2020 target of 10 percent cannot be reached by the further stimulation of 5 percent blends alone. Naturally, an even higher share of biofuel usage in the transport sector would be preferable. Therefore, to increase biofuel demand, one could consider allowing a higher percentage of biofuel blending in petroleum fuels, such as up to 10 percent, as in the rest of the world, or alternatively, high-blends could be made more readily available at refuelling stations. The focus in this study is on the latter option. It is believed that a successful biofuel policy should aim to replace petroleum-based fuels rather than supplement them, since this could potentially lead to a complete eradication of the use of fossil-fuels in road transport, thereby decreasing demand and reducing the rate of fossil fuel consumption (see, for example, Gilbert and Perl, 2008).

1.3 Proposed Solution: Biofuels Corridors

Various ways to increase the use of high-blends have been adopted, such as making them available at local fuel stations and providing specific public transport fleets with the fuel. However, all these measures are currently at the local level and on a modest implementation scale. As mentioned above, a wider scale implementation of high-blends may be preferable in order to further increase the sustainability of the transport sector and could be necessary for achieving the targets stated in the Directive 2009/28/EC.

Moreover, NEA Transport Research and Training, the transport research and consultancy company sponsoring this project, wanted to investigate the possibilities of introducing so-called 'green corridors'. This concept which involves clean transport fuels being offered at specific locations on long-distance road routes, could help to facilitate EU ambitions regarding clean transport fuels. Road traffic intensity is highest on these road segments which means the EC focus on developing a coherent transport network is high. Introducing clean fuels on such a wide cross-border scale could then serve as a catalyst for the further transition towards renewable energy.

The green corridor concept, with a focus on biofuels, led to the proposed solution to be examined in this thesis: to increase the use of high-blends in road transport by making them readily available on long-distance European road routes. One may refer to such routes as 'biofuels corridors'. An example of a biofuels corridor can be found in the United States, in the form of the so-called Interstate 65 (I-65) Biofuels Corridor. This 886-mile stretch of highway from Lake Michigan to the Gulf of Mexico, offers E85 ethanol and B20 biodiesel along the entire route.



The Interstate 65 is America's first Biofuels Corridor. The project concept, originating with the United States Department of Energy (DOE), called for an increase in the biofuels fuelling infrastructure along the Interstate to be upgraded, giving drivers the opportunity to travel along the entire corridor using high-blends only.

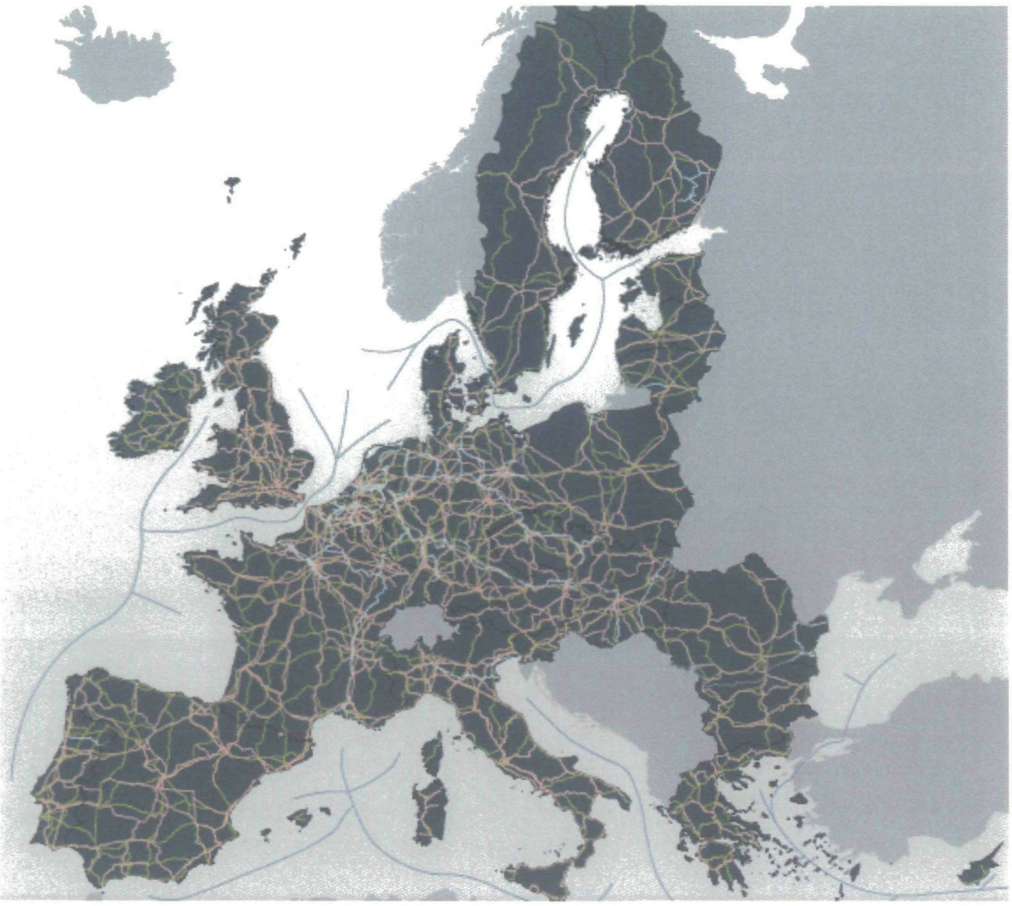
The Indiana Office of Energy Development was awarded $1.3 million from the DOE to fund E85 and B20 fuelling stations along Interstate. The funding was made available by the DOE through the Clean Cities Programme. The grant provided funding to 31 refuelling stations.

Most of the infrastructure was in place by October 2008. A celebration was held to mark the completion of the project. The celebration included a corridor drive, that started in both Mobile, Alabama and Gary, Indiana. A caravan of Flex-Fuel Vehicles (FFVs) (i.e. vehicles compatible with E85) leaving both of those locations for a celebration event (IOED, 2009).

The idea of implementing high-blends by means of biofuels corridors has not yet been adopted in the EU. Nevertheless, it is believed for various reasons that EU biofuels corridors could effectively promote and stimulate the use of biofuels, and could thereby contribute to achieving the EU renewable energy targets. Firstly, the implementation of EU biofuels corridors could lead to a more coherent strategy and international cooperation on the promotion of biofuels, instead of individual MSs struggling to achieve their own biofuel targets. Their development may be a first step towards an EU refuelling network for high-blends, which would facilitate refuelling over large distances. Moreover, biofuels corridors could strengthen the EU vision on sustainability in transport and could serve as a catalyst for the transition to renewable and sustainable transport fuels. Secondly, it is generally argued that the long-term potential of biofuels lies in the field of long-distance and heavy goods transport. Other alternatives, such as electric- and hydrogen-powered vehicles would, because of their restricted action radius, be more suitable for short-distance and urban transport. The fact that freight transport uses a lot of fuel relative to the total road transport sector could make it easy to obtain a large market share for biofuels. Thirdly, the biofuels corridor approach would immediately increase the visibility of the use of biofuels in transport, as opposed to low-level blending. The latter remains regularly unnoticed by road users. High visibility of biofuels would likely increase the environmental awareness among society and in turn stimulate their use.

Biofuels corridors could be implemented on the TEN-T Network roads. This EU road network would be suitable as it consists of high-quality and cross-border roads facilitating European's highest transport intensities. It is part of the wider TEN-T Network, which also consists of the other EU infrastructure components rail, inland waterway networks, motorways of the sea, seaports and inland waterway ports, airports and other interconnection points between modal networks (see Figure 1.1).

Figure 1.1 Representation of the Trans-European Transport Network



Source: TEN-T Executive Agency, 2009

An EU biofuels corridor is defined as a long-distance (minimum length 1000 kilometres (km)) and cross-border route on the TEN-T Network roads on which high-blends are offered regularly along the entire length of the route. The principle is that there would be several EU biofuels corridors being established gradually over time and that, by 2020, when the RED targets are due to be achieved, the use of high-blends on the TEN-T Network roads would have risen considerably. This research aims to assess the potential of EU biofuels corridors as a means to stimulating the use of transport biofuels in the EU. The following section presents the research questions which must be answered in order to achieve this.

1.4 Research Objectives

The overall EU policy objective is to reduce fossil-fuel dependency and to contribute to environmental sustainability in transport. The purpose of this study is to contribute to these overall policy objectives by investigating the potential for increasing the use of biofuels in EU road transport by means of offering blends with a higher biofuel content or pure biofuels on TEN-T road routes, referred to as biofuels corridors.

The central research objective of this thesis is:

To determine the potential contribution of biofuels to achieving the EU sustainable transport policy objectives and to examine the potential of biofuels corridors to stimulating the use of biofuels in EU road transport.

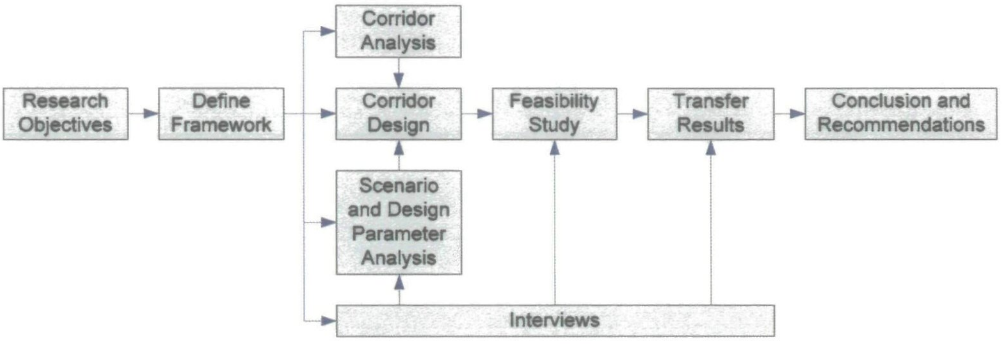
This objective can be formulated in a central research question:

To what extent can biofuels corridors on the Trans-European Transport Network roads increase biofuels usage in the EU and is their implementation viable from a technical, economic and policy perspective?

1.5 Methodology and Sources

The potential and feasibility of EU biofuels corridors is assessed by means of a case study for one specific corridor on the TEN-T Network roads; the Rotterdam-Constanta highway. Subsequently, the outcomes of this case study are generalised to other corridors to determine their potential at the EU level. The following paragraphs describe the methodology used in this report, which is schematically shown in Figure 1.2. In addition, the sources which have been used are discussed.

Figure 1.2 Overview of the Overall Research Methodology



The study begins with an overall examination of the future potential of biofuels in the EU. This includes an overview of the history of biofuels, EU biofuels policy, technical aspects, and the present-day biofuels market. The use of biofuels is surrounded by many controversial views, which are also addressed. Furthermore, factors which may be relevant for the development of biofuels corridors are identified. The literature, mainly consisting of scientific publications and policy documents, provides the input for this part of the study. With this information, the scope for the future role of EU biofuels is determined and a solid background for further analyses is created.

Next, various design parameters of biofuels corridors are identified and inserted into four future scenarios in which high-blends will play a prominent role in achieving the EU renewable energy targets. A scenario analysis is thus used as a way to narrow down the amount of possible design configurations. Subsequently, a specific corridor is selected based on various criteria and the characteristics of this corridor are identified. The predefined parameters (i.e. based on the scenarios) are then applied to this corridor, which results in the creation of four biofuels corridor designs.

The potential and feasibility of the specific biofuels corridor designs is assessed by means of various analyses. Firstly, a SWOT analysis is conducted. Information for this analysis was obtained from interviews with various stakeholders closely associated with the concept of biofuels corridors (e.g. EC, oil companies, ministries and road transport companies). The relevance of the factors determined by the SWOT analysis are further investigated by means of a market, technical, economic and policy options analysis.

Since the case study results are used to predict the possible impact of an EU-wide implementation of biofuels corridors, the representativeness of these results are first assessed. This is done by examining the extent to which the corridor-specific aspects hold for other EU corridors on the TEN-T Network roads. The feasibility and potential contribution of EU biofuels corridors is then determined, providing an answer to the central research question.

The statistics and other quantitative information used in this study have mostly been obtained from publicly accessible documents from various institutions, including the EC, other public institutions, sector- and business associations active in the field of transport biofuels and other relevant sources. Input for the literature research mainly consists of scientific publications. Furthermore, information regarding transport flows on corridors other than that gained from one of the aforementioned documents, originates from the TRANS-TOOLS model and forthcoming publications by NEA Transport Research and Training. A full list of references is provided in the Reference List. Lastly, other information has been obtained from interviews with key stakeholders closely associated with the concept of biofuels corridors. These stakeholders include oil companies, the EC, governments, transport companies, sector- and business association's active in the field, and research institutions. The list of interviewees, as well as a summary of the interviews, can be found in Annex A.

1.6 Structure

This thesis is structured as follows. The report is divided into 6 chapters:

Chapter Two determines the potential and future role of EU biofuels. This includes an overview of the history of biofuels, EU biofuels policy, technical aspects of biofuels, and the present-day biofuels market. The use of biofuels is surrounded by many controversial views, which are also addressed in this chapter. Chapter Three details the creation of biofuels corridor designs. Various design parameters of biofuels corridors are identified and inserted into future scenarios. These predefined parameters are applied to a specific corridor. Chapter Four assesses the potential and feasibility of the corridor designs by means of a SWOT analysis as well as market, technical, economic and policy options analyses. Chapter Five generalises the case study results to the EU context by examining the extent to which the corridor-specific aspects hold for other EU corridors on the TEN-T Network roads. Subsequently, the maximum contribution of biofuels corridors to the renewable energy targets is estimated. Chapter Six provides conclusions and recommendations on future research.

2 Transport Biofuels: The State of Play

2.1 Introduction

This chapter defines the framework for the promotion and implementation of transport biofuels in the EU by examining their technology, policy, and market conditions, as well as previous developments in the field and controversial issues related to biofuels. It does so in order to address the first part of the central research objective which aims to determine the potential contribution of transport biofuels to EU sustainable transport policy objectives. In addition, the information provided in this chapter offers valuable input for the various analyses included in the ensuing feasibility study on EU biofuels corridors.

The first section includes a description of biofuels history, EU policy, technical aspects of biofuels, and the current biofuels market. Secondly, controversial views surrounding the use of biofuels are described in Section 2.3. These two sections then lead to the identification of crucial factors (Section 2.4) which may impact on the feasibility of biofuels corridors. This section also shows how these aspects are taken into account in this thesis by outlining the assumptions made regarding the development of each factor. The chapter concludes by answering the first research question (Section 2.5).

2.2 Biofuels: Technology, Policy and the Market

A Short History

Biofuels have been used in road transport ever since the emergence of the automotive industry. The prototype of the Otto motor, which currently powers gasoline cars, was developed for burning ethanol and sponsored by a sugar factory, and, Rudolf Diesel used peanut-oil to premiere his diesel engine on the 1898 World Exhibition in Paris. Furthermore, the first widely available and affordable car, the Ford Model T produced by Henry Ford's Motor Company from 1908 through 1927, was able to run on any range of ethanol-gasoline blend. However, along with the increasing popularity of cars, the fuel market became overwhelmed by cheap petroleum-based fuels, limiting the share of biofuels in the transport sector to a negligible amount.

It was only in cases in which the oil supply was restricted that the fuel market, as well as academics and governments, became aware of the vulnerability of their transport energy supply, and that, as a consequence, biofuel demand increased, as these have historically been the favoured type of fuels to compensate for temporary shortcomings. Examples of periods in which there was a shortage of petroleum-based fuels include the Second World War and the various energy crises in the 1970s. The latter were due to political conflicts and were characterised by heavy cuts in the global oil supply, brought about by the Organisation for Petroleum Exporting Countries (OPEC).

The energy crises in the 1970s were followed by several national action programmes aimed at stimulating the production of biofuels, mainly ethanol, in order to reduce dependency on imported fuels. An additional driver for the promotion of biofuels was to develop the agricultural sector. In 1975, Brazil launched the so-called 'Proálcool' ethanol programme, which uses sugar cane as feedstock, and, furthermore, the US government began to support its ethanol production from corn in 1978. The 're-discovery' of biodiesel was led by South-Africa and Germany and took off in the early 1990s.

More recently, the promotion of biofuels has been strengthened by the following three factors: an awareness that oil production is likely to peak in the coming decades thereby increasing the risk of a new energy crisis; an increased awareness of the environmental pollution caused by the burning process of petroleum-based fuels in vehicles; and the promotion of activities within the agricultural sector.[1]

EU Biofuels Policy

In 2003, the EU set indicative non-binding targets for biofuel consumption by way of its Biofuels Directive 2003/30/EC. The Directive aims to promote the use of transport biofuels in road transport in order to contribute to '...meeting climate change commitments, environmentally friendly security and promoting renewable energy sources' (EC 2003: 3). Individual MSs are also required to set their own targets for biofuels usage. Although these national targets can legitimately differentiate from the EU-wide ones, they must present suitable reasons for doing so on the basis of Article 4 of the Directive. By 2005, the objective was to replace 2 percent of the energy used in road transport with biofuels. This was then to grow by 0.75 percent annually in order to achieve a share of 5.75 percent by 2010. The 2005 target has not been met and the 2007 progress report indicated that it is 'not likely' that the 2010 target will be achieved either (EC 2007a: 6).

In 2008, the Commission proposed new targets for the use of renewable transport energy to the Council of the European Union. The target of 10 percent was accepted as a *mandatory* target to be achieved by all EU MSs and is stated in the Renewable Energy Directive (RED) 2009/28/EC. The Directive falls under the broader 'EU Energy and Climate Change Package' (EC, 2008). This package is commonly referred to as the '20/20/20 package', as the objectives for 2020 are to reduce greenhouse gas (GHG) emissions by 20 percent, to improve energy efficiency by 20 percent, and to have an overall share of 20 percent of renewable energy in the EU energy mix.

Ethanol and Biodiesel

Biofuels can be made from various organic materials, referred to as biomass, which in turn stem from plants (including algae, trees and crops). These organisms are characterised by the ability to convert carbon dioxide (CO_2) into

[1] Information regarding biofuels history has been obtained from Reijnders and Huibregts, 2009; Worldwatch Institute, 2007; and Demirbas, 2009.

organic compounds (mostly glucose ($C_6H_{12}O_6$)), and subsequently into biomass, by using solar irradiation for the conversion. Biomass is thus organic material in which sunlight is stored in the form of chemical energy. The conversion process is referred to as photosynthesis and occurs in plants, algae, trees and canyobacteria. The generalised chemical reaction of photosynthesis is:
$6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$.

The reverse process of breaking the glucose bonds between carbon, hydrogen and oxygen (e.g. by combustion or digestion), releases energy and is the basic principle of using biomass as a renewable energy source. The use of biomass for energy production is therefore, theoretically, carbon neutral. Although fossil-fuels originate from fossilised biomass, they are not considered to be renewable, due to the fact that their conversion takes millions of years (Reijnders and Huibregts, 2009).

Energy from biomass is therefore promising and currently represents approximately 14 percent of world's total energy consumption (Demirbas, 2009). Most of this consumption takes place in developing countries by simply burning wood. There are several other ways in which biomass is used in the EU: for heat production (66 percent), electricity production (31 percent), in chemical products typically made from petroleum (e.g. plastics), and for conversion into gas-like or liquid fuels (e.g. ethanol) (3 percent) (USDA, 2008). The latter are referred to as biofuels.

Various types of biofuels have been proposed which can be used in the most common transport engines: the diesel motor and the Otto motor (gasoline). A distinction is made between so-called first generation and next generation biofuels (see Table 2.1). First generation biofuels refer to biofuels made from food crops, such as sugar, starch, vegetable oils or animal fats. These biofuels currently dominate the global biofuels market and it is expected that, at least over the next decade, food crops will continue to provide the bulk of biofuel feedstock (see, for example, Worldwatch, 2007). Second generation biofuels are produced from lignocellulosic biomass, such as agricultural residues and wood, and waste residues. Also algae, referred to as the third generation, may serve as next generation biofuel feedstock. Second and third generation biofuels are still at the experimentation or demonstration phase, as they have not yet succeeded in becoming economically viable (Worldwatch, 2007).

The following paragraphs elaborate on the characteristics of the two most commonly-used biofuels, ethanol and biodiesel, as it is not within the scope of this research to discuss all the various types of biofuels. Ethanol and biodiesel are generally first generation biofuels which currently comprise over 95 percent of the EU biofuel market (USDA, 2009). And it should be emphasised that biodiesel and ethanol will most likely remain the most dominant biofuel types available in the near future, although probably either in slightly different forms (e.g. FT-Diesel, Bio-DME or BIO-SNG replacing biodiesel), or consisting of different feedstocks (e.g. second generation bioethanol replacing first generation bioethanol). This last prediction has been confirmed by several interviewees. It is to the most widely-used of these two types, ethanol, that we first turn.

Table 2.1 Overview of Biofuels Types, Feedstock and Classification

Feedstock			Classi-fication	Biofuel				
				Biodiesel	Bioethanol	FT-Diesel	Bio-DME	Bio-SNG
Energy crops	Lignocellulosic crops	Woody plants 1)	2^{nd}		X	X	X	X
		Herbaceous plants 2)	2^{nd}		X	X	X	X
	Oil crops	Rapeseed	1^{st}	X				
		Sunflower	1^{st}	X				
	Sugar crops	Sugar beet	1^{st}		X			
		Sugar cane	1^{st}		X			
	Starch crops	Wheat	1^{st}		X			
		Maize	1^{st}		X			
		Triticale	1^{st}		X			
		Sweet sorghum	1^{st}		X			
Residues	from agriculture	Digestible	1^{st}		X			X
		Non-digestible (straw)	2^{nd}		X	X	X	X
	from forestry		2^{nd}		X	X	X	X
	from wood industry		2^{nd}		X	X	X	X
Waste	Organic waste	Used oils/fats/fatty acids	1^{st}	X				

1) Short rotation forestry: poplar, willow, eucalypt
2) Perennials: miscanthus, switch grass, reed canary grass
1^{st} First generation of biofuels
2^{nd} Second generation of biofuels

Source: Refuel, 2008

Ethanol

Ethanol is an alcohol derived from carbohydrates and is currently the most commonly used transport biofuel. Ethanol can be used in Otto motors and thereby serves as a replacement for gasoline. The energy content of one litre of ethanol is approximately two-thirds of the energy content of one litre of gasoline (Worldwatch, 2007). The EU standard for bioethanol is EN 15376.

Ethanol is produced by the fermentation of sugars which can be obtained from natural sugars (e.g. sugar beet, sugar cane), starches (e.g. corn, wheat, cassava), or cellulosic biomass (e.g. straw, grass, wood). Fermentation is the process in which glucose ($C_6H_{12}O_6$) is converted into ethanol (C_2H_5OH) and carbon dioxide (CO_2), and the corresponding chemical reaction is: $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ (Reijnders and Huibregts, 2009). The use of starches and cellulosic biomass as feedstock requires expensive pre-treatment, as they contain large molecules which first have to be converted into simple sugars by the process referred to as saccharification. This is why most commercial production of ethanol (approximately 60 percent) is from sugar cane and sugar beet (Demirbas, 2009).

Ethanol can be blended with gasoline or used in its pure form, but the use of high ethanol contents in gasoline (more than 10 percent) or pure ethanol requires adaptations to vehicle engines (Bomb et al, 2006). This is mainly due to the fact that the chemical characteristics of ethanol may lead to the deterioration of rubber parts and to the corrosion of certain metals (Worldwatch, 2007). The use of highly concentrated ethanol blends also requires different distribution equipment, such as special tanks and separate refuelling systems. Additional concerns with the blending of ethanol are the occurrence of phase separation between ethanol and gasoline due to water contamination, and the raising of the fuel's vapour pressure. The latter issue may negatively affect engine performance. However, both issues are addressed by refiners by means of lowering the vapour pressure of the gasoline and by 'splash blending' the ethanol, respectively (Worldwatch, 2007).

Flexi-Fuel Vehicles (FFVs) are vehicles which can run on pure gasoline or any ethanol-gasoline blend and are becoming 'increasingly popular' (Worldwatch 2007: 17). This is evidenced by the large amount of FFVs in countries like Brazil and Sweden. The ethanol content is automatically detected by sensors in the system, after which the combustion process is optimised. Usually, the E-additive indicates the percentage of ethanol in the mixture. For example, E10 signifies a blend containing 10 percent ethanol and 90 percent gasoline. The fuel economisation of FFVs, compared to that of gasoline cars, decreases with the ethanol content, because of its lower energy content. However, ethanol could also increase fuel efficiency in dedicated ethanol vehicles by up to 20 percent, as it allows higher compression ratios (Worldwatch, 2007). To avoid cold-start problems in colder climates, such as in the US and Europe, E85 is often the blend with the highest ethanol content available (Worldwatch, 2007).

Another option which allows easier blending of ethanol and gasoline is the use of Ethyl Tertiary Butyl Ether (ETBE). This additive consists of ethanol and isobutylene components (the latter originates from fossil fuels), and is preferred to ethanol by some countries (Worldwatch, 2007).

Biodiesel

Biodiesel is derived from lipids and is widely used (particularly in Europe) to replace petroleum-based diesel fuel. The most commonly-used type of biodiesel is referred to as FAME (Fatty Acid Methyl Ester). Other types of diesel substitutes, such as FT-Diesel, Biomass-to-Liquid (BtL), Bio-DME and Bio-SNG, are currently in the developmental stages and are thus not yet commercially available (Worldwatch, 2007). Their production processes are more advanced and the fuel characteristics vary slightly from those of FAME biodiesel. This section is exclusively about FAME biodiesel which, from here onwards, is referred to simply as biodiesel. A litre contains between 88 and 95 percent of the energy in conventional diesel (Worldwatch, 2007). The EU standard for biodiesel is EN 14214.

Biodiesel is produced by chemically combining vegetable oils and fats with an alcohol, mostly methanol, in the presence of a catalyst (e.g. NaOH or KOH). The purpose of the process, referred to as transesterification, is to lower the oil's viscosity and to transform the oil's large molecular structure into smaller straight-chain molecules to allow them to be used in present-day diesel engines (Demirbas, 2009). These biodiesel molecules are of a similar length as compared to those present in conventional diesel, yet their precise characteristics vary due to the variety of vegetable oils and fats that can be used for their production. The oil-alcohol ratio in the production process is approximately 80-20 percent (Worldwatch, 2007). Glycerine molecules are the primary co-product and they are further used in various industries. The lipids can be obtained from a wide variety of oilseed-crops, such as rapeseed, soybeans and palm, as well as from animal fats and potentially micro-algae.

Biodiesel can be easily blended with petroleum-based diesel or used in its pure form. Its use in diesel engines can improve lubrication due to the higher viscosity of the fuel, which may extend the life span of vehicles. However, in most cases, the use of high biodiesel contents or pure biodiesel in conventional diesel engines (more than 20 percent) requires adaptations to vehicle engines (Worldwatch, 2007). The main reason for this is that some engine parts (e.g. rubber hoses) could be negatively affected by the solvent characteristics of the biodiesel. When using biodiesel, fuel economisation decreases slightly with biodiesel content, because of its lower energy content (Worldwatch, 2007).

Another option is the use of Straight Vegetable Oil (SVO) in diesel engines. Instead of converting the vegetable oils, which are extracted from oilseed-crops such as sunflower, they can also be burned directly in diesel engines. However, the use of SVOs is currently limited to niche markets and certain vehicle fleets and its market share is expected to decrease (see, for example, USDA, 2009 and Reijnders and Huibregts, 2009). This is due to the fact that distribution of SVOs is more complex. Furthermore, using SVOs, in contrast to biodiesel, requires major engine modifications, due to its high viscosity, and these fuels cannot be easily blended with conventional diesel (Worldwatch, 2007).

Theoretical Maximum Contribution to EU Transport Sustainability

Biomass availability is key to the potential replacement of petroleum-based fuels by biofuels, and thereby its ability to contribute to the EU sustainable transport policy objectives. Once sufficient feedstock is available for its production and processing (the latter including the winning, refining and distribution), biofuels could potentially replace all petroleum-based transport fuels.

The potential availability of biomass has, therefore, regularly been examined in the literature (see, for example, De Vries et al, 2007 and Moreira, 2006). Although the exact outcomes of these studies vary significantly, mainly due to uncertainties surrounding the most important input parameters - land availability and yield levels in energy crop production - they overwhelmingly state that the potential of biomass energy is 'very substantial' (Reijnders and Huibregts 2009: 3). Berndes et al (2002: 19) analyse the outcomes of 17 different studies and conclude that the future supply of biomass may exceed 'several hundreds of exajoules per year'. This is also supported by more recent studies, carried out by De Vries et al (2007) and Moreira (2006), which show that liquid biofuels may amount for up to 300 exajoules (EJ, 1.0E+18) and 455 EJ in 2050, respectively. The global transport sector uses approximately 100 EJ annually (Worldwatch, 2007), and therefore, even when its demand is growing steadily, the biofuel potential would not be restricted by a shortage in biomass feedstock.

Fossil-fuel dependency is defined in this thesis as the extent to which the EU relies on the use of fossil fuels to meet its energy needs. It is calculated by dividing the fossil-fuel energy need by the total energy need. Total EU-27 gross energy consumption is 1825.2 Mtoe (million tonnes of oil equivalent), and 1436.1 Mtoe of this is provided by the use of fossil fuels. Therefore, 78.7 of the EU energy sector and 98 percent of the EU transport sector (297.2 Mtoe per annum) (EC, 2006a) currently relies on the use of fossil fuels. When an average efficiency of approximately 88 percent is taken into account, representing the refinery process of crude oil into diesel and gasoline transport fuels (Wang, 2008), the total (gross) oil use in the transport sector is estimated at 337.7 Mtoe annually. A total displacement by biofuels in the sector would therefore reduce overall EU fossil-fuel dependency to 60.2 percent, a total reduction of 18.5 percent.[1]

Total EU-27 GHG emissions are estimated at 5447.8 $mtCO_2e$ (million tonnes CO_2 equivalent). The contribution of road transport is 924.2 $mtCO_2e$. Therefore, assuming that both the production and processing of biofuels are carbon neutral, this indicates a potential reduction of 17.0 percent in GHG emissions.

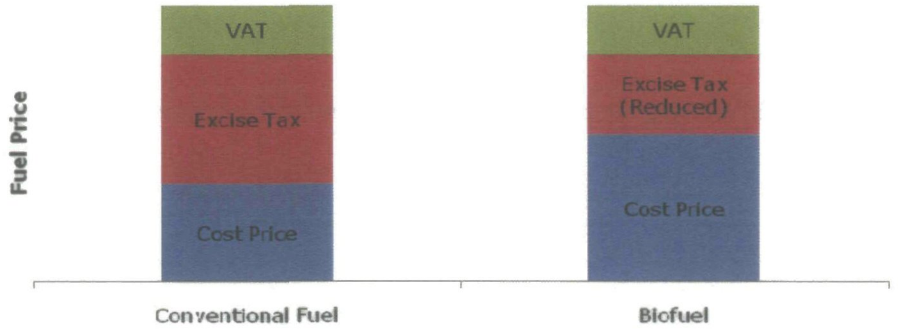
Biofuels in EU road transport could theoretically reduce fossil-fuel dependency and GHG emissions by approximately 18.5 and 17.0 percent, respectively, and thereby deliver a substantial contribution to the overall EU sustainable policy objectives. Naturally, a much higher reduction could be achieved in this case as it is assumed that other industries, such as electricity, will presumably also increase *their* use of biomass. The main condition for achieving this is a sufficient availability of biomass feedstock exclusively for transport biofuels. However, it must be clearly emphasised that it is assumed here that the processes of cultivation, harvesting, refinery and delivery of biofuels are also conducted in a sustainable manner (e.g. by biomass energy). This is currently not the case.

Biofuels Market

Biofuel retail prices depend on government policy and on their competitiveness with conventional fuels. As biofuels are generally more costly than petroleum-based fuels[2], the price also relies heavily on government (e.g. tax) policy. This is illustrated by the indicative fuel price outline in Figure 2.1, in which granting a partial tax reduction makes up for higher biofuel costs.

[1] The figures originate from 2006 and have been obtained from The EU Statistical Pocketbook: Energy and Transport in Figures 2009 (EC, 2009).
[2] It should be noted that the positive externalities of biofuels compared to conventional fuels, such as a reduction in GHG emissions, are not taken into account, and that these benefits may well make up for the higher biofuel costs.

Figure 2.1 Petroleum-Based and Biofuels Price Outline



The literature indicates that the high costs for biofuels is particularly true for Europe because of higher production costs, freight rates and border protection (see, for example, Reijnders and Huibregts, 2009). Only Brazilian ethanol, made from sugar cane, comes close to competing with the low price of gasoline. The competitiveness of biofuels with conventional fuels, in turn, mainly depends on crude oil and biomass feedstock prices and their fluctuations, as well as on the efficiency of biofuel production.

The impact of crude oil prices on the competitiveness of biofuels is twofold. A rise in crude oil prices, leaving all other factors unchanged, will increase biofuels demand, and, following economic rules, will thereby also increase biofuel prices. In turn, approximately 80 percent of biofuels prices depends on biomass feedstock prices (Kondili and Kaldellis, 2006), which therefore also rises with the price of crude oil. In addition to this demand-side effect on biofuel prices, there is also a supply-side effect that makes biofuel prices rise with the price of crude oil. This is due to the fact that crude oil prices are directly linked with the price of other fossil fuels which are commonly used in biofuel production, e.g. for harvesting crops and the conversion process to liquid fuels. These two effects make biofuel prices follow the price of crude oil to a certain degree, a fact which is widely supported in the literature (see, for example, USDA, 2009 and OECD, 2008). Aside from crude oil and biomass feedstock price impacts, efficiency improvements in the biofuel production chain reduce overall biofuel prices.

Recent history tells us that crude oil and biomass feedstock prices are subject to severe changes and impact on the relative attractiveness of biofuels (Reijnders and Huibregts, 2009). It has previously been argued that higher oil prices in particular would improve the economic viability of biofuels significantly. EU biofuels, for example, would become competitive with fossil fuels at oil price levels between 70 and 80 dollars per barrel, a development which was not expected in the near future (Bamiere, 2007). However, when oil prices temporarily rose to well over $100 in 2008, biofuels remained more expensive than conventional fuels (USDA, 2009). Efficiency improvements, which have been continuously occurring over the last decade, have not even come close to compensating for these increasing feedstock prices, leaving the competitiveness of transport biofuels unchanged (OECD, 2008). It is argued that relative feedstock cost will decline if cellulosic biomass is used, which may set the scope for additional cost reductions by way of efficiency improvements and a possible increase in the future competitiveness of biofuels (Reijnders and Huibregts, 2009).

In order to stimulate the EU biofuel market, and thereby giving response to the EU Biofuel Directives, various policy instruments – *incentives*, *mandates* and *barriers* – have been applied (see, for example, USDA, 2009). OECD (2008) models confirm that, without this support, the use of biofuels in the EU would be radically reduced. At the EU level, the production of biomass feedstock has been stimulated by the so-called Energy Crop Aid, which falls under the Common Agricultural Policy (CAP). The CAP provides incentives for using crops for energy production. Furthermore, the EU domestic biofuel market is protected by import tariffs on ethanol and biodiesel. Biodiesel imports into the EU are subjected to a tax duty of 6.5 percent. Tariffs of 19.2 and 10.2 euros per hectolitre apply to undenatured and denatured alcohol, respectively (USDA, 2009). Duty free ethanol imports are allowed from Least Developed Countries under the so-called 'Everything But Arms' initiative, as well as from various African, Caribbean and Pacific (ACP) States, under the Cotonou Agreement (Bamiere, 2007). Nevertheless, most policy instruments have been adopted at Member State (MS) level. These measures predominantly focus on stimulating biofuel demand and supply. Demand for biofuels has mostly been supported by granting (partial) fuel excise tax exemptions for ethanol and biodiesel, which is allowed by Article 16 of the EU Directive 2003/96/EC on energy taxation. These incentives lead to a reduction in retail biofuel prices, as average biofuel taxation is about 50 percent lower than for conventional fuels (OECD, 2008). Although this has been proven to be effective for establishing an early-stage biofuel market, there is a recent trend in moving towards or combining tax incentives with biofuel obligations.[1] This is due to the fact that the application of tax incentives alone leads to significant revenue losses for governments. By setting mandatory blending targets on fuel suppliers, the additional costs are, in most cases, directly passed on to the consumers. The main drawback of biofuel obligations is that strategies for lowering costs will be adopted by fuel suppliers, which might contradict the underlying EU objectives of stimulating and using domestic and sustainable biofuels, as these are more expensive. The supply of biofuels has been strengthened by promoting domestic biofuel production, which is done by way of subsidy systems as well as through incentives originating from the CAP (OECD, 2008). In addition to stimulating demand and supply, MSs have applied various other policy instruments, such as investments in research and development and introducing user incentives.

Although the EU 2010 target of 5.75 percent will most probably not be achieved, the use of biofuels in EU road transport has increased significantly over the last few years (see Table 2.2 and Figure 2.2). This indicates that the aforementioned biofuel support policies are offering a 'substantial stimulus' for the growth of the EU biofuels market (OECD 2008: 111). Table 2.2 shows the gradual increase in biofuels consumption between 2006 and 2010. Instead of the indicative target of 5.75 percent, the share of biofuels in EU road transport is expected to increase to 4 percent in 2010 (USDA, 2009). And one expert even estimates this figure at over 4.2 percent.[2]

[1] From interview with John Neeft (SenterNovem)
[2] From interview with Paul Hodson (EC)

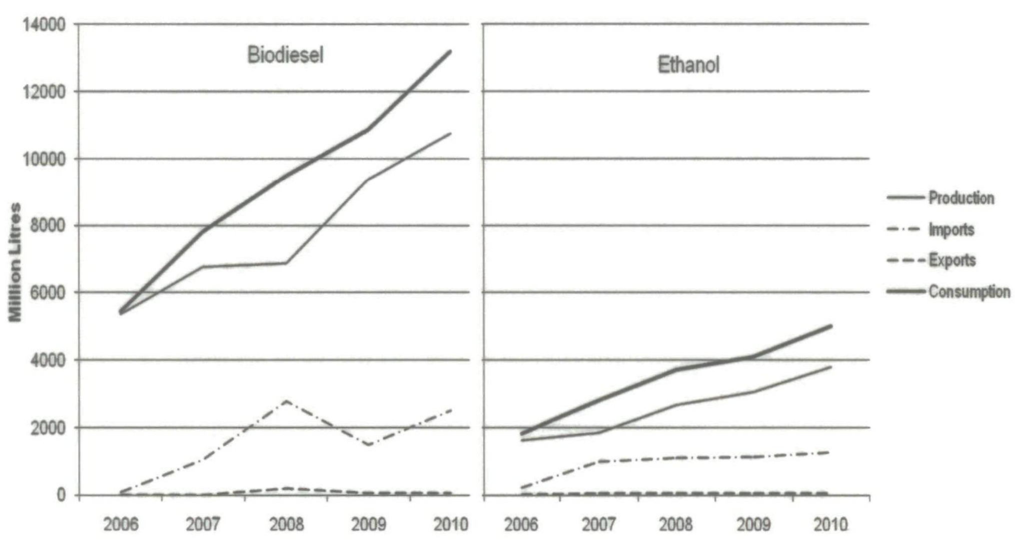
Table 2.2 EU (Bio)Fuel Consumption for Road Transport in Ktoe (2009 and 2010 figures are based on predictions)

Year	*2006*	*2007*	*2008*	*2009*	*2010*
Biodiesel	4,110	5,900	7,160	8,170	9,980
Ethanol	880	1,380	1,790	2,070	2,560
Straight Vegetable Oil	920	660	370	100	100
Total Biofuels	5,910	7,940	9,320	10,340	12,650
Diesel	183,702	189,596	192,250	194,940	197,670
Gasoline	109,829	106,071	105,650	105,220	104,800
Total Transport Fuels	299,440	303,610	307,220	310,510	315,120
Percentage Biofuels	**1.97 %**	**2.62 %**	**3.03 %**	**3.33 %**	**4.00 %**
EU Targets	2.75 %	3.50 %	4.25 %	5.00 %	5.75 %

Source: United States Department of Agriculture (USDA), 2009

Figure 2.2 shows the EU ethanol and biodiesel production, exports and imports in millions of litres between 2006 and 2010, respectively. The focus is on ethanol and biodiesel, as these currently serve over 95 percent of the EU biofuel market. The following paragraphs elaborate on each of these developments, and it is to EU biofuel trade that we first turn.

Figure 2.2 EU Ethanol and Biodiesel Market Developments (2009 and 2010 figures are based on predictions)



Source: Data from United States Department of Agriculture (USDA), 2009

Imports have been increasing recently in order to achieve a higher share of biofuels in road transport. Despite EU trade barriers and transport costs, imports may still be economically attractive, due to the comparative advantage of biofuel production in tropical areas (Worldwatch, 2007). The fact that the domestic production of biofuels is relatively expensive can also be seen as a reason why EU *exports* are negligible. Forecasts indicate that the potential of EU biofuel imports is large and that biofuels are increasingly traded internationally (USDA, 2009 and EC, 2006a).

The issue of increasing biofuel imports to meet the EU targets is under debate (Lucia et al, 2007). Some argue that importing biofuels would conflict with the underlying EC objectives in terms of reducing energy dependency. Besides, it is more difficult to monitor sustainability criteria regarding biofuel production in lesser-developed countries. On the other hand, others argue that biofuels, in contrast to crude oil, can be imported from a wide variety of regions, and thereby also contributes to increased energy security by reducing dependency on politically instable regions. Moreover, the GHG balances of imported biofuels, such as Brazilian ethanol which is made from sugar beet, are often better than those of domestic biofuels.[1]

Production within EU MSs is increasing rapidly, and represents approximately over 70 percent of the total biofuel supply. The EU is the world's leader in biodiesel production, mainly from rapeseed. EU ethanol and biodiesel production accounted for approximately 4 and 80 percent of the world total in 2007, respectively (Monfort, 2008 and USDA, 2009).

Consumption of EU biofuels is strongly oriented towards biodiesel, accounting for 77 percent of the market (USDA, 2009). This can be explained by the high share of diesel engines in road transport. In addition, oil companies tend to favour biodiesel, due to the fact that, within the EU, there is generally a shortage of conventional diesel and an oversupply of gasoline (Bomb et al, 2006 and EU, 2006). The high share of biodiesel is in contrast to other countries, such as Brazil and the US, as their biofuel markets mainly consist of ethanol (OECD, 2008).

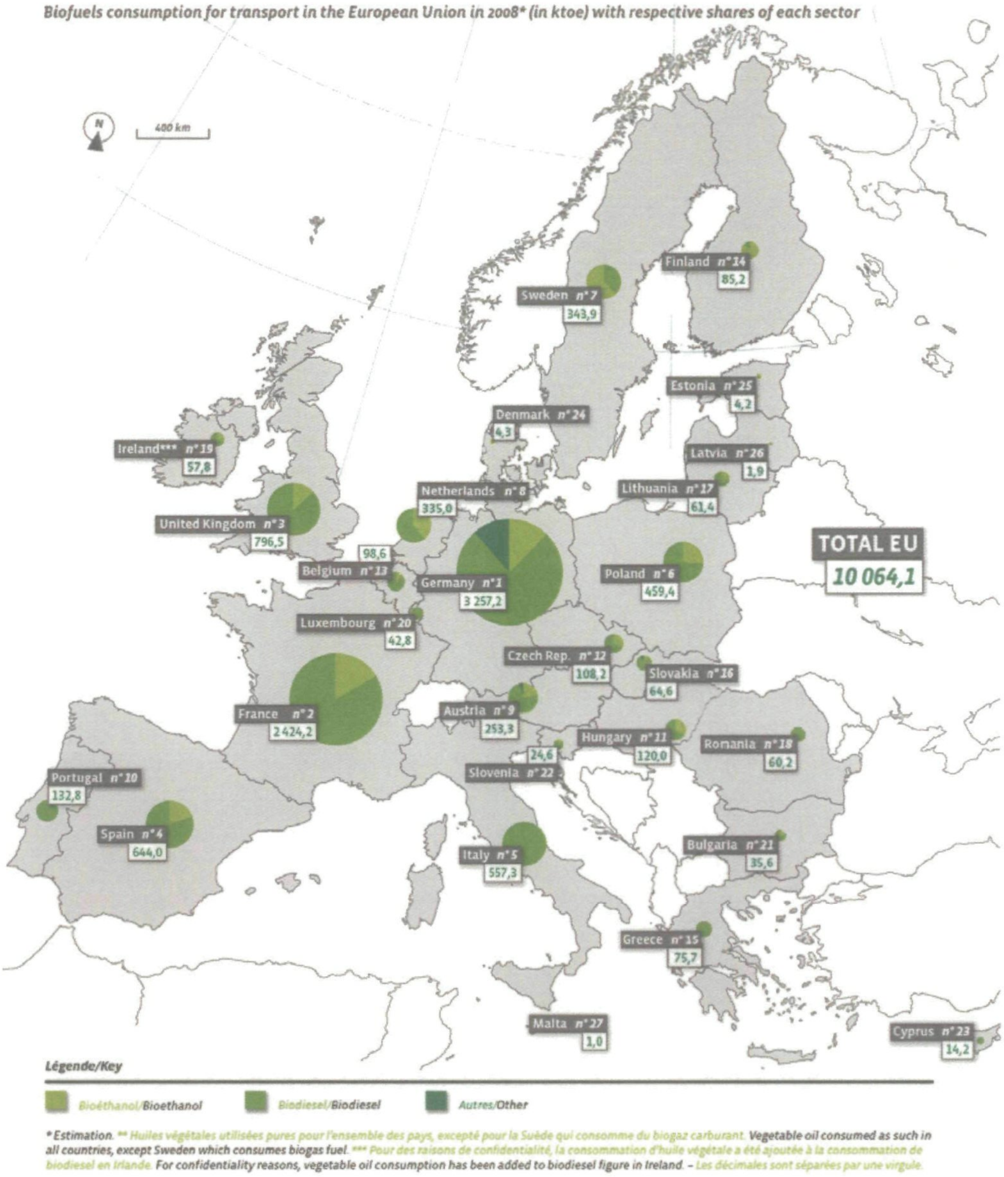
Almost all EU biofuels are used in road transport and most biofuels are currently sold as low-level blends with petroleum-based fuels. Only Germany and Sweden have developed a significant market for blends with a high biofuel content, for B100 (100 percent biodiesel) and E85 (85 percent ethanol, 15 percent gasoline), respectively (see, for example, Ethanol Producer, 2008). In Europe, blends up to 5 volume percent of ethanol in gasoline or biodiesel in diesel are covered under warranty by vehicle manufacturers (Wiesental et al, 2008). This is also the maximum according to the European standards for gasoline (EN228) and diesel (EN590). Blends with a higher biofuel content may not be sold as conventional gasoline or diesel and thereby should meet the EN 15376 and EN 14214 certifications, respectively. The fuel standards, however, are currently being revised by the EC to allow higher volumes of biofuels in gasoline and diesel, up to 10 volume percent for ethanol and 7 volume percent for biodiesel (SenterNovem, 2008). These standards have already been adopted in the RED in order to facilitate the 10 percent obligation and Neeft indicates that these

[1] From interview with Philippe Marchand (Total)

standards will be in place by around 2015.[1] However, it must be noted that the EU biofuel targets are based on a particular energy content and that the energy contents of ethanol and biodiesel are lower.

Progress in biofuel consumption among the EU-27 MSs varies significantly. Figure 2.3 shows that Germany and France have already developed a considerable outlet, while countries like Romania and Denmark are lagging behind.

Figure 2.3 Respective Shares of Transport Biofuels Consumption within the EU in 2008 (Ktoe)



Source: Eurobserver, 2009

[1] From interview with John Neeft (SenterNovem)

Summary

This evaluation has shown that, owing to strong government support, the share of biofuels in EU road transport, predominantly ethanol and biodiesel, has grown rapidly in recent years. The emerging biofuel incentives, mandates and barriers, which have come about as a direct result of the EU Directive 2003/30/EC, have strengthened the market. Moreover, the future potential of EU biofuels, in terms of reducing GHG emissions and providing energy-security, is far from being reached.

Despite the high potential for biofuels, they are not expected to completely replace fossil transport fuels. Even the EU biofuel targets, of 5.75 percent and 10 percent in 2010 and 2020, respectively, are deemed to be very ambitious and it remains doubtful whether these targets will be actually achieved. This raises the following question: what factors are hampering the introduction of transport biofuels in EU road transport and, more importantly for this research, which of these factors are relevant for the development of biofuels corridors? To answer this question, we now turn to what Lucia et al (2007: 538) refer to as the 'fundamental disagreements' on the use of transport biofuels.

2.3 The Controversy Surrounding Biofuels

Transport biofuels have been considered as a very important alternative in contributing to EU sustainable transport policy objectives in the short and medium term (Londo and Deurwaarder, 2007). Biofuels offer various advantages for EU MSs, which are broadly in line with these objectives. First among these advantages is that biofuels show a reduction of net GHG emissions with respect to petroleum-based fuels, which, in turn, is key to tackling climate change (OECD, 2008). Secondly, biofuels – whether blended with conventional fuels or in pure form – generally burn more cleanly in terms of air pollutants (Demirbas, 2009 and Worldwatch, 2007). Air polluting emissions, such as nitrogen oxides, sulphur dioxides and particle matter, are associated with negative effects on public health. Thirdly, biofuels have the ability to reduce countries' dependency on crude oil for powering transport. Well over 80 percent of the EU's crude oil is imported, often from politically instable regions, which makes the transport sector vulnerable (EC, 2009a). Moreover, fuel demand is expected to grow significantly during the upcoming decades, because of the rapidly growing world population. Fourthly, compared to other sustainable transport options, such as electrical or hydrogen-powered vehicles, biofuels can be implemented without major changes to the current methods used for distributing and consuming petroleum-based fuels. And biofuels can easily be blended with gasoline or diesel, which makes the transition go almost unnoticed by vehicle users (Worldwatch, 2007). Lastly, the production of biofuels may stimulate rural development in terms of income and employment. This increase goes beyond the direct effects on agricultural feedstock markets, as, for example, biofuel plants need to be installed and additional infrastructure has to be developed.

Despite these advantages, the use of transport biofuels is currently surrounded by global controversy. There is an ongoing discussion on the extent to which biofuels, in particular so-called first generation biofuels, are sustainable, from an economic, environmental and societal perspective. The debate is presently being strengthened as the biofuel industry is growing rapidly and due to the fact that more research, pointing to the negative side effects of biofuels, has been done. The following sections elaborate further on the substance of this discussion. It should be emphasised that it is not within the scope, nor the research objective of this thesis, to provide a thorough analysis of the ongoing discussions related to the biofuels industry, and therefore, this section only identifies the main aspects of the debate. The purpose is to give an overview of these controversies with a focus on examining the relevant aspects which may impact on the assessment of EU biofuels corridors.

Economic

Several studies indicate that the energy balances of present-day biofuel production processes are rather limited (Bamiere, 2007). It is argued that the amount of (fossil) energy needed for the cultivation, harvesting, refinery and delivery of biofuels may outweigh the potential benefits of using biomass as a renewable energy source in the transport sector and that biomass can be used much more efficiently for heat and electricity generation (Reijnders and Huibregts, 2009). The low efficiency of transport biofuels is confirmed by Pimentel (2003: 132), who even points to a 29 percent negative energy balance of ethanol, and thereby concludes that this type of biofuel is 'uneconomical'. More generally, studies indicate that EU ethanol production has an energy ratio of 1.3, which indicates a net energy saving of 30 percent compared to fossil fuels. Energy balances of biodiesel are more encouraging, with between 2.5 and 3 units of fossil fuel saved for every unit used (Bamiere, 2007). A drawback of biodiesel production, however, is that its feedstock requires more land than for ethanol feedstock (Bamiere, 2007). Nevertheless, it must be noted that results of the various studies vary considerably, mainly depending on the type of feedstock used and on the production process.

However, according to Dale (2007: 14), the net energy argument concerning biofuels is 'dead wrong and dangerously misleading'. Different energy carriers cannot be compared on an energy basis as they provide different services which are all valued differently (e.g. heat versus transport). The energy balance of biofuels should therefore only be compared with those of conventional transport fuels. In addition, it should be noted that the energy balance of biofuels could be much more favourable if renewable energy, such as biomass, is used in the production process. Secondly, the metric of energy balance itself would be irrelevant, as biofuels should not be rated on energy efficiency, but rather on their ability to tackle climate change and to reduce oil-dependency (Dale, 2007). The latter issue may be especially relevant here, as, instead of oil products, mostly coal or natural gas are used in the production process of biofuels, energy sources which are often much easier available in the EU MSs. In these cases, biofuels can still reduce oil-dependency by replacing imported oil by other forms of (fossil) energy.

This does not alter the fact that present-day biofuels remain an expensive way to reduce oil-dependency and to tackle climate change. It has been shown that biofuel prices have generally remained higher than conventional transport fuel prices, even when oil prices were well above $100 a barrel in 2008. This was mainly due to the higher fossil-fuel input prices of the biofuels and the steeply rising feedstock prices. Sourie et al (2005) estimate that, under French biofuel support policy, GHG emission reductions come at a price of 43 euros per tonne of *carbon, which seems a rather high figure compared to the global trade prices for* carbon emissions. It is commonly argued that these prices should be in line with what can be considered as a tolerable price for GHG emission reductions.

Therefore, the discussion regarding biofuel economics focuses on the efficiency of biofuels and their relative competitiveness with conventional fuels as well as the extent to which biofuels support policy is justified. Although biofuels are considered as the most viable solution to contribute to EU sustainable transport policy objectives, it remains questionable whether biofuels have the potential to become competitive with petroleum-based fuels in the short-term. Biomass may well be used in other processes, such as electricity generation, which yield higher efficiency. It seems that the debate is focussed on the competitiveness of next generation biofuels and technical developments which will probably reduce costs, and, until then, biofuels will mainly be supported on behalf of what Bamiere (2007: 23) refers to as the 'infant industry' argument.

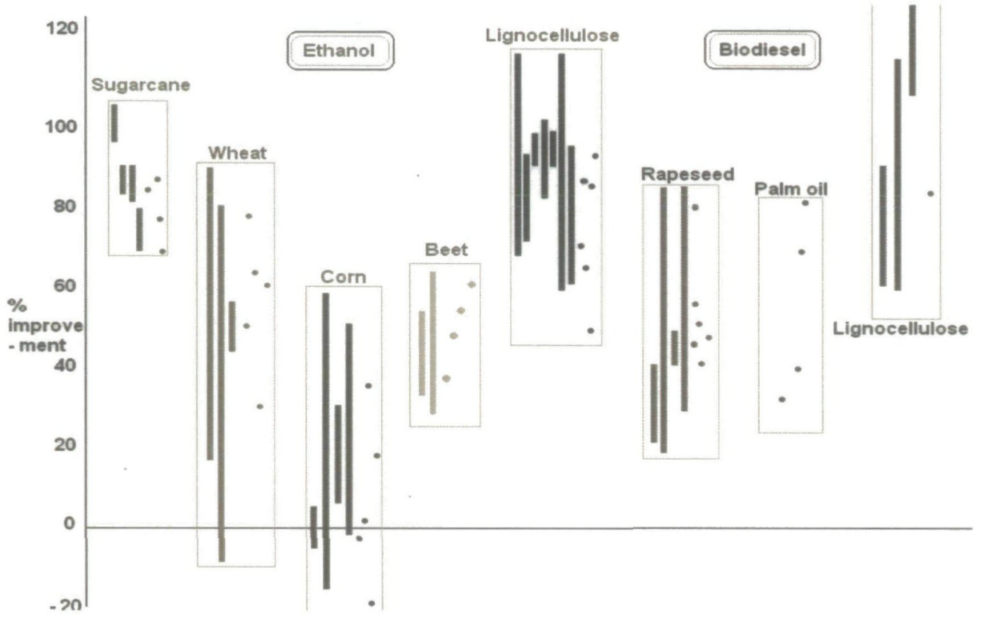
Environmental

The ability of first generation biofuels to reduce GHG emissions is increasingly appearing to be less positive than former evaluations suggested. Recent research by Searchinger et al (2008: 3) even argues that the expansion of the biofuel industry would 'exacerbate global warming' as a result of land use changes. Commonly used approaches in the literature to assess the environmental performance of biofuels are Life Cycle Assessments (LCAs) and Agro-Economic Modelling (AEM).

LCA studies assess the full biofuel chain from the plantation field to the fuel combustion in vehicle engines, and are commonly referred to as 'well-to-wheel' studies. These studies are widely available and provide worthy insights into the respective GHG reductions of biofuels compared to conventional fuels, yet their outcomes vary considerably and are often inconsistent. This variance in GHG reductions can generally be explained by the variety of 'biofuel chains, biomass feedstock, geographical scope and the inclusion of crop displacement effects' (OECD 2008: 40). In addition, three main assumptions seriously affect the quantitative outcomes of LCA studies and are of particular relevance when examining GHG reductions brought about by different biofuel pathways (OECD, 2008). First among these assumptions is the way in which the impacts of co-products have been allocated. Secondly, the amount of released N_2O emission during the agricultural phase is often uncertain. N_2O emissions result from nitrogen fertiliser production and the application of fertilisers in the field, and is a significant contributor to overall GHG emissions. Thirdly, the amount of energy used in the conversion process and, more importantly, the type of energy that is used varies (e.g. natural gas or biomass).

The outcomes of a review of LCA studies using various biofuel feedstocks, carried out by the Organisation for Economic Co-operation and Development (OECD) (2008), are presented in Figure 2.4. The figure shows the improvements in GHG reductions of ethanol and biodiesel compared to gasoline and diesel, respectively. The analysis includes 60 reports on the environmental performance of first generation biofuel production in Europe and the United States.

Figure 2.4 GHG Balances of Ethanol and Biodiesel using Various Biofuel Feedstocks



Source: OECD, 2008

The OECD study indicates that although the estimates of GHG emission reduction caused by biofuels do indeed vary significantly among various studies, except for ethanol produced by the fermentation of wheat or corn, LCA studies show a fairly positive GHG balance. The potential of both ethanol and biodiesel production from lignocellulosic materials, next generation biofuels, is high.

However, critics point to the fact that most LCA studies do not take the effects of land use changes into account, which may adversely impact on the potential GHG reductions from transport biofuels (see, for example, Searchinger, 2008 and Fargione et al, 2008). Therefore, AEM studies are increasingly being conducted. Land use changes can occur directly, when non-crop land is converted into crop land, or indirectly, when existing food crops are replaced by energy crops. The fact that the conversion of forests and savannah to cropland releases CO_2, due to either burning or microbial decomposition of organic carbon, could radically affect GHG balances of various biofuel chains, depending on the former nature of the land (see, for example, Fargione et al, 2008). Also indirect land use changes, to which Searchinger (2008) points, could lead to high land-use related CO_2 emissions. In the worst case scenario, land use changes might 'completely offset' the potential GHG reduction obtained from transport biofuels (OECD 2008: 52).

Other environmental issues concerning large-scale biofuel production include soil depletion and deforestation. Deforestation is a direct consequence of direct land use changes and could possibly destroy tropical ecosystems and reduce biodiversity. Examples can be found in Brazil and South-East Asia, where tropical forests are cleared to make room for soybean crops and palm plantations, respectively (Worldwatch, 2006). As well as this, soil quality could be reduced, although there is evidence that energy crops may restore degraded soils, which leads to a win-win strategy (Lal and Pimentel, 2007).

Social

The production of biofuels increases food prices and there are concerns that this might negatively impact on the world's poorest. The rapid growth of the biofuel industry places increasing demands on key agricultural commodities, such as corn, wheat and maize, which have traditionally been used for food. As a result, the prices of these commodities are rising in international markets, which in turn negatively impact upon food prices. A recent example includes the rise in corn-based tortilla prices in Mexico early 2007, also referred to as the 'tortilla crisis' (see, for example, GMO, 2007). The additional food costs are especially relevant for rural communities in developing countries, as these populations spend a relatively high share of their income (around 80 percent) on foodstuffs (Naylor et al 2007: 41). Besides, the link between food and international commodity prices is generally stronger in these regions than in Western countries, due to the fact that the manufacturing and packaging costs, for example, only account for a small amount of the total food costs (Naylor et al, 2007). It is argued that, because of this so-called 'food versus fuel' debate, the support for biofuels is 'morally unacceptable and irresponsible' (Peter Brabeck-Letmathe, Head of Nestlé, in Tenenbaum, 2008: 255).

The OECD (2008) estimates that present biofuel support policies would increase average wheat, maize and vegetable oil prices by approximately 5, 7 and 19 percent in the medium term, respectively, and conclude that the impact on the food market should therefore 'not be overestimated' (OECD 2008: 68). However, there are concerns that a further global expansion of biofuels, along with a rapidly increasing world population, could lead to much further rises in food prices (see, for example, Runge and Senauer, 2007, Daschle, 2007 and Naylor, 2007 in Reijnders and Huibregts, 2009). Since EU biofuel targets for 2020 are 'unlikely' to be achieved by domestic production alone, the policy may only serve to intensify the problem (Bamiere 2007: 11) .

On the other hand, it has been argued that further expansion of the biofuel industry could also benefit poor communities in developing countries (see, for example, Worldwatch, 2007 and EuropaBio, 2007). Developing countries are often located in regions with a tropical climate which provides them with a comparative advantage in growing biofuel feedstock. The development of a biofuel industry could bring new income opportunities for these communities which may possibly compensate for the higher food prices. In Brazil, for example, the biofuel industry already constitutes an important driver for economic development and job creation, employing around half a million people (Worldwatch, 2006).

It is expected that next generation biofuels, which are made from non-food biomass, can reduce the upward trend of rising food prices. Next generation feedstock could possibly be grown on land which is less suitable for food crops, and thereby the competition with food production would be reduced (NEAA, 2008). Yet it remains to be seen to what extent these new biofuels may supply the market in the future.

EU Response to the Critique

In response to the critique regarding environmental and societal sustainability, the EU has developed regulations and certification schemes to address the sustainability issues. The sustainability criteria are presented in Article 17 of the RED. These criteria include minimum requirements for GHG emission savings, limited allowance of land-use changes and various monitoring rules regarding social sustainability (EC 2009b: Article 17). Developments with respect to the sustainability of EU biofuels policy will be reported to the European Parliament and the Council every two years, starting in 2012 and it remains to be seen how this strategy may impact on the debate over biofuel usage.

2.4 Critical Factors for the Future Role of Biofuels

Various critical factors may impact on the potential of biofuels to effectively contribute to reductions in GHG emissions and in fossil-fuel dependency, and thereby also on the potential effects of biofuels corridors. This section aims to identify these factors, based on the analyses in the previous sections. It further explains how these will be taken into account in this study.

The main uncertainty and crucial factor is whether, or to what extent, the EU will continue to support the use of transport biofuels by way of its RED. As long as the conditions of the Directive apply, which is to be expected, EU biofuel use in transport will steadily increase up to the mandatory target of 10 percent in 2020, or even higher, and effective support policies or initiatives, which may be the case for biofuels corridors, may be welcomed as a means to achieving this. However, there is controversy surrounding the extent to which transport biofuels are sustainable, in economic, environmental and social terms, which may undermine the EU objectives. Only future research and developments can exactly tell what the impacts of the EU biofuel policies are, and therefore, there is a risk that the Commission might propose adjustments to the Directive over time. These possible adjustments, referred to by the EC as 'corrective action' (EC 2009b: Article 17), will only take place if the biannual progress reports on the Directive point to an unsustainable biofuel policy.

The sustainability of biofuels will be assessed in biannual progress reports, starting in 2012, and will depend upon their economic, environmental and social performance. As has been shown in the previous sections, these criteria, in turn, depend on various factors. Firstly, the competitiveness of biofuels with petroleum-based fuels is relevant. It has been shown that the competitiveness of biofuels mainly depends on the price of crude oil, the price of biofuel feedstock and on technological improvements in the production process which could lead to cost reductions. It is argued that supporting biofuels is an expensive way of contributing to EU sustainable policy objectives, and these factors could influence the economic sustainability of transport biofuels. Secondly, more research in the field of environmental and social side-effects will provide EU policymakers with new insights. It has been shown that the literature is rather inconsistent regarding these secondary effects of biofuel production, and it may well be that near-future research will show a clearer and more coherent vision on these issues. Thirdly, new developments regarding next generation biofuels, which are, according to the OECD (2008: 39), 'widely expected to happen', may significantly affect both their environmental and social sustainability performance. Next generation biofuels will most probably have a more positive effect on GHG balances compared to those of first generation biofuels, and the fact that non-food crops can be used for their production, preferably on agricultural land which is not suitable for growing food crops, may separate the biofuel market from the food market and thereby end the 'fuel versus food' debate. Fourthly, developments in the field of other sustainable transport options, such as hydrogen- and electrical-powered vehicles, might reduce the demand for transport biofuels. According to the RED, the mandatory 2020 target of 10 percent can be met by 'all types of energy from renewable sources consumed in all forms of transport', which means that energy sources other than biofuels are also considered (EC 2009b: Article 3). Hydrogen and electrical cars are a proven technology and a breakthrough in overcoming the main obstacles for wide-scale and short-term implementation, such as with regard to their infrastructure, could seriously affect the near-term future of transport biofuels.

Several assumptions are made regarding developments of the critical factors which may affect the future role of biofuels (and thereby the feasibility of EU biofuels corridors), as it is not within the scope of this research to assess all factors. The assumptions apply to the entire time scope of the biofuels corridor project, up to 2020, and are listed in Table 2.3.

Table 2.3 Critical Factors and Assumptions for the Future Role of Biofuels

Critical Factor	*Assumption*
Price of crude oil	These factors may develop in various ways, but biofuels will remain more expensive than conventional fuels. Supply of biofuels will be sufficient to meet the EU targets.
Price of biofuel feedstock	
Efficiency of biofuel production	
Research on environmental and social effects	Environmental and social sustainability issues are not taken into account in the rest of this study. The EU sustainability criteria will secure the sustainable production of biofuels. Developments in second generation biofuels will happen, but EU targets will mainly be achieved by the first generation.
Development of next generation biofuels	
Development of other renewable transport options	The contribution of other sustainable transport options, such as hydrogen and electrical-powered vehicles, will be nil in the near future, due to the fact that overcoming their infrastructural barriers takes more time. The renewable energy targets will therefore be mostly met by biofuels.

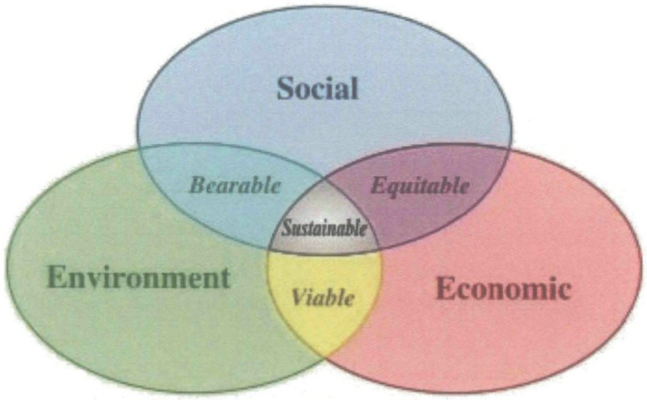
2.5 Epilogue

Biofuels are considered by EC policymakers as a viable alternative which could replace fossil transport fuels in the short run. The biofuel industry is booming, owing to strong government support, and first generation ethanol and biodiesel dominate the existing market.

It has been shown that biofuels could add greatly to the reduction of EU GHG emissions and fossil-fuel dependency, and thereby contribute significantly to the EU sustainable transport policy objectives. In addition, domestic production of biofuels would strengthen the agricultural sector in terms of employment and rural activity.

However, reductions in GHG emissions and fossil-fuel dependency seem less favourable from the perspective of current implementation practice. There is an ongoing discussion, led by academia and society, on the extent to which present-day biofuels are sustainable, and in turn, whether EU support for biofuels is justified. According to the Brundtland Commission, sustainable development is defined as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs', and it is generally accepted that achieving sustainability requires successfully dealing with the economic, environmental and societal dimension. These aspects are referred to as the 'three pillars' of sustainable development (see Figure 2.5) (IUCN, 2006). As has been indicated in the previous sections, it is hotly debated whether present-day biofuels can fulfil these requirements, as all of these dimensions are surrounded by controversial views. Present-day biofuels are therefore not considered to be completely sustainable.

Figure 2.5 The Three Pillars of Sustainable Development



Source: IUCN, 2006

It is difficult to indicate where exactly in Figure 2.5 biofuels would be placed, as all three aspects are currently under discussion. To make biofuels more sustainable would require an improved performance of all three pillars. This means trade-offs must be made, and the previous analysis has shown that these trade-offs mainly exist between economics on the one hand and social and environmental impacts on the other. Improving their social and environmental performance by using and developing next generation biofuels, for example, would require additional financial resources, as the technology is not yet fully developed. A large contribution by means of biofuels to the EC policy objectives would only be possible with sustainable biofuels, which requires investments in new biofuel technologies and a strong and common EU policy regarding sustainability criteria.

The potential role of biofuels in contributing to the EU sustainable transport policy objectives depends, therefore, on the development of crucial factors which have been identified above. These factors determine the sustainability of biofuels and include market drivers, developments and research in the production technology of next generation biofuels, and developments in other renewable energy sources for transport. They are also relevant to the feasibility of biofuels corridors. If support for biofuels were to be withdrawn, biofuels corridors would no longer be feasible.

Assumptions have been made regarding the developments of these crucial factors in a way that the future role of biofuels is determined by the RED targets. These assumptions are strengthened by various measures which have also been introduced in the RED, such as EC's sustainability criteria, for example. This chapter has thereby defined a plausible framework for further (national) biofuel policy and practical implementation, which biofuels corridors may consolidate.

3 Design of Biofuels Corridors

3.1 Introduction

This chapter details the creation of four biofuels corridor designs on a specific TEN-T Network route. The methodology used to create these biofuels corridor designs is based on future scenarios and is generally applicable to other corridors on the network.

The design of a biofuels corridor can take many forms, depending on the intervals and range of input factors. Examples of these factors include the number of biofuel stations on the corridor and the biofuel type(s) that are offered. While some of these factors can be influenced (design parameters), others are fixed and therefore cannot be changed (preconditions). One can systematically create and distinguish between different designs by changing the input value of the design parameters. The preconditions and design parameters that apply to biofuels corridors are elaborated upon in Section 3.2.

However, changing the value of design parameters would result in an extensive number of potential biofuels corridor designs, as many configurations exists. It is not within the scope of this study to assess the potential of all design options, and, aside from this, certain combinations of parameter inputs appear more logical than others. To clarify the latter aspect, it would be unbeneficial to offer biodiesel on a massive scale on the corridor if the fuel supply is low, for example. Such developments mainly depend on the future role of certain high-blends in the EU. Anticipating the future developments in this field, therefore, is a way to narrow down the number of plausible options for corridor designs. A scenario analysis is conducted in Section 3.3 as this serves this purpose well.

The input values of the design parameters are chosen in such a way that they are able to accommodate each of the future scenarios. This results in the definition of so-called corridor scenarios in Section 3.4, with the aim of ensuring the optimal effectiveness of corridor designs. The parameter values that are used in the corridor scenarios can be applied to any corridor on the TEN-T Network roads, such as the corridor selected for this case study (Section 3.5). The application of these parameter values, together with the characteristics of this specific corridor, results in various biofuels corridor designs which are provided in Section 3.6.

3.2 Preconditions and Design Parameters

This section elaborates on the various design parameters that apply to biofuels corridors (see Table 3.1). The preconditions, also outlined in Table 3.1, are considered to be unchangeable from the initiator's perspective and are therefore not taken into account any further in this section. Conversely, each design parameter has a certain input range, which can vary. When applied to a specific corridor, any input from these design parameters results in a biofuels corridor design. The following sections elaborate upon each of the three parameters. This involves a definition and an indication of each input range, as well as an analysis of the potential impact of these variations on the design of biofuels corridors.

Table 3.1 Preconditions and Design Parameters of Biofuels Corridors

Preconditions	*Parameters*
▪ Member State Biofuel Policy ▪ Biofuel-Compatible Vehicle Fleet	▪ Market Access ▪ Product Supply Diversity ▪ Station Coverage

Design Parameter 1: Market Access

Market access represents the percentage of corridor users that is permitted or able to refuel with biofuels on the corridor. Varying the market access would impact on the potential biofuel sales on the corridor, as well as the scale of implementation and thereby the respective strategy. As the effects of changing market access could influence the potential of the corridor both positively and negatively, it is considered to be an important parameter in the development of biofuels corridors. Lower market access, for example, could decrease biofuel sales on the corridor, meaning the corridor would then contribute to the EU policy objectives to a lesser extent. However, restricted market access could also *benefit* biofuels corridors, as this would allow increased control of possible financial support for the corridor project. The provision of incentives to biofuel-users would be easier to manage, and, as fewer fuel stations would be able to offer biofuels, the project's infrastructure investments could be controlled more tightly. This situation may well be preferred therefore, from an investors' perspective or in the early stages of implementation.

A distinction is made between four levels of market access: a dedicated user group (also referred to as 'captive fleet'), freight transport, passenger transport, and all road transport using the corridor. These levels cover a wide spectrum from low to high-level market access (see Figure 3.1). Various methods can be used to distinguish between these different market segments. This could involve putting constraints on users without access to the market. First among these methods is the provision of refuelling cards to a specific user group. These cards could be required to refuel with biofuels at certain locations on the corridor. Secondly, fiscal incentives could be provided to a specific user group to encourage their use of biofuels.[1] Thirdly, one could adjust market access by varying the biofuel types which are offered on the corridor. For example, the provision of biodiesel only would exclude the majority of the private car market. Lastly, the infrastructure could be designed in such a way that allows only specific users to refuel (e.g. special pumps for trucks).

Although the public transport fleet is an important niche market in which refuelling behaviour can easily be influenced by public money, it is not

[1] It must be mentioned that these measures could lead to unfair competition in the market, as some users would be financially supported, while others would not. For the purpose of this section, these possibilities have not been further examined.

considered to be a viable market for biofuels corridors. This is because most public transport companies refuel at predefined hubs (i.e. not along motorways), and would therefore not represent an attractive separate market segment for biofuels corridors.

The choice of market access in the design is interrelated with station coverage and product supply diversity to a certain extent (see the following sections). A lower degree of market access will naturally lead to reduced station coverage and vice versa. Furthermore, market access for diesel vehicles alone would reduce product supply diversity, and, likewise, a less diverse product supply could impact on the market access.

Figure 3.1 Design Parameter: Market Access

Design Parameter 2: Product Supply Diversity

Product supply diversity represents the different biofuel types and corresponding blends offered on the biofuels corridor. The parameter level increases with the amount of biofuel products that are offered, and in connection with the contribution to the EU policy objectives also with the content of the biofuel in the blend. Diversification of products could impact the potential of biofuels corridors, as it is directly linked with infrastructure adaptations which may be required and additional logistic costs. Moreover, diverging interests among stakeholders may favour the provision of certain blends on the corridor.

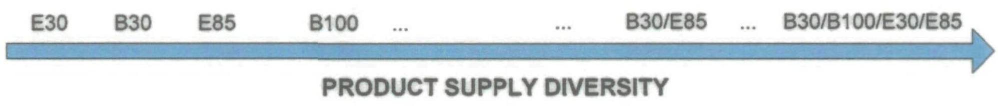
Only ethanol and biodiesel blends are taken into account, as they now represent over 95 percent of the total biofuels market in the EU. The analysis in Chapter Two indicates that they will remain the most dominant transport biofuels available on the market in the upcoming decade. Furthermore, biofuel blends with an ethanol or biodiesel content lower than 20 percent are not considered, due to the fact that this research focuses on the promotion of high-blends only. It is further assumed that there will be no diversification of product supply among individual biofuel stations on a certain corridor.

Four high-blends are considered in these designs: E30 ethanol, B30 biodiesel, E85 ethanol, and straight B100 biodiesel (see Figure 3.2). These blends are commonly available on the present-day markets, and there is no particular reason why other blends should be offered (see, for example, SenterNovem, 2008). E85 and B100 offer the highest content of biofuel per litre which is practically possible in the EU. Mid-level blends generally vary between 20 and 40 volume percent biofuel, and a wider range of vehicles could handle these fuels. An average of 30 percent mid-level biofuels has therefore been chosen for the purpose of this study.

In the corridor designs, various methods can be used by policymakers to have only specific blends offered on the corridor. One can choose to increase the demand for these blends, by way of specific incentives, for example, which would discourage fuel stations to offer the other blends. Or, the supply of either ethanol or biodiesel may be restricted.

The product choice for the biofuels corridor has consequences for the user group (market access), the logistic supply complexity and adaptations to fuel station infrastructure. A wider product variety would increase infrastructure and logistics costs and vice versa. And offering only ethanol blends, for example, would automatically exclude freight transport.

Figure 3.2 Design Parameter: Product Supply Diversity



Design Parameter 3: Station Coverage

Station coverage defines the intensity of stations that offer biofuels on the corridor. The parameter level increases with the number of stations per unit distance, referred to as 'station spacing'. Only stations directly on the corridor are considered (i.e. motorway stations). It is to be expected that possible detours, in order to refuel with high-blends at local stations slightly away from the corridor, will cause a significant user disutility. Station coverage influences the scale and complexity of the corridor project. It will also influence implementation and logistic costs, and market access. This, in turn, could affect the potential of biofuels corridors.

A minimum station spacing applies for all biofuels corridors. This is to avoid occurrences of vehicles running out of biofuel while driving on the corridor. Although vehicles can also use conventional fuels, this is not considered as an optimal design solution since the aim is to encourage the use of high-blends specifically.

The station spacing is dictated by the vehicle range and depends on the supply reliability of biofuel stations. The vehicle range, in turn, depends on the vehicle's tank size, the engine's fuel efficiency, and on the type of biofuel considered. The supply reliability is taken into account by applying a safety factor of two, as travellers should be able to make it to the next station in case one station on the corridor runs out of biofuels. Figures on minimum station spacings are provided in Table 3.2. It can be seen that minimum station spacing would be lower if freight transport alone is considered. Calculations and assumptions can be found in Annex C.

Table 3.2 Station Spacing for Various Vehicle Types and High-Blends

Vehicle Type	*Biofuel Blend*	*Minimum Station Spacing (km)*
Gasoline Car/Van	E30	234
Gasoline Car/Van	E85	185
Diesel Car/Van	B30	252
Diesel Car/Van	B100	234
Diesel Truck	B30	788
Diesel Truck	B100	732

Station coverage increases with the amount of stations offering biofuels on the corridor (see Figure 3.3). The minimum station spacing on the corridor represents its lowest value, and the situation in which all existing fuel stations on the corridor offer biofuels, represents its highest value. Methods to establish a certain level of station coverage vary. Agreements could be made with specific fuel stations on the corridor, for example, or multinational oil companies could participate in order to create a high-level coverage. Building new biofuel stations has not been considered as a viable options, due to the high costs involved.

Station coverage is closely linked with the level of market access and with the various stakeholders that would be involved in the biofuels corridor. Increasing station coverage, and thus biofuel supply, would naturally increase demand on the corridor, which would mean a higher level of market access. The opposite is also true. Therefore, for an open market including short distance traffic, station coverage should be high. Furthermore, a high station coverage could well limit the participating stakeholders to multinational fuel distribution companies only.

Figure 3.3 Design Parameter: Station Coverage

3.3 Scenario Analysis

This section defines four future scenarios for the increase of the use of high-blends in the EU, and thereby anticipates the interpretation of the EU Renewable Energy Directive 2009/28/EC (RED). This also defines the scope of biofuels corridors, as they may contribute to the promotion of these blends. The scenarios make it possible to narrow down the number of potential corridor designs with regards to their future viability.

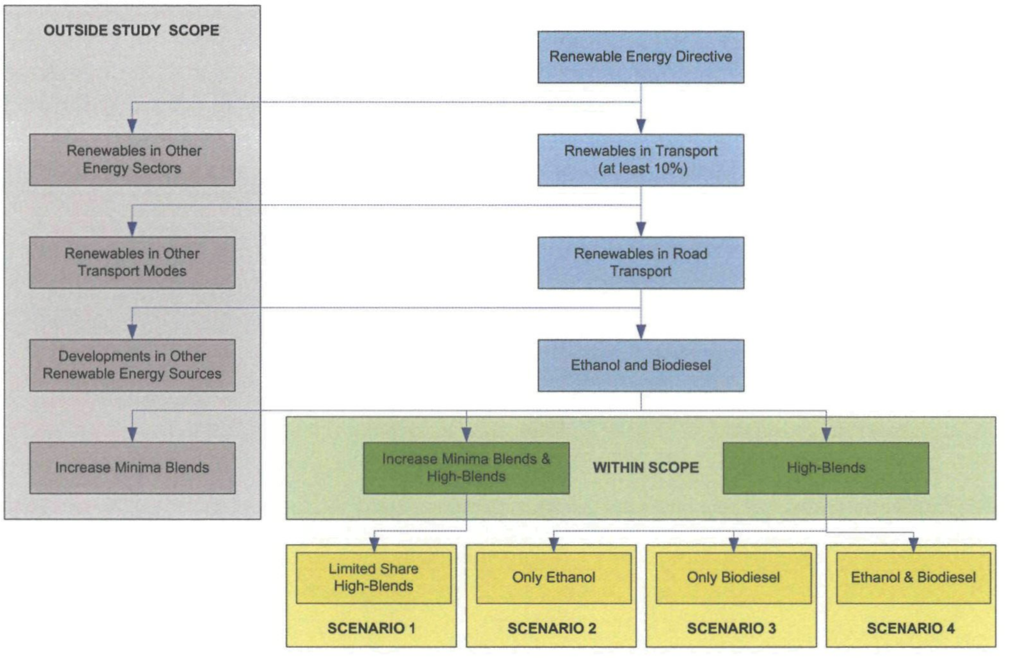
The RED is the key piece of legislation regarding the use of renewable energy in the EU. Despite some controversy surrounding the biofuels parts of the Directive, it has been assumed that the Directive will be maintained. It was argued in Chapter Two that this is to be expected, partly due to the inclusion of strong sustainability criteria for biofuels in the RED. The implementation of the RED, however, is open to interpretation by MSs and could therefore take various directions.

Ways to achieving the national targets for the share of renewable energy as stated in the RED, as well as the targets for each of the individual energy sectors themselves, have not yet been defined. The RED has only recently been adopted, and, at the time of writing, the only factor which is clear is that the share of renewable energy in the EU's total energy consumption must make significant progress in the upcoming decade. The overall EU share of renewable energy should be 20 percent in 2020, and different mandatory targets have been set for each MS (EC, 2009b). This includes a minimum renewable energy share of 10 percent in transport applicable to all MSs, and biofuels can and will play a prominent role in achieving this. This minimum target for transport lays the foundation for further stimulation of biofuels in the EU. Each MS must submit a national action plan before 30 June 2010, indicating their specific targets for each of the energy sectors and how these targets will be achieved. The public sector would then provide the industry with a level of stability regarding the future role of transport biofuels and this would set the scope for further biofuel promotion measures.

Biofuels corridors would become very interesting for the stimulation of the use of biofuels if high-blends in road transport are required or preferred for the sake of achieving the RED targets. The fact is that, aside from achieving the targets by implementing high-blends, there are also other alternatives which could lead to an achievement of the RED targets. It is likely that the role of high-blends will become clearer in one or two years, when the transport targets have been set and national strategies to achieve these targets have been defined. It will also depend on future developments in the production efficiency of second generation biofuels.

Figure 3.4 provides an overview of the various directions that the realisation of RED could possibly take. The diagram follows a hierarchical setting. The following paragraphs elaborate on each of the possible developments, with a focus on defining the scope of future scenarios for biofuels corridors.

Figure 3.4 Scenario Overview of the Future Role of High-Blends in the EU



First among the developments are uncertainties regarding the interpretation of the RED targets by MSs, as this would directly influence the renewable transport energy targets. Every country has an individual overall 2020 target for the use of renewable energy, based on their Gross Domestic Product (GDP). MSs are free to allocate different targets across the various energy sectors, under the condition that its share in transport meets the minimum of 10 percent. According to Hodson[1], all solutions are difficult to implement, and therefore, it may be that some countries decide to go beyond this minimum target in transport. This could then change the perspective on the promotion of transport biofuels, as going beyond 10 percent could be seen as an opportunity to achieve less in the other sectors.

Secondly, once the renewable energy shares in transport have been defined by the MSs, various options exist for the implementation of these targets within the transport sector. Aside from implementing the biofuels in road transport alone, other transport sectors, such as aviation, rail and inland shipping, could also make a contribution towards these biofuel targets.

Thirdly, the question remains as to what extent MSs deploy present-day biofuels, ethanol and biodiesel, or focus on developments in other forms of renewable energy. It has been previously argued that almost all renewable transport energy in 2020 will be provided by biofuels, as other alternatives (e.g. hydrogen-powered and electric transport modes) are either not mature enough, need more time to develop, or are too costly at this stage. This has been confirmed by various interviewees.[2] However, second generation biofuels could also be a

[1] From interview with Paul Hodson (EC)
[2] E.g. from interviews with John Neeft (SenterNovem) and Paul Hodson (EC)

realistic option. Most of these biofuels, such as BtL and hydrogenated vegetable oil, would allow blending of biofuels with conventional fuels in higher volumes, up to the targets which have been set, for example, without the need for engine adaptations. In addition, second generation biofuels count double towards the RED targets to stimulate their use. This means, for example, that the overall target of 10 percent can also be achieved by 5 percent of second generation biofuels alone. Both aspects would then reduce the need for further measures, as, naturally, an infrastructure for high-blends, such as biofuels corridors, would no longer be necessary. It would reduce the 'chicken-and-egg' problem related to biofuels promotion. This is in contrast to focussing on a further stimulation of the use of ethanol and biodiesel, as their acceptable future blending quotas will likely be limited to 10 and 7 volume percent in the coming decade, respectively.[1] This is approximately 6 percent on an energy basis, which would not be sufficient to even meet the minimum of MSs' targets.

Fourthly, and particularly relevant for this study, is how the remaining share of renewable transport energy that is not achieved by low-blends or any other alternative that has been mentioned above, would be accommodated. Two main options exist. First would be to change the gasoline and diesel fuel specifications in such a way that the allowable percentage of ethanol and biodiesel to be blended with these fuels is increased. This option is referred to as 'increasing the minima'. As noted earlier, the percentages are currently limited to 10 and 7 percent of ethanol and biodiesel, respectively, but one might decide to increase these values up to E20 ethanol and B15 biodiesel, for example. This would, however, also require engine manufacturers to produce new vehicles compatible with these blends. The second option would be to offer high-level ethanol and biodiesel blends. A middle course would be the incorporation of both solutions. A focus on just high-blends is not to be expected without strong government support, due to a lower efficiency of the supply chain brought about by offering more products.[2]

If high-level ethanol and biodiesel blends become an important part of MSs' RED strategy, biofuels corridors could have the potential to make a contribution to these targets. There would then be a need for an infrastructure for high-blends, which defines the scope for the biofuels corridors study. This scope is marked green in Figure 3.4.

Within this scope, various scenarios can be defined, as, if high-blends become important, the implementation could take various directions. These developments depend on the type of biofuel which becomes most popular, and on the required level of contribution from high-blends towards the targets. Four future scenarios are defined for the promotion of high-level ethanol and biodiesel blends. These scenarios are elaborated upon in the following paragraphs and are marked yellow in Figure 3.4.

[1] From interview with John Neeft (SenterNovem)
[2] From interview with Senior Manager (Oil Company)

Scenario 1: The minima of present-day biofuel blends would be slightly increased and high-blends would have compensate for the remaining mandate of biofuels in road transport. The implementation of high-blends is therefore limited.

If high-blends would need to contribute significantly to the biofuel targets, as only approximately 6 percent could be achieved by low-level blending, various other scenarios are possible.

Scenario 2: High-blends would focus on ethanol rather than on biodiesel, due to sustainability concerns with the production of biodiesel on such a large scale. Experts indicate that there is a risk that the production of biodiesel on such a large scale would absorb significant amounts of specific feedstock resources, which would lead to strong competition between food and fuel. The limited potential of biodiesel is in stark contrast with that of ethanol, which can be produced in much greater quantities in a sustainable manner (e.g. in Brazil).[1]

Scenario 3: High-blends would focus on biodiesel. Presently, experts indicate that there is currently an imbalance between the production and use of gasoline and diesel in the EU, meaning that the EU has to export gasoline and to import diesel. Marchand points to a sub-optimal refinery setup and tax policy in the past as reasons for this. [2] The imbalance will continue to grow, as more diesel vehicles are sold. Therefore, substitutes for diesel are preferred by oil companies, as substitutes for ethanol would only serve to intensify the imbalance. Aside from this, biodiesel would be easier to sell in high-blends, as a large amount of freight transport could be targeted.[3]

Scenario 4: High-blends would incorporate both ethanol and biodiesel, and would thereby accommodate almost all road transport markets. There is no particular preference for either one of these biofuel types in the market.

It should be mentioned that, although other and more specific scenarios could be developed, it is not within the scope of this research to do so. The scenarios that are chosen follow logically from the literature and from stakeholder interviews with industry leaders and experts. The scenarios cover a wide and sensible spectrum range of the future role of high-blends in EU road transport. Developments which could lead to these scenarios will certainly become clearer when the national action plans are published.

[1] From interview with Philippe Marchand (Total)
[2] From interview with Philippe Marchand (Total)
[3] From interview with Paul Hodson (EC)

3.4 Definition of Corridor Scenarios

This section defines four corridor scenarios in which the design parameter inputs (Section 3.2) accommodate each of the predefined scenarios (Section 3.3). The following paragraphs elaborate on these corridor scenarios and choices which have been made. The input values of design parameters are summarised in Table 3.3. These values can be applied to any TEN-T Network road corridor to develop biofuels corridor designs. This is done for the case study corridor in Section 3.6.

Corridor Scenario 1: There is a limited focus on high-blends in this scenario as there would be little need for high-blends to complement the low-blends in order to achieve the RED targets. To achieve this with minimal costs and good control of the high-blend market, the market access to these blends on the corridor is restricted to a captive fleet of freight transport companies that use high-level biodiesel blends. Due to the restricted access to biodiesel on corridors, and thereby easy control of suitable engines, straight B100 biofuel is offered. Long-distance transport companies using corridor stations are selected and therefore, minimal station coverage for trucks would apply.

Corridor Scenario 2: The renewable energy strategy in transport focuses on high-blends, but market access is restricted by the type of biofuel that is offered on the corridor, ethanol. This means that only gasoline vehicles, including passenger vehicles, have access to high-blends on corridors. E85, as opposed to medium ethanol blends, is offered on the corridor due to the high market activity in this field (see, for example, SenterNovem, 2008). Certain EU countries, such as Sweden and France, have already developed a considerable market share for E85. In addition, the impact on sustainable policy objectives of E85, as opposed to E30, is much higher. Furthermore, station coverage is high, as passenger transport (part of the market) is mostly short distance.

Corridor Scenario 3: The renewable energy strategy in transport focuses on high-blends, and market access is restricted by the type of biofuel that is offered on the corridor, biodiesel. This means that only diesel vehicles can use biofuels on the corridor, and this includes freight transport, as well as a share of passenger transport. In order to increase the market for biodiesel, in terms of engine support, B30 will be offered on the corridor. This choice for B30 on a free market scale is also supported by biodiesel activities of the industry (e.g. Total), as this would allow more vehicles to use the fuel. Station coverage for both markets must be high, as short-distance traffic is also part of the market.

Corridor Scenario 4: The renewable energy strategy in transport focuses on high-blends. There is no restricted market access, as both ethanol and biodiesel blends are offered on corridors. The fuels on offer are E85 ethanol and B30 biodiesel. Station coverage along corridors must be high, as short-distance traffic is also included.

Table 3.3 Definition of Corridor Scenarios

Parameter	*Corridor Scenario 1*	*Corridor Scenario 2*	*Corridor Scenario 3*	*Corridor Scenario 4*
Product Supply Diversity	B100 Biodiesel	E85 Ethanol	B30 Biodiesel	E85 Ethanol B30 Biodiesel
Market Access	Restricted Freight	All Gasoline	All Diesel	All Transport
Station Coverage	Low coverage	High coverage	High coverage	High coverage

3.5 Corridor Analysis

This section details the selection of a specific corridor on the TEN-T Network roads and describes its main characteristics in terms of transport flows, biofuel policy and refuelling infrastructure. The case study designs (see Section 3.6) will be based on this corridor. The corridor which has been selected runs from Rotterdam in the Netherlands to Constanta in Romania (see Figure 3.5).

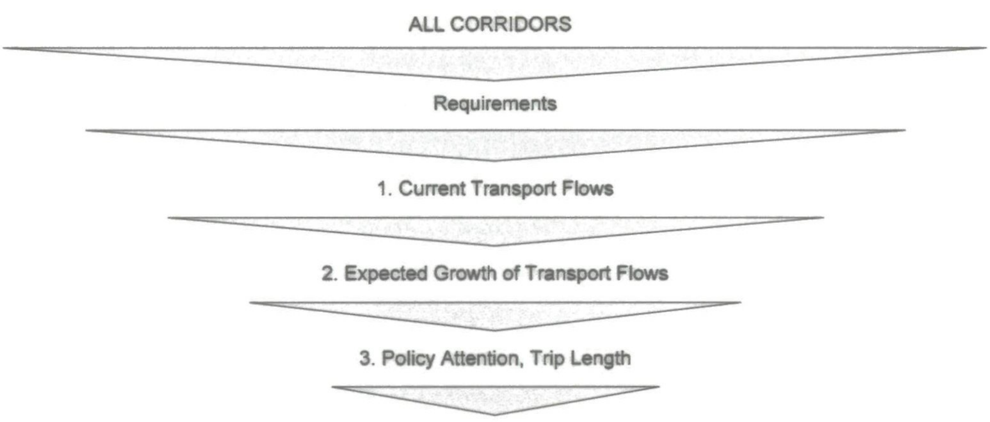
Figure 3.5 Corridor Rotterdam (the Netherlands) to Constanta (Romania)

3.5.1 Corridor Selection

The TEN-T Transport Network Roads comprise most European main roads which results in an extensive number of potential biofuels corridors. The specific corridor for the feasibility study is chosen with respect to several requirements and criteria. Requirements include that the corridor should be part of the TEN-T Network roads and should be at least 1000km in length. This is according to the definition of biofuels corridors in Chapter One. Furthermore, the corridor must originate from the Netherlands, as this study is conducted in cooperation with two Dutch institutes.

Various criteria determine the potential rate of biofuel sales along the corridor, and thereby the future impact that the biofuels corridor could have on the EU sustainable transport policy objectives. These criteria include current transport flows on the corridor (1), expected future growth of these transport flows (2) and various other criteria, such as EC policy attention and average trip length of vehicles on the corridor (3). It should be mentioned that, although passenger transport is also covered by the criteria, there was a slightly higher focus on the freight transport side when selecting the corridor. This is because of the higher data availability of this sector. The criteria are ranked in order of importance and individual assessments have gradually narrowed down the total number of corridors. This is schematically shown in Figure 3.6. The following paragraphs elaborate briefly on each analysis.

Figure 3.6 Overview of the Corridor Selection Process



The first analysis, with regards to current transport flows, resulted in the selection of four European corridors. This selection includes spatially different alternatives, two East-West and two North-South corridors. Transport flows, in terms of passenger-km and tonnes-km, are based on inputs of senior experts at NEA Transport Research and Training in the Netherlands, as well as on outcomes of the TEN-CONNECT[1] study (TEN-CONNECT, 2008). The selected corridors are listed below:

[1] This EC traffic study focuses on the effects of the TEN-T policy, and is carried out using the transport model TRANS-TOOLS.

- Rotterdam (Netherlands) - Barcelona (Spain) (1,482km)
- Rotterdam (Netherlands) - Warsaw (Poland) (1,250km)
- Rotterdam (Netherlands) - Constanta (Romania) (2,480km)
- Rotterdam (Netherlands) - Venice (Italy) (1,278km)

The second analysis, based on the expected future growth of transport flows, indicates that the East-West corridors to Poland and Romania offer highest potential for future growth. This is evidenced by traffic forecasts in TRANS-TOOLS for 2030 (NEA, 2009 and TEN-CONNECT, 2008). Eastern European countries have only recently joined the EU and this is driving developments in the field of transport activities between Eastern and Western MSs. This is in contrast to the North-South corridors to Spain and Italy. Although existing transport flows on these corridors are high, their future growth will remain limited.

The third analysis has led to the selection of the corridor which runs from Rotterdam in the Netherlands to Constanta in Romania. This appraisal is based on the performance of the two remaining East-West corridors with respect to various aspects. First among these aspects is the fact that transport growth on the Romanian corridor is expected to be higher than on the Polish corridor. Romania recently became an EU member in 2007 and its transport sector is now developing rapidly (EC, 2009). This is also evidenced by the increasing activities of the Port of Constanta in recent years, which will also increase the corridor's future transport flows. The port is currently the ninth busiest European cargo port and serves as the main container hub in the Black Sea (EIC, 2006). Furthermore, Constanta serves as a node on the TRACECA and Pan-European IV Corridor Networks, and thereby offers important (future) transport connections between Western Europe, and Central Asia. The development of these two networks will also lead to a growth in transport flows on this corridor. Secondly, the longer length of the Constanta corridor would set the scope for a higher average trip length on the corridor. This would be particularly relevant for freight transport trucks. Naturally, these trucks top up their fuel tanks at the start of their journey, which is often done internally, and only long routes, which the corridor to Romania would serve, would force these companies to refuel along the route. Thirdly, the corridor to Constanta is part of the Pan-European Corridor IV. This implies that the corridor is receiving special attention from EC policymakers, which could stimulate interest in and support of the biofuels corridor initiative. Lastly, it has been argued in the literature that the potential of biofuel production in far Eastern European countries, such as in Romania and Ukraine, is high (see, for example, Kondili and Kaldellis, 2006). A corridor running to Constanta in Romania would therefore have easier access to domestic biomass supply and could stimulate rural development in these areas.

3.5.2 Corridor Characteristics

The corridor from Rotterdam to Constanta consists of two corridor routes which are frequently driven (see Figure 3.5), in a southerly direction via Mannheim in Germany and in a northerly direction via Hanover and Dresden.[1] Transport flows on both sections running through the Netherlands and Germany are particularly high, and incorporating both routes, as opposed to a single route, could increase biofuels sales substantially. The total length of the corridor (i.e. including the two sections) is just over 4000km. Details of the routes can be found in Annex C. Most of the roads are motorways, with the exception of some Romanian roads which are currently under development. These are all expected to be finished by 2011.

The following sections elaborate on the corridor characteristics. Firstly, the corridor transport flows and the corresponding fuel consumption is estimated. Secondly, the biofuel policy in each of the MSs that are involved in the corridor and the refuelling infrastructure are examined.

Corridor Transport Flows and Corresponding Fuel Use

This section examines the transport fuel used by vehicles using the Rotterdam-Constanta corridor. This is done in order to estimate the potential impact of the corridor on the use of biofuels and thereby its impact on the EU sustainable transport policy objectives. The methodology used for this estimation is first described, followed by an overview of the assumptions which have been made. Then, limitations of the approach used are discussed. Finally, the outcomes are presented in terms of total fuel consumption on the corridor, as well as their relative shares at MS level.

It should be clearly emphasised that the fuel use as estimated in this section is based on transport flows and thus could well be different from the actual fuel sales at refuelling stations along this corridor (see Chapter Four).

Methodology

To estimate the fuel consumption on the corridor, the transport flow shares on the corridor as a percentage of total transport activity are multiplied by the national diesel and gasoline fuel consumption of the respective markets at MS level. It should be mentioned that the results which are provided include all transport activity on the corridor, and not only traffic running from Rotterdam to Constanta.

The national diesel and gasoline fuel/energy consumption follow from the MS progress reports of the 2003/30/EC Directive. Each MS is required to provide information regarding the annual quantities of diesel and gasoline fuel being brought on the market. These figures count for the entire transport sector, and therefore, various assumptions are made to derive the specific quantities for the passenger and freight road transport sectors.

[1] From interview with Anton Stam (E van Wijk Logistics)

TRANS-TOOLS has been used to determine the transport flows on the corridor as a percentage of the total transport activity in the respective countries. TRANS-TOOLS, developed by the EC's Joint Research Centre, is a European transport network model which covers both passenger and freight transport, as well as intermodal transport. The model contains origin-destination matrices up to NUTS2[1] and NUTS3 level, a comprehensive transport network, and advanced modelling techniques in trip generation and assignment. The combination of these inputs has resulted in a 2005 TRANS-TOOLS assignment which provides, among other data, information regarding transport flows on individual links for each of the respective modalities.

The transport flows on the corridor, in terms of passenger-km (pkm) and freight-km (fkm), are calculated by multiplying the number of vehicles on each corridor link by the length of this link, and subsequently adding up the outcomes (see Formula 3.1). The shares of passenger and freight transport activity on the corridor are obtained by dividing the corridor flows by the total pkm and fkm values at the level of MS (see Formula 3.2).

$$CorridorFlow = \sum_{Link=1}^{Link=\max} linkflow * linklength$$ [Formula 3.1]

$$ShareCorridor = \frac{CorridorFlow}{TotalMSFlow}$$ [Formula 3.2]

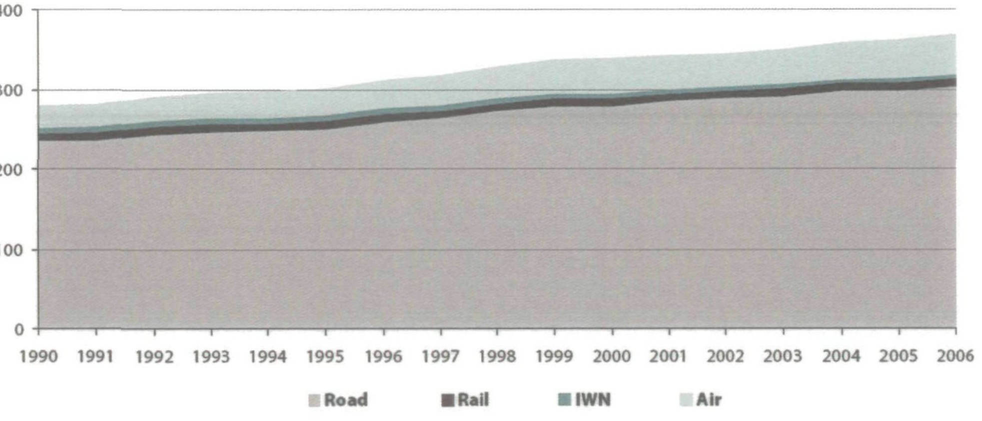
Assumptions

The following paragraphs elaborate upon the assumptions that have been made for the estimation of transport flows and fuel consumption on the corridor.

Firstly, all national diesel and gasoline fuel sales are assumed to be used in road transport. The total fuel sales provided by MSs include all transport modes, but, according to the EU-27 statistics on transport energy consumption by mode (see Figure 3.7), fuel consumption in the other sectors is negligible. Air transport, which accounted for 14 percent of total energy use in 2006, uses kerosene, and is thereby not relevant here (Eurostat, 2009). Rail and Inland Water Navigation (IWN) may use diesel fuel, but the energy share of these sectors is very small, particularly when considering that EU rail transport mainly uses electric traction (EC DG TREN, 2008).

[1] Nomenclature of Territorial Units for Statistics (NUTS) is a so-called geospatial entity object code standard which refers to the administrative divisions of countries for statistical purposes. Higher NUTS levels indicate higher precision (e.g. provinces or departments).

Figure 3.7 EU-27 Transport Energy Consumption by Transport Mode

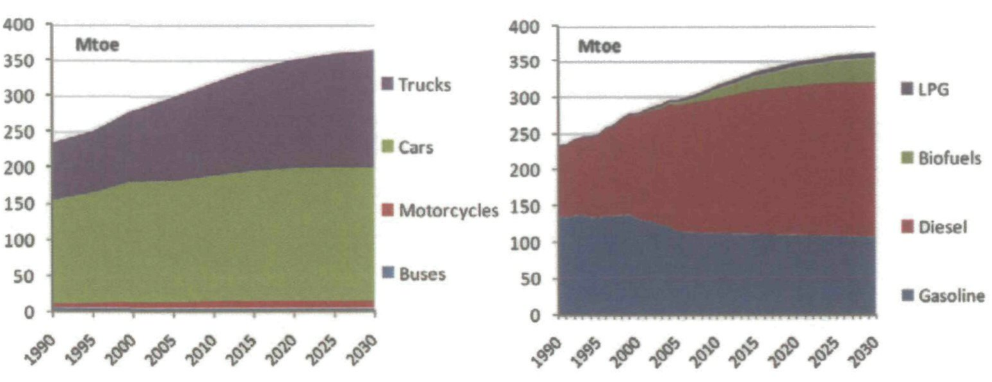


Source: Eurostat, 2009

Secondly, within the road transport sector, 55.9 percent of the total energy is used to power passenger cars and 39.4 percent for trucks (total 95.3 percent) (see Figure 3.8) (EC DG TREN, 2008). It is assumed that all EU road transport uses exclusively diesel and gasoline fuel. The shares of LPG and CNG, amounting to a total of currently 1.7 percent, are very small (EC DG TREN, 2008). Furthermore, freight trucks are assumed to use diesel only.

Thirdly, the expected growth of transport flows, and thereby transport energy consumption (see Figure 3.8), will follow the national trends observed since 1990. Figures regarding these developments originate from EU statistics (EC, 2009). The analysis (see Annex C) has resulted in annual growth rates per country, whereby a distinction is made between passenger and freight transport. The average annual growth rates are listed in Table 3.4. Freight transport growth (3.32 percent) in the MSs is more than twice as big as passenger growth (1.39 percent).

Figure 3.8 Predictions of EU Fuel Consumption in Road Transport by Vehicle and Fuel Type



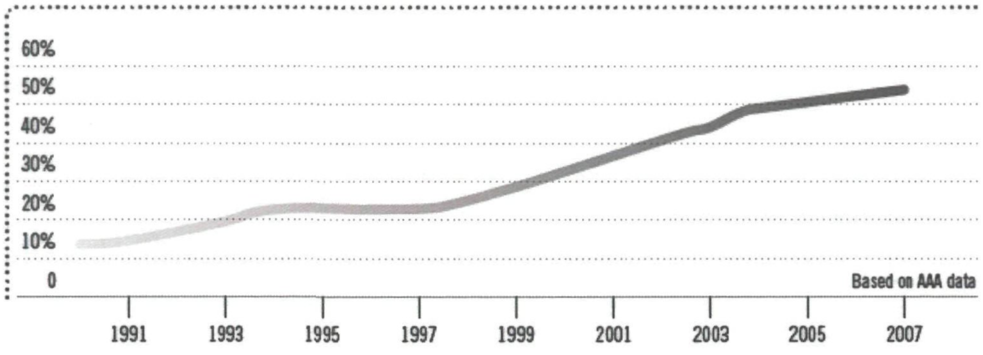
Source: EC DG TREN, 2008

Table 3.4 Annual Freight and Passenger Transport Growth Rates

	Passenger Transport	*Freight Transport*
Austria	1.14%	2.43%
Czech Republic	1.98%	2.92%
Germany	0.51%	2.56%
Hungary	-0.80%	5.12%
Netherlands	0.97%	1.16%
Romania	3.33%	5.58%
Slovakia	2.57%	3.45%
Average	**1.39%**	**3.32%**

Fourthly, aside from growths in passenger and freight transport flows, the share of diesel use in passenger transport will rise. A rise of 5 and 10 percent in diesel use among car passenger transport is assumed by 2015 and 2020, respectively. This leads to a lower gasoline consumption at that time relative to diesel consumption. The assumption is made because of the sharp increase in the amount of diesel vehicles during the last decade (see Figure 3.9). In France, Belgium and Luxembourg, for example, the percentage of diesel cars sold in recent years has hit 70 percent. The EU-27 passenger car market consists of approximately one third diesel and two thirds gasoline cars (ACEA, 2008). Reasons for the rapid growth are its stronger consumer market in the context of rising fuel prices, and diesel is more energy efficient (Eurostat, 2009). The rising diesel demand is supported by predictions from EC DG TREN (2008) (see Figure 3.8), although some of the growth might also be explained by the sharper increase of freight transport compared to passenger transport (see Table 3.4 and also Figure 3.8).

Figure 3.9 Share of Newly Sold Diesel Vehicles in the EU



Source: ACEA, 2009

Limitations

Aside from the assumptions which have been made for the estimation of fuel use on the corridor, other limitations of the approach that has been used should be mentioned. The transport flow shares on the corridor are based on the outcome of a model assignment. Although TRANS-TOOLS is currently one of the most accurate and functional models available, which involves both passenger and freight transport at EU level, the true shares may well slightly deviate from the outcomes.

Another limitation regarding the use of TRANS-TOOLS is that assignments do not include intrazonal traffic. One might argue that, because of this, transport flows on the corridor segments could be slightly lower in reality. Intrazonal trips are often shorter compared to interzonal trips, which might reduce the average chance of taking the motorway, which in turn may constitute a part of the corridor.

Results and Observations

The following tables and figures detail the future fuel consumption by vehicles using the Rotterdam-Constanta corridor. The expected fuel consumption of the passenger gasoline, passenger diesel, and freight diesel market segments are listed in Tables 3.5, 3.6 and 3.7, respectively. The tables also list the transport flow on the corridor as a percentage of national driven-km. Total fuel use is estimated to be approximately 8280 million litres annually in 2020 (see Figure 3.10). Further calculations are provided in Annex D.

Table 3.5 Passenger Gasoline Fuel Use on the Rotterdam-Constanta Corridor in Millions of Litres

Member State	**Gasoline Consumption by Passenger Cars**			% of National Driven-km on Corridor
	2010	2015	2020	
Austria	218	205	193	9.1%
Czech Republic	319	325	335	11.9%
Germany	1501	1437	1374	5.8%
Hungary	181	160	139	9.3%
Netherlands	509	498	488	9.9%
Romania	210	226	249	9.5%
Slovakia	40	42	45	4.0%
Total	**2978**	**2893**	**2823**	**8.5%**

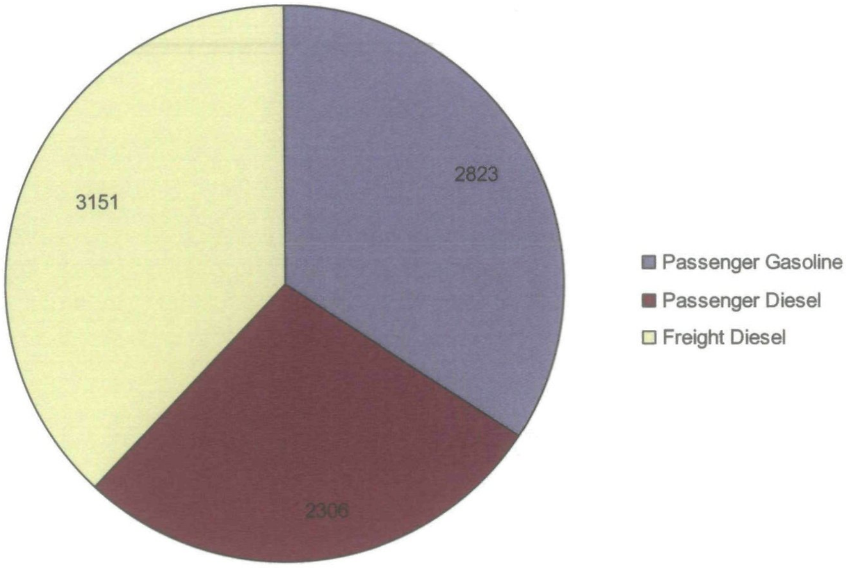
Table 3.6 Passenger Diesel Fuel Use on the Rotterdam-Constanta Corridor in Millions of Litres

Member State	Diesel Consumption by Passenger Cars			% of National Driven-km on Corridor
	2010	2015	2020	
Austria	298	341	385	9.1%
Czech Republic	215	264	315	11.9%
Germany	557	675	792	5.8%
Hungary	99	109	119	9.3%
Netherlands	219	266	314	9.9%
Romania	216	275	342	9.5%
Slovakia	25	32	39	4.0%
Total	**1628**	**1962**	**2306**	**8.5%**

Table 3.7 Freight Fuel Use on the Rotterdam-Constanta Corridor in Millions of Litres

Member State	Diesel Consumption by Freight Trucks			% of National Driven-km on corridor
	2010	2015	2020	
Austria	145	163	184	3.7%
Czech Republic	543	627	724	18.0%
Germany	721	818	929	3.0%
Hungary	115	148	190	5.2%
Netherlands	437	463	491	9.1%
Romania	342	449	589	11.0%
Slovakia	42	38	45	3.0%
Total	**2336**	**2707**	**3151**	**7.6%**

Figure 3.10 Expected Fuel Consumption by Users on the Rotterdam-Constanta Corridor in Millions of Litres, by Fuel Type and Market in 2020



Given the outcomes above, it can be concluded that transport flows and the corresponding fuel use on the Rotterdam-Constanta corridor as a percentage of their national values are striking. On average, approximately 8 percent of national fuel use originates from the specific corridor traffic. This indicates the national importance of main corridors in terms of transport flows. A large fuel market might therefore be served by means of biofuels corridors.

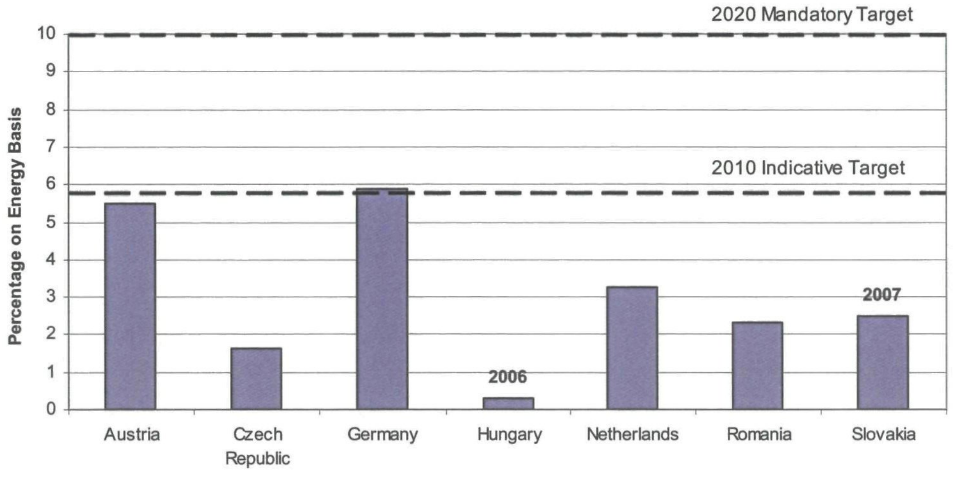
Several other observations follow. Firstly, the share of freight and passenger transport using the corridor in the MSs is almost equal, approximately 8 percent. The values are particularly high for freight transport in the Czech Republic (18 percent) and Romania (11 percent), where the biofuels corridor could thus achieve more than in other countries. Secondly, the percentage of diesel use among passenger cars is presently at approximately 36 percent. As only around 30 percent of present-day passenger cars has a diesel engine in these MSs, this supports the view that diesel cars drive more km compared to gasoline vehicles (ACEA, 2008). Furthermore, the fuel consumption of the freight transport sector on the corridor will account for over one third of all fuel being used.

(Bio)fuel Policy and Progress along the Corridor

Biofuel policies among the seven MSs that are involved in the specific corridor vary significantly. These differences may have implications for the development and implementation of trans-national biofuel stimulation. This section aims to provide an overview of these factors.

First are variations in the policy and progress related to the Biofuels Directive 2003/30/EC. Figure 3.11 provides an overview of the respective biofuel shares in 2008. The dotted line in the graph indicates the first Biofuels Directive's indicative target for 2010, which is set at 5.75 percent.

Figure 3.11 Member State Biofuel Shares in Transport in 2008

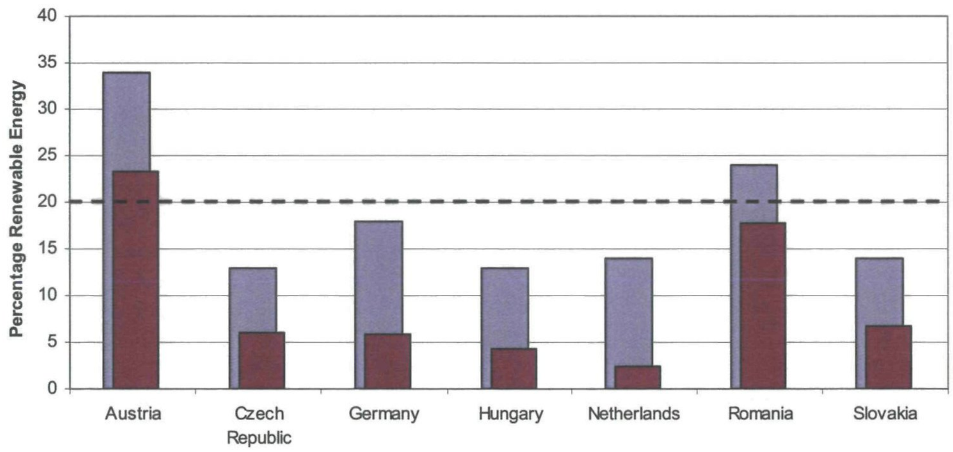


Source: National Reports on the Biofuels Directive 2003/30/EC

Austria and Germany are forerunners in the field of biofuels consumption, and, by 2008, their indicative 2010 EU targets had roughly been achieved. Their fast progress, compared to the other MSs, could be attributed to high levels of government support and/or a strong domestic biofuels production industry.

Figure 3.12 shows the mandatory targets for renewable energy in 2020 per country and the 2005 shares of countries' renewable energy. A minimum of 10 percent applies for the transport sector. The overall target share of 2020 is indicated by the dotted line.

Figure 3.12 Member State 2005 Renewable Energy Shares (Purple) and 2020 Renewable Energy Targets (Blue) (>10% Transport)



Source: EU Renewable Energy Directive 2009/28/EC

Renewable energy targets vary considerably between MSs. It can also be seen from Figure 3.12 that countries like the Netherlands and Germany, due to their high GDP, have relatively tough targets compared to Eastern European MSs.

Although no conclusions can be drawn on these figures, one could anticipate Western MSs considering more ambitious targets for renewable energy in transport than only 10 percent, in order to meet their overall targets.

MS support policy for the promotion of biofuels is listed in Table 3.8. At the time of writing, all MSs, with the exception of the Netherlands, make use of excise duty tax exemptions in order to promote the use of high-blends. However, as has been mentioned in Chapter Two, a shift towards obligations to use biofuels exclusively can be seen. This is, for example, evidenced by the gradual disappearance of German support for high-level biodiesel blends. More specific information regarding these present-day measures for the individual MSs can be found in Annex C.

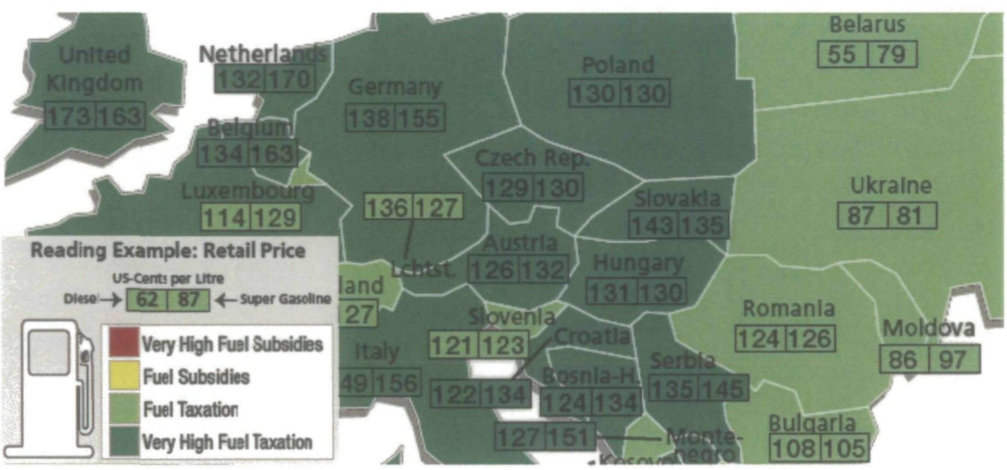
Table 3.8 Current Member State Promotion Measures of Biofuels

Support Measures High-Blends	*AU*	*CZ*	*GE*	*HU*	*NL*	*RO*	*SK*
Biofuel Obligations	All Member States						
Excise Duty Reductions	V	V	V	V	-	V	V

Source: National Reports on the Biofuels Directive 2003/30/EC and Task39, 2009

Figure 3.13 provides an overview of retail diesel and gasoline prices in Europe and also shows that excise duties on these products vary. The ratio between diesel and gasoline prices is particularly interesting, as it varies considerably among MSs. This is mainly because of the different interests these countries have. On the corridor, diesel prices are relatively low in the Netherlands, Austria and in Romania, in order to stimulate the transport sectors. This makes it attractive for freight companies to refuel in these countries.[1] Overall, gasoline prices become lower in the Eastern-European MSs.

Figure 3.13 Retail Diesel and Gasoline Prices in EU Countries in 2007



Source: International Fuel Prices, 2007

[1] From interview with Senior Policy Advisor (Dutch Ministry of Housing, Spatial Planning and the Environment) and Anton Stam (E van Wijk Logistics)

Refuelling Infrastructure

The total number of fuel stations has been obtained from the road maps of the Royal Dutch Touring Group (ANWB, 2009). Exact figures are provided in Annex C. Data for the Romanian sections was not available, which means that the number of stations on these sections have been obtained by the extrapolation of other segments. The total current number of stations is estimated to be 212. This means one station every 38km.

A 10 percent increase in the amount of fuel stations on the corridor is expected by 2020. This is particularly because of ongoing developments in the Eastern European road sections of the corridor and rising transport flows. This means that the number of fuel stations will be approximately 230 in 2020.

However, density of fuel stations along the corridor varies and is higher in Western European countries, e.g. up to once every 20km in the Netherlands. Therefore, even the minimum station spacings for E85 infrastructure can easily be met by existing refuelling infrastructure.

3.6 Definition of Rotterdam-Constanta Biofuel Corridor Designs

This section provides a short description of four biofuels corridor designs for the Rotterdam-Constanta Corridor. The designs have been developed by applying each of the corridor scenarios (Section 3.4) to this specific corridor (Section 3.5). Quantification of the design parameters is done as far as possible and is required for the case study in Chapter Four.

Corridor Design 1 (Rotterdam-Constanta): Biodiesel B100 is offered at freight pumps. Minimum station spacing applies for long-distance transport, which is estimated to be one station every 732km. Considering the corridor length of just over 4000km, this results in a total of approximately 12 biofuel stations (both sides of the corridor). Freight transport companies that regularly refuel at these stations are selected for the captive fleet. The number of participating freight companies depends on the required biofuel sales as a percentage of total fuel sales. It is assumed that, in this design, the total of these freight transport companies will account for 5 percent of the total freight transport on the corridor. This results in a total diesel consumption on the corridor by the specific market of around 158 million litres in 2020 annually.

Corridor Design 2 (Rotterdam-Constanta): Ethanol E85 is offered. The minimum station spacing of once every 185km applies, which would result in a total of approximately 44 biofuel stations. However, due to the high access market, including local short-distance passenger transport, many more stations on the corridor would need to offer biofuels. Therefore, over 50 percent of the total number of stations will offer the high-blend. The exact number of stations depends on the market and oil companies. The total fuel use of gasoline passenger cars on the corridor will account for approximately 2823 million litres annually in 2020.

Corridor Design 3 (Rotterdam-Constanta): Biodiesel B30 is offered, both for freight transport and for passenger transport. Minimum station spacing for freight is almost 800km and for passenger around 250km, which results in a minimum of 32 biofuel stations on the corridor. One in every four stations must also have a biodiesel pump for trucks. However, the high access market also includes short-distance transport, which therefore would require more stations. The exact number depends on the market and the oil companies, and will be over 50 percent of the total number of stations on the corridor. The total fuel use of the market on the corridor (i.e. all diesel vehicles) accounts for approximately 5457 million litres annually in 2020.

Corridor Design 4 (Rotterdam-Constanta): Both biodiesel B30 and ethanol E85 are offered at the corridor. Many fuel stations would need to offer the biofuels, which is over 50 percent of the total number of stations. The exact number depends highly on the market analysis and on the oil companies. The potential market includes all traffic on the corridor, which account for approximately 8280 million litres annually in 2020.

3.7 Evaluation and Conclusions

This chapter has detailed the creation of four biofuels corridor designs for the Rotterdam-Constanta road corridor. This is done using a methodology which is generally applicable to other corridors on the TEN-T Network roads. The methodology involves the selection of various design parameter inputs for biofuels corridors with respect to future EU scenarios for the promotion of high-level ethanol and biodiesel blends. The parameter choice is then quantified by the characteristics of the Rotterdam-Constanta corridor.

One must be aware of the existence of other ways to develop designs for biofuels corridors and the limitations of the methodology used here. Firstly, different methods could be used to narrow the number of potential designs down and may result in different outcomes for corridor designs. However, it has been previously argued that, due to the uncertainties surrounding the future EU use of biofuels, a scenario approach is very suitable for this. In addition, the scenario approach has led to a wide diversity of design parameters inputs, which indicates that the corridor designs used in this study cover a wide spectrum of the possible solution space. Secondly, changing the selection criteria for the specific corridor might lead to a different corridor choice. The specific corridor for the case study has been selected by applying various requirements and criteria to the TEN-T Network corridors. The criteria used in this study are predominantly based on transport flows on the corridor, as this is regarded as an important indicator for the potential biofuel consumption on the corridor. Nevertheless, one could for example also take the MS biofuel support policy as the main criterion for selecting countries that should be involved in the countries. It is likely that this would have led to different countries, such as Sweden and France, being included in the corridor. Thirdly, there is no universal methodology available to analyse the total fuel used by vehicles on a specific EU trans-national road corridor. An estimation of this figure could take various forms. The results of this study are based on an application of the TRANS-TOOLS model and various assumptions regarding the allocation of national diesel and gasoline fuel shares among the passenger car and freight market segments. This approach is subject to limitations, which have also been addressed above.

Two main conclusions can be drawn from the analyses presented in this chapter. Firstly, the scope of biofuels corridors will presumably be limited to the scenarios in which high-level ethanol and biodiesel blends become an important part of MS strategies to achieve the RED targets. One can distinguish between four main scenarios in this case. More certainty regarding these developments can be expected in the coming years. Secondly, the Rotterdam-Constanta corridor displays high potential to be used as a biofuels corridor in terms of transport flows and fuel consumption. Estimates indicate that the transport flows on the corridor as a percentage of national transport flows could be as high as 18 percent. Total fuel consumption will reach approximately 8280 million litres annually in 2020.

4 Feasibility Study: Rotterdam to Constanta

4.1 Introduction

This chapter examines the potential and feasibility of each of the four Rotterdam-Constanta biofuels corridor designs. General background information regarding transport flows, biofuels policy and the refuelling infrastructure of this corridor has been provided in the previous chapter, in addition to four potential designs of the corridor. The purpose in this chapter is to determine the effect of this biofuels corridor in terms of the increased use of biofuels and other positive externalities, as well as to identify the likelihood of creating a policy landscape which is conducive to the development and operation of the concept. The results of this case study are used in the following chapter to make further pronouncements on an EU-wide implementation of biofuels corridors on the TEN-T Transport Network roads.

The principal starting point for the feasibility study is a SWOT analysis based on stakeholder interviews (Section 4.2). The SWOT analysis is generic for EU biofuels corridors and comprises different aspects, i.e. the market, technical and economic aspects and policy options, which are further assessed for the Rotterdam-Constanta biofuels corridor specifically. The market analysis (Section 4.3) determines the gasoline and diesel volumes which could possibly be replaced by biofuels on the corridor. The percentage of corridor users that will buy high-blends at corridor stations is estimated by means of several assumptions (e.g. attitude towards high-blends and price). The technical analysis (Section 4.4) examines the availability of vehicles and infrastructure equipment required for the handling and use of high-blends. The economic analysis (Section 4.5) investigates the costs related to the development and operation of the biofuels corridor, and also indicates who might bear these costs. A distinction is made between vehicle costs, logistical costs, and the extra costs of biofuels. The policy options analysis (Section 4.6) aims to identify viable policy options that could target the key threats identified in the previous analyses. Finally, the overall potential and feasibility of the Rotterdam-Constanta biofuels corridor designs are evaluated and conclusions are presented (Section 4.7).

4.2 General SWOT Analysis for Biofuels Corridors

The SWOT analysis presented in this section refers to the strengths, weaknesses, opportunities and threats of developing EU biofuels corridors (see Figure 4.1). The main input for the SWOT analysis was interviews with key stakeholders who would be closely associated with the development and operation of biofuels corridors (e.g. EC, road transport companies, oil industry and national governments). Summaries of these interviews are provided in Annex A. The SWOT analysis is further supplemented with data and information from the previous chapters.

Based on these interviews and the literature, a stakeholder analysis was carried out (see Annex B). The aim of the stakeholder analysis was to establish a clear and coherent overview of the power relations among the stakeholders, and their particular roles in the stimulation of the use of high-blends. The analysis serves as a tool to supplement other quantitative analyses in this chapter with qualitative data in order to assure whether certain measures or policies (which may seem preferable based on the quantitative data) are likely to be adopted or accepted. This avoids drawing conclusions based solely on these quantitative data (e.g. fuel use) and theoretical policy options. Furthermore, the stakeholder analysis can also be used as secondary data for future research and/or policy advice for policymakers and consultants in the field of establishing promotion measures for high-blends.

Two statements must be made regarding the SWOT analysis. Firstly, general factors that apply to the promotion of biofuels are not taken into account in the SWOT. Examples include the development of the agricultural sector and the issues regarding the sustainability of biofuels, which have already been thoroughly explored in Chapter Two. By taking the RED as given, it is to be expected that these factors will also hold for alternative biofuel support measures. Secondly, one can distinguish between factors which apply to the promotion of high-blends in general, and those that are specific for biofuels corridors. The biofuels corridor scenarios (defined in Section 3.3) assume a policy landscape which is conducive to the promotion of high-blends, and therefore, the specific factors for biofuels corridors alone would seem most relevant to examine. However, as both factors are closely connected, one can say much more about the potential and feasibility of the corridor if the factors which are general for the promotion of high-blends are also included. A clear distinction between the two will be made throughout this section.

Figure 4.1 SWOT Analysis of Developing EU Biofuels Corridors

Strengths	*Weaknesses*
Contribution to the EU renewable energy targets by means of high-blends	Future support policy must focus on the promotion of high-blends
Opportunities	*Threats*
Cross-border cooperation in the promotion of biofuels Inclusion of long-distance freight transport as a market for high-blends Marketing stunt for oil companies to promote the use of biofuels Make biofuels more recognisable among road users	Availability and implementation of biofuel-compatible vehicles and infrastructure technology Cost-effectiveness of the measure to promote biofuels Need for structural public policy (and money) to promote high-blends and biofuels corridors

The main strength of EU biofuels corridors would be their potential contribution to achieving the EU renewable energy targets by means of high-blends. This is supported by the outcomes of the transport flow analysis, which in turn points to significant amounts of fuel being used on main road corridors (see Section 3.5). A market and demand analysis of the Rotterdam-Constanta corridor will provide more insight into this matter. Aside from this, various opportunities have been identified. Firstly, there are opportunities related to the international character of the measure. This would encourage the adoption of a coherent strategy among the countries involved in the biofuels corridor and may lead to a certain harmonisation of MSs policy or visions. This, in turn, could stimulate European integration. International cooperation between the energy and vehicle manufacturing industry may progressively develop, as this would be more efficient for implementing changes at the EU level. Vehicle manufacturers, for example, would then have a larger outlet for biofuel-compatible vehicles. In addition, there would be no diversification of biofuel blend-types among EU countries. Secondly, biofuels corridors would lead to the inclusion of long-distance freight transport as a potential market for biofuels. According to Stam, freight transport companies would only consider switching to biofuels if the specific fuel is widely and internationally available, something which would be possible with biofuels corridors.[1] Nearly half of the EU international freight transport trips is longer than 500km, resulting in an additional potential market of over 5 percent (EC, 2009). Thirdly, the corridor approach could serve as an international marketing stunt for the promotion of renewable energy. Oil companies may take advantage of this by developing this new market. Lastly, high-blends (as opposed to low-blends) would make biofuels more noticeable to road users.

The main weakness, as also identified by the stakeholders, is that the future policy should stimulate the use of high-blends in road transport. This has also been confirmed by the scenario analysis in Chapter Three. Other ways to achieving a higher use of biofuels exist, and could be more effective than promotion through the creation of biofuels corridors. This observation leads to several threats related to the successful development and operation of biofuels corridors. One can distinguish between technical, economic and policy threats. Firstly, two technical aspects generally apply for the promotion of high-level ethanol and biodiesel blends. These include the vehicle technology to support the use of these blends, and the adaptations to the equipment used for distribution and refuelling. These aspects could be seen as possible barriers, as corridor users and fuel stations want to be sure that the technology is available and reliable. Secondly, there are concerns about the economic feasibility of biofuels corridors. Using high-blends requires additional investments in biofuel-compatible vehicles and refuelling infrastructure. Both MSs and oil companies are generally seeking to find the most cost-effective ways to meet their mandatory targets. Aside from this, the willingness among road users to pay more for biofuel vehicle technology or vehicle maintenance related to the use of biofuels is limited. Therefore, it is not clear whether the advantages of the corridor approach would compensate for these extra costs, and, if not, who would bear these costs. Thirdly, a strong and coherent government support policy must be in place to initiate and accommodate the development of biofuels corridors in a

[1] From interview with Anton Stam (E van Wijk Logistics)

timely manner. For the promotion of high-blends in general, this means that the biofuel-compatible vehicle fleet must develop rapidly. For biofuels corridors specifically, there are concerns that certain forms of international cooperation, particularly in the field of tax policy and encouraging the participation of fuel companies, are very ambitious.

Conclusions

The SWOT analysis has shown that biofuels corridors will increase the use of high-blends in road transport and thereby contribute to EU targets for renewable energy. A market analysis is conducted for the Rotterdam-Constanta biofuels corridor to quantify this potential strength (see Section 4.3).

In addition, several aspects (i.e. weaknesses and threats) which could potentially hamper the development and operation of EU biofuels corridors have been identified by the SWOT. Technical, economic and policy options analyses have been carried out in order to examine the relevance of these aspects for the Rotterdam-Constanta biofuels corridor (see Sections 4.3, 4.4, and 4.5). These analyses also provide suggestions on ways to deal with these threats, if applicable.

4.3 Market Analysis

This section examines the expected biofuel consumption in each of the four Rotterdam-Constanta biofuels corridor designs. It does so in order to determine their effectiveness in increasing the use of biofuels in the respective MSs.

The demand analysis basically consists of two parts: to determine the percentage of corridor users that actually refuel at stations along this corridor, and to determine the percentage of fuel sold that will be replaced by biofuels in each of the corridor designs. General assumptions which have been made in order to conduct these analyses are first discussed, followed by the aforementioned analyses to determine the expected biofuels demand in 2020.

Market Assumptions

Various assumptions are made in order to conduct the market analysis. These assumptions include: the supply of biofuels along the corridor; the number of biofuel-compatible vehicles available over time; and, the price of biofuels. The assumptions follow largely from the literature and interviews, and are elaborated upon in the following paragraphs.

Supply of High-Blends along the Corridor

The scenario analysis has dealt with developments regarding the availability of various biofuel types. This has been done by assuming a shortage of one biofuel type and abundance of another in a certain scenario, meaning certain scenarios focus on certain biofuel types, e.g. Scenario 2 assumes the availability of ethanol alone and a lack of biodiesel. According to Hodson, this last scenario (i.e. a lack of biodiesel) is more likely to occur.[1]

Biofuel-compatible Vehicles

The number of vehicles compatible with the use of high-blends that are offered on the corridor depends on the future scenarios. The probability of occurrence of each of these scenarios, in turn, will be largely influenced by the policy and strategy adopted by the MSs regarding the promotion of these high-blends. It has been noted above that car manufacturers will follow these policies (and presumably support) and seize upon developments in the field of high-blends by making their vehicles compatible with specific biofuels. This has been confirmed by several interviewees. It is therefore to be expected that, if countries focus on E85 ethanol, for example, car manufacturers will respond by increasing the amount of Flex-Fuel Vehicles (FFVs) on the market. Nevertheless, car manufacturers must be made aware as soon as possible of what type of biofuels will be focused upon in the upcoming decade, in order to produce a significant number of compatible vehicles by 2015-2020. At the time of writing, there is no long-term policy in place towards the promotion of high-blends, which leads to a 'very nice public policy problem'.[2]

If high-blends become an important part of MSs strategy to achieve RED targets, it is presumed that these countries will come up with a strong policy regarding the promotion of high-blends. It is likely that such policy would lead to one of the four scenarios presented in the previous chapter. More certainty regarding this future vision may be given in mid-2010, when national action plans have to be submitted. A focus on high-blends would provide the car manufacturing industry with a clear signal on which cars should be entering the market. It is then assumed that car manufacturers will steadily increase their sales of biofuel-compatible vehicles from 2011.

The current share of biofuel-compatible passenger vehicles in the MSs that are involved in the corridor is negligible. Regarding ethanol, Sweden is the only country that has a significant share of FFVs, constituting approximately seven percent of the country's vehicles. FFV sales elsewhere in Europe have not yet taken off to the same extent (Ethanol Producer, 2008). The same holds for the vehicle support of high-level biodiesel blends. Given this information, it is assumed that biofuel support for passenger vehicles needs to start from scratch.

Present biodiesel support for freight trucks is more widely available than for passenger vehicles, as the engine technology is generally more robust. Official advice and warrantees for the use of these blends vary per country and per truck manufacturer. While some manufacturers consider five percent as acceptable, others provide support for up to B100 (e.g. MAN and Scania). Following the information of the National Biofuels Group and the National Biodiesel Board, it is estimated that at present, ten percent of all trucks are compatible with B100 biodiesel and that 30 percent are compatible with B30 biodiesel (NBB, 2008 and NBG, 2008).

[1] From interview with Paul Hodson (EC)
[2] From interview with Paul Hodson (EC)

Assumptions are made for the level of increase of biofuel-compatible vehicles in each of the corridor designs. These have resulted in a growth pattern as shown in Figure 4.2. The following paragraphs elaborate upon these assumptions.

In Design 1, the role of high-blends remains modest. Only five percent of the trucks on the corridor are required to be compatible with B100 biodiesel. In order to achieve this, the companies which are part of the market will only acquire new trucks compatible with B100 biodiesel. Considering the average life span of a truck of five years[1], a complete shift towards biofuel-compatible vehicles for the specific market could be achieved by 2020. In addition, considering the small user group, engines can individually be adapted in order to facilitate the use of high-blends. It is therefore assumed that, by 2020, all of the participating trucks can drive on B100 biodiesel.

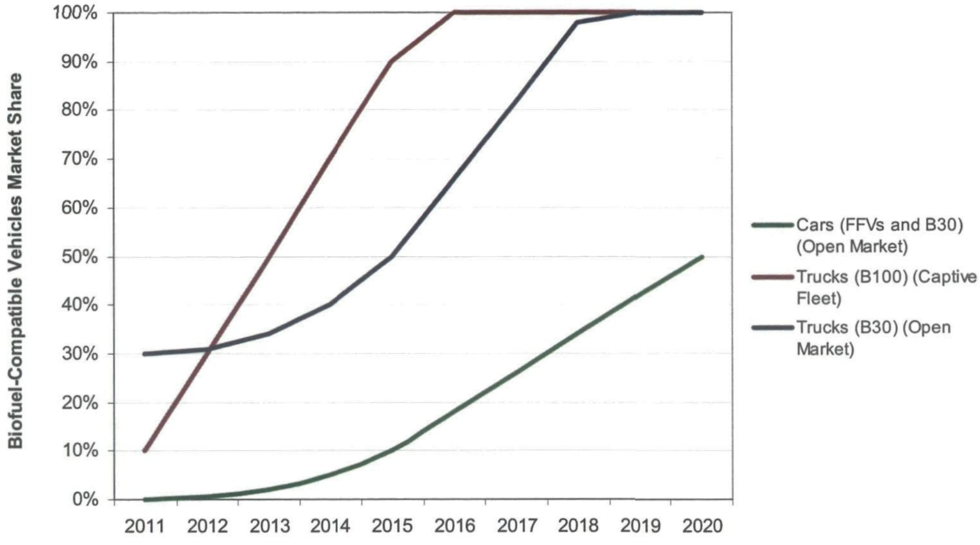
In Design 2 the focus is on selling E85 ethanol on the corridor. It is assumed that the sales of FFVs will increase steadily from 2011 onwards. The share of new FFVs being sold will gradually rise over time (i.e. five percent in 2012, 15 percent in 2013, 30 percent in 2014 and 50 percent in 2015). It is estimated that 80 percent of all cars being sold between 2016 and 2020 will be Flexi-Fuel. The average life span of a car is approximately 12 years (SenterNovem, 2008). The fact that newer vehicles drive longer distances and thus will consume more fuel has also been taken into account. This information leads to a rise of the FFV market share as shown in Figure 4.2. In 2020, approximately 50 percent of all gasoline vehicles will be FFVs.

In Design 3, diesel vehicles must be compatible with the use of B30 biodiesel. A similar growth pattern of the B30 diesel passenger vehicle market is assumed as for the FFVs. The replacement of diesel trucks, however, would be much faster, due to their shorter life span which is equal to five years on average. This means that, according to these assumptions, 50 percent of diesel passenger vehicles and 100 percent of diesel trucks will be B30 biodiesel-compatible by 2020, respectively (see Figure 4.2).

Design 4 includes a similar growth pattern for the biofuel-compatible vehicle fleet as that used in Scenarios 2 and 3. The only difference is that both E85 ethanol and B30 biodiesel will be offered on the corridor.

[1] From interview with Anton Stam (E van Wijk Logistics)

Figure 4.2 Development of Biofuel-Compatible Vehicle Market Share



Biofuel Prices

The price of biofuels offered on the corridor is assumed to equal the price of straight gasoline and diesel on the corridor. This final price will be based on the energy content of the biofuel mixture relative to that of their fossil fuel counterparts. An equal price is required to encourage road users to actually use the biofuels.[1] In this study, only Design 1 includes a slight reduction of biodiesel prices in order to compensate for the disutility of lower station coverage for the dedicated freight companies involved.

Fuel Consumption at Corridor Stations

This section determines the percentage of the total fuel use on the corridor that is actually obtained from fuel stations along the corridor. The total fuel use on the Rotterdam-Constanta corridor, as estimated in the previous chapter (8280 million litres annually), is based on the total amount of km being driven. However, the actual fuel consumption at fuel stations along the corridor (i.e. motorway stations) could well be different. There are many alternative places to refuel. The relatively high costs of fuels along the motorway compared to at other locations is the main reason for road users to adopt a certain 'refuelling behaviour'.

The freight transport market is very competitive and truck companies mostly refuel at predefined locations to reduce costs. This is confirmed by the literature and several interviewees.[2] Most haulage companies have their own refuelling infrastructure or have special price agreements with specific stations, particularly the larger ones. The TLN (2008) study indicates that on average only approximately 10 percent of all freight transport refuelling takes place at random

[1] From interview with Anton Stam (E van Wijk Logistics)
[2] E.g. from interview with Senior Manager (Oil Company)

(i.e. motorway) stations. Experts agree that this figure is likely to hold also for other MSs. This aspect, therefore, will significantly impact upon the effectiveness of biofuels corridors for freight transport, as, with biofuels corridors, access to high-blends is restricted to fuel stations on the corridor only.

Also passenger car users refuel more often at local stations because of the fact that fuel prices on motorways are generally higher. According to Marchand, if users can avoid it, they will not go to the motorway station.[1] Most business users having a refuelling card could well be an exception to this rule. However, clear data on passengers cars' fuelling behaviour has not yet been found.

The fact that only a small percentage of fuel use in passenger transport is actually obtained at fuel stations along the corridor can, however, be confirmed by way of further calculations. Rating (2007) and Marchand indicate that the average total fuel sales at EU motorway stations is approximately 5 million litres per year. Some reports, however, estimate this throughput to be slightly higher or lower; e.g. ECORYS (2009) estimates aan annual throughput of approximately 7 million litres at large Dutch motorway stations, while the Union of European Petroleum Independents (2008) points to a maximum of approximately 4 million at Swiss motorway stations. Due to the lower traffic intensity on corridor section in the Eastern European countries, an average annual throughput of 5 million litres has been assumed for fuel stations on the Rotterdam-Constanta corridor.

Given the fact that there will be approximately 230 fuel stations on the corridor in 2020 (see Section 3.5), a simple calculation shows that total fuel sales on the corridor would be approximately 1150 million litres annually by 2020. This is a rather small figure when considering that the total fuel used by vehicles driving on the corridor has been estimated at 8280 million litres and this severely impacts on the potential of the corridor as a means to sell high amounts of biofuels. Given that the freight transport trucks will refuel approximately 315 million litres at corridor stations (i.e. 10 percent of their total use) per year, this would leave approximately 835 million litres for passenger transport. In turn, this indicates that only 16 percent of passenger vehicles using the corridor would actually refuel at stations on the corridor. This figure is taken into account in the further calculations.

It should be noted that more research would need to be done to assess the actual fuel sales at Rotterdam-Constanta corridor stations in more detail, as this may influence the share of passenger vehicles refuelling at motorway stations. Data regarding fuel sales at individual stations is, however, difficult to obtain, as it seems that fuel companies are not keen on giving this information easily away, nor is information regarding fuelling behaviour publicly available. Nevertheless, the calculations carried out in this analysis, by means of comparing estimates of the fuel use with the fuel sales on the corridors, have clearly shown that the share of vehicles refuelling at motorway stations is very small. Even if fuel stations on the corridor were able to sell up to 7 million litres annually, this percentage would remain below 20 percent.

[1] From interview with Philippe Marchand (Total)

Demand Analysis

The previous assumptions and the fuel market for corridor stations allow a calculation to be carried out of the share of conventional fuels that can be replaced by biofuels in each of the biofuels corridor designs. These calculations are described in the following paragraph and are detailed further in Annex E. Results are provided in Table 4.1 and Figure 4.3.

The total amount of fuel (gasoline or diesel) being consumed at stations on the corridor is calculated as follows. Firstly, the total fuel used by the specific market is calculated. The total fuel used on the corridor was calculated in Chapter Three to be approximately 8280 million litres annually. For the open market designs, as the market is defined by the product type, these figures follow directly from Figure 3.10. For Design 1, the potential market is 5 percent of the total freight diesel consumption. Secondly, the fuel used by the specific market is multiplied by the percentage of users that actually refuel on the corridor.[1] Thirdly, the fuel use at corridor stations is multiplied by the share of biofuel-compatible vehicles in 2020 for the specific market. This leads to the volumes of conventional fuel that could be displaced by high-blends. Fourthly, to obtain the amount of conventional fuel that will be replaced by biofuels, this value is multiplied by the percentage of biofuels (based on energy content) in each specific high-blend. This is 79, 28 and 100 percent for E85, B30 and B100, respectively (see Annex E). And, to calculate the amount of specific high-blend(s) in litres required to realise this shift, the total fuel consumption at the corridor stations by the respective market is divided by the energy content of this high-blend relative to that of the specific conventional fuel. This is approximately 0,71; 0,97; and 0,90 for E85, B30 and B100, respectively (see Annex E). The total displacements of conventional fuels by biofuels in each of the Rotterdam-Constanta biofuels corridor designs are provided in Table 4.1. The table also indicates the displacements as a percentage of the total fuel use on the corridor.

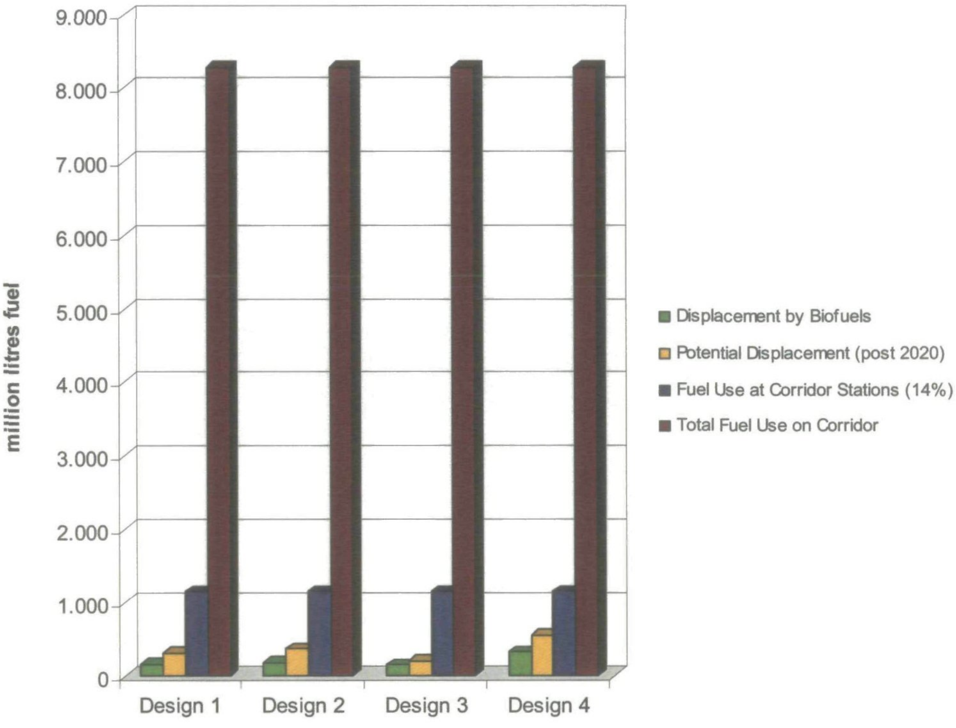
Table 4.1 Expected Displacements of Conventional Fuels by Biofuels in each of the Rotterdam-Constanta Corridor Designs in 2020

	Design 1	*Design 2*	*Design 3*	*Design 4*
Displacement by biofuels in millions of litres	158	179	140	319
Percentage of total fuel use on the corridor	1.9%	2.2%	1.7%	3.9%

Figure 4.3 gives a graphical presentation of the expected displacements of conventional fuels by biofuels on the corridor in 2020. The blue bars in the figure show the amount of fuel that is actually being fuelled at stations on the corridor. The green bars indicate the amount of litres that would be displaced by biofuels in 2020. Lastly, the potential market shares (in yellow), will only be reached if all vehicles are biofuel-compatible. In Corridor Design 4, the share of biofuels would be almost 4 percent of total fuel sold on the corridor.

[1] A captive fleet of freight trucks is considered in design 1. This means that the composition of this fleet is selected in such a way that all trucks will refuel at corridor stations.

Figure 4.3 **Expected Displacements of Conventional Fuels by Biofuels in each of the Rotterdam-Constanta Corridor Designs**



Conclusions

The analysis indicates that, despite the enormous transport flows on the corridor, the overall effect of offering high-blends on the corridor is strikingly low (i.e. green bar versus red bar). Demand would be highest in Corridor Design 4, accounting for approximately 4 percent of the total fuel use on the corridor. This analysis has provided several reasons to support this observation.

The theoretical maximum amount of fuel being displaced by biofuels on the Rotterdam-Constanta corridor will, taking the corridor approach, be limited to the fuel sales at the corridor stations, which is shown by the blue bar. This is only approximately 14 percent of the corridor's total fuel use, which has been indicated by the model calculations and corroborated by stakeholder and expert interviews. Due to the fact that high-blends also contain a certain share of conventional fuel, the actual maximum displacement by biofuels will be even lower. Although these consumption rates may rise post-2020 (yellow bar), due to an expansion of the biofuel-compatible vehicle fleet, the displacements by means of this biofuels corridor alone will, because of this, remain limited.

The only way to significantly increase the market for high-blends is by making them also available at other locations, away form the corridor. This analysis has indicated that for passenger transport most fuels are obtained through local stations, and freight transport trucks refuel mostly at business stations or have their own refuelling infrastructure.

4.4 Technical Analysis

This section examines the availability of vehicles and infrastructure equipment required for accommodating and using high-blends. Furthermore, the challenges involved in their implementation are analysed.

The distribution and infrastructure adaptations which are required for the handling of high-blends is proven technology. This is evidenced by the many existing E85 and B100 refuelling stations worldwide, as well as by experiences in Brazil (see, for example, Worldwatch, 2007). However, the literature and oil industry experts point to various aspects which require special attention when distributing high-blends. E85/B30/B100 require separate pumps at fuel stations, as they may not be sold as conventional diesel and gasoline. The materials used in these pumps need to be compatible with the characteristics of ethanol and biodiesel, which react differently to certain types of plastics and rubbers (Biofuel Cities, 2009). In addition, the handling of E85 ethanol requires a special authorisation for stations and a different tank for its distribution and storage may be required due to its instability when in contact with air and/or water (SenterNovem, 2008). Although biodiesel faces similar aspects, its distribution is easier, as the conventional diesel infrastructure can generally be used (Worldwatch, 2007 and Biofuel Cities, 2009).

The fact that high-blends require a separate pump is important to oil companies. Filling stations mostly have limited space, especially in Western European countries. For this reason, most fuel stations cannot afford to have more than two pumps, one for each product type (i.e. gasoline and diesel). These pumps, therefore, have to be used as efficiently as possible. Presently, for example, stations often offer a basic type and premium type (e.g. Shell V-Power). Motorway stations could accommodate more pumps, but to offer more fuel types would be more complex to organise logistically. According to Marchand, an efficient business model is a simple model and more products will incur additional costs.[1] In short, for high-blends this means that there must be a large enough amount of road users ready to use the fuel before the fuelling technology will be adjusted.

There are no technical barriers for vehicles to be expected with the use of the high-blends in biofuel-compatible vehicles. FFVs can drive on any blend of ethanol-gasoline, and the literature does not point to any additional problems or costs related to the use of E85 in these engines (see, for example, Worldwatch, 2007 and Biofuel Cities, 2009). Support of high-level biodiesel blends can be guaranteed if engine parts are chosen in a way that they can cope with the higher aggressiveness of biodiesel to plastics. In particular for B30 this is not too difficult to do, but B100 requires more radical changes (SenterNovem, 2008). The only drawback is that manufacturers are not keen on introducing these vehicles, as this could affect the engine performance. Furthermore, the use of high biodiesel blends may require more frequent maintenance of some of the engine parts, which is due to the its higher aggressiveness to plastic materials. This mainly holds for vehicles that drive long-distances, such as freight trucks,

[1] From interview with Philippe Marchand (Total)

as for other vehicles this can be covered by the general maintenance intervals (SenterNovem, 2008).

Conclusions

It can be concluded that all Rotterdam-Constanta corridor designs would not face any insurmountable technological problems, due to the fact that the necessary technology is proven and available. However, this technology must also be implemented and in order to make this implementation viable from a business perspective (i.e. for fuel stations and vehicle manufacturers) additional financial resources and/or a stronger policy may be required. These aspects will be dealt with in the economic and policy options analyses.

4.5 Economic Analysis

This section provides an overview of the costs involved in the development and operation of the biofuels corridor, and also indicates who might bear these costs. The costs are mainly related to the promotion of high-blends in general. One can distinguish between three types of costs: costs related to the vehicles using biofuels; distribution and refuelling infrastructure costs; and the costs of biofuels compared to those of conventional fuels.

It must be emphasised that it is not within the scope of this study to perform a social cost-benefit analysis. Therefore, robust conclusions with respect to the cost-effectiveness of the specific biofuels corridor designs will not be made. However, an outline of the costs, as well as a consideration of cost allocation among the stakeholders, is still very valuable to determine the main financial hurdles which need to be overcome to develop the biofuels corridor. Conclusions will thus be drawn on the proportion of each type of cost in each of the corridor designs.

Vehicle Adaptation Costs

The use of high-level ethanol or biodiesel blends in vehicles lead to additional vehicle costs compared to as for conventional gasoline and diesel vehicles. These additional costs can be attributed to the incorporation of Flex-Fuel technology for gasoline cars, and to the possible need for extra maintenance and engine adaptations for diesel vehicles.

SenterNovem (2008) provides price indications for vehicle adaptations. The price of Flex-Fuel technology for gasoline vehicles largely depends on economies of scale. The costs of building the technology into present-day cars is estimated to be approximately €500 per vehicle. However, these costs go down significantly to just €100, if the Flex-Fuel is built into newly sold cars and produced in large quantities. In countries in which FFVs are very popular, such as Brazil and the United States, costs of FFVs are similar to those of baseline gasoline cars (Worldwatch, 2007). For the purpose of this study, an additional cost of €100 per vehicle is taken into account. For diesel vehicles, the adaptation costs to make them compatible with B30 or B100 are considered to be negligible. However, in the case of biodiesel trucks which drive long distances, a one-year maintenance interval would not be sufficient. Additional maintenance costs for B30 and B100 trucks are estimated to be €250 and €850 per year, respectively.

In order to provide an estimate of the annual costs of vehicle adaptations in each corridor design, the number of biofuel-compatible vehicles must be known. This depends on the distance travelled by road users on the specific corridor as part of their total distance travelled per year. Several assumptions are made to estimate these figures.

In Corridor Design 1, it is assumed that 60 percent of the total distance travelled by the trucks is on the corridor. This is a reasonable figure, considering that a high operation intensity on the corridor of participating haulage companies is the main criterion for their selection. An average truck mileage of 150,000km per year, with a average fuel efficiency of 3.25km per litre,[1] results in an annual diesel consumption of approximately 28,000 litres per truck. As 158 million litres of diesel is to be replaced by B100, this leads to approximately 5640 trucks whose engines will need more frequent maintenance.

The total distance travelled on the corridor by passenger cars as a percentage of their total annual mileage will be much lower and is assumed to be 5 percent for people who live close to the corridor. Passenger cars, in contrast to freight transport, will drive more locally, and even when long distances are being travelled, there is little chance that the corridor will be included in the route. It is expected that this figure will rise if more biofuels corridors emerge, as the chance of being on a biofuels corridor would then be increased. Aside from this, only 16 percent will refuel at these corridor stations. The average mileage of passenger vehicles is approximately 15,000km per year (Kunert and Kuhfeld, 2007) which, with an average fuel efficiency of 13km per litre (Zachariadis, 2005), results in a total gasoline/diesel consumption of approximately 1150 litres per car annually. This would be 58 litres annually for each vehicle on the corridor, of which only 9 litres will be purchased at corridor stations. There would thus be a need for approximately 25 million passenger vehicles to be Flex-Fuel-compatible in Corridor Design 2 and 28 million to be B30-compatible in Corridor Design 3. No distinction has been made between gasoline and diesel cars. The average life expectancy of passenger cars is 12 years (SenterNovem, 2008).

Furthermore, regarding the truck transport using B30, it is assumed that 10 percent of the total distance is travelled on the corridor. Again, this figure will rise if more biofuels corridors are established, reducing average vehicle investments. As the corridor is open for the free market, only a maximum of 10 percent will refuel at motorway stations. Diesel consumption on the corridor would then be at about 460 litres per truck annually, which, in turn, results in over 540,000 trucks needing additional maintenance due to the use of B30 biodiesel in Corridor Design 3 and 4. Table 4.2 shows the additional vehicle costs in each corridor design, based on their annual average.

[1] From interview with Anton Stam (E van Wijk Logistics)

Table 4.2 Estimation of Annual Vehicle Costs in Each Corridor Design

Rotterdam-Constanta	*Design 1*	*Design 2*	*Design 3*	*Design 4*
Biofuel-compatible vehicles needed (x1000)	6	25,000	28,540	53,540
Estimation of annual costs (€ million)	5	208	135	343
Cost-effectiveness: Cost per litre of fuel (€)	3 cents	116 cents	96 cents	108 cents

The cost estimates indicate that offering high-blends to the open market (i.e. as in Corridor Designs 2, 3, and 4) on a single corridor only is a cost-ineffective way to stimulate the use of biofuels. Despite the fact that various assumptions have been made to make estimates, the numbers give a clear signal that the annual vehicle costs of the corridor designs in which E85 ethanol is offered are most significant and may reach over €200 million annually. Corridor Design 2 in particular might seem as an expensive way to go, as the average vehicle costs per litre of gasoline fuel replaced by ethanol is highest. These costs could be even higher as costs reductions due to economies of scale (i.e. 'only 25 million' vehicles) could also be limited in this case.

This observation confirms that the development of the corridor for the open market would only be feasible if the future focus is on high-blends, as then, the vehicle costs will not be allocated to just the biofuels corridor alone. In the scenario in which high-level ethanol and biodiesel blends become vital for achieving EU targets, the biofuels corridor will be accompanied by other support measures to stimulate the use of high-blends (e.g. local stations offering high-blends). These initiatives will also require biofuel-compatible vehicles, reducing the average additional vehicle cost. Design 1 could however also be interesting without a focus on high-blends as it concerns a niche market. Money spent on vehicle maintenance can be allocated much more effectively, as the market is selected in such a way that users do refuel regularly at the corridor stations.

It remains a complex issue as to who would bear the additional vehicle costs. The extra costs for Flex-Fuel technology are considered to be manageable, and one may assume that it would not be too difficult to pass these costs through to end users. However, according to Marchand, car manufacturers are not keen on doing this in Europe. The Flex-Fuel technology would apply on the very competitive market segment of cars, and a small price increase alone (e.g. due to the Flex-Fuel technology) would reduce their competitiveness. Furthermore, the costs related to the extra maintenance of freight trucks driving on biodiesel might also be difficult to deal with, as there is the risk that haulage companies will not want to carry these costs and thus continue to use conventional diesel. These factors imply that there would also be a role for public policy in the promotion of these vehicles.[1]

[1] From interview with Philippe Marchand (Total)

Distribution and Refuelling Infrastructure Costs

Special equipment and materials to handle high-blends are required for their distribution. In addition, adaptations to the refuelling infrastructure are also needed and these aspects would increase costs.

According to the experts, the distribution of high-blends is in essence not much more expensive than for conventional gasoline and diesel. The quantities of biofuels that will be sold at filling stations must only meet a certain threshold in order to become interesting from the perspective of oil companies. It has been noted earlier that fuel stations are often limited by space and logistical aspects, and they want to do whatever is possible to increase the operational efficiency at fuel stations. If there is sufficient demand, oil companies will offer the fuel.[1]

The demand analysis indicates that in 2020 there will most likely be enough demand for high-blends in all corridor designs to make offering high-blends attractive. It was noted above that total fuel sales at motorway stations is approximately 5 million litres annually (diesel and gasoline in total) and a rather significant percentage of the total fuel sales on corridors per individual fuel station would then consist of high-blends. The biofuel content sold at each station would be approximately 10 percent of the total fuel sales (see Figure 4.3). However, as not all stations would offer these fuels, this percentage would be higher at stations who do sell high-blends. As 70 percent of B30 consists of conventional gasoline, the volumes are relatively greater than for the E85 design, despite their lower contribution.

There are, however, various factors which could decrease the willingness of oil companies to offer high-blends on the corridor. The consumption of high-blends will grow steadily as more biofuel-compatible vehicles enter the market (i.e. up to the values presented in the market analysis), but will be significantly lower in the initial stage of the project making it unattractive to offer high-blends at the start of the project. Furthermore, the relative consumption among filling stations could vary for different reasons. Firstly, transport intensity will be higher on certain road sections of the corridor. For example, the fuel consumption per distance-unit on the corridor in Romania may be lower than in the Netherlands. This implies that the annual sales per station in Romania would be reduced. Secondly, in Corridor Design 1, and partly in Designs 3 and 4, the focus would be on biodiesel implementation for freight transport. This market could have a significant impact on the potential biofuel sales locations, as, naturally, freight companies will mostly refuel in countries in which diesel prices are lowest. On the corridor, these countries are the Netherlands, Romania and Austria.[2] It is to be expected that the companies will continue to behave in this way if biodiesel prices follow the prices of conventional diesel. This means that the additional logistical attractiveness of offering biodiesel in countries like Germany could be lower than for other countries, due to the large length of corridor in Germany and its relatively low biodiesel sales. This aspect is not relevant for passenger cars, as most trips remain within national boundaries.

[1] From interview with Philippe Marchand (Total) and Senior Manager (Oil Company)
[2] From interview with Anton Stam (E van Wijk Logistics)

The additional tank infrastructure costs are low. Depending on the station lay-out, two options exist. One can either change an existing storage tank and pump (which was formerly being used for gasoline, for example) to accommodate the new biofuel blend, or one can decide to install a new pump and storage tank. In the first and latter cases, costs for retrofit are estimated to be approximately €830 and €18,000, respectively (SenterNovem, 2008 and Worldwatch, 2007). The installation of new tanks will be rare, as, due to space and logistical restrictions at fuel stations, an additional tank is not viable.[1] This means that, even when all stations on the corridor would offer high-blends, the total costs for refuelling infrastructure will remain well below one million euros. Marchand and the experiences with the I-65 Biofuels Corridor confirm that infrastructure costs do not form a real barrier for offering high-blends.

In sum, distribution and refuelling infrastructure costs are low and can be covered by oil companies if there is a high enough demand of high-blends on the corridor stations. Since the analysis indicates that this would be the case by 2020, this would most likely make it feasible to offer high-blends. However, especially in the developmental stage, this demand could be much lower. Then, it is possible that offering high-blends in an alternative way is more cost-effective. This is something which could possibly be addressed by additional policies to persuade the companies to offer high-blends on corridor stations. The latter issue will be dealt with in the policy analysis.

Costs of Biofuels Compared to Conventional Fuels

Biofuels are more costly than conventional fuels and it is expected that they will also be more costly in the upcoming decade (see Chapter Two). The ECN (2008) study has been used to estimate the additional costs of biofuels for the year 2020. The report has developed various scenarios for the future role of alternative motor fuels and also provides predictions of future fuel prices. Although such costs are typical of all biofuel pathways, they provide insight into the proportion of additional costs that come with the stimulation of high-blends. Table 4.3 shows the biofuel costs in 2020 under each of the scenarios. The figures indicate that the additional costs of biofuels themselves are certainly high when promoting their use. Calculations are provided in Annex E.

Table 4.3 Estimation of Annual Biofuels Costs in Each Corridor Design

Rotterdam-Constanta	*Design 1*	*Design 2*	*Design 3*	*Design 4*
Average annual costs in € million	€ 51	€ 64	€ 45	€ 109
Cost-effectiveness: Cost per litre of fuel (€)	32 cents	36 cents	32 cents	34 cents

[1] From interview with Philippe Marchand (Total)

Conclusions

Additional costs related to the promotion of high-blends on the Rotterdam-Constanta corridor can be categorised into vehicle costs, distribution and refuelling infrastructure costs, and the costs of biofuels compared to conventional fuels. Various conclusions can be drawn from the cost estimations regarding the biofuels corridor.

High-blends increase costs and a large share of these additional costs can be attributed to the biofuels themselves. The logistics of high-blends are affordable from an economic perspective if there is sufficient demand. This can only be created if there is a significant biofuel-compatible vehicle fleet.

Vehicle costs in Corridor Designs 2, 3 and 4 are substantial, especially in the scenarios in which E85 ethanol is offered, and this confirms that the Rotterdam-Constanta biofuels corridor for an open market will only be viable if the future focus is on high-blends. The implementation of the biofuels corridor would then be accompanied by other promotional measures for high-blends which reduces average costs for vehicles and logistics. Despite the fact that the extra costs for biofuel-compatible vehicles are modest, it is not to be expected that the vehicle park will develop itself, due to difficulties in the allocation of these costs. A captive fleet (Design 1) would significantly reduce vehicle costs to an acceptable level and has a higher chance of being viable from an economic viewpoint.

The demand of high-blends on corridor stations in 2020 would be sufficient to make offering high-blends attractive for oil companies, particularly given that not all stations would need to offer the blends. However, particularly in the developmental stage of the corridor, sales of high-blends would be lower and if these cannot make the logistics of high-blends cost-effective, there would be a risk that oil companies will not offer them on the corridor.

4.6 Policy Options Analysis

This section examines the form which the strong policy landscape needed to develop and operate the biofuels corridor designs would take. Furthermore, the relevance of the potential threats for the specific corridor, mostly following from the economic analysis, are addressed. Three potential policy-related threats have been presented: a timely penetration of biofuel-compatible vehicles, the participation of fuel companies on the corridor, and maintaining a low and similar price for high-blends on the corridor.

Development of the Biofuel-Compatible Vehicle Market

A timely penetration of biofuel-compatible vehicles into the market is essential to obtain the potential biofuel market shares which have been calculated above. There is a risk that a lack of biofuel-compatible vehicles could prevent or delay the initiation of the corridor project. It should be mentioned that the same risk holds for most of the other initiatives to promote high-blends. The market for biofuel-compatible vehicles has yet to expand significantly in the countries involved in this corridor. There is no strong vision towards the promotion of high-level ethanol and biodiesel blends, meaning there is little incentive for car manufacturers to introduce them. In addition, conventional vehicles are very competitively priced, and only a small price increase (i.e. due to the Flex-Fuel technology, for example) would reduce their competitiveness. Furthermore, high-blends are not readily available at filling stations, which hampers the need for the introduction of suitable vehicles. This latter issue is commonly referred to as the chicken-and-egg problem.

A clear public signal on the future importance of high-blends, as presumed in the scenarios, will help to stimulate the introduction of biofuel-compatible vehicles. It is to be expected that car manufacturers will automatically expand their high-blend vehicle fleet if the policy focus is on high-blends (e.g. by tax reductions or incentives).[1] Volvo and Saab have already adopted this strategy in Sweden, for example. At present, one third of the world's passenger cars are produced in the EU and approximately 25 percent of total cars are driven in the EU (ACEA, 2008), which indicates that a change in EU policy could certainly have a strong influence on the vehicle manufacturing market.

There are various ways in which public policy can stimulate a transition towards biofuel-compatible vehicles. The first, and according to Hodson the most obvious solution, is to oblige vehicle manufacturers to make their vehicle compatible with the use of high-blends (i.e. regulatory method).[2] There would then be a role for EU policymakers since, similarly to the case of high-blends promotion, an EU-wide policy would be most effective for achieving this. Secondly, one could trigger the penetration of biofuel-compatible vehicles into the market by way of subsidies. Once a sufficient market share has been obtained and infrastructure has been developed, the vehicles will become standard. The provision of subsidies will probably remain at the MS level. The feasibility of this measure has been evidenced by the subsidy for the Toyota Prius in the Netherlands. Subsidies could also compensate for the future expenses for maintenance of these vehicles.

The above therefore indicates that a strong and ambitious policy would be required to initiate an en masse introduction of vehicles compatible with high-blends as required in the designs for the open market. The market for the Rotterdam-Constanta corridor alone would not be sufficient to achieve this. And, even if the focus of MSs were to be on high-blends, it remains to be seen whether such a large penetration of these vehicles is realistic. The regulatory way would be a rather ambitious solution, and, according to the interviewees, obliging manufacturers to produce vehicles which are compatible with slightly increased minima-blends would be more likely to occur.[3] Furthermore, the provision of subsidies would involve substantial amounts of public money, which, particularly at the time of writing during an economic recession, may not be made available by MSs.

[1] From interview with Paul Hodson (EC) and Senior Policy Advisor (Dutch Ministry of Housing, Spatial Planning and the Environment)
[2] From interview with Paul Hodson (EC)
[3] From interview with Philippe Marchand (Total)

Participation of Fuel Companies

The feasibility of biofuels corridors would depend on fuel companies offering specific high-blends along the corridor and there is a risk that other strategies to fulfil their high-blends obligations, particularly in the initial stage of the corridor project, would be preferable.[1] Various opportunities related to the participation of fuel companies have been mentioned, but it may ultimately come down to a cost-effectiveness assessment. The higher the potential sales per station, the more likely it is that fuel companies will want to participate. Biofuels consumption on the corridor might be low in the beginning, as biofuel sales will grow gradually. During this time, additional support policies should be in place.

The participation of oil companies will most likely require public money, directly or indirectly, particularly at the initial stage of the project. One can distinguish between various types of support policies to encourage oil companies to offer high-blends on the corridor. Firstly, one could subsidise fuel stations. Public money can be made available both at the MS or EU level. At the MS level, grants could be provided to develop the infrastructure at fuelling stations. An example is the funds made available by the Dutch government to cover the costs of E85 infrastructure. At the EU level, structural funds could be allocated for these purposes.[2] Secondly, governments could oblige oil companies on the corridor to offer biofuels at specific locations. This regulatory method might include the provision of certain conditions regarding the fuels to be offered in concession agreements with fuel stations. The feasibility of this measure should be further assessed. It must be noted that if these measures are viable, it is likely that they will indirectly involve public money, as bids on locations with biofuel requirements will generally be lower. Thirdly, policymakers could stimulate demand on the corridor by promoting biofuels corridors.

Maintaining Low Prices for High-Blends

Maintaining a biofuel price which is not higher than the price of conventional fuel is vital to encourage corridor users to purchase high-blends. For the Rotterdam-Constanta corridor, this is regarded as a very complex task, as seven countries are involved in the corridor, each with different legislation. Theoretically speaking, two options exists which are outlined below; oil companies or public policy.

Governments could contribute to establishing the required prices for biofuels on the corridor. Tax policy would be the most obvious policy tool available for achieving this. Equal biofuel prices would encourage a harmonisation of this policy in the MSs involved in the corridor. However, one should be aware of two aspects which may hamper such an alignment.

[1] From interview with Senior Manager (Oil Company)
[2] From interview with Senior Policy Advisor (Dutch Ministry of Housing, Spatial Planning and the Environment)

Firstly, tax policy will presumably remain at the MS level because of the current veto that each MS has on any fiscal measure within the EU. Interests among EU countries vary considerably which makes a harmonisation of EU tax policy fall out the scope if this research. Only a slight form of EU energy taxation was incorporated into the Directive 2003/96/EC, but the minimum imposed taxes are not significant. Having said this, uniformity in tax-policy would only be possible by way of an agreement between the individual MSs. However, due to different interests among the countries regarding energy taxation, the chance of having a coordinated biofuel tax strategy in these countries - purely for the sake of a single biofuels corridor - is considered to be negligible. A remaining option would be to establish a certain price level of high-blends by way of a separate tax policy for stations on the corridor. However, this would also lead to a complex situation, as certain stations would benefit from low taxes, while others cannot.

Therefore, in the future scenarios for high-blends, it is most likely that each country will have different policies in place to stimulate the use of these blends. Naturally, the strategy to achieve the renewable energy targets in transport may vary among these countries, which would lead to an even bigger diversification of policy. This also means that the prices of high-blends and the attractiveness to offer them will vary per country. The fact that prices in each country vary is not considered to be an issue, as this presently holds for conventional fuels too, but if the prices are higher than those of conventional fuels, the biofuels will not be bought in the specific MSs.

Secondly, it is unlikely that the countries will maintain excise duties on biofuels for the coming decade, even when their focus is on high-blends. Tax reductions costs a lot of money and it is evidenced by the recent developments in biofuel policy that MSs are making a shift towards biofuel obligations (see Chapter Two). Particularly at the time of writing, countries would do anything possible to reduce expenses. Other support measures could also be applied, which may be more favourable. The duty to cover additional biofuel costs could be passed on to oil companies.

Oil companies might be willing to cover these additional costs to reduce the price of the high-blends on the corridor. This would occur in a situation in which oil companies are required to place a certain amount of biofuels on the market (by means of mandatory targets, for example), and part of that share cannot be met by low-level blending. In this case, the biofuels corridor should be the most cost-effective way to meet the additional share target. In addition, oil companies may benefit from other opportunities that the corridor approach offers. This, in turn, will largely depend on the corridor sales and the policy and strategy in each MS. Any additional government support measure related to the biofuels corridor would help to achieve this. The solution would be easier if an international oil company is in charge of all biofuel stations, as this would increase control over prices. These companies would have the ability to spread the extra costs involved and thereby secure competitive prices of high-blends.

If it is not possible to have biofuel prices equal to those of conventional fuels, there could be different consequences related to each of the designs. Firstly, in Corridor Design 1, and partly in Designs 3 and 4, due to the large action radius of freight transport trucks, they may adapt their refuelling behaviour according to the biodiesel price level and refuel in countries in which fuel prices are lowest. This depends to a significant extent on MS tax policy. It could mean that countries with lower taxes on biodiesel could benefit from the corridor, as it would be an effective way for those countries to sell high volumes of biofuels at just a few locations on the corridor. However, it may well exclude certain countries' participation on the corridor, as the number of customers refuelling there would be reduced. This risk will be reduced if the focus is on ethanol (i.e. Corridor Designs 2 and 4) as passenger cars drive more locally. Furthermore, MS policy could focus on stimulating different biofuels. In Design 4, it could mean some countries focussing on biodiesel and others on ethanol due to different interests. Examples include the need for diesel replacements in countries in which oil usage in the transport industry is dominant, the potential contribution of ethanol imports to meeting the targets, and the domestic availability of a particular biofuel feedstock.

Conclusions

It can be concluded that the timely development of a biofuel-compatible vehicle fleet for high-blends is most important for the implementation of the biofuels corridor, yet very ambitious in an open market setting (i.e. Corridor Design 2, 3, and 4). This would require high government intervention, and possibly large amounts of public money. The development of the vehicles, in turn, influences the difficulty of involving oil companies. The analysis has shown that there are policy options available to help this to happen, such as by promoting the corridor, but this would again involve public resources. Corridor Design 1 would be much easier to implement, as specific incentives can be allocated to the captive fleet. Furthermore, fuel price differences among MSs will presumably remain, but, as long as incentives at the national level allow high-blends to be priced competitively, this will not hamper the operation of the corridor designs.

4.7 Overall Feasibility Evaluation and Conclusions

A SWOT analysis based on stakeholder interviews has been conducted for EU biofuels corridors. The factors which have been identified included potential positive aspects (e.g. increase of the use of biofuels) and aspects which could hamper the introduction of biofuels corridors (e.g. developing a biofuel-compatible vehicle fleet and public support policy). The SWOT has led to several other analyses to be conducted in order to assess the feasibility of the Rotterdam-Constanta biofuels corridor designs.

Firstly, the market analysis has shown that demand for high-blends on the corridor, as a percentage of total fuel use by corridor users, is limited in all corridor designs. It is estimated that a maximum displacement of just 4 percent of all fuel used on the corridor could be realised. The main reason is that corridor users rarely refuel at these stations. Secondly, the technical analysis indicates that the availability of biofuel-compatible vehicles and infrastructure technology required for the corridor is not considered as a threat to biofuels corridor development, although the implementation of this technology could be, due to economic concerns. Thirdly, the economic analysis confirms that a single biofuels corridor for the open market would not be cost-effective, due to high vehicle-related costs. A low share of biofuel-compatible vehicles would reduce demand, which, in turn, would be insufficient to make fuel companies offer high-blends. Therefore, the corridor designs for the open market (i.e. Corridor Designs 2, 3 and 4) could only work if the biofuels corridor were to be accompanied by other measures to promote high-blends, as average vehicle costs would then be reduced. This threat would, however, be less applicable to Corridor Design 1, as the focus on a captive freight fleet would increase the cost-efficiency of vehicle adaptations as well as the certainty of demand for high-blends. Fourthly, the policy options analysis has shown that several policy options exist to create a policy environment which is conducive to the development of high-blends and thereby for the development of the biofuels corridor concept. A biofuel-compatible vehicle fleet could be established by way of subsidies or using regulatory methods. In addition, at the initial development phase, there would be a role for public policy to make the supply of high-blends on the corridor more attractive to potential consumers. This would mean that, by 2020, there would be sufficient demand for the oil companies to be self-sustainable from a logistical point of view. Fuel price differences among the MSs will presumably remain, but, as long as incentives at the national level allow high-blends to be priced competitively, this will not hamper the operation of the corridor designs. These policy measures would, however, involve a very robust public policy which would potentially require high amounts of public money being spent.

Based on the analyses, it can be concluded that the effectiveness of the biofuels corridor as a way to increase the use of biofuels on its own is limited. The calculations show that the potential biofuel sales on the corridor, in all designs, do not represent the actual amount of km driven on this corridor, and are much lower than the values that were obtained from the corridor analysis in Chapter Three. The market analysis indicates that the maximum potential of the biofuels corridor remains limited to the level of fuel sales on the corridor. This implies that a large market penetration of high-blends would also involve other stations, away from the corridor, to offer them. Besides, Corridor Designs 2, 3, and 4 in particular present economic and policy barriers, which require a strong vision and policy towards the use of high-blends. Several options could help to overcome these barriers, but, due to the fact that these would require large amounts of public money, their actual implementation is less realistic. Moreover, several experts have indicated that the use of high-blends at a large scale to meet EU targets is a rather sub-optimal solution, as many other alternatives, such as increasing the minima, would be easier to achieve.

However, if high-blends are to be marketed en masse, then the biofuels corridor designs for the open market could be implemented. Access to high-blends would then be increased, and vehicle costs would not be allocated to just the biofuels corridor alone. This would reduce the main barrier of increasing a significant market for biofuel-compatible vehicles. However, the results indicate that the primary advantages of the corridor approach would lie in the externalities such as making biofuels more recognisable among road users and promoting them, rather than in a significant increase in biofuels use.

When relating these outcomes to the development of the I-65 Biofuels Corridor in the United States, which was described in the introduction, similar obstacles can be observed. An evaluation report of this biofuels corridor points to the fact that the success of the corridor was highly influenced by the price differences between high-blends and their conventional fossil counterparts (DOE, 2009). Therefore, sufficient public money was made available to make it economically attractive for all participating fuel companies to offer high-blends. This confirms that if the policy environment is conducive to the promotion of biofuels corridors (in this case by having sufficient funding), the biofuels corridor can certainly be implemented. However, although the I-65 Biofuels Corridor has, according to the evaluation, made high-blends more 'mainstream', no information has been found about the actual effects and contribution of the corridor in terms of increasing the national share of biofuels in road transport. Furthermore, no feasibility study was carried out prior to implementation.[1] This, unfortunately, limits the extent to which the outcomes of the I-65 corridor can be compared with the Rotterdam-Constanta biofuels corridor and used in this study.

Corridor Design 1, which focuses on a captive freight fleet, however, would be more realistic and easier to develop. Although the concept would still require additional policies (and public money), the implementation would be more cost-effective as opposed to the open market designs. The relatively low biofuel sales on the corridor as a percentage of total fuel use is not considered to negatively affect the design, as in the corresponding Scenario 1 (see Chapter Three) only a small share of biofuels would be achieved by high-blends. Moreover, the demand for biofuels could rise if the number of participating haulage companies were to be increased. And, as truck companies often refuel at certain locations, overall demand could be increased further by also including these stations. Freight transport consumes about one third of the total fuels on the corridor, which means that there is a lot of scope for expanding the concept in this way. Nevertheless, truck companies may well require a wider coverage of the fuelling network (e.g. more biofuels corridors) instead of just a single corridor, and incentives should be in place to make using biofuels and producing high-blend-compatible trucks an attractive option from their perspective.

[1] From e-mail correspondence with Julie Howe (Indiana Office of Energy Development)

5 EU-Wide Impact of Biofuels Corridors

5.1 Introduction

This chapter examines the extent to which the case study results presented in Chapter Four can be applied to other corridors on the TEN-T Network roads and in doing so, identifies in what way and to what extent biofuels corridors could contribute to the EU renewable energy targets, based on the policy scenarios defined in Chapter Three. This information allows the central research question on the potential of EU biofuels corridors to be addressed (Chapter Six).

Firstly, the representativeness of the case study for the wider TEN-T Network is determined by analysing the extent to which outcomes of the case study analyses apply to other EU corridors (Section 5.2). This involves all aspects which one might come across when generalising the case study results in a structural manner, such as synergy effects and differences in MS policy. Secondly, the maximum potential of biofuels corridors to contribute to the RED targets is estimated. Biofuels corridors would then be implemented on the entire TEN-T Network roads. The market analysis of the Rotterdam-Constanta corridor and its representativeness analysis for other EU corridors serve as the input for these calculations. Subsequently, the limitations of the results are discussed (Section 5.4) and the EU policy landscape for biofuels in 2020 and thereafter is described, with and without biofuels corridors (Section 5.5).

5.2 Transferability of Results

The case study on the Rotterdam-Constanta biofuels corridor has indicated that the effect of a single corridor in terms of increasing use of biofuels would be low. Besides this, the biofuels corridor, particularly in an open market setting, presents significant economic and policy barriers which need to be overcome in order to make their implementation viable. These conclusions have been obtained by conducting several analyses as part of the case study.

The market, technical, economic and policy options analyses were specifically aimed at the Rotterdam-Constanta corridor and assessing the extent to which their outcomes apply to other corridors on the TEN-T Network roads provides insight into how these outcomes can be used to make statements regarding the potential and feasibility of the corridor approach EU-wide.

Market Analysis

The amount of conventional fuels that could be replaced by biofuels on the Rotterdam-Constanta corridor depends mainly on the transport flows on the corridor (and corresponding fuel use) and the refuelling behaviour of the corridor users. Additionally, various assumptions were made regarding pricing, biofuel-compatible vehicles and the supply of high-blends on the corridor. These assumptions will presumably be applicable to other biofuels corridors, but the transport flows and refuelling behaviour may well be corridor-specific. For this reason, prudence is called for when generalising the potential biofuel demand at corridor stations on other EU routes. There is a risk that assuming the same biofuel consumption per distance unit on different EU corridors as for the Rotterdam-Constanta corridor, would lead to biased estimations.

Transport flows and refuelling behaviour on other TEN-T corridors could be different than for the Rotterdam-Constanta corridor. There are two basic options for providing an estimate of the demand for high-blends on an average EU biofuels corridor per distance-unit. The first and most accurate way would be to conduct a similar demand assessment for the entire TEN-T Network roads, and then taking the average. However, this is not within the time scope of this research. Secondly, one could assume a certain deviation (i.e. sensitivity) from the case study results for the rest of the network. It is believed that, due to the characteristics of the Rotterdam-Constanta corridor, the latter method could provide satisfactory estimates which would serve the purpose of this study.

The Rotterdam-Constanta corridor involves many countries with a diverging road transport intensity, from Eastern and Western European MSs. It is therefore likely that transport activity and fuel consumption in these MSs provide a weighted EU average. Nevertheless, as the corridor selection was predominantly based on transport flows, it is also likely that transport flows on other corridors will be slightly lower than for the Rotterdam-Constanta corridor. If the project is to be implemented on a small scale, then only the most active corridors will be chosen, as they would be more effective for achieving the targets. It is assumed that, in these cases, the potential demand will be comparable to the Rotterdam-Constanta corridor. But when a significant share of the TEN-T Network roads is to be transformed into biofuels corridors, TEN-T routes with lower average transport flows will also be included.

In addition, the refuelling behaviour of road users could be different at other sections of the TEN-T Network roads. For the Rotterdam-Constanta corridor, it has been estimated that approximately 14 percent of the total fuel use on the corridor is obtained from corridor stations. There are two important factors which could possibly influence these outcomes for other routes. Firstly, the price difference between fuels at motorway and local stations may vary. This, in turn, could depend on many factors such as price competition between these stations and rents for station locations along the corridor. If the price at these stations is higher, it is likely that road users will refuel less here, and vice versa (see, for example, ECORYS, 2009). Secondly, many of the TEN-T Network roads are toll roads. Users may refuel more often at toll roads, as it would be more difficult to exit and re-enter the motorway. The extent to which refuelling behaviour on other corridor is different is, however, expected to be modest, as the Rotterdam-Constanta corridor comprises a significant share of the TEN-T Network roads including a variety of road segments.

Technical Analysis

Technical aspects of vehicles and infrastructure for high-blends are generic for all EU biofuels corridors. Therefore, no technological problems are to be expected when implementing additional biofuels corridors.

Economic Analysis

As regards the economic analysis, the establishment of more biofuels corridors would lead to economies of scale, particularly for the open market designs, reducing the average costs of vehicle adaptations. The chance of being on a biofuels corridor would then be increased. However, as it is likely that other corridors will also see most refuelling taking place off the corridor, other support measures for high-blends would still be needed to make introducing these vehicles en masse interesting. Furthermore, the relative logistical costs among fuel stations may be slightly different on certain corridors, because of a relatively lower or higher demand for high-blends on some corridors compared to the Rotterdam-Constanta corridor. Therefore, it might be relatively more straightforward or more challenging to achieve a satisfactory coverage of stations offering high-blends on the entire network on a free market basis. This could change the role of public support policy in providing more or less incentives.

Policy Analysis

The penetration of biofuel-compatible vehicles into the EU market will be easier if high-blends are offered on several corridors. Vehicle manufacturers would then have a significant sales market and economies of scale which will reduce technological costs. With an expansion of the implementation scale, the role of public policy to trigger developments in bringing more biofuel-compatible vehicles onto the market might change from subsidising the purchase of these vehicles towards creating obligations to produce vehicles compatible with high-blends. The latter may be rather ambitious and will probably be most effective at the EU level, or, if countries with a significant car industry participate in the corridors, also at the MS level.

Oil companies could be more willing to participate in the corridor project if it is implemented on a large scale. This would provide the companies with a clear signal on the future role of high-blends and undermine their arguments against high-blends. They would have higher certainty that vehicle support for high-blends will develop positively and that demand for high-blends will grow as a result. Aside from this, various other aspects regarding the cooperation of oil companies must be taken into account if more biofuels corridors are to be implemented. The coverage of the TEN-T Network roads is extensive and companies will focus on locations in which traffic intensity is at its highest in order to increase their biofuel sales. Moreover, oil company interest in participating may differ among EU countries due to differences in policy and thereby in the attractiveness of offering the high-blends. However, since similar issues hold for conventional fuels it is to be expected that they will be solved thanks to the free market system. If, because of this, high-blends would not be offered on certain corridor segments (and therefore prevent minimal station spacings from being met), there would be a role for public policy to make supplying high-blends on these locations more attractive.

Different policy measures might be in place to keep the price of high-blends low if biofuels corridors are implemented elsewhere. A harmonisation of tax policy regarding (bio)fuels is still not considered to be viable within the time scope of the RED, but, as international agreements on this matter could increase efficiency, an EU-wide approach would certainly help progress in this direction. Examples include CO2 taxation or energy taxation, although, according to Neeft and Hodson, both of these concepts are still in a developmental stage.[1]

Conclusion

The results of the Rotterdam-Constanta corridor can be transferred to other corridors on the TEN-T Network roads when taking the following factors into account. First among these factors is that transport flows and refuelling behaviour could be corridor-specific. Therefore, further research should be done into the potential demand on other corridors in order to obtain more accurate estimates of the impact of biofuels corridors at the wider EU level. However, it has been argued that extrapolating the results of the Rotterdam-Constanta corridor, accompanied by sensitivity intervals, would be suitable in order to provide a first indication of the effects of biofuels corridors at the EU level. Furthermore, vast differences in technology and infrastructure costs are not expected. The introduction of biofuel-compatible vehicles will become easier and more cost-effective, due to economies of scale. In addition, it is likely that oil companies will show more interest if biofuels corridors are implemented on a large scale, as this would provide more certainty that a substantial vehicle fleet for biofuels will develop.

5.3 Contribution to the EU Targets

This section provides an indication of the potential displacement of conventional fuels by biofuels by means of implementing EU biofuels corridors on the entire TEN-T Network roads. Is does so in order to determine the potential contribution of biofuels corridors to the RED targets. Calculations are provided in Annex E.

The RED requires MSs to have a share of at least 10 percent of renewable energy in transport, and in the corresponding scenarios (see Chapter Three) a certain percentage must be achieved by high-blends. In Corridor Scenario 1, this would only be a small share of the total renewable transport energy targets, which is presumed to be one percent. The remaining share will be met by increasing the minima of low-blends as well as by other alternatives. In Corridor Scenarios 2, 3 and 4, high-blends would entirely complement low-blends, which implies that, based on the minimum ten percent target, approximately 4 percent of total EU transport energy should be achieved by high-blends. It should be mentioned again that MSs may decide to adopt higher targets, which means that the scope of high-blends could be increased.

The maximum potential contribution of EU biofuels corridors in 2020 is, therefore, expressed as the total share of transport energy that could be replaced by biofuels. This share for each of the corridor scenarios is calculated as follows. To obtain the maximum contribution of EU biofuels corridors, the average use of high-blends (in energy terms) per km of biofuels corridor is

[1] From interview with Paul Hodson (EC) and John Neeft (SenterNovem)

multiplied by the total length of the TEN-T Network roads. Subsequently, this figure is divided by total EU transport energy use.

This calculation requires three input values: the total length of the TEN-T Network roads; the total EU transport energy use; and, the replacement of conventional fuels by biofuels per corridor-km. Firstly, the TEN-T Network roads are expected to comprise approximately 90,000km of motorways and high-quality roads by 2020 (EC, 2009c). Secondly, the total EU transport energy use in 2006 was 15.5E9 Gigajoules (GJ) (Eurostat, 2008). As transport energy is expected to grow by 0.75 percent annually between 2005 and 2030 (EC DG TREN, 2008), the total transport energy use would be 17.2E9 GJ in 2020. Thirdly, the biofuels use per corridor-km can be obtained from the Rotterdam-Constanta corridor demand analysis. The total length of this corridor is just over 4,000km (see Chapter Three). The RED is based on energy terms, which means that the biofuels use must also be expressed in energy terms (GJ).

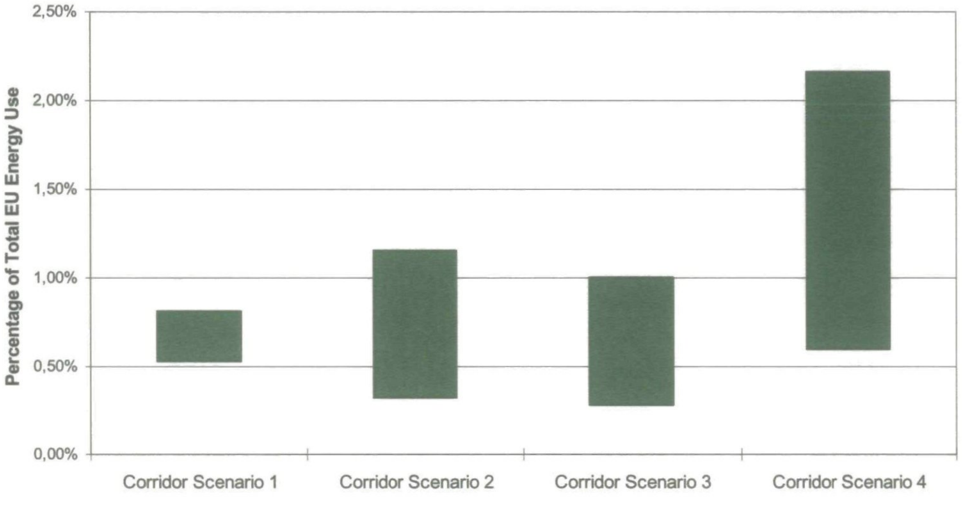
However, it has been argued in Section 5.2 that the biofuels use per corridor-km on the Rotterdam-Constanta corridor could be slightly different than for other TEN-T Network routes. Therefore, in order to provide an estimate of the demand per corridor-km, a certain deviation interval regarding transport flows and refuelling behaviour on this specific corridor have been assumed. Firstly, transport flows on other TEN-T road corridors may be different than for the Rotterdam-Constanta corridor. It has been argued in the previous section that, because of the fact that this specific corridor was selected on the basis of high transport flows, it is likely that average transport flows might be slightly lower if implemented on the entire TEN-T Network roads. Therefore, a deviation interval of between 70 and 110 percent of total Rotterdam-Constanta transport flows has been assumed. Secondly, approximately 10 and 16 percent, for the freight trucks and passenger transport respectively, of the total fuel use on the Rotterdam-Constanta corridor will actually be obtained at corridor stations. Yet, this share may be slightly higher or lower for other corridors, because of different refuelling behaviour. The previous section has pointed to price differences and toll roads as possible reasons for this, but argued this deviation to be modest. Therefore, a deviation interval of between 60 and 140 percent from the Rotterdam-Constanta corridor values has been assumed. Both assumptions apply to all markets, including freight and passenger transport alike, and lead to maximum and minimum values for the energy displacement on EU corridors per corridor-km as given in Table 5.1. It is important to bear in mind that, because of these assumptions, the true results could be slightly different, yet it does allow a first indication to be made of the effect that biofuels corridors could have if implemented at the EU level.

Table 5.1 Displacements in Energy Terms by Biofuels per EU Corridor-km

Energy displacement per corridor-km by biofuels in GJ	*Corridor Scenario 1*	*Corridor Scenario 2*	*Corridor Scenario 3*	*Corridor Scenario 4*
Minimum	990	604	526	1130
Maximum	1556	2213	1930	4144

Figure 5.1 presents an estimate of the maximum contribution of EU biofuels corridors in 2020 under each of the four corridor scenarios. The green bars represent the sensitivity of the calculations, i.e. the contribution of Corridor Scenario 4 is estimated to be between 0.5 and just over 2 percent.

Figure 5.1 Estimation of the Maximum Contribution of EU Biofuels Corridors to the RED Targets in 2020



Conclusions

Figure 5.1 shows that EU biofuels corridors in Corridor Scenarios 2, 3, and 4 as a measure on its own does not come close to complementing low-blends in 2020 (i.e. 4 percent). Moreover, it is assumed that biofuels corridors are implemented on the entire TEN-T Network roads, which can already be considered as very ambitious. The maximum contribution of biofuels corridors in Corridor Scenario 4 would increase the amount of biofuels as a percentage of total energy consumed in transport by just one or two percent. The other scenarios would be much less powerful.

However, it is assumed that in the corresponding scenarios, biofuels corridors would be the only measure to stimulate the use of high-blends. It is to be expected that, if the focus is on high-blends, these will also be offered at other locations, and that EU biofuels corridors can therefore certainly make a contribution to a higher use of high-blends. In addition, if biofuels corridors are to be implemented, the use of high-blends on the corridors could continue to grow after 2020, as the share of biofuel-compatible vehicles will also rise. Figure 4.3 in Chapter Four indicates that the use of biofuels on EU corridors after 2020 may be twice as much as current values.

In Scenario 1, a much lower contribution to the RED targets (approximately one percent) is required. Although the figure indicates that this target would also not be achievable by biofuels corridors alone, this scenario nevertheless offers scope to increase the number of participating truck companies and thus may become more interesting in the drive to meet RED targets.

5.4 Limitations of the Results

The results and conclusions presented in these final chapters should be taken with caution, since the study has several limitations. Some of these limitations have already been pointed to in Chapter Three. These and other limitations are now further examined and the effect of alternative assumptions and methodologies on the outcomes is also addressed.

Firstly, different overall policy scenarios and thereby *corridor* scenarios could be developed. This would have led to different corridor designs, offering other type of high-blends, for example. In turn, this could have influenced the outcome of other analyses in this report. If, for example, E30 ethanol was to be offered (i.e. instead of E85 ethanol) in Corridor Scenario 2, its contribution to the RED targets would naturally be lower. However, it was argued in Chapter Three that these scenarios are, according to the interviewees, most realistic to occur. Moreover, the scenarios offer a wide range of ambition regarding the implementation of biofuels corridors, thereby covering also other possible scenarios.

Secondly, a different corridor could be chosen for the case study. Chapter Three points to different selection criteria as a reason for this. As fuel demand on other corridors could be different than for the Rotterdam-Constanta corridor, for example, one could argue that this may impact on the results made in this chapter. However, thanks to the many and diverging countries involved in this particular corridor, the Rotterdam-Constanta corridor is considered to be very representative for other corridors on the TEN-T Network roads. Additionally, sensitivity factors have been included in the generalisation of the results in this chapter in order to take these divergences into account. It can be argued that, because of these aspects, the criteria that were initially used for the selection of the corridor (e.g. policy attention and trip length) may have been, when looking back, considered to be of less importance; it is likely that a case study for a different TEN-T corridor would have led to similar findings.

Thirdly, transport flows and the corresponding fuel use on the Rotterdam-Constanta corridor have been estimated using a transport model (see Section 3.5). Assumptions have also been made regarding the annual fuel throughput at fuel stations on the corridor, as limited information was found on this topic (see Section 4.3). Different assumptions and methods could therefore lead to a relatively more or less favourable demand outcome for the Rotterdam-Constanta corridor, as this would impact on the refuelling behaviour of road users. However, it is not expected that this would severely affect the conclusions made in this report, as it was also shown that the differences would be relatively small. The same would be true of the transfer of case study results to the wider TEN-T Network; these are also considered to be reasonably representative but again, should be interpreted with caution.

5.5 The Biofuels Corridors Policy Scenario

Ideally, the public sector will decide in a year or two how it will go forward to accommodate renewable energy in transport. One of the options is that the focus of MSs is on high-blends for road transport. Possible ways to provide a clear signal to the corresponding industry include the provision of incentives for high-blends and biofuel-compatible vehicles. Governments could also decide to introduce new biofuel obligations. In the latter case, the responsibility to achieve the EU targets would be transferred to the industry itself, which, in turn, may also opt for high-blends.

If the industry focuses on high-blends, with or without government support, biofuel-compatible vehicles will have to win ground and fuel stations will need to start supplying a wide range of high-blends. It is expected that in each country, depending on the respective government's strategy, a biofuel refuelling network will be developed as the biofuel-compatible vehicle market grows. The form and extent of this network and the product range of high-blends will most likely depend on individual oil companies strategies, which are, in turn, based particularly on cost-effectiveness. There is a risk that the provision of high-blends to the open market will be the last resort for multinational companies, as, particularly at the beginning, the market for high-blends will be very small. Unless national governments give a clear signal to the car manufacturing industry, the en masse introduction of biofuel-compatible vehicles will remain slow. Therefore, some oil companies may focus on specific captive fleets, while others may spread out their biofuel stations for other markets. High-blends may be seen as an interesting niche market, indicating that some companies will bring more biofuels onto the market than necessary. Subsequently, these companies can sell their remaining biofuel quotas to other companies. The Dutch Tamoil branch provides one example of this strategy.[1]

If biofuels corridors are to be implemented, this could certainly lead to a higher use of high-blends, particularly in the field of long distance transport. In addition to local initiatives, an EU-wide refuelling network of high-blends on the TEN-T Network roads would be established. This would also make biofuels more recognisable internationally among road users and provide the EU industry with a clear signal regarding the future of high-blends. There would be a role for policymakers at the EU and MS levels to stimulate the development of biofuel stations on the corridors. It is expected that, due to relatively high consumption rates on corridor stations, the provision of high-blends is self-sustainable for a certain amount of stations on the corridor.

At present, it is not known whether the promotion of biofuels will continue after 2020. If it does, it is likely that there would be a movement towards second generation biofuels. This could be BtL or second generation ethanol, for example. Some of these biofuels do not require special vehicles and infrastructure, which means that the role of biofuels corridors would then be reduced. There would be little point in offering special blends for special vehicles at stations, if biofuels can be blended without any vehicle changes. These aspects would be particularly

[1] From interview with Cees van de Peppel (Tamoil)

true for biodiesel, which could be replaced by BtL. Second generation ethanol is basically similar to the first generation, which means that a post-2020 market for the ethanol scenarios would be more likely to remain.

If the post-2020 focus were no longer on biofuels, the biofuels corridor approach could possibly be applied to other forms of renewable road transport energy. Examples include electric vehicles and hydrogen. These vehicles may still have a very short action radius and could therefore benefit from a corridor approach, as road users would always have access to vehicle power then. Furthermore, the concept could also be applied to other modes of transport, by making biodiesel available on inland shipping routes, for example.

6 Conclusions and Recommendations

6.1 Introduction

Biofuels are considered by EC policymakers as a viable alternative for reducing fossil-fuel dependency and environmental degradation. This thesis has examined the potential and feasibility of biofuels corridors on the TEN-T Network roads as a way to increase biofuels use.

The future role of biofuels was first addressed by means of a literature study. This showed that, although the potential of biofuels to reduce GHG emissions and fossil-fuel dependency is high, the growth of biofuels use in transport will presumably occur gradually as it follows the targets stated in the EC Renewable Energy Directive 2009/28/EC (RED). This restricted growth is due to the economic, environmental and social barriers which present-day biofuels raise and which need to be overcome before their use can be widespread.

Following this, a scenario analysis anticipated the interpretation of RED by EU MSs and defined the future scope for EU biofuels corridors. This led to the creation of four scenarios in which high-blends are vital for achieving EU targets. Based on these scenarios, four potential biofuels corridor designs were established and a corridor was chosen for case study analyses, based on several criteria: the Rotterdam-Constanta road corridor.

The potential and feasibility of the Rotterdam-Constanta biofuels corridor was assessed by way of several analyses. Input for these analyses was obtained from interviews with key stakeholders on the corridor as well as calculations regarding the potential market demand for high-blends on the corridor. Subsequently, the case study results were generalised in order to examine the potential and feasibility of other biofuels corridors on the TEN-T Network roads.

This concluding chapter summarises the most important findings by answering the central research question of this study. Furthermore, recommendations are made for further research.

6.2 Answer to the Central Research Question

The central research question of this study is: *To what extent can biofuels corridors on the Trans-European Transport Network roads increase biofuels usage in the EU and is their implementation viable from a technical, economic and policy perspective?*

Having conducted the analyses outlined in the previous chapters, it can be concluded that the extent to which EU biofuels corridors alone can increase the use of biofuels is limited. A maximum contribution to the RED targets of just one or two percent can be expected if biofuels corridors are to be implemented on the entire TEN-T Network roads. The limited effectiveness of biofuels corridors is mainly due to the fact that the enormous transport flows on the TEN-T Network roads are not representative of actual fuel sales at stations on this network (i.e.

motorway stations). This has been confirmed for the Rotterdam-Constanta corridor by means of a demand analysis. Comparisons between fuel use by road users driving on this corridor, as estimated by transport model TRANS-TOOLS, and the actual fuel sales on this corridor indicate that a mere 14 percent of road users actually refuel at stations on the corridor. This study has shown that, instead, the majority of passenger vehicles refuel at local fuel stations, and freight trucks refuel mostly at business pumps or have their own business refuelling infrastructure. This can be explained by adopting different fuelling behaviour when faced with different fuel prices at motorway stations, which are often significantly higher. The high prices, in turn, can be attributed to the high rental prices of their attractive locations and the free market they operate in. There may thus be a role for governments in reducing these rents if certain preconditions are met (i.e. offering high-blends) which could serve to increase fuel demand at these stations. However, the implementation of this kind of incentive would be complex due to conflicting interests locally, not to mention at the cross-border level. A radical change in consumer fuelling behaviour would also have to occur, and, even then, it remains to be seen to what extent the total (bio)fuel sales at corridor stations would increase. Although fuel sales at corridor stations may be slightly different (perhaps higher) for other corridors on the network due to different refuelling behaviour, for example, it is not believed that biofuels corridors alone, even if they were to be present on the entire TEN-T Network, would be able to make a high enough contribution to achieving the RED targets in each of the corresponding scenarios.

Besides relatively low demand, the viability of biofuels corridors for an open market (i.e. Corridor Scenarios 2, 3, and 4) seems to depend on a future public policy focus on high-blends, which, according to the analyses, would be rather ambitious. In the corresponding scenarios, high-blends would have to contribute significantly to the RED targets, i.e. up to 4 percent of EU total transport energy. Yet several barriers would need to be overcome if high-blends were to be focussed upon, and there would be an important role for public policy, at both the EU and MS levels, in allowing this to be achieved. This is due to the fact that stakeholders are unwilling to cover the additional costs related to the promotion of high-blends and are being guided by cost-effectiveness. Most vehicle manufacturers, for example, are reluctant to introduce cars which can run on high-blends, as this would reduce their competitiveness in the sector. In addition, oil companies will not introduce high-blends en masse if demand is not high enough to ensure logistical efficiency. The priority thus would be to increase the share of biofuel-compatible vehicles. Successfully targeting barriers to their production would create a policy landscape which is conducive to the implementation of biofuels corridors accessible to the open market, including the provision of strong incentives in MSs to make high-blends attractive. For this reason, various alternative policy options have been presented in this study which could stimulate the use of high-blends, such as providing grants for refuelling infrastructure and tax reductions for biofuels. Whether the occurrence of such developments is realistic, however, remains doubtful. Yet, there are many other alternatives available to stimulate the use of biofuels, which, from the perspectives of various stakeholders, would be more favourable than focussing on high-blends alone, including increasing the minima low-blends.

The future role of high-blends, however, will presumably become clearer when national RED action plans are presented. If future MS policy stimulates the use of high-blends as a strategy to achieving RED targets, biofuels corridors for the open market could be developed. The role of public policy regarding the development of these corridors, aside from stimulating the use of high-blends in general, would then mainly be on the promotional side. It is expected that the refuelling infrastructure for high-blends on the TEN-T Network would develop automatically once demand increases. In these scenarios, biofuels corridors would serve to increase the awareness of biofuels among road users and could encourage international cooperation in fuel standards and taxation. Furthermore, the corridors would naturally increase the use of biofuels to a certain extent. However, as most fuels are obtained at local stations or business pumps, the creation of a significant market for high-blends should also be directed at these market segments rather than the motorway segment alone. The latter, in turn, would imply a focus of high-blends on the entire road fuel market, something which would be more realistic if higher biofuels targets were to be adopted by MSs.

A scenario in which just a small share of the RED targets is to be achieved by high-blends is, however, more realistic. High-blends would play a limited role in this scenario, as the focus would also be on other alternatives to achieve the RED targets (e.g. second generation biofuels and increasing the minima). The most promising *corridor* scenario to accommodate these would be one which incorporates a focus on a captive freight truck fleet (i.e. Corridor Scenario 1). The contribution in this corridor scenario to the RED targets is estimated to be just under one percent and could help to fulfil the mandate to be met by high-blends. Besides, there is scope to increase the participating truck fleet. Aside from being more realistic, the analyses point to other positive aspects of Corridor Scenario 1 compared to the open corridor scenarios. Firstly, it would be more cost-effective in terms of vehicle costs and it would be easier to develop, as incentives could be allocated to just a specific niche market. Secondly, oil companies favour the introduction of diesel replacements, which would increase their willingness to support the realisation of the concept.

Furthermore, the results of this study indicate that, particularly for the freight truck market, it may not be too challenging to extend the corridor concept and increase demand further. Trucks mainly refuel at predefined trucks stops or have their own fuelling infrastructure, and the amount of fuel used by the sector is sufficiently high to warrant dedicated logistics. By focussing on these market segments also, preferably located closely to the main corridors, the measure could become more effective (and also more interesting for oil companies) in contributing to EU targets. It was shown in Chapter Three that EU freight trucks use approximately one third of the total fuel used on corridors and a significant share could potentially be targeted in this way. Nevertheless, it must be mentioned that this would go beyond the initial corridor concept, as stations off the TEN-T Network roads would also offer the fuels. And, more research would needed to be carried out to assess the effect of an extension of the corridor concept (see Section 6.4).

The main challenge in ensuring the success of this corridor scenario lies in the cooperation of the various stakeholders that are involved. For example, an international group of freight transport companies who would be willing to use high-blends at these stations should be created. This, in turn, would require various conditions to be met, such as establishing a large network coverage and competitive prices for high-blends. Moreover, oil companies must offer high-blends and truck manufacturers must warrantee their vehicles to run on high-blends. It has been shown that there will be conflicting interests, and that is why public policy will still play an important role. Public policy would need to be conducive to this scenario by ensuring competitive prices for the fuel and stimulating vehicle manufacturers to increase their sales of biofuel-compatible vehicles, for example. Therefore, the realisation of biofuels corridors must be seen as a process rather than as a well-defined project, as successfully targeting the conflicting interests and possible risks is merely a matter of joint development.

6.3 Evaluation of the Approach

This section evaluates the approach that has been taken to address the potential of biofuels corridors. It does so in order to examine how this may have influenced the outcomes and conclusions that were made in this report. It also allows the outcomes to be placed into the wider perspective of promotional measures for renewable energy and could serve as valuable information for similar future research.

This research has addressed the central research question from an EU point of view. In doing so, aside from stimulating the use of biofuels, the concept was directly associated with the TEN-T Network and EU international cooperation, since these aspects are considered to be important for EU policymakers. However, one should be aware of the fact that this specific perspective has led to the potential contribution of biofuels corridors to the RED targets becoming an important criterion to assess their success.

The focus on reaching RED targets may have been less relevant if the potential of biofuels corridors was assessed from a different angle. For oil companies or road users, for example, other criteria may have been more important, and would be more related to the economic effects of the an increased use of biofuels.

In addition, the fact that not many road users refuel at corridor stations was announced at a late stage of the report. This information indicated that, even if biofuels corridors were to be implemented on the entire TEN-T Network roads, their potential contribution to the RED targets will remain low. One could therefore argue that the research presented here may have taken a different direction if this information had been known at an earlier stage. Instead of focusing on corridor stations alone, one could, for example, have abandoned the plan or extended the concept in an earlier research stage (i.e. to include other stations as well).

These two factors indicate that the conclusions of this report could be seen as a direct consequence of the approach that has been taken. However, it has also been argued here that there are several reasons why different approaches would only have led to slightly different outcomes and that this research is fundamental to further research in this field.

The extent to which a different viewpoint, and thereby a lower focus on demand and displacements, would have led to different conclusions is doubtful for two reasons. Firstly, other analyses (i.e. economic and policy options) have also pointed to the fact that the potential of biofuels corridors is limited. Going for high-blends, particularly just for corridors, is an ambitious plan, because of severe obstacles which need to be overcome first. The conclusions made in this report are therefore a result of a combination of all these analyses, rather than just of the observation that users rarely refuel at corridor stations. Moreover, the conclusions also state that if the rest of the policy environment is conducive to the development of corridors, it is still a good idea to implement them. Secondly, the outcomes of this research show that the promotion of biofuels requires the active participation of various stakeholders (e.g. road users, oil companies, governments). Developing promotional measures for biofuels must occur jointly. Therefore, although the focus was from an EC viewpoint, perspectives and interests of other stakeholders have also been taken into account in this study.

In addition, if the information regarding low demand on corridors had been known at an earlier stage, then the research could have taken a different direction. However, this direction would presumably lie outside of the scope of the biofuels corridors study, as the information points to other stations, away from corridors, also offering high-blends. It is likely that the conclusions that have been made specifically regarding biofuels corridors would thus be unchanged. Furthermore, it is not certain that it would have been possible to introduce this information earlier in the report. There is little publicly accessible information available on fuelling behaviour in the literature, not to mention at the cross-border corridor level. Reasons for this could be that this information is non-existent or that stakeholders (i.e. oil companies) are not keen on publishing this kind of data. The fact that this information only became apparent at a late stage is, therefore, a result of the structural approach that has been followed; namely an analysis of the future role of biofuels, followed by the creation of biofuels corridors designs, and subsequently by the feasibility study. The results regarding fuelling behaviour on the Rotterdam-Constanta corridor followed from a comparison of model data calculations with the actual fuel sales, which, in turn, originate from the structural approach this thesis has taken.

Based on this evaluation, it can be concluded that the conclusions regarding biofuels corridors may have been slightly different if the viewpoint were that of another stakeholder or if different criteria had been used. Furthermore, the research may have taken a different direction if specific information regarding fuelling behaviour had been known at an earlier stage. However, this information was not readily available and this fact should therefore also be considered as an important finding of this research. The alternative directions this thesis could have taken have been pointed to in the conclusions, and require further research.

6.4 Recommendations

Based on the outcomes of this study, several recommendations can be made.

First among these recommendations is to reconsider the implementation of biofuels corridors for the open market once there is more certainty regarding the future role of high-blends. The study indicates that the development of biofuels corridors is very much dependent on the national support policy for high-blends. It has been mentioned above that MSs must present their plans in mid-2010. This information would provide a significant amount of additional data which would assist in assessing whether or not the implementation of biofuels corridors is realistic and viable.

Secondly, the conclusions show that biofuels corridors for the freight transport truck market could be a promising development. A scenario in which high-blends would be required to contribute to just a small percentage of EU targets is a realistic one, and it was shown that targeting this market (i.e. captive fleet of freight trucks) could help to achieve this contribution in an effective way, from both a cost and future policy perspective. Preferably, the initiative would not only include corridor stations, but also business and home-based fuel stations to increase demand and thereby produce the corresponding effects. The ultimate aim would then be to create a kind of bunker fuel[1] consisting of large biodiesel components for the EU freight transport market. This fuel, e.g. B30 or B100 biodiesel, would then become one of the standard truck fuels in the EU and would be available at most fuelling locations for trucks.

Therefore, if the future corresponding scenario becomes reality and MS policy promotes the use of high-blends, further research should be undertaken into realising a high-blends refuelling network for freight transport trucks. This would include market segments other than corridor stations alone, such as business and home-based fuel stations, as most truck fuels are obtained at these locations. The research could take the form of a case study in order to examine the potential effects of this measure in terms of their contribution to the EC targets in more detail. Moreover, a social cost-benefit analysis could be conducted to examine the rates of (monetary) contribution that could justifiably be sought from public policy (i.e. EC or MSs). If these studies point to an optimal way to promote biofuels, then implementation can begin. This may take the form of a recommended process, including the most important stakeholders, which will automatically shape the precise specifications of the refuelling network (e.g. type of blend and station locations).

Thirdly, the corridor approach could be transferred to other modes of transport as well as to other sustainable transport alternatives. One could, for example, investigate the opportunities of a biodiesel refuelling network for inland shipping. Or, alternatively, for hydrogen or electric-powered road transport.

[1] Bunker fuel refers to standard fuels that are used by international shipping and which are present in most harbours.

6.5 Conclusion

As world leaders continue to negotiate over further agreements to reduce GHG emissions, EU attempts to achieve these also keep progressing. An analysis of a new promotion measure for biofuels in road transport presented here is therefore appropriate and relevant. In addition, an overview of the diverging interests of stakeholders involved in the promotion of biofuels and the challenges encountered provides valuable material for debates on biofuels stimulation in other contexts. But from all that has been learned from this study, it is just one small part of the long process of the transition towards a fully sustainable transport system.

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ANNEX A Stakeholder Interviews

Several stakeholders kindly agreed to be interviewed as part of this study. This Annex provides a summary of each interview.

I. Anton Stam, E van Wijk Logistics
Position: Director

II. Dutch Ministry of Housing, Spatial Planning and the Environment
Position: Senior Policy Advisor

III. Dr John Neeft, SenterNovem
Position: Coordinator of the GAVE Programme

IV. Paul Hodson, European Commission
Position: Head of Biofuels / Deputy Head DG Transport and Energy Unit D1 Regulatory Policy and Renewable Energy

V. Oil Company
Position: Senior Manager

VI. Cees van de Peppel, Tamoil
Position: Supply and Biofuels Manager Tamoil Netherlands

VII. Philippe Marchand, Total
Position: Director Strategy and Regulations Total R&M and Biofuels

I. Anton Stam, E van Wijk Logistics
***Position:* Director**

Wednesday 16 September 2009, 9.00-9.50pm, Giessen, The Netherlands

Anton Stam is director of E van Wijk Logistics, which is an international haulage company offering a wide range of logistic services. Most dominant among these services are lorry transport and conditioned transport. The company owes its success to approximately 600 employees in the Netherlands, Romania and the Ukraine, including 300 drivers in its own employment.

The Dutch branch of E van Wijk occupies approximately 130 trucks, the Romanian 100, and the Ukraine 20. The Dutch trucks are mainly employed in the Benelux, Germany, Austria, Italy and Switzerland. The Romanian and Ukraine branch mainly drive to the Benelux, France and Italy. Stam confirms that both routes (as pointed on the map) from Rotterdam to Constanta are frequently being driven by E van Wijk.

Refuelling of Trucks

The Dutch establishment of E van Wijk has its own diesel pump (referred to as home base), which, according to Stam, is rather common for large road transport companies. The aim is to refuel as much as possible at this place, purely to reducing costs, and the Dutch trucks predominantly refuel here. Most of the journeys do not last longer than a week, and the tank capacity (see below) is often sufficient to continue without refuelling. In these cases, refuelling along motorways occurs rarely.

Aside from their own tank infrastructure, there are arrangements with oil companies in various countries. Thereby, the type of fuel stations across these countries varies. In countries like Germany, a national diesel discount applies, while in other countries agreements are made with a selection of stations.

E van Wijk does not have a home base in Romania and Ukraine, but instead, agreements exits with certain local fuel distributors. Stam adds that transport companies who do not have their own pump will always focus on countries in which diesel prices are low, such as in the Netherlands. Germany in particular is mostly skipped when driving long distances, because of high diesel prices. On the specific Rotterdam-Constanta route, Austria is among the other countries in which trucks regularly refuel.

Fuel stations along motorways are generally more expensive than stations which are just of the motorway. Stam mentions that therefore a trade-off has to be made, although he adds that these price differences are often small. A detour for cheaper fuel is only made if the station is a few hundred meters away from the main road. The money gained is relative small, as, if the price difference is 10 cents, a full tank would only be 100 euros cheaper.

Tank capacity of E van Wijk's trucks is approximately 1,000 litres. Stam confirms that this size is rather common for international transport trucks. Their average fuel consumption is between 3 and 3.5km for one litre of diesel fuel. A maximum import of diesel applies to some of the European countries, which then limits the amount of fuel to be brought in from the home country. Stam mentions Slovenia as an example for this, but he notes that this rarely impacts on E van Wijk's refuelling strategy. A maximum import of fuel does not apply in Germany.

Fleet of Trucks

Most of E van Wijk's trucks are DAF. Stam indicates that the average use of trucks is between 3 and 4 years, although the practical life expectancy is higher, between 8 and 10 years. The average mileage of trucks is about 1.2 million km. The fact that trucks are being renewed quite frequently is due to the high costs and inconvenience related to additional maintenance at the later stage, for example. Stam approximates that 60 percent of their trucks now meet the Euro5 standard. He adds that focus on emission reductions has outweighed the past technological progress in fuel efficiency, as this has remained between 3 and 3.5km for one litre of diesel fuel.

General View on Biofuels in Road Transport

Stam feels that further developments in the field of biofuels are closely related to the technical possibilities in this field. It is crucial that the fuels are being produced in an cost-effective way. He points to the recent controversy surrounding the energy-effectiveness of biofuels to clarify this view.

Presently, Stam feels hesitant about the use of high-level biodiesel blends. The first argument which is brings up is the uncertainty related to the impact that biofuels may have on the engine of their trucks. This is certainly an important barrier for all transport companies, he notes. Furthermore, even if the alternative fuels can be used safely in the engines, the actual use would depend on the costs of the fuel relative to the cost of conventional diesel. Stam indicates that, in all fairness, the extent to which haulage companies want contribute to sustainability is often negligible. Practically, the incorporation of sustainability measures eventually comes down to cost-benefit calculations. Thereby, companies follow the legislation regarding sustainability aspects. He clarifies his view by pointing to the Euro5 standards for trucks, which reduces the toll tariffs on motorways. The fact that these trucks are also better for the environment is a nice side-effect. He expects that the same will hold for the use of biofuels.

Biofuels corridors

Stam points to various aspects that are important from the perspective of haulage companies in order to participate in such project: the availability of biofuels, the biofuel price, and the technical aspects of trucks, including maintenance. If all factors are similar to those of conventional diesel, no company will hesitate to use the biodiesel along the corridor.

The sustainability argument alone would not be sufficient to trigger haulage companies to use biofuels. The corridor should offer something which equals conventional fuel in terms of availability, price and quality. A very good refuelling network must be in place, as various companies have all different routes. Stam indicates that this could only be established successfully by large oil companies. Stam does not see the fact that the biofuels will be cheaper in some countries on the corridor compared to others as a problem, as this also holds for present-day fuels.

II. Dutch Ministry of Housing, Spatial Planning and the Environment *Position:* Senior Policy Advisor

Tuesday 25 August 2009 3.00-4.10pm, The Hague, The Netherlands

The Directorate Biofuels of the Dutch Ministry VROM was set up in April 2009 and consists of eight team members. Its main task is to ensure the Dutch implementation of the EC Renewable Energy Directive 2009/28/EC. This includes juridical and implementation aspects, as well as the actual enforcement of the Directive.

Introduction to Dutch Biofuel Policy

The main reason of transport biofuels is to reduce CO_2 emissions, which is required under the Kyoto framework. Transport accounts for 21 percent of these emissions and grows fastest of all sectors, despite the fact that vehicles are becoming less-polluting. Therefore, transport is certainly a sector which could make a significant contribution to reduce these emissions. Although biofuels are not the only solution to emission reductions in transport, their contribution is considered to be very important, at least for the upcoming two decennia. Long-term focus, between 30 and 40 years, is mainly on electric-powered vehicles. Secondly, there is an economic reason. A higher share of biofuels would reduce oil-dependency of politically unstable regions.

However, biofuels go hand in hand with a lot of criticism. Especially in 2008, biofuels have been increasingly surrounded by negative publicity. It has been argued, for example, that food prices were rising due to the use of feedstock for biofuels. Additionally, the production of biofuels would lead to deforestation and CO_2 reductions would be lower than previously indicated. Most of these issues have now been covered by EC's latest Renewable Energy Directive (RED).

The RED requires to have an average of 20 percent of renewable energy in 2020. Targets are different per country, the Dutch target is set at 14 percent. A minimum of 10 percent renewable energy in transport applies to all MS. Controversial issues have been covered by additional sustainability measures. Firstly, second generation biofuels count double towards the targets. Secondly, only biofuels which have a certain reduction in CO_2 emissions (starting at 35 percent, up to 60 percent) will be included. Thirdly, feedstock may not originate from land with a high biodiversity and so forth. Important is that land condition may not be affected by the cultivation of the feedstock.

The Dutch Approach to the RED

The RED requires a minimum share of 10 percent biofuels in road transport in 2020 for all MS. However, governments may well decide to go beyond this target, depending on their total targets for renewable energy and their ambitions in this field. In order to take these decisions, the Dutch Directorate Biofuels wants to be sure that biofuels are sustainable, as there is a risk that implementing biofuels on a large scale could seriously affect environmental and social performance. Therefore, the government will be assisted by a team called 'Duurzaamsheids Vraagstukken Biomassa'. This commission, headed by Dorette Corbey, will provide advice regarding the long-term sustainability of larger scale biofuel production. The commission will examine land-use changes and emission reductions, for example.

It is emphasised that the Dutch government acts progressively in the field of environmental and social sustainability, as it has been one of the first MS that insisted on having EU-wide criteria regarding sustainable performance of biofuels. This is evidenced by the early Dutch Cramer criteria, which have now largely been covered in the RED. For the first time, sustainability criteria have been accepted for consumer products at the European level. This could be important for future developments in this field.

Dutch biofuel targets of 5.75 percent in 2010 have recently been adjusted to 4 percent. Main reasons for this have been the increasing controversy surrounding the use of biofuels and several practical reasons regarding the implementation. The new RED, however, sets scope for further expansion of transport biofuels. The fact that progress in other MS has been higher so far, such as in Germany and France, is mainly be ascribed to diverging interests, such as developing the agricultural and car manufacturing industry.

Biofuels corridors

Biofuels corridors is a very sympathetic idea. Particularly the cross-border vision of biofuel promotion would make it interesting. However, there will be significant hurdles which need to be overcome, in particular regarding fiscal arrangements.

Biodiesel is, at least on present-day scales, not competitive with conventional diesel. Therefore, there has to be some kind of lower excise tax on biodiesel, as otherwise no one will buy the fuels. Additionally, station owners must be able to recover their costs on infrastructure, which may be particularly relevant for ethanol distribution. Every MS has their own grant systems in place to support these investments and additional biofuel costs, but these policies vary significantly. A harmonisation of biofuel policy would be very ambitious, despite the fact that, as regards contents, it would be very stimulating to do so.

The role of the EU

To establish uniformity in fuel taxation would be particularly difficult. Fuel taxation is tricky due to the many diverging interests, and MS will not give this easily away. Luxembourg, for example, benefits from low fuel taxes, as now everyone refuels there. Also Dutch taxation on diesel is relatively low, which is to encourage the domestic transport sector. MS are now competing with each other on fuel prices. An alignment of fuel taxes among MS would at least involve the touching of fiscal boundaries. Even in the new constitution of the European Union, MS have a veto on any fiscal measures within the EU. And, therefore, fiscal incentives to encourage biofuels use presumably remains at the level of

MS, especially in the medium-term. This includes that there will always be fuel price differences.

Investments in infrastructure, however, could partly be covered at the EU level by way of structural funds. Various of these funds are available which may possible qualify for this kind of initiative. Naturally, criteria include that the project is cross-border, for example.

The role of Member States

National support policy, however, is much wider, and would mostly focus on tax law. Aside from partial excise tax exemptions for biofuels, one could also think of fiscal support policy for infrastructure investments.

Support of Biofuel-Ready Vehicles

The problem of sufficient engine support for biofuels will resolve itself. The Directive is now approved and blending percentages will be rising in the following decade. Vehicle manufacturers cannot afford to neglect developments in this field, and therefore, this automatically includes that support for biofuel blends will grow, likely up to 10 percent for ethanol and up to 7 percent for biodiesel. If it turns out that the EU targets can only be met by also introducing high-blends, vehicle manufacturers will certainly expand their Flex-Fuel Vehicle fleets. This is evidenced by developments in Sweden, for example. Vehicles which can run on high-blends are proven technology, and easy to sell elsewhere in Europe.

Infrastructure

Although there are possibilities to force fuel stations to offer specific fuels, these kind of measures are unlikely to be necessary. Some fuel distributors would certainly be willing to contribute to such an initiative, as this could be part of a marketing stunt in the promotion of sustainable fuels. Small companies in particular could be more willing to participate, due to their flexibility. However, current biofuel policy is quite uncertain at the moment and this makes it risky for fuel distributors to make high investments in new biofuel infrastructure. These investments are substantial, and require at least a continuous biofuel support at the national level. Once this condition of a solid support policy has been met (e.g. by means of national action plans), this would automatically set scope for additional biofuel infrastructure.

III. Dr John Neeft, SenterNovem
Position: Coordinator of the GAVE Programme

Friday 14 August 2009 10.00-11.10am, Utrecht, The Netherlands.

SenterNovem is an agency of the Dutch Ministry of Economic Affairs, which promotes sustainable development and innovation, both within the Netherlands and abroad. The aim is to achieve tangible results that have a positive effect on the economy and on society as a whole. On behalf of the Dutch government, SenterNovem implements policy regarding innovation, energy and climate change, and environment and spatial planning.[1]

Dr John Neeft is coordinating the Dutch government programme GAVE since 2005. GAVE is a Dutch abbreviation for Neutral Gaseous and Liquid Energy Carriers and the programme is implemented on behalf of three Ministries (Spatial Planning, Housing and the Environment; Economic Affairs; and Transport, Public Works and Water Management). The GAVE team supports the Dutch Ministry of VROM in decision making and provides the market with relevant information. Examples of this support include setting up sustainability criteria, providing technical background information and supporting with the setup of a legislative framework of biofuels.

The Future of Dutch and European Biofuel Policy

Neeft indicates that near-future Dutch biofuel policy will follow the EU directives. The exact share of biofuels in road transport in 2020 will need to be approximately between nine and nine-and-a-half percent, depending on the penetration rate of other alternative transport solutions, which will mainly consist of electric-powered vehicles.

Various EU MSs have different biofuel support policies in place. The most common measures are obligations for biofuels and tax reductions, or even complete tax exemptions on biofuels. Neeft indicates that MSs increasingly abandon tax incentives and switch to obligations as being the dominant measure. He sees this development as a way of increased alignment between biofuel policy in different MSs. Nevertheless, he mentions that all 27 MSs will always have specific legislation in place, and that their biofuel policy will therefore never be exactly the same.

Dutch biofuel policy focuses on obligations for biofuels rather than on tax incentives, which is set at four percent in 2010. Tax reductions only apply to a limited extent for PPO, up to 2010. There are no further Dutch tax incentives for biofuels, although Neeft adds that there is an ongoing discussion on the taxation level of ethanol relative to that of gasoline. Ethanol contains only two-thirds as much energy as gasoline, and it is argued that tax rates should be in accordance with the respective energy content. Regarding biofuel obligations, Neeft emphasises that energy companies are free to achieve the targets in any way, as long as they can prove that their *average* share of biofuels which they bring on the market meets the national obligations. In other words, not every litre should contain at least four percent of biofuel, but high level blends, or trading of biofuel quotas by means of so-called biotickets, could also be applied.

Neeft sees no reason why the Dutch focus on biofuel obligations would change in the upcoming decade. He also favours biofuel obligations over tax incentives. Tax incentives need only to be applied carefully, and there should be a particular reason to use tax measures, of which he mentions two examples. Firstly, the role of tax reductions could be favourable in case the characteristics of specific biofuels are evidently preferable, such as for the promotion of more sustainable

[1] Available from www.senternovem.nl, accessed 17 August 2009.

biofuels (e.g. second generation). Furthermore, tax incentives could play an important role in an early implementation stage of biofuels for specific market segments. This might be the case for the development of biofuels corridors.

Neeft gives two possible reasons why fuel taxation systems based on (CO2) emission savings have never been seriously considered. Firstly, methods which make it possible to measure CO2 performance of various fuels have only been developed recently, and Neeft does not think that their reliability until recently was sufficient yet to draw financial consequences upon their outcomes. Secondly, the concept would be very complex from an administrative viewpoint. Well-to-wheel emissions of biofuels vary highly, depending on feedstock choice and production process, for example, and this would require an enormous database system including all different biofuel configurations with their corresponding emissions. This, in turn, would add to the concept's complexity and costs, which is not likely to be in the proportion of the relative (small) market share of biofuels.

Neeft is not optimistic about a future harmonisation of biofuel policy between EU MSs. The first reason is that the establishment of the present EU Directive on Renewable Energy has been surrounded by discussion due to diverging interests of MSs. This is exactly why the agreement on renewable energy progress is by way of the Directive as it is now. Neeft points to various examples to clarify this diversification. German and French biofuel interests mainly include the development of the agricultural sector; the Swedish strategy focuses on second generation biofuels; and Denmark focuses on electricity instead of biofuels. These discussions and divergent interest have led to a compromise in which every MS is free to use any policy instrument and strategy in order to achieve the EU targets on renewable energy in transport. Only if biannual progress reports show that diversification of the implementation of the Directive is inconvenient, because it influences the biofuel market in a negative way, for example, the Commission could undertake appropriate action. This could then lead to an alignment of MS policy, but gradually, and only to a certain extent. Secondly, Neeft argues that an EU tax incentive on biofuels would be complex to put in practise and it remains to be seen to what extent the policy support measure is sustainable. The consumers' response to the policy can only be evaluated afterwards and could result in high revenue losses for governments.

Trade of Biofuel Quotas - Biotickets

All parties offering transport fuels have the obligation to report the selling of a certain share of biofuels. In order to place biofuels on the market, certain supply provisions need to be in place. The actual adaptations depend on the type of biofuel which will be offered. As not all companies are able to carry these additional costs, biofuel quotas can be traded among various parties. These trade tickets are referred to as biotickets. Although biofuel quotas may be traded nationally, international trade is unwelcome. Every MS has to subject to their own obligations, and should report to the EC accordingly.

Vision on Biofuels corridors

Neeft starts by pointing to experiences with a Dutch project to promote B30 biofuels in which SenterNovem has been recently involved. Transport of the organisation named Flora wanted to go 'green' and the use of high-blends were seen as a suitable means to achieve these ambitions. However, the practical implementation was not reached without a number of hurdles that had to be taken. Neeft points to several complexities as a reason for this. Among these aspects was that it turned out to be difficult to motivate oil companies. Biofuels are more expensive than conventional fuels and neither the fuel companies nor Flora transport were willing to bear these additional costs. Neeft indicates that enthusiasm among stakeholders will only rise in case more of such projects are carried out, and when oil companies are required to place more biofuels on the market.

The conclusion which Neeft draws from this and from other experiences is that initiatives which aim to promote the use of high-level biofuels in general are already ambitious in a national setting, not to mention in a corridor setting and on an international scale. He gives various arguments to support this view.

Firstly, major hurdles need to be overcome for the respective stakeholders which are involved in the promotion of high-level biofuels. Oil companies need to offer biofuels which can compete with conventional fuels. This is difficult, given the higher costs of biofuels. On the other hand, transport companies, who may take advantage from the green image, need to deal with these alternative fuels in their vehicles. Neeft adds that the road transport market is highly competitive and even small cost reductions are key to success. Transport companies would therefore only consider a switch to biofuels as part of their market strategy. The hurdles which need to be overcome are big and the respective stakeholders do not want to be depending on each other. This dependency would be reduced if such a project would be implemented on a local scale with a captive fleet and having a steady supplier on a specific location, which is not the case for biofuels corridors.

Secondly, the focus of biofuels promotion is on low-level blends, and, currently, there is no urgent need to develop an infrastructure for high-blends, as the present-day targets can easily be met by low-level blending. Neeft mentions that, although E85 and B100/B30 fuel stations are increasingly appearing, particularly in Western European countries, 99 percent of biofuels are currently sold as low-level blends. The success of offering high-blends depends mainly on national biofuel policy support measures. There is no need develop these market in countries without these policies, as high-blend vehicles are backwards compatible with conventional fuels. Neeft adds that most passenger kilometres are driven locally, and a biofuels corridor for E85 would therefore be 'illogical'. This might well be different for long-distance heavy goods transport.

Neeft admits that focus on low-level blending may change over time, when the obligatory share of biofuels as part of the total fuel sales would be increased to up to 10 percent of energy content. Depending on the blending limits of biofuels in conventional fuels, this would force oil companies to also bring high-blends on the market. However, still then, local and national initiatives for captive fleets would have a higher chance of success to make up for the remaining percentage. Naturally, the complexity will only rise when such projects are to be implemented on an international scale. Neeft mentions differences in biofuel policy among MSs as an example for this.

Development of Fuel Standards and Vehicle Specifications

The automotive industry is increasingly guaranteeing the use of higher-level biofuel blends in their vehicles. For ethanol, most vehicles support the use of up to E10, yet an official EU approval remains forthcoming. Neeft notes that this support will only be relevant in a later stage of the implementation of the Directive, when higher blends are entering the market. The market for Flex-Fuel Vehicles (FFVs) is increasing, but varies significantly in each MS. FFVs mainly drive locally. For biodiesel, support for high-blends varies for each brand. Neeft notes that new specifications of trucks limit the support of high-level biodiesel blends and refers to Biofuel Cities for an overview of biodiesel support of various engine manufacturers.

Official approval of 10 and 7 percent blending of ethanol in gasoline and biodiesel in diesel, respectively, is still in discussion, but it is clear that, according to Neeft, the new fuel standards will be in place by 2015-2016 in order to help facilitating the 10 percent obligation as stated in the EC Renewable Energy Directive. These upcoming fuel changes are reported in the EC Fuel Quality Directive.

IV. Paul Hodson, European Commission
Position: Head of Biofuels / Deputy Head DG Transport and Energy Unit D1 Regulatory Policy and Renewable Energy

Thursday 10 September 2009, 4.10-4.50pm, Brussels, Belgium

Paul Hodson has been working at the Commission since 1995, and since 2004 on renewable energy in general and on biofuels in particular. He was responsible for the in 2008 proposed directive on renewable energy, which has successfully been adopted (Directive 2009/28/EC). He is now heading the biofuels mission at the European Commission.

How would you evaluate the progress of the first Biofuels Directive?

Astonishing, I mean really. The target was set at 5.75 percent in 2010. And two or three years ago where we asked where would we get to, and we said probably around 4.2 percent. Even if we only got to 4.2 percent that would be amazing progress considering that we started from nothing. In fact, I think we will probably do better than that. I do not think we will get to 5.75, but we will get closer than 4.2 percent.

What have been key obstacles regarding the acceptance of the new Renewable Energy Directive?

The Renewable Energy Directive was proposed by the Commission in 2008, and politically approved in 2008. The Directive does not only deal with biofuels. Biofuels was one of the most controversial parts.

The Commissions proposal already had sustainability criteria for biofuels, but there was quite a strong reinforcement of those criteria by the time that the Directive was finally adopted by the Council and the Parliament. And that was called for both by the Council and by the Parliament.

The level of ambition of the target was very slightly reduced, because second generation biofuels count double towards the targets, which they did not in the Commissions proposal. But that is a relatively small change, of course depending on how much second generation biofuels there will be. We were happy with the outcome.

What is your vision on the future role of transport biofuels?

Biomass in energy is going to play a critical role. If we are going to both meet our greenhouse gas requirements and also achieve security of energy supply. The role that it plays in transport depends partly on other factors. It is in aviation that it is most clear that there is no alternative, apart from oil. In land based transport there is plenty of potential for actually switching to more efficient modes, and reducing demand for transport. All of those count, which would make the given amount of oil that we have go further. One could image that technological breakthrough to happen, either hydrogen or electricity. Hydrogen cannot happen before 2020. It is possible that there will be a breakthrough, I mean electricity will already happen. One of the things is that people go by train rather than by car, but to get a big move in that direction would involve a massive investment project in rail which I am not sure it is going to happen. Electric cars is very interesting to know whether we will get a breakthrough in that direction. There is a lot of interest in that area at the moment. We would be very glad if that happened. From the 2020 perspective, even if, for example, you have a 20 percent share of electric cars in new cars, it is still going to be very difficult to contribute much towards the energy, as most cars on the roads will still be old cars. I expect that the most of the transport targets will be met by biofuels.

Would you expect biofuel targets to exceed 10 percent in the upcoming national action plans?

That is an interesting question. I think Germany or France, or the Netherlands, for example, have all thought about this. They have a difficult problem. The targets are not set on the basis of potential, but they are set on the basis of GDP. So the rich countries have quite though targets. The national action plans force MSs to say how they are going to reach them. Not only biofuels, but all other solutions are also difficult to implement. It will be extremely interesting what they will write in their national action plans. I do not have a prejudgement about what the outcome is going to be.

One of the purposed of that part of the Directive is to give industry a sense of where to invest. The binding targets give a level of stability, but still if you have binding targets of a very high level of generality, they do not tell you as much. If you see that every MSs wants a very high share of PV in electricity, that tells banks that it is a good idea to back big projects in PV. We do not know how much PV there will be in the national action plans, because MSs are still working. The same counts for biofuels.

At this stage, the conversations that I have heard, are that MSs are doing this in a very responsible way. That is what we would fully expect. And that they see a role for electric cars and biofuels, which would reduce their role of what they need to do. They are not gambling on absurdly high numbers there.

How would you identify the role and future market of high-blends?

That is a really interesting question. Let us stay with the 10 percent and let us imagine that you have about 8 and 9 percent coming from biofuels. At the moment we have B7 and E10, and they are both worth about 6 percent in energy terms. The Directive is based on energy terms. So if you need 8 percent and you have only got 6 percent, you have to do something else. So there is a problem. High-blends is one of the solutions to that problem, but there are other solutions.

Aviation, maritime and rail, which are capable of using high-blends in the engines that they have, with certain adaptations of course, are not caught by those limits. So one of the questions is what role will those sectors play. Aviation in particular has got quite a good potential.

Another question is whether we have BtL, if you have second generation ethanol it does not help, because it is just the same as first generation, but if you have BtL, second generation, then it really does help. BtL is actually better than diesel. Biodiesel is worse than diesel and BtL is better than diesel, and better than jet fuel. If BtL happens, but unfortunately the progress is not as fast as we would want, then you avoid this problem. Another possibility is hydrogenated vegetable oil, which is a BtL like fuel, but made from first generation biodiesel components. BtL can be made from any kind of biomass, but hydrogenated vegetable oil is vegetable oil. But it is treated in a process, which leads to it taking a form which can be blended much above the B7 blends. Neste Oil are a Finish company has a project on this which they have launched two years ago, but it really has not taken off as a kind of biofuel. But if it did, that would be another way round this problem.

But if those solutions do not take off, we need to go with high-blends, or either we need to lift E10 to E15 and E20 and lift B7 to B10 and B15. If we went for high blends, then there could be a role for European action to making that happen. I personally believe that high-blends is probably quite an optimal solution. You really need a piece of policy work to compare those different possibilities. If you go for high-blends, E85 solves more problems than B100 does, because we can produce ethanol in much greater quantities, and the sustainability concerns are less than they are for biodiesel.

The future role high-blends depends, therefore, on futurish developments. Let us say that none of those other things happen, then from about 2015-2016, we would need to be having new cars, that are compatible with B15 and E20, for example. Car makers need to know that now. We need to decide now, or probably in a year or two, which of these paths we are going to go. It is a very nice public policy problem.

Car companies will follow the policy. They say, you have to tell us what you want. But we, the public sector, are not giving a clear signal on what we want. And whether we can get to that point is another question.

There are no particular support measures for high-blends in the EC Directive. There may well be on the research side. I am not sure that there is much at the moment. It is clear that support mainly depends on MS policy.

What is your first impression of the biofuels corridor approach?

I think it is a nice idea, but your are still hitting up against the chicken and egg problem. If we decide at the European level that we want to promote high-blends, we have think about how to tackle the chicken and egg problem. But the most obvious solution, and I am speaking personally, is to require vehicle manufacturers to make their vehicles compatible with high-blends. Ideally, the public sector would decide in a year or two how it is going to go forward on accommodating renewable energy in transport, and then this is one of the options, but not the only option.

Let us say we have to take this decision in one year or two, we will not be able to say that we do not need to do this as BtL will solve our problem. Even if BtL at the end solves our problem, it will not be possible to say that with confidence in one or two years time. I do not know enough about hydrogenated vegetable oil to know why is has not taken off. And biobutanol is a kind of similar solution, although not as good in the ethanol side, and that has not taken off either. I guess the reason is that there is some price problem or other problem, which means that they are going to be in the solution. But I cannot say that with any certainty.

Let us assume they are not the solution, then your decision is really one between high-blends or increasing the minima. My guess is that we would go for increasing the minima, but I am not sure. Lets assume that you have narrowed down the problem, so it is agreed really that you have to chose between one of those two approaches. Partly you are in the old who does the work, the industry or the car industry problem. The compromise is a bit of both. Much more of both, of course, than it is now.

Let us say that the sustainability concerns lead to a real desire to rebalance a way from biodiesel to bioethanol. Then that might end up with a package where both industries depart from their work, so an E85 and E20 package. That must be more likely than a B100 and a B15 package. You then have three types of ethanol pumps, E10, E20 and E85. And you are then in the chicken and egg question, and indeed you solve a problem by having biofuels corridors. You clearly do solve a problem with biofuels corridor then, because, although the E85 are Flex-Fuels, down that corridor, you know that you are going to get your E85. You need to be sure that the pricing of the E85 is right, but lets suppose that we solve that problem, it is a solvable problem, by way of tax policy. It is also influence by the oil price, and the ethanol price, but particularly by the oil price. But also by the tariffs, because the Brazilians could sell ethanol at prices that could compete.

It is a very interesting problem that you have got. I do not want to answer your question, but if you can write something intelligent about how all these factors fit together, I think that is an interesting idea. The plan would certainly help, but the question is how much it would help.

What would be the main challenges and hurdles which need to be overcome regarding the implementation and development of biofuels corridors?

It is not too difficult to have some filling stations on certain routes to sell high-blends, I mean, with public money this is not too difficult to do. You could also do it in a regulatory way, but I do not have much experience in regulation petrol stations. This would definitively depends on the MS's policy.

What could be the role of the EU in supporting biofuels corridors?

We have the TENs policy, we have the structural funds, we have cohesion funds, we have the power, of whatever that power is, of a route is or is not a TEN-T corridor. But this is all transport policy other than energy policy.

Obviously it would be nice to link it to the sustainability requirements. I think we are sort of presuming that we have moved forward in the sustainability debate by the time that this happens.

If you make energy taxes proportionate with CO2, then you discover that your transport taxes are much to high. And governments are not going to drop those taxes, and it is not good in environmental terms to drop those taxes. And governments are not going to increase taxes on electricity or heat to the same level. So we will end up with something more complicated then just CO2 taxation. It would be attractive to go to the CO2 approach, but then you have got the problem that the tax rates on fuels are much more then on the electricity, for example.

Moving to energy-based taxation would be helpful, because it would mean that the E85 was cheaper. And if the cars were optimised for E85, so that they went more kilometres per mega joule, then you would actually create a situation in where a rational driver would chose the E85. So it would be right to conclude that a shift in energy-based fuel taxation would be a big step forward.

How would you define the role of the various stakeholders that are involved in the corridor?

If it were to offer a cheap way for MSs to achieve what they have got to achieve for the Directive, they would like it. Anyway, they are operating through obligations on oil companies, so they have plenty of scope to make oil companies do things. It is really the cost-effectiveness questions of the people in the mix of the MSs. The cost-effectiveness assessment that they do will take into account the effect on the oil companies, especially in countries where oil companies are important to the economy, such as in the Netherlands. The cost-effectiveness is interesting.

If it is a B100 strategy it would do more, because there is more freight to hit. With the B100 scenario it is more critical to know first of all about the availability of resources of a sustainable type, whereas with ethanol we know that there is plenty of potential of availability of a resource in a sustainable way. It may be that the conclusion we all reach in a year time is that is also true for vegetable oil, but we do not know that now. And that makes it more difficult to evaluate this concept. So your conclusion can be, if vegetable oil is sustainable, and available in large quantities, then the B100 strategy is a very powerful strategy. If it is not, you could have an E85 strategy, but that would be significantly less powerful. That is a conclusion which you could reach. You need to show that you are aware that there are substantial differences on the supply side. We always say very crudely that the farmers want to make ethanol, and the oil companies want a replacement for diesel.

What aspects of the study would be particularly relevant and interesting from an EC viewpoint?

Obviously it would be very interesting to see what the quantities are. From my point of view, we have a policy scenario of 10 percent renewable energy in transport in 2020, and you can imagine a base-line in which that is achieved, and there are no biofuels corridors, and then, if you make your policy scenario, one in which there are biofuels corridors, what is the difference between the base-line and the policy scenario. That is an interesting question, focussing on the environmental benefits. The financial side is interesting, but it is more a sense of a second question. How this might the policy landscape post 2020 is quite an interesting second question. But the first question is what would it do in the 2020 scenario.

V. Oil Company
Position: Senior Manager

Thursday 6 August 2009 16.00-17.30pm, The Netherlands

Introduction

A distinction is made between the company's two main branches, referred to as the 'up-' and 'downstream'. The upstream side is involved in locating and extracting oil and gas. The downstream side includes processing, as well as selling the goods. The downstream side is divided into three divisions, which are retail, business-to-business (B2B) and the chemical branch. B2B delivers fuels to the aviation and marine industry, for example, but the main activity is selling commercial fuels, mainly for road transport. Selling commercial fuels includes the delivery of fuels at home and the provision of tank cards for company fleets. This is why there are many contacts with various carriers. One of the key challenges for this division is to provide support to these companies, especially in the field of sustainability.

Vision on Renewables in Transport

Three main challenges are defined in relation to increasing the use of renewable transport energy in the near future: the increasing demand for oil and other fossil fuels; fossil fuels becoming harder to obtain due to the fact that they often originate from politically instable countries and are located in more remote places; and, CO2 emissions and the increasing global awareness of climate change.

Developing alternative fuels and improving fuel efficiency are the two main goals regarding securing sustainability in transport. Biofuels fit well in the company's energy strategy, which is evidenced by its global activities in this field. Biofuels are not seen as a threat, as it is expected we need all the energy sources available to meet the demand. It is emphasised that there is also still an enormous potential to improve fuel efficiency, by driving economically and reducing traffic congestion, for example.

Liquid fossil transport fuels are expected to remain the most dominant transport fuels in the near future. It is estimated that by 2050, approximately 70 percent of transport fuels will still consist of fossil fuels. The composition of these fuels, however, may be a blend with biofuels.

Alternative Fuels

The focus is on introducing future fuels which are scaleable and can be offered throughout the network. Small scale future fuel alternatives which are supply constraint may offer local solutions, the company is keen to develop large scale solutions able to offer in the wider network. (International) road transport is dependent on a reliable source of energy widely available. Therefore these companies are likely to depend on diesel blends for a longer period, whilst for local transport small scale alternatives may offer an opportunity.

Company's Biofuels Strategy

There is currently an ongoing discussion on whether the EU 2020 biofuel target is based on energy or volume content. High-blends may lead to a wider diversification of the number of products offered, which, in turn, increases the complexity of the supply chain and storage costs. In addition, more products would confuse customers and create chaos regarding refuelling vehicles. Therefore, to achieve a higher share of biofuels in road transport, the company would preferably increase its biofuels share in low-level blends. Low-level blending would be easier and would also increase the efficiency of the supply chain.

The company has the ability to introduce high-blends on a large-scale, yet three major obstacles are defined which need to be overcome first:

- OEM manufacturers must accept the use of these biofuels in their engines (e.g. Mercedes, DAF etc). New motors are becoming more sensitive over time for fuel quality.
- The logistical supply of biofuels should be affordable. The equipment for distributing and selling biofuels needs to be adapted.
- There must be a sustainable support policy in place for the promotion of biofuels. Individual Member States currently have differing biofuel support policies which vary highly over time, making the introduction of biofuels on a large scale risky.

If high-level blends are needed to secure the achievement of EU targets, this will most probably be done by focusing on niche markets. Supplying captive fleets with biofuels is particularly interesting, as large amounts could be supplied from a single location.

Experiences with Biofuels

Fuel blends with a biofuels content higher than 10 percent have reportedly resulted in technical complications with end users. The OEMs therefore have so far maintained warranty on their engines for blends up to 7% FAME. The only reason why B100 has been increasingly used in Germany is because of the fact that it was much cheaper than conventional diesel fuel. Some truck companies were therefore willing to take the risk of engine failure.

Promotion of Biofuels

Subsidies are not considered to be the most efficient way to stimulate the use of alternative fuels and should be considered to be only a short term incentive, a product should be able to sustain in a level playing field. Two reasons are given to support this view. Firstly, subsidies are expensive and the extent to which subsidies have a sustainable long-term impact on the increased use of transport biofuels is rather limited. The German B100 case is an example for this. Secondly, subsidies distort the free market. Instead of subsidies, a different taxation system for renewable fuels, for example, may be more appropriate.

Biofuel Corridors

Biofuels corridors are regarded as an interesting, but very complex concept for various reasons. Firstly, air pollution is generally an urban issue. Secondly, niches have to be found where mass is available, which is most probably not the case for long-distance transport, as 80 percent of road transport is local. Higher logistic supply costs and adaptations would most probably not make up for the small additional market share. From this perspective, smaller oil companies are more flexible and could implement such plans more easily. Furthermore, many other obstacles need to be overcome, which may, for example, require a harmonisation of fuel tax policies among EU Member States (e.g. CO2 taxation).

The corridor approach possesses some questions:

Who will pay for the biofuels along the corridor in the end? Is there a risk that it will mainly be countries with lower fuel taxes?

How feasible are biofuel corridors and how sustainable is it? Would everyone keep refuelling in Austria, as they do now?

Perspectives of Users

Freight transport companies only make very small profits on their services. Although they would like to use alternative fuels, they do not want to pay more just to contribute to sustainability. Transport companies are therefore not willing to pay extra for alternative fuels. Instead, the government should provide them with fiscal incentives and oil companies would need to deliver the fuels. Government fleets are much easier to control as they have additional money available.

VI. Cees van de Peppel, Tamoil
Position: Supply and Biofuels Manager Tamoil Netherlands

Tuesday 28 July 2009, 10.10-11.20am, Rotterdam, The Netherlands

Tamoil Group is a leading oil company in Europe. Tamoil's crude oil originates from the Libyan region and their main refinery is located in Italy. The retail outlet of Tamoil includes approximately 2,600 fuel stations in Italy, 340 in Switzerland, 270 in Germany, 43 in Spain and 164 in the Netherlands. Cees van de Peppel is Supply and Biofuel Manager of Tamoil Nederland B.V. and is the main initiator of the Tamoil Biofuels strategy in the Netherlands. Tamoil Nederland B.V. is progressive in the field of biofuels and is presently offering E85 ethanol fuel at over 20 stations across the Netherlands.

Van de Peppel emphasises that the biofuel interests and strategies of Tamoil establishments in different countries across Europe vary significantly and that his comments are only representative for Tamoil Nederland B.V. He begins by describing the position of Tamoil and biofuels in the international oil market.

Views towards the use of transport biofuels among dominant players in the oil sector, such as Shell and BP, vary significantly, but are mostly negative. This is because the promotion of biofuels would directly conflict with their refinery business elsewhere. This is somehow in contrast to the view of Tamoil Nederland B.V., as they are independent from Tamoil's oil refineries. This in turn sets the scope for offering alternative, in this case, biofuels.

As a consequence of the ban on gasoline containing small amounts of lead earlier this decade, several fuel tanks at fuel stations have suddenly become unused. Shell and BP anticipated this by introducing Shell V Power and BP Ultimate fuels, respectively, as an alternative use for these tanks. Tamoil for one has decided to offer E85 blends on several locations instead. The marketing and promotion of E85 has been done in cooperation with Volvo, Ford and Saab by means of incentives on selling Flex-Fuel Vehicles and on E85 fuel.

Key arguments for Tamoil's promotion of E85 fuel are high reductions in GHG emissions and the fact that the ethanol which they sell is made from sugar cane.

Due to the oversupply of sugar cane, ethanol production has practically no impact on world food prices. Tamoil also stimulates the use of natural gas, which will be on offer at thirteen of their stations in the near future. Moreover, Tamoil is holding talks with power companies such as Essent regarding the development of quick charging points for electrical vehicles. Van de Peppel is more critical about biodiesel, as its use in Europe has led to higher vegetable oil prices which have not yet gone down again. Furthermore, there have been some technical complications with the blending of biodiesel and diesel.

What is the vision of Tamoil Nederland B.V. on the use of transport biofuels and thereby on the EU Biofuel Directives?

Tamoil is very positive about the use of biofuels in road transport and Van de Peppel mentions that oil companies are now facing the start of a transition period towards alternative fuels. He mentions the negative environmental aspects of petroleum-based fuels, as well as their availability and affordability, as key drivers for this transition.

Van de Peppel therefore welcomes the EU biofuel targets. The binding EU Directives are especially important in order to persuade the dominating oil companies to go sustainable. He mentions the substantial variations between different stimulation policies among EU MSs as one of the main shortcomings of the implementation strategy. Instead, a more coherent incentive system would be preferable, such as equal fuel taxes and incentives among MSs, although he admits that this will probably take many years. At present, there is no point in competing with the German and French E85 market, for example. Furthermore, EC policy should aim to promote high-blends, as their contribution to environmental sustainability is far more significant.

Van de Peppel also indicates that the International Tamoil Group's vision of biofuels is rather positive too. Alternative fuels will simply become part of future business which offers new opportunities.

What strategy is in place at Tamoil in order to raise the share of transport biofuels? Which types of biofuels should be on offer? Is there any focus on a particular market?

Van de Peppel estimates that the share of biofuels which is currently sold by Tamoil Nederland B.V. amounts to approximately 6.5 percent of the total fuels being sold by the company. Approximately 4 percent of this is sold as low-level blends and the E85 blends makes up for the other 2.5 percent.

The promotion of biofuels, as well as other alternative fuels, is at the centre of Tamoil's business strategy. New stations are built with a view to facilitating new fuels in the near future, such as BtL and LNG. Presently, Tamoil is working on the implementation of B30 biodiesel fuel.

Van de Peppel is brief regarding the types of biofuels which should be on offer. All types of biofuels are welcome, as long as they do not impact on food prices. Tamoil is now offering E85 and will most probably start offering B30 biodiesel in the near future. It should be noted that Tamoil focuses on second-generation B30 biodiesel, as they will not impact on vegetable oil prices.

The types of alternative fuels which should be offered at fuel stations are predominantly market-driven. The E85 is particularly focussed on the private consumer market. The market for B30 and ED95 is particularly meant for freight trucks and public transport busses, and therefore could be more controllable.

What national policies are preferred in order to stimulate the use of biofuels?

Van de Peppel argues that the Dutch government acts inconsistently regarding the promotion of transport biofuels, which he partly ascribes to divergent interests. He clarifies this view by pointing to various examples of wasted money, such as consumer incentives on hybrids like the Toyota Prius. He is also disappointed by the fact that Dutch biofuel targets have recently been adjusted to 4 percent in 2010, instead of 5.75 percent, as this has prevented the big oil companies from having to introduce high-blends.

Van de Peppel has a rather clear and consistent view on the type of national policies which should be in place. The policies should only focus on influencing the fuel price. Fuel prices can easily be controlled by tax reductions, which in turn should be based on the respective GHG emission reduction, as this is the main EC sustainable policy objective.

What is the view on using the biofuels corridor approach for stimulating the use of biofuels and what role could Tamoil play in order to establish such corridors?

Van de Peppel sees the biofuels corridor approach as an interesting and original idea. The concept would be particularly suitable to make biofuels more recognisable among road users and could help to create a coherent biofuel refuelling network. The marketing of such a corridor to end users would therefore be key to its success. He also mentions that such corridors would offer high potential for the sustainability of international freight transport.

The corridor approach would fit well within the Tamoil business strategy and it would also lead to a more coherent strategy between the different Tamoil establishments in different EU countries.

What is the future vision of Tamoil on the role of transport biofuels?

Van de Peppel believes that in the future multi-fuel vehicles and multi-fuel stations will dominate the market. There will be no particular fuel which will be the fuel of the future, but rather a variety of alternative fuel options. Prices for the respective fuels, which can be easily influenced by tax reductions based on GHG performance, are decisive for the consumer. This view, in turn, translates itself into the strategy of Tamoil Nederland B.V. which aims to service a wide variety of transport fuels.

VIII. Philippe Marchand, Total
Position: Director Strategy, Regulations Total R&M and Biofuels

Thursday 22 October 2009, 7.00-9.30pm, Brussels, Belgium

Philippe Marchand is Director of Biofuels at Total Refining and Marketing. His work also includes Total's regulatory aspects, such as CO2 emissions, refinery emissions, and bunker specifications. Total has establishments in 120 countries worldwide, yet the main issues concerning biofuels are in the OECD countries. It is in these countries where biofuels directives are being implemented.

Total's Vision on the Use of Biofuels in Road Transport

Biofuels play a large role in three fields: climate change, improving the security of energy supply, and supporting the agricultural sector. Total has been involved in the biofuels field since the beginning of the nineties, long before there were even directives concerning biofuels. At that time, the main reason for Total's involvement was to provide a new outlet for the French agricultural sector. At present, the main philosophy behind the promotion of biofuels is linked to climate change. Total does not deny that climate change is happening, and therefore, is proactive in attempts to mitigate it and is more than willing to follow guidelines from the EU biofuels directive.

Total strongly believes that there should be a high focus on research and development of second generation biofuels, or algae, due to the competition between food and fuel brought about by the use of first generation biofuels. It is very hard to justify, and also unacceptable, that food is becoming more expensive due to the rising demand for transport energy. Climate change is important, but not as important as food. First generation biofuels are therefore seen a fast-track solution, but this is not the real solution for tackling climate change. The real transport-related solution is a mix of various measures, such as changing driving behaviour (i.e. using public transport or driving economically), improving fuel efficiency (i.e. hybrid cars), and next generation biofuels.

Meeting the Biofuels Directive

By 2020, most of EU targets for renewable energy in transport will be achieved by using first generation biofuels; ethanol and biodiesel. Marchand believes that second generation biofuels in 2020 will not represent more then a few percent of the total biofuels available, a view that is shared by many consultants in this field. The production of second generation biofuels is currently more at the research and development stage, and will presumably become more widespread in 2020-2030.

This means, however, that in order to achieve the 2020 biofuels targets, most biofuels would need to come from agricultural raw material, which is in competition with food. For ethanol, this would not cause severe problems, as it is likely that ethanol feedstock would be available in sufficient quantities at that time. Brazil, for example, has the flexibility to answer on increasing demand for ethanol on a sustainable basis.

An expansion of biodiesel production, however, could be more problematic, as the competition between food and fuel on these kind of crops is generally stronger. Marchand indicates that a further expansion of the EU biodiesel market could mean that more than 50 percent of the basic world resources would be used for the production of biodiesel. This also imposes a political risk, as the EU would then be depending on biodiesel produced in countries like Malaysia. One could argue that this contradicts the argument of securing energy supply by means of biofuels.

Sustainability concerns with biodiesel are particularly relevant in Europe, as this is where diesel is mostly marketed. During the last decades, an imbalance between the production and use of gasoline and diesel in the EU has been created, meaning that the EU has to export gasoline and import diesel. Marchand points to a sub-optimal refinery setup and tax policy in the past as reasons for this. This imbalance will continue to grow, as more diesel vehicles are sold. Eventually, if no further action is undertaken, the price of diesel will rise. This would affect everyone, leading to yet another insecurity of supply. Therefore, substitutes for diesel are preferred by oil companies, as substitutes for ethanol would only serve to intensify the imbalance.

As Total is only at the end of the biofuels chain, the success of achieving the targets lies mainly within the capacity of the agricultural business and transformation plants. If sufficient biofuels can be produced in a sustainable manner, it is not particularly challenging for Total to increase biofuels sales. The actual marketing and sales of biofuels, however, can take various directions.

Role of High-Blends

Marchand identifies several obstacles which need to be overcome if high-blends (i.e. E85 or B30) are to be focussed upon in order to meet EU targets. These include the en masse introduction of vehicles compatible with the use of high-blends, and the coverage of additional biofuels costs.

To increase the share of vehicles compatible with high-blends, car manufacturers must make these cars available on the market at competitive prices. However, Marchand mentions that car manufacturers are not very keen on introducing vehicles compatible with the use of high-blends (i.e. Flexi-Fuel) and gives two reasons for this. Firstly, the vehicles manufacturers seem to instead place a higher focus on the development of electric cars. Secondly, the technology needed to make vehicles compatible with the use of high-blends would increase prices. As this market is very competitive, just a small price increase (for example, due to Flex-Fuel technology) would reduce the competitiveness. There could thus be a role for regulations or subsidies to encourage car manufacturers to introduce vehicles compatible with high-blends, but Marchand believes that car companies would rather favour marginally higher blends (i.e. E15, B10) rather than high-blends to facilitate the directive.

In turn, if the share of vehicles which are compatible with high-blends remains low, there is little point in offering specific blends. Marchand points to the current situation with E85 in France; most stations offering E85 have zero customers for this fuel because of a lack of demand. It is not more expensive to distribute high-blends which means that making high-blends available is not the problem. However, due to space and logistical restrictions, most fuel stations cannot afford to have more than two pumps, especially in Western European countries. These pumps, therefore, have to be used as efficiently as possible. Presently, stations mostly often offer a basic type and premium type fuel. Although some of the motorway stations (selling approximately 5000-6000 cubic metres annually) could accommodate more pumps, as generally more space is available, the supply of more fuel types would be more complex to organise logistically. There are not many motorway stations and it would not be feasible to have a different business model for these stations alone. According to Marchand, an efficient business model is a simple model and more products at certain locations will incur additional costs. This means that a significant market must be created first which demands high-blends, before these are made available.

Aside from increasing the vehicles, biofuels today are much more costly than conventional fuels. Making high-blends available at competitive prices will thus largely depend on state subsidies. Marchand points to the B30 market in France as an example of this. Although users have to modify their engines, they can then profit from tax incentives. However, because of the enormous demand on the national debt, due to the economic crisis, it is not sure whether countries will keep subsidising high-blends.

Therefore, Marchand believes that to accommodate EU targets, the current E10 and B7 will evolve towards slightly higher blends (i.e. E15, B10) and high-blends will likely remain at the niche market level. He indicates that the CEN is already working on B10 specifications.

Biofuels Corridors

Marchand finds the concept of biofuels corridors a good idea and could imagine a refuelling network for B30, for example, all along EU motorways. If there were a consensus with a certain number of European countries, one could imagine the B30 specification, for example, being made available at the wider EU level. There would be a role for big transport companies to initiate the concept and to create a sufficient demand. However, if biodiesel prices remain high, there would still be a need for subsidies.

The concept would be less interesting for ethanol, because it would increase the imbalance between the production and use of gasoline and diesel in the EU. But for diesel, according to Marchand, whatever can be done to improve the situation regarding the security of its supply is good news. For this reason the truck business is an important factor.

The feasibility of biofuels corridors would depend on two aspects. Firstly, engine manufacturers must be able to deliver vehicles which can run on the blend. Secondly, subsidies for the specific blend must be put in place to make them interesting for the business. Fuel station logistics are flexible and can easily be adapted, if sufficient demand has been created.

ANNEX B Stakeholder Analysis

This annex presents an overview of the stakeholders that would be involved in biofuels corridors and their corresponding interests and responses. The methodology is mainly based on Preble (2005), 'Towards a Comprehensive Model of Stakeholder Management'.

Stakeholder Identification and Nature of Stakeholder Claims

Primary: Stakeholders whose continuing participation is required.
Public: Those who provide infrastructural/legal frameworks in which to operate.
Secondary: Those who influence or affect, or are affected by the initiative, but are not engaged in direct transactions with it and are not essential for its survival.

European Commission - Problem Owner

The EC has economic, political and social stakes in the project.

The European Commission (EC) supports the use of biofuels, as these would reduce EU fossil-fuel dependency and polluting (GHG) emissions. The EC wants to achieve a higher share of biofuels in EU road transport as part of the sustainable transport policy framework, hence their support by way of the Directives 2003/30/EC and 2009/28/EC. The Directives set the regulatory framework for the further promotion of biofuels at the MS level. Biofuels corridors might be an effective way to stimulate the use of EU biofuels if the future focus of MSs were to be on high-level ethanol and biodiesel blends.

MS Governments - Primary and Public

MSs have economic, political and social stakes in the project.

Individual MSs wish to stimulate the use of biofuels. They are required to set national targets for the use of biofuels in road transport in accordance with the EC Directives. Directive 2003/30/EC is not binding, but MSs need to present suitable motivations if they do not meet the target of 5.75 percent. Directive 2009/28/EC is binding and requires MS to have a minimum biofuels share of 10 percent replacing petroleum-based road transport fuels in 2020. Higher targets are also possible. Biofuels corridors might contribute to the stimulation of biofuels in the MSs and the approach is therefore received positively. Cost-effectiveness in the implementation of the Directive is important.

European Farmers and Biofuel Producers - Primary

European farmers have an economic stake in the project.

European farmers and biofuel producers should guarantee sufficient supply of biomass feedstock and biofuels, respectively, in order to facilitate an expansion of the EU biofuel market share by domestic production. European farmers and biofuel producers are supporting the use of EU biofuels, and thereby any form of biofuel support measure. They highlight the potential of biofuels in terms of GHG reductions and development of the agricultural and biofuels sectors, and advocate continuing support policies. They argue that the discussion on the sustainability of biofuels (e.g. food price increases and the pressure on soil, water and biodiversity) is out of proportion.[1]

Energy Suppliers - Primary

Energy suppliers have economic power.

Energy suppliers are responsible for the distribution and retail supply of various transport fuels. It is assumed that they are responsible for the production, storage and distribution of biofuels, as well as the retail outlets for transport fuels at fuel stations (i.e. motorway stations in the case of corridors). Their current market consists primarily of petroleum-based fuels, such as diesel and gasoline. Depending on the respective MS biofuel policy, energy suppliers are required to replace part of their petroleum-based fuels with biofuels.

True interests among energy suppliers to promote and replace part of their conventional fuels with biofuels vary. This depends mainly on the economic attractiveness of biofuels, but also on experiences with the biofuel market and the vision towards the use of biofuels. From the interviews with leading oil companies, it becomes clear that biofuels are not necessarily seen as a threat to their core business, due to limitations on global biofuel supply. Biofuels could play an important future role as petroleum fuels are becoming scarce, offering new opportunities. Biofuels corridors are therefore seen as an interesting concept for a new market, but its potential will mainly depend on the cost-effectiveness of offering high-level ethanol and biodiesel blends on corridors. This, in turn, mainly depends on creating a sufficient demand for high-blends.

[1] Obtained from the European Farmers and European Agri-Cooperatives (COPA-COGECA), the European Bioethanol Fuel Association (eBIO), and the European Biodiesel Board (EBB) in EurActiv (2009)

Corridor Users – Passenger Cars and Freight Transport – Primary

Corridor users have economic power.

Corridor users represent all passenger cars and freight transport who use transport fuels on the corridor. Their view on the use of transport biofuels is positive, and thereby also on the stimulation by means of biofuels corridors. However, economic performance of the fuels are generally regarded as decisive for their actual use.[1]

Vehicle Manufacturers – Primary

Vehicle manufacturers have economic power.

The use of high-level ethanol and biodiesel biofuel blends on corridors requires adaptations to road transport vehicles. This should be facilitated by vehicle manufacturers. Vehicle manufacturers believe that biofuels are important in order to reduce CO_2 emissions in road transport and thereby support the EU vision of stimulating the use of transport biofuels. This has resulted in agreements which would allow all new car models to run on either a 10 percent ethanol-gasoline or a 7 percent biodiesel-diesel blend by 2010. Additional measures, such as promoting Flex-Fuel Vehicles (FFVs) and making diesel engines compatible with high-level biodiesel blends, are also part of their influence on the success of biofuels corridors. However, they prefer the introduction of slightly higher blends over introducing vehicles compatible with high-blends because less adaptations to vehicles would be needed.[2]

Environmental Organisations – Secondary

Environmental organisations have political and social stakes in the project.

Environmental organisations are not in favour of the 10 percent EU biofuel target, as they believe that biofuels are economically, socially and environmentally unsustainable. It would be more sustainable to use biomass in the electricity and heating sectors. Biofuel production would lead to food price increases, biodiversity loss and deforestation. In order to overcome these issues there should be a legally-binding certification scheme in place. Second generation biofuels could partially solve these problems.[3] It is therefore expected that environmental organisations would not favour a wide-scale implementation of high-level ethanol and biodiesel biofuel blends on the entire TEN-T Network roads, until the sustainability of biofuels is secured.

[1] From interview with Cees van de Peppel (Tamoil) and Senior Manager (Oil Company)
[2] Obtained from the European Automobile Manufacturers' Association (ACEA) in EurActiv (2009) and interview with Philippe Marchand (Total)
[3] Obtained from WWF, Greenpeace, Friends of the Earth, the European Federation for Transport and Environment (T&E), the European Environmental Bureau (EEB), BirdLife and Biofuelwatch in EurActiv (2009)

Research and Development Institutes – Secondary

Research and development views towards biofuels vary drastically, but it is not expected that their influence as opponents of the corridor approach could negatively impact on the concept.

Vehicle Service Companies – Secondary

Vehicle service companies would favour an increase in transport biofuels. Vehicles running on biofuels generally need more maintenance which increases their activities and expands their market.

Possible Performance Gaps and Prioritisation of Stakeholder Demands

The EC biofuels corridor approach will be surrounded by divergent expectations and conflicting interests, leading to possible performance gaps. These gaps should be given particular attention in order to improve the project's feasibility. This section gives an overview of these so-called performance gaps in reference to each stakeholder group, based on interviews with the respective stakeholders. Moreover, in order to prioritise stakeholder demands, a distinction is made between three types of stakeholder claims and interests: power, legitimacy and urgency.

MS Governments – Primary

MS support for biofuels in the upcoming decade will largely depend on their implementation strategy for Directive 2009/28/EC. This would determine the national support policy for high-level ethanol and biodiesel blends, and, in turn, could lead to performance gaps if the strategy focuses on other alternatives to increase the share of biofuels. If, for example, MSs focus on the stimulation of low-blends by increasing the minima, there will be little scope for the introduction of tax incentives for high-blends. Presently, there is no alignment between fuel tax and biofuel policies in the respective MSs. Although these uncertainties have already been covered by the scenario analysis, one could still end up in a situation in which certain MSs go for high-blends, while others do not. There would then be a risk that selling biofuels along a corridor would be concentrated in countries with lowest fuel taxes and/or highest biofuel incentives.

MS governments must decide in the coming years how to achieve the EU biofuel targets. The further stimulation of high-level ethanol and biodiesel blends will depend to a large extent on MS support policy. The sooner these means to go forward are defined, the higher the potential of biofuels corridors could be, as the industry could undertake action accordingly. Therefore, MS governments have power, legitimacy and urgency.

European Farmers and Biofuel Producers - Primary

There will be no performance gaps. European farmers and biofuel producers would favour any form of biofuel support incentives, as this would directly stimulate biofuels sales.

European farmers have economic power, as the potential of the corridor will likely depend on ethanol and biodiesel feedstock availability.

Energy Suppliers - Primary

Oil companies point to the economic feasibility of the stimulation of high-blends as a potential barrier to the development and operation of biofuels corridors. Low-blends are more efficient in terms of supply logistics, as demand is high, and would naturally be easier for achieving the mandatory targets set by MSs. If high-blends are to be offered, a substantial market should be developed at each refuelling point to compensate for their additional logistical costs. Or, alternatively, additional MS support should be present. A performance gap in the case of biofuels corridors could arise if the biofuel volumes to be sold at refuelling stations along biofuels corridors are too low to be affordable.[1]

Energy suppliers have economic power and legitimacy. The success of the project hinges on their supplying high-blends on the corridor.

Corridor Users - Passenger Cars and Freight Transport - Primary

Corridor users will only use biofuels if certain preconditions are met. Firstly, the blends should not be any more expensive on an energy basis than conventional fuels. The green image attached to biofuels is rarely sufficient to trigger users to pay more. Secondly, biofuels should not negatively affect the vehicle engine. And, thirdly, the fuel must be available at many stations. Performance gaps would arise if the biofuels corridor design does not fulfil these requirements.[2] However, as biofuel-compatible vehicles are also compatible with conventional fuels, the latter aspect is less important.

Corridor users have economic power. If biofuel sales on the corridor are too low, then the initiative will fail.

Vehicle Manufacturers - Primary

Vehicle manufacturers are reluctant to produce vehicles compatible with high-blends for two reasons. Firstly, vehicle manufacturers seem to instead place a higher focus on the development of electric cars. Secondly, high-blends would apply to the very competitive segments of cars being sold. They therefore endeavour to avoid even the smallest price increases.[3] The fact that support for biofuel-compatible vehicles has not been widespread is due to the limited long-

[1] From interview with Senior Manager (Oil Company) and Philippe Marchand (Total)
[2] From interview with Anton Stam (E van Wijk Logistics)
[3] From interview with Philippe Marchand (Total)

term policy support for high-level ethanol and biodiesel biofuel blends at the EU and MS levels.

Vehicle manufacturers have economic power and urgency. The potential of the corridor is largely dependent on the availability of biofuel-compatible vehicles, for which they bear responsibility.

Environmental Organisations – Secondary

There will be no performance gaps. It is to be expected that ethanol and biodiesel will comply with the sustainability criteria of the EU Directive 2009/28/EC.

Research and Development Institutes – Secondary

There will be no performance gaps.

Vehicle Service Companies – Secondary

There will be no performance gaps.

ANNEX C Rotterdam-Constanta Corridor Analysis

This Annex presents several specific calculations and additional information to complete the information that is provided in Chapter Three.

Re: Section 3.2 - Calculation of Minimum Station Spacing

The minimum station spacing (see Section 3.2) depends on the vehicle's fuel tank size, the engine's fuel efficiency and the specific biofuel blend. Table 0.1 lists the energy content of ethanol and biodiesel as found in Chapter Two. Table 0.2 gives the minimum fuel tank capacity of passenger cars and freight truck and their average engine's fuel efficiency. The vehicle range is then calculated by multiplying the energy content of the specific blend with the fuel tank capacity and fuel efficiency. Applying a safety factor of two (see Section 3.2) leads to the minimum station spacings for various vehicles and high-blends (see Table 0.3).

Table 0.1 Energy Content of Ethanol and Biodiesel Relative to that of Gasoline and Diesel, Respectively

	Ethanol	*Biodiesel*
Energy content	66 percent	90 percent

Source: Data obtained from Worldwatch (2007)

Table 0.2 Fuel Tank Capacity of Passenger Cars and Freight Trucks

	Passenger car	*Freight truck*
Minimum fuel tank capacity	40 litres	500 litres
Average fuel efficiency	13km per litre fuel	3.25km per litre fuel

Source: Data obtained from Zachariadis (2005) and interview Anton Stam (E van Wijk Logistics)

Table 0.3 Vehicle Range and Minimum Station Spacing

Blend and vehicle type	*Vehicle range in km*	*Minimum station spacing*
Passenger Car - E30	467	234
Passenger Car - E85	370	185
Passenger Car - B30	504	252
Passenger Car - B100	468	234
Freight Truck - B30	1576	788
Freight Truck - B100	1463	732

Re: Section 3.5.2 - Specification of Rotterdam-Constanta Corridor Route

Table 0.4 details the two corridor route from Rotterdam to Constanta. The total length of both routes is just over 4000km.

Table 0.4 Specification of the Corridor Route: Rotterdam-Constanta

Road transport corridor: Rotterdam-Constanta	
Countries	Netherlands, Germany, Austria, Czech Republic, Slovakia, Hungary, Romania
Route 1	Rotterdam – Hannover – Dresden – Prague – Bratislava – Budapest – Timisoara – Bucharest – Constanta
	Rotterdam – Utrecht (A20/E25 and A12/E25/E30) (58km) Utrecht – Amersfoort (A28/E30) (25km) Amersfoort – Dutch/German Border (A1/E30) (123km) Dutch/German Border – Magdeburg (A30/E30) (363km) Magdeburg – Dresden (A14/E49) (260km) Dresden – German/Czech Republican Border (A17/E55) (45km) German/Czech Republican Border – Prague (D8/E55) (93km) Prague – Brno (D1/E65) (207km) Brno – Czech Republican/Slovakian Border (D2/E65) (70km) Czech Republican/ Slovakian Border – Bratislava (D2/E65) (66km) Bratislava - Slovakian/Hungarian Border (D2/E65) (23km) Slovakian/Hungarian Border – Budapest (M1/E75) (192km) Budapest – Szeged (M5/E75) (173km) Szeged – Hungarian/Romanian Border (M43/E68) (55km) (Construction 2014) Hungarian/Romanian Border – Arad (A1/E68) (107km) (Construction 2011) Arad – Timisoara (A1/E671) (53km) (Construction 2010) Timisoara – Sibiu – Bucharest (A1) (554km) (Partly Construction 2010) Bucharest – Constanta (A2) (226km) (Partly Construction 2010)
Route 2	Rotterdam – Arnhem – Mannheim – Nurnberg – Vienna – Budapest – Timisoara – Bucharest – Constanta
	Rotterdam – Utrecht (A20/E25 and A12/E25/E30) (58km) Utrecht – Dutch/German Border (A12/E35) (80km) Dutch/German Border – Düsseldorf – Frankfurt – Würzburg (A3/E35) (438km) Würzburg – Nurnberg – German/Austrian Border (A3/E56) (344km) German/Austrian Border – Wels (A8/E56) (70km) Wels – Vienna (A1/E60) (203km) Vienna – Austrian/Hungarian Border (A4/E60) (72km) Austrian/Hungarian Border - Budapest (M1/E75) (188km) Budapest – Szeged (M5/E75) (173km) Szeged – Hungarian/Romanian Border (M43/E68) (55km) (Construction 2014) Hungarian/Romanian Border – Arad (A1/E68) (107km) (Construction 2011) Arad – Timisoara (A1/E671) (53km) (Construction 2010) Timisoara – Sibiu – Bucharest (A1) (554km) (Partly Construction 2010) Bucharest – Constanta (A2) (226km) (Partly Construction 2010)

Re: Section 3.5.2 - Current Biofuel Policy in Rotterdam-Constanta MSs

Table 0.5 details the current biofuels policy in the MSs that are involved in the Rotterdam-Constanta road corridor.

Table 0.5 Current Biofuel Support Policy in the MSs Involved in the Corridor

Member State	*Biofuel Policy*
Hungary	Full tax exemption on biodiesel and ethanol (until 31 December 2010). From 1 July 2007 lower tax on 4.4% low-level biodiesel and ethanol blends (volume%). Respectively, 103.5 HUF/litre instead of 111.8 HUF/litre and 85 HUF/litre instead of 93 HUF/litre. 'Significant progress expected in the production of base materials and in the preparation and distribution of biofuels in Hungary as of mid-2007.'
Slovakia	Duty is reduced by 48% of the percentage of a biogenous substance that is contained in the blend, to a maximum of 7.2%. For petrol, duty is reduced by the percentage of a biogenous substance that is contained in the blend, to a maximum of 5%. The amendment (53/2009) to the Act on Mineral oil excise tax (98/2004) has been in force since March 1, 2009.
Germany	Energy tax for pure biodiesel (B100) is being phased in until 2013 when taxes for diesel and biodiesel will be at the same level. Annually, 3 cents will be add to the tax on B100, starting from 0.15 cents in 2008, from 2009 onwards 6 cents per year, up to 0.47 cents per litre as for conventional diesel.
Romania	No excise duty on biofuels.
Czech Republic	Partial reimbursement of excise duties on mineral oils for using a diesel blend containing at least 31% RME. Excise duty reduction for high concentration biofuel blends in proportion of their biofuel content. Excise duty exemption for pure biofuels. 6 years.
Austria	Pure biofuels are completely exempt from mineral oil duty. Complete exemption for blends ethanol 65-85%.
Netherlands	Currently no incentives.

Sources: Data obtained from USDA (2008); USDA (2009); Task39 (2009); National Member State Progress Reports of EU Directive 2003/30/EC

Re: Section 3.5.2 - Fuel Stations on the Rotterdam-Constanta Corridor

Table 0.6 shows the number of fuel stations on the two selected routes running from Rotterdam to Constanta.

The total number of fuel stations has been obtained from the road maps of the Royal Dutch Touring Group (ANWB, 2009). Data for the Romanian sections was not available, which means that the number of stations on these sections have been obtained by the extrapolation of fuel station coverage on the other road segments.

Table 0.6 Number of Fuel Stations on the Corridor in 2009

Corridor Route 1	*Stations*	*Corridor Route 2*	*Stations*
Rotterdam - Hannover	28	Rotterdam - Arnhem	12
Hannover - Dresden	14	Arnhem - Mannheim	24
Dresden - Prague	4	Mannheim - Nurnberg	14
Prague - Bratislava	20	Nurnberg - Vienna	18
Bratislava - Budapest	10	Vienna - Budapest	14
Budapest - Szeged			6
Szeged - Constanta* (extrapolated 900km section)			48
Number of fuel stations along the corridor			**212**

Source: Data from ANWB (2009)

ANNEX D Calculations: Transport Flows, Fuel Use

This analysis presents data regarding the calculations of the fuel use on the Rotterdam-Constanta corridor as described in Section 3.5.2.

Table 0.7 and Table 0.8 present the transport flows on the Rotterdam-Constanta corridor as a percentage of the total transport activity in the respective Member States, as obtained from the TRANS-TOOLS model assignment.

Table 0.7 TRANS-TOOLS Model Outcome: Transport Flow on Rotterdam-Constanta Corridor Segments as Percentage of the National Transport Flow, Passenger Transport

Member State	*Total Car-km*	*Corridor Car-km*	*% on the Corridor*
Austria	138,710,884,079	12,617,196,950	9.10%
Czech Republic	78,094,964,034	9,291,019,214	11.90%
Germany	1,075,343,529,923	62,651,587,495	5.83%
Hungary	55,144,305,194	5,126,387,495	9.30%
Netherlands	258,267,241,840	25,537,483,966	9.89%
Romania	49,730,700,738	4,729,060,362	9.51%
Slovakia	29,469,086,997	1,181,713,737	4.01%

Table 0.8 TRANSTOOLS Model Outcome: Transport Flow on Rotterdam-Constanta Corridor Segments as Percentage of the National Transport Flow, Freight Transport

Member State	*Total Truck-km*	*Corridor Truck-km*	*% on the Corridor*
Austria	11,313,812,456	418,394,325	3.70%
Czech Republic	13,225,597,930	2,378,443,584	17.98%
Germany	112,399,748,246	3,385,297,751	3.01%
Hungary	7,552,025,694	392,906,341	5.20%
Netherlands	27,018,027,505	2,450,308,698	9.07%
Romania	17,643,126,162	1,937,603,477	10.98%
Slovakia	5,345,867,709	158,667,464	2.97%

Table 0.9 and Table 0.10 present the expected annual growth rates of EU passenger and freight transport, following national trends observed since 1990. Table 0.11 presents energy conversion factors to be used in further calculations.

Table 0.9 Estimation of the Annual Growth Rate in EU Passenger Transport in Thousand Million Passenger-km

Member State	*1990*	*1995*	*2000*	*2005*	*2006*	*2007*	*Annual Growth*	
Austria	55.68	62.16	66.67	70.55	70.89	72.02	0.82	1.14%
Czech Republic	n.a.	54.50	63.94	68.64	69.63	71.54	1.42	1.98%
Germany	683.10	815.30	831.27	856.90	863.30	868.70	4.45	0.51%
Hungary	47.00	45.40	46.18	46.60	46.85	41.42	-0.33	-0.80%
Netherlands	137.30	131.40	141.10	148.80	148.00	148.80	1.45	0.97%
Romania	n.a.	36.00	45.00	56.00	58.00	60.00	2.00	3.33%
Slovakia	n.a.	17.98	23.93	25.82	26.34	25.99	0.67	2.57%

Source: Data obtained from EC (2009)

Table 0.10 Estimation of the Annual Growth Rate in EU Freight Transport in Thousand Million Tonnes-km

Member State	*1990*	*1995*	*2000*	*2005*	*2006*	*2007*	*Annual Growth*	
Austria	n.a.	26.50	35.12	37.04	39.19	37.40	0.91	2.43%
Czech Republic	n.a.	31.30	37.31	43.45	50.38	48.14	1.40	2.92%
Germany	n.a.	237.80	280.71	310.10	330.02	343.45	8.80	2.56%
Hungary	n.a.	13.80	19.12	25.15	30.48	35.81	1.83	5.12%
Netherlands	n.a.	67.10	79.57	84.16	83.19	77.92	0.90	1.16%
Romania	n.a.	19.70	14.29	51.53	57.29	59.52	3.32	5.58%
Slovakia	n.a.	15.90	14.34	22.57	22.21	27.16	0.94	3.45%

Source: Data obtained from EC (2009)

Table 0.11 Energy Conversion Factors for Gasoline and Diesel Fuel

1 MT Gasoline	0.001342	million litres
1 MT Diesel	0.001195	million litres
Diesel	42.80	GJ/MT
Gasoline	43.10	GJ/MT

Source: Data obtained from USDA (2009)

Tables 0.12-0.18 gradually calculate the fuel use on the Rotterdam-Constanta corridor for different road transport markets: freight diesel, passenger gasoline, and passenger diesel. The assumptions and overall methodology used are described in Section 3.5.2.

Firstly, the national gasoline and diesel fuel use are presented (see Table 0.12). From these values, the national fuel use for freight diesel, passenger gasoline, and passenger diesel have been obtained (see Table 0.13, Table 0.14, and Table 0.15).

Table 0.12 National Gasoline and Diesel Fuel Use in 2008 in GJ

Member State	*Gasoline*	*Diesel*	*Total*
Austria	79,088,241	260,609,200	339,697,441
Czech Republic	86,846,500	172,484,000	259,330,500
Germany	859,586,400	1,210,940,400	2,070,526,800
Hungary	66,805,000	115,988,000	182,793,000
Netherlands	170,055,514	258,662,427	428,717,941
Romania	69,670,935	184,905,416	254,576,351
Slovakia	31,786,983	60,422,943	92,209,926
Total	**1,363,839,573**	**2,264,012,386**	**3,627,851,958**

Source: National Member State Progress Reports of EC Directive 2003/30/EC

Table 0.13 National Gasoline and Diesel Fuel Use in 2008 in GJ for Passenger and Freight Transport (95.3 percent)

Member State	*Gasoline*	*Diesel*	*Total*
Austria	75,371,094	248,360,568	323,731,662
Czech Republic	82,764,715	164,377,252	247,141,967
Germany	819,185,839	1,154,026,201	1,973,212,040
Hungary	63,665,165	110,536,564	174,201,729
Netherlands	162,062,905	246,505,293	408,568,198
Romania	66,396,401	176,214,861	242,611,262
Slovakia	30,292,995	57,583,064	87,876,059
Total	**1,299,739,113**	**2,157,603,803**	**3,457,342,916**

Table 0.14 National Passenger (58.7 percent) and Freight (41.3 percent) Fuel Use in 2008 in GJ

Member State	*Passenger*	*Freight*	*Total*
Austria	190,030,485	133,701,176	323,731,662
Czech Republic	145,072,334	102,069,632	247,141,967
Germany	1,158,275,468	814,936,573	1,973,212,040
Hungary	102,256,415	71,945,314	174,201,729
Netherlands	239,829,532	168,738,666	408,568,198
Romania	142,412,811	100,198,451	242,611,262
Slovakia	51,583,247	36,292,812	87,876,059
Total	**2,029,460,292**	**1,427,882,624**	**3,457,342,916**

Table 0.15 National Passenger Diesel and Gasoline Use in 2008 in GJ

Member State	*Gasoline*	*Diesel*	*Total Passenger*
Austria	75,371,094	114,659,391	190,030,485
Czech Republic	82,764,715	62,307,620	145,072,334
Germany	819,185,839	339,089,629	1,158,275,468
Hungary	63,665,165	38,591,250	102,256,415
Netherlands	162,062,905	77,766,627	239,829,532
Romania	66,396,401	76,016,410	142,412,811
Slovakia	30,292,995	21,290,252	51,583,247
Total	**1,299,739,113**	**729,721,179**	**2,029,460,292**

By using the energy conversion factors as stated in Table 0.11, the values for the specific markets have been converted into millions of litres fuel (see Table 0.16).

Table 0.16 National Fuel Use by Sector and Fuel Type in 2008 in Million Litres

Member State	*Passenger Gasoline*	*Passenger Diesel*	*Freight Diesel*
Austria	2,347	3,201	3,733
Czech Republic	2,577	1,740	2,850
Germany	25,507	9,468	22,753
Hungary	1,982	1,077	2,009
Netherlands	5,046	2,171	4,711
Romania	2,067	2,122	2,798
Slovakia	943	594	1,013
Total	**40,470**	**20,374**	**39,867**

Subsequently, by multiplying these numbers by the shares of transport flows on the corridor (i.e. provided in Table 0.7 and Table 0.8), the fuel use on the specific corridor is obtained (see Table 0.17).

Table 0.17 National Fuel Use by Sector and Fuel Type on the Rotterdam-Constanta Corridor in 2008 in Million Litres

Member State	*Passenger Gasoline*	*Passenger Diesel*	*Freight Diesel*
Austria	213	291	138
Czech Republic	307	207	513
Germany	1,486	552	685
Hungary	184	100	105
Netherlands	499	215	427
Romania	197	202	307
Slovakia	38	24	30
Total	**2,924**	**1,590**	**2,205**

The fuel use on the corridor is then multiplied by the growth factors (see Table 0.9 and Table 0.10) in order to obtain the fuel use on the corridor in 2010 (see Table 0.18), 2015 (see Table 0.19), and 2020 (see Table 0.20). Furthermore, the further rise of diesel vehicles, as presumed in Section 3.5.2, has also been taken into account.

Table 0.18 National Fuel Use by Sector and Fuel Type on the Rotterdam-Constanta Corridor in 2010 in Million Litres

Member State	*Passenger Gasoline*	*Passenger Diesel*	*Freight Diesel*
Austria	218	298	145
Czech Republic	319	215	543
Germany	1,501	557	721
Hungary	181	99	115
Netherlands	509	219	437
Romania	210	216	342
Slovakia	40	25	32
Total	**2,978**	**1,628**	**2,336**

Table 0.19 National Fuel Use by Sector and Fuel Type on the Rotterdam-Constanta Corridor in 2015 in Million Litres

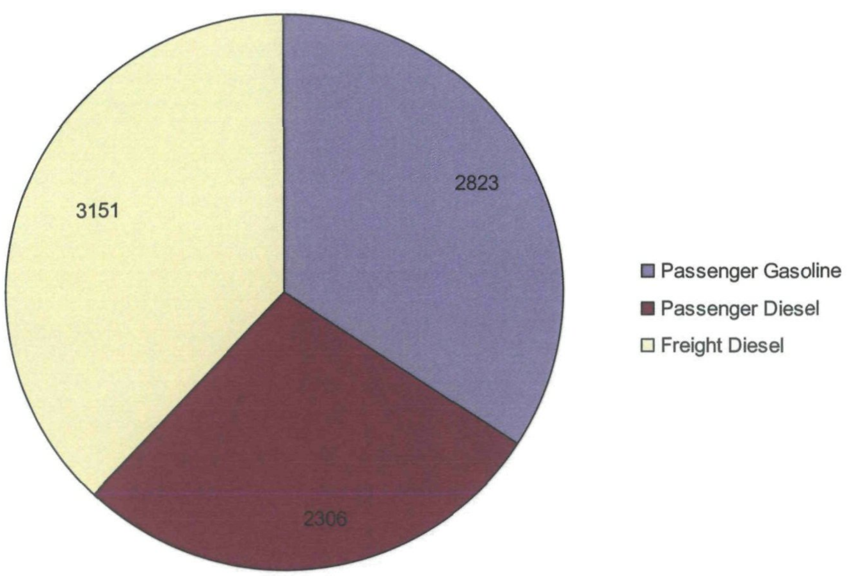
Member State	*Passenger Gasoline*	*Passenger Diesel*	*Freight Diesel*
Austria	205	341	163
Czech Republic	325	264	627
Germany	1,437	675	818
Hungary	160	109	148
Netherlands	498	266	463
Romania	226	275	449
Slovakia	42	32	38
Total	**2,893**	**1,962**	**2,707**

Table 0.20 **National Fuel Use by Sector and Fuel Type on the Rotterdam-Constanta Corridor in 2020 in Million Litres**

Member State	*Passenger Gasoline*	*Passenger Diesel*	*Freight Diesel*
Austria	193	385	184
Czech Republic	335	315	724
Germany	1,374	792	929
Hungary	139	119	190
Netherlands	488	314	491
Romania	249	342	589
Slovakia	45	39	45
Total	**2,823**	**2,306**	**3,151**

Figure 0.1 provides an overview of the total fuel use on the Rotterdam-Constanta corridor in 2020 per road transport market.

Figure 0.1 **Expected Fuel Consumption by Users on the Rotterdam-Constanta Corridor in Millions of Litres, by Fuel Type and Market in 2020**



ANNEX E Calculations: Feasibility Study

This Annex presents the calculations which have been made for the market and economic analysis in Sections 4.3 and 4.5, respectively, in further detail.

Re: Section 4.3: Biofuels Demand at Corridor Stations

The total fuel (gasoline or diesel) use at stations on the corridor is calculated as follows; i.e. the outcomes of these calculations are gradually provided in Table 0.21. Firstly, the total fuel used by the specific market is calculated. The total fuel used on the corridor was calculated in Chapter Three to be approximately 8280 million litres annually. For the open market designs, as the market is defined by the product type, these figures follow directly from Figure 3.10. For Design 1, the potential market is 5 percent of the total freight diesel consumption. Secondly, the fuel used by the specific market is multiplied by the percentage of users that actually refuel on the corridor.[1] Thirdly, the fuel use at corridor stations is multiplied by the share of biofuel-compatible vehicles in 2020 for the specific market. This leads to the volumes of conventional fuel that could be displaced by high-blends. Fourthly, to obtain the amount of conventional fuel that will be replaced by biofuels, this value is multiplied by the percentage of biofuels (based on energy content) in each specific high-blend. This is 79, 28 and 100 percent for E85, B30 and B100, respectively (see Table 0.22). And, to calculate the amount of specific high-blend(s) in litres required to realise this shift, the total fuel consumption at the corridor stations by the respective market is divided by the energy content of this high-blend relative to that of the specific conventional fuel. This is approximately 0,71; 0,97; and 0,90 for E85, B30 and B100, respectively (see Table 0.23). The total displacements of conventional fuels by biofuels in each of the Rotterdam-Constanta biofuels corridor designs are also provided in Table 0.21. The table also indicates the displacements as a percentage of the total fuel use on the corridor.

[1] A captive fleet of freight trucks is considered in design 1. This means that the composition of this fleet is selected in such a way that all trucks will refuel at corridor stations (i.e. 100 percent).

Table 0.21 Calculations of Biofuels Demand for Each Corridor Design in Million Litres

Type of Calculation	*Design 1*	*Design 2*	*Design 3*	*Design 4*
Total use of biofuels on corridor	8,280	8,280	8,280	8,280
Total use of biofuels by specific market	158	2,823	5,457	8,280
Fuel use at corridor stations	158	452	684	1,136
Biofuel-compatible vehicles	158	226	499	725
Displacement by biofuels	158	179	140	319
Percentage of total fuel use on the corridor	1.9%	2.2%	1.7%	3.9%
Amount of the specific high-blend required	176	318	514	832

Table 0.22 Energy Content of Biofuel in Each High-Blend

E85 = 0.85 (percentage ethanol) * 0.66 (energy content ethanol) = 0.561; 0.561 + 0.15 (percentage gasoline) = 0.711; 0.561 / 0.711 = 0.79 = <u>79 percent</u>
B30 = 0.30 (percentage biodiesel) * 0.90 (energy content biodiesel) = 0.27; 0.27 + 0.70 (percentage diesel) = 0.97; 0.27 / 97 = 0.28 = <u>28 percent</u>
B100 = 1 (percentage biodiesel) * 0.90 (energy content biodiesel) = 0.90; 0.90 + 0.00 (percentage diesel) = 0.90; 0.90 / 0.90 = 1.00 = <u>100 percent</u>

Table 0.23 Energy Content of High-Blend Relative to the Conventional Fuel

E85 = 0.85 (percentage ethanol) * 0.66 (energy content ethanol) = 0.561; 0.561 + 0.15 (percentage gasoline) = 0.711 = <u>71 percent</u>
B30 = 0.30 (percentage biodiesel) * 0.90 (energy content biodiesel) = 0.27; 0.27 + 0.70 (percentage diesel) = 0.97 = <u>97 percent</u>
B100 = 1.00 (percentage biodiesel) * 0.90 (energy content biodiesel) = 0.90; 0.90 + 0.00 (percentage diesel) = 0.90 = <u>90 percent</u>

Re: Section 4.5: Costs of Biofuels Compared to Conventional Fuels

Additional costs of biofuels in each corridor design are calculated in Table 0.24. These calculations require the energy conversion factors (see Table 0.25) and the expected fuel cost in 2020 (see Table 0.26).

Table 0.24 Total Biofuels Costs per Year

	Corridor Design 1	*Corridor Design 2*	*Corridor Design 3*	*Corridor Design 4*
Displacement by biofuels in litres	158	179	140	319
Displacement by biofuels in GJ	5,658,912	5,748,808	5,014,226	10,763,034
Type of biofuel	Biodiesel	Ethanol	Biodiesel	Both Fuels
Additional costs per GJ	€ 9	€ 11.1	€ 9	€ 9 /€11.1
Total Costs in millions	€ 51	€ 64	€ 45	€ 109

Table 0.25 Energy Conversion Factors for Gasoline and Diesel Fuel

1 MT Gasoline	0.001342	million litres
1 MT Diesel	0.001195	million litres
Diesel	42.80	GJ/MT
Gasoline	43.10	GJ/MT

Source: Data obtained from USDA (2009)

Table 0.26 Expected Fuel Costs in 2020 per GJ in Euros

Gasoline	€ 13.3
Diesel	€ 13.0
Biodiesel	€ 22.0
Ethanol	€ 24.4

Source: Data obtained from ECN (2008)

ANNEX F Calculations: EU-Wide Results

This Annex provides the calculations which have been made provide an estimate of the contribution of biofuels corridors on the TEN-T Network roads to the RED targets. It thereby complements the methodology as described in Section 5.3.

Firstly, the energy displacement per corridor-km for the Rotterdam-Constanta corridor is calculated in Table 0.27 (i.e. following from the demand analysis). Secondly, these results are generalised for other corridors in Table 0.28 by using the sensitivity values which have also been introduced in Section 5.2. This results in a minimum and maximum energy displacement per average TEN-T corridor-km, and when implemented on the entire TEN-T Network roads (90,000km). As the total fuel use in 2020 is also known (i.e. 17.2E9 GJ, see Section 5.3), the maximum and minimum contribution of biofuels corridors to the RED targets as a percentage of total energy use can be calculated (see Table 0.29). Figure 0.2 presents these outcomes.

Table 0.27 Displacement of Conventional Fuels by Biofuels on the Rotterdam-Constanta Corridor per Corridor-km in GJ

	Corridor Design 1	*Corridor Design 2*	*Corridor Design 3*	*Corridor Design 4*
Million litres diesel	158	0	140	140
Million litres gasoline	0	179	0	179
Total energy in GJ	5,658,912	5,748,808	5,014,226	10,763,034
GJ per Corridor-km	1,415	1,437	1,254	2,691

Table 0.28 Approximated Displacements of Conventional Fuels by Biofuels per Corridor-km on an Average EU TEN-T Road Corridor, as well as on the Entire TEN-T Network Roads (90,000km) in GJ

	Corridor Scenario 1	*Corridor Scenario 2*	*Corridor Scenario 3*	*Corridor Scenario 4*
Minimum per corridor-km	990	604	526	1130
Maximum per corridor-km	1556	2213	1930	4144
Minimum on TEN-T Network	89,127,866	54,326,233	47,384,435	101,710,668
Maximum on TEN-T Network	140,058,075	199,196,189	173,742,929	372,939,117

Table 0.29 Approximated Maximum and Minimum Contribution of EU Biofuels Corridors to the RED Targets in 2020

	Corridor Scenario 1	*Corridor Scenario 2*	*Corridor Scenario 3*	*Corridor Scenario 4*
Minimum contribution	0.52%	0.32%	0.28%	0.59%
Maximum contribution	0.81%	1.16%	1.01%	2.17%

Figure 0.2 Estimation of the Contribution of EU Biofuels Corridors to the RED Targets in 2020