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DEVELOPMENT OF INTERNATIONAL TRADE AND USE OF BIOFUELS

- Brazil, Canada, Finland, Netherlands, Norway and Sweden

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Summary

The international trade and use of biofuels is rapidly increasing all over the world, and it is projected to continue the next years according to conclusions in this report. The main reasons are a global increased demand of energy, an increased awareness and knowledge of the environment, and the fact that conventional energy resources are running dry. Traditionally, has biofuels been produced and used within the same geographical region. This has however started to change due to an increased international demand. Consumption, production and trade do however differ between countries due to different conditions for production and consumption of biofuels.

The intention of this report has been to study the current and future consumption, production and trade of biofuels in the countries, which are participating in the IEA bioenergy workgroup Task 40. Participating countries in Task 40 are Brazil, Canada, Finland, Netherlands Norway and Sweden. The objectives has more precisely been to give a survey of existing international trade of biofuels of the studied countries, and a roughly estimate how the trade and use will develop in the future. In the survey has also driving forces, barriers and structures behind the existing trade been recognized.

The study has been accomplished through collecting and analyse information from the six countries. All participating countries has contributed with a Country report, were crucial information has been presented. Information has also been collected from literature and policy documents etc. The survey of existing trade has mainly been based on country reports. The estimation of future trade has been performed in a few steps. First were crucial factors for the development of biofuels identified in order to predict the development in each country. The factors that emerged were: macroeconomic-, geographical-, industrial, technical aspects and development and policy measures on the energy market. Second, were above factors compared with real data. And finally were the gathered information put together and analyzed.

In the survey of each countries trade of biofuels can it been seen that the international trade of biofuels is rapidly increasing; the quantities has in some cases been double in just one year. For example Netherlands import of biofuels. Barriers that have been identified in the report are insufficient spreading of existing technique, institutional obstacles and problems, lack of knowledge and uncertainty, absence of entrepreneurs, resistance from other interested parties, both through direct and indirect resistance and lack of global professional logistics. Driving forces and structures behind existing trade that have been recognized are: raw material/biomass push, market pull, utilizing the established logistics of existing trade, incentives and support institutions, technical developments and innovations, entrepreneurs and innovators, and unexpected opportunities.

In the estimation of future production, use and trade of biofuels has it been concluded that all studied countries will increase their activity within the bioenergy field. The countries activities do however differ from each other.

Brazil, Canada and Sweden are likely to heavily increase their production, consumption and export. This is also the case for Norway the increase will however be on a more moderate level. Finland and Netherlands are according to this study likely to increase their consumption and import of biofuels.

1 PRESENTATION OF THE STUDY

1.1 Introduction

The energy world is changing with an increased global demand of energy, especially renewable energy. The growing demand is pushed of a global economical growth particularly in countries like China and India. This together with a growing environmentalism, trigged of political actions has created a need of renewable energy sources. A major international action is the Kyoto protocol signed by a majority of the world's countries, in which countries have agreed to reduce and control their emissions of green house gases (GHG). According to the protocol shall the global GHG reduction be 5 % 2012, compared with the emission level of 1990.

The growing need for renewable energy sources imply great possibilities for an increased use of biofuels[1]. A prerequisite is however that biofuels can be supplied to competitive costs. Resources of biomass and possibilities to effectively produce biomass differ around the world due to several factors, including labor costs, land productivity and access to land. In order to achieve a competitive supply of biofuels all over the world, international trade is needed from regions with surpluses of biomass resources and/or from regions with good conditions to produce biofuels to regions with less possibility and in need for energy.

Traditionally, has biofuels been produced and used within the same geographical region. This has however changed with a growing international trade, especially in Northern Europe (Alakangas, Hillring & Nikolaisen, 2002). International trade differ from local- and regional trade in various ways e.g. generally longer distances of transportation and influence of trade barriers. This have caused a development were new solutions and techniques have been developed, in order to cost-effective trade biofuels. An example is reduced costs for shipping biofuel, which partly been achieved through shipping larger quantities.

The international flow of biofuel are affected by various factors the most fundamental factor is that there are differences in supply and demand between countries. The supply and demand is determent of conditions within countries, examples of such conditions are governmental regulations for consumption and production of biomass, and factors that influence the overall costs for production and use e.g. alternative energy sources, experiences, infrastructure, knowledge, transportation system and tax incentives.

Increased consumption of renewable energy implies benefits for the environment. This can however to some extent be achieved without an extensive international trade due to the fact that many environmental problems are global. The optimal solution from a resource perspective would be to consume biofuels in the same geographical region as it has been produced due resources is needed for transportation. Instead of trade, use of regional energy sources and trade with power would be preferred. Reduction of GHG according to the Kyoto protocol can be achieved through other actions e.g. the flexible mechanism; improvements/reductions in other countries and emission trading.

[1] Biofuel is defined as a fuel produced directly or indirectly from biomass

1.3 Background

The International Energy Agency (IEA)[2] is an intergovernmental body committed to advancing security of energy supply, economic growth and environmental sustainability through energy policy co-operation (The IEA website, 2006). The IEA consequently works with energy from several different sources, including bioenergy. Within the IEA there is an international collaboration in the Bioenergy field, IEA Bioenergy. The IEA Bioenergy has the goal to accelerate the use of environmentally sound and cost-competitive bioenergy on sustainable bases, and thereby achieve a sustainable contribution to future energy demands (The official website of IEA bioenergy, 2006). The work is carried out through a series of Tasks, each having a defined work programme.

Task number 40 (Task 40) works with sustainable bioenergy trade. The objectives of the Task are to develop the market for biomass trade into a real commodity market, which will secure the supply and demand of biomass in a long-term sustainable way. Participating parties in Task 40 are Brazil, Canada, Finland, Netherlands, Norway and Sweden and the organizations The European Commission, Food and Agriculture Organization of the United Nations (FAO) and the World Bank is associated. To reach the objectives of Task 40 a work program with several deliverables will be carried out. Deliverable 1 deal with gathering and analyses of experiences of international trade with biofuels, and that is also the objective of this report. This report is a part of Deliverable 1 in Task 40; it is also the Master thesis of my studies at Energy System at the University of Uppsala.

1.2 Objectives

There are two main objectives; first to give a survey of existing international trade with biofuels in countries, which are participating in the IEA Bioenergy workgroup, Task 40. Participating countries were: Brazil, Canada, Finland, Netherlands, Norway and Sweden. In the survey will there also be a short analysis of the driving forces, barriers and structures behind existing trade. The survey will be based on information from country reports, and is found in the presentation of each country in chapter 4. The second objective is to make a rough estimation of how the trade and use in the studied countries will develop in the future.

[2] IEA are an free-standing organization within the OECD

1.4 Illustration of future trade

In order to illustrate the huge need of trade and transports with biofuels in the future, a simplified example of EU, Japan and the US is presented. The example is based on the assumption that political environmental ambitions are full field, i.e. that conventional energy is substituted with renewable energy. Assumption that have been made are that EU and Japan reduce their emissions of GHG according to the Kyoto Protocol i.e. 8% and 6%, and that USA reduces the emissions with 7 %, which initially was negotiated in the agreement. Further, 50 % of the reduction is made through substituting light oil with biofuels (here exemplified as pellets). And that EU needs to import 40 % of the biofuel, Japan 70% and USA 30%. The scenario would imply following trade and transport with biofuels:

Table 1: Scenario of future trade (Enclosure 1 - Calculation of trade scenario)

Country/Region	*Amount of biofuel (ton)*	*Panamax-vessel*
European Union	*51.83 million tonnes*	*864 annually*
Japan	*19.25 million tonnes*	*320 annually*
USA	*49.75 million tonnes*	*829 annually*

As can be seen in Table 1, the need of international trade with biofuels are planned to grow in the future. If assuming that the biomass is transported with fully loaded Panamax-vessels[3], which at the moment are one of the biggest and most cost-effective vessels (Roeland Reesinck, 2003). The number of transports that is needed for this scenario can be seen in table 1. This also enlightens the need of a functional and rational transportation system both to and from the harbours and over the seas. Further it is not likely that all future biofuel transport is carried out by large vessels, because of local conditions and other circumstances, e.g. can not all harbours receive Panamax-vessels (Doug Bradley, 2005). These conditions will consequently increase the number of vessels carrying biofuels even more.

1.5 The structure of the report

Chapter 1; contain a short introduction and background of the study, and also the study's objectives. There is also an illustration of future trade, in order to demonstrate the huge demand of international trade of biofuels in the future, and of course also the importance of this work. The second chapter has the purpose to strengthen the credibility and the transparency of the work. This has been done through describe how the work has been performed, and through define concepts used in the study. In the chapter are also factors that influence the development of biofuel trade introduced. These factors are later used as a tool in the subsequent analyses. In Chapter 3 are factors that influence the development of biofuel trade compared with real data in order to predict future biofuel markets and trade patterns. Chapter 4 contain a presentation of each studied country within the workgroup Task 40. Each presentation contains a survey of every country's current production, use and trade of biofuels. The presentations are based on information from country reports. There are also a short analyses of the information presented in the country reports, in the end of each presentation. The analyses deal with future use and trade of biofuels, and forces behind exiting international trade. In Chapter 5, are previous analyses and information put together, in an overall analysis for the development of future use and trade. In chapter 5 are also recognized barriers and driving forces of existing international trade presented. In the last chapter are the conclusions presented and discussed, thus in Chapter 6.

[3] A Panamax-vessel carries 60.000 tonnes

2 METHOD

2.1 How the work has been performed

The study has been performed through collecting and analyzing information from the six countries participating in Task 40. Every country has contributed with a country report, were crucial information has been presented, which include:

- An overview of each country's, international trade with biofuels.
- Driving forces and factors behind existing consumption, production and international trade of biofuels.
- Barriers that restrict international trade of biofuels.
- Key issues for a further development of international trade with biofuels.

The country reports have been based on accessible information in each country. It is therefore not sure that given surveys in the country reports have been all-embracing. My expectation is however that the main flows and factors have been presented and therefore gives a significant picture of the biofuel situation in each country.

Information has also been collected from literature. Further, has information from the Kyoto protocol, EU-directive, policy documents and other international agreements been used in the project.

The analyses have been performed in four steps, first are factors that influence the development presented and discussed. These factors are chosen from a discussion with the Swedish representatives in Task 40; Bo Hektor from Talloil and Erik Ling from Sveaskog, both works professional in the bioenergy field. Second are the above mentioned factors compared and discussed with real data. In the third step is information gathered and analysed from country reports. And finally, are all the information put together and analysed.

2.2 Definition of studied factors

In order to reduce uncertainty related to basic assumptions there will follow a definition of important factors used in the study. One of the reports main objectives are to make a compilation of the driving forces and barriers behind existing trade, and the countries experienced key issues for further development. A driving force for international biofuel trade is defined as an incentive for trade. A barrier is an obstacle that restricts international trade. And a key issue for further development are a factor of great importance for the development of international trade with biofuels.

2.2.1 Fuel Categories

To get the report as distinct as possible different biofuels has been divided in groups, see Table 2. The division is mainly based on the fuels quality, but also in which field of application the fuel is used in, and from where the fuel originate.

Table 2: Biofuel Categorise

Fuel Category	*Examples of Biofuels*
Motor fuels	*Ethanol, Methanol,*
Other liquid fuels	*BioOil, Black liquor, Tall oil and Vegetable oil*

Unrefined by-products from agriculture and food industry	*Straw, Grains*
Unrefined biofuels	*Chips, Round wood, Wood residues*
Densified biofuels	*Briquettes and Pellets*
Biofuels from dedicated energy plantations and crops	*Poplar, Salix, Sugar canes, Willow Fuel crops*

2.2.2 Direct- and indirect trade

Trade with biofuels can be direct or indirect. The difference is that in direct trade, the primary purpose for the biomass is to be used as biofuel, while in indirect trade the biomass has another primary purpose. In indirect trade, the biomass usually has the main purpose to be used as pulp or round wood in the process industry. By-products from the industries can later be used as biofuels, either internally or be sold on the market. By-products that can be used and traded as biofuels are, e.g. black liquor, tall oil, sawdust and residues from the food industry.

The main focus in this study will be on direct trade, but also indirect trade will be considered. The reason is that indirect trade corresponds to a considerable amount of the international trade of biofuels.

2.3 Factors that influence the development of biofuel trade

To describe and explain international trade with biofuel, different factors and aspects has been used. In the work have important factors for the development of biofuel trade been identified, which are: macroeconomic factors, geographical conditions, industrial structure, technical development, and governmental incentives. Below follows a description of the factors and how they affect international biofuel trade. In the subsequent analyse will these factors be used as a tool on the latter presented data.

2.3.1 Macroeconomic factors

Macroeconomic factors affect a country's development and purchasing power, which influence the possibilities for use and trade of biofuels. In this work the regarded macroeconomic factors that will be studied are: GDP-growth, the oil price, transportation price, and trade restrictions. There are however also other macroeconomic factors e.g. inflation and the situation on the labor market, these factors are however assumed to have limited affect on the biofuel development. (Michael Parkin & David King, 1995)

Gross Domestic Product (GDP)

A country's GDP describes the value of all the final goods and services produced in a country's economy during one year. The GDP measure is used to give information about fluctuation in the economic activity. A growth in GDP is the result of an increased purchasing, which consequently also increases a countries possibility to trade and use biofuel. A measure closely related is GDP per capita, which describes GDP per inhabitant. There is a close link between the energy demand and the GDP (World Energy Outlook, 2004), a increased GDP means an increased demand of energy.

There are four reasons that make the real GDP grow:

- Growing population

- Population acquires more human capital
- Growing stock of capital equipment
- Advance in technology (Michael Parkin & David King, 1995)

According to the International Monetary Fund (IMF) will the world's economy grow the next two years. The world real GDP growth are predicted to 4,3 % both 2005 and 2006. However, the growth is not equal distributed among the world's regions, largest growth will be in China with a yearly growth of 9, 0 %.

A high GDP per capita implies that a country has a extensive need of energy because the close relationship between energy consumption and GDP per capita. It also implies that the country has a strong purchasing power. These conditions together create possibilities and incentive for biofuel trade, especially import. A low GDP per capita implies that the cost of production is relative low e.g. because low labour costs. It also implies a relative low demand of energy. These conditions together are most suited for production and export of biofuels. It should however be noted that developing countries with a low GDP, in general consume large amount of biofuels, which may reduce their future export.

The Oil Price

Oil is at the moment a very important raw material for the world's population and societies. In fact it is the most important energy source in the world. The price of oil has a great influence on energy markets around the world mainly due to that the oil price determines the marginal cost for energy. The oil price also has an effect on the whole world economy, e.g. can a high price can block the economical growth. A reduced economical growth implies lower GDPs and thereby less consumption of energy, which can reduce future use and trade of biofuels. On the other side, can a high price stimulate technical development of alternative energy sources or technical equipment (Karlberg, 2005).

The world-market price of oil is dependent of several factors, among other; the markets trade cycle, the political situation in the Middle East, conflicts in regions with a significant production of oil, threats of terrorist attacks and the development of the dollar rate. The oil price has fluctuated heavily the last years because of experienced uncertainty of mentioned factors, but also because of production limitations from OPEC (Statens energimyndighet (2004) – Energiläget, 2004). The development of the international oil price can be seen in Figure 1, in chapter 3.

The price of oil both affects markets and trade of biofuel. A high price makes it more advantageously to use and trade with biofuels because oil is a competing energy source. It also stimulates a technical development on alternative sources, thus development of biofuels techniques. Accordingly, is a low price acting as a restricting factor for biofuel consumption and trade.

Transportation cost

The cost of transporting biofuel is another significant macroeconomic factor. In order to stimulate a positive development it is important to increase the efficiency and the effectiveness and thereby reduce the costs of transportation. At the moment the expenses of transport biofuels correspond to a significant share of the total cost of traded biofuels, e.g. only the shipping corresponds to approximately 20-25 % (Interview - Bo Hektor, Talloil). Operations that are a part of the overall transportation cost are: packing, loading, transportation, unload and storage.

There are three major means for transportation of biofuels; ship, train and trucks. Sea shipping is the most competitive alternative over long distances, followed by trains and trucks. In order to show the relation between different means of transportation a rough estimation has been done. Assumptions that have been made are that large quantities are transported i.e. the transports are fully loaded and occurs in a well functional logistical system. The estimation can be seen below and shows how far it is possible to transport one unit of biofuel to the cost of €20 with the different means of transportation.

- Trucks – 200 km
- Railroad – 600 km
- Sea shipping 10.000 km

Trade restrictions

Governments restrict international trade in order to protect domestic industries from foreign competition. There are two main methods used by governments; tariffs and non–tariffs barriers. Tariffs are a tax imposed on goods by the importing country when goods cross the international border. It can be advantageously for a government to impose tariffs because, tariffs provide revenues to the country and because it is possible to satisfy domestic interest groups in import competing industries. There are five different types of non-tariffs barriers; quotas, voluntary export restraints, product standards regulation, public sector procurement bias and frontier delays and administrative burdens on international trade. It is however mainly quotas that restrict international trade of biofuel. A quota is a quantitative restriction on import of particular goods. It specifies the maximum amount of goods that may be imported in a given period of time. Quotas are common on agriculture products and thereby certain biofuels that originate from the agriculture industry (Michael Parkin & David King, 1995).

There are benefits for governments to employ free international trade i.e. international trade without trade restriction. Benefits from free trade are e.g. economic growth, increased competition etc. This was observed already 1947, when the free trade General Agreement on Tariffs and Trade (GATT) first was signed by 23 countries. The agreement was designed to encourage free trade between member states, by regulating and reducing tariffs on traded goods and by providing a common mechanism for resolving trade disputes. Since 1947 several new countries has joined the agreements and today are 148 countries in the collaboration. The collaboration has now changed name to World Trade Organization (WTO) (Michael Parkin & David King, 1995).

2.3.2 Geographical conditions

Geographical conditions influence a country's need of energy and possibilities to effectively produce and trade biofuels. The conditions differ heavily between the world's countries due to several factors, e.g. where the country is located and the size of it. In the study will the following factors related to a country's geographical conditions be regarded: land productivity, population density, area and the access to infrastructure/transportation. These factors are assumed to have biggest impact on the future biofuel development. There are also others but they are assumed to have a limited impact.

Land productivity

Land productivity refers to the capacity of the soil to produce biomass. The productivity is a combination of several factors including solar radiation, moisture content, soil conditions, length of the growing season etc. The productivity differs in different geographical regions depending on above mentioned factors, but also depending on what type of crop that is cultivated. For example is the average yield of sugar cane 35 dry tonnes (dt) per hectare annually, while it is 10 dt of corn (Godfrey Boyle, 2000).

High land productivity implies good conditions for production of biofuels and possible export. Consequently, are countries with high land productivity suited for production and export. While countries with less productive land in general is more suited for import.

Density of the population

The density of the population in a country influences the conditions for production of biofuels. Humans are distributed varying over the world's countries; the most crowded country in the world is Monaco with a density of 16620 inhabitants per km^2. And the country with less people per area is Mongolia with 1 inhabitant per km^2. The average density on earth is 43 inhabitants / km^2 (The wikipedia.org (2006) – density of population).

Density of population can be used as a measure of available land for production of biofuels. A low population density implies a low competition of available land and thereby better prerequisites for production of biofuels. While a high density imply harder competition of land and thereby less available land for production of bioenergy. It can also be used as a measure for energy consumption; accordingly a high density implies a high need of energy and vice versa.

Access to infrastructure and transportation

In order to provide biofuels to competitive costs an efficient logistic chain is needed from the source to the consumer. A prerequisite for an efficient logistic system are access to transportation and infrastructure that are adapted for biofuel transportation. In general international transports of biofuels are transported with ships, because it is the most cost-effective mean of transportation over long distances. It is therefore advantageously from a biofuel trade perspective if both the sources and consumer have access to sea or oceans. It is also important that the ports are easy accessed and have equipments and space to handle biofuel efficiently. In some cases this can be problematic because biofuels are a relative new commodity.

It is of great importance that infrastructure is adapted for biofuel purposes. It can however be problematic to adapt infrastructure for biofuel transports due to an organisational problem in the society. The problem arises because the society consists of actors and institutions in different systems or organizations e.g. companies, local authorities, governments, which don't support each other. The various systems are often ruled from internal goals, not for wider perspectives. To develop the whole society it is important to see all systems as a big system and together solve the society's problems (Eric Rehnman, 1975).

2.3.3 Industrial structure

The industrial structure influences both the need and the capacity to produce energy. A high level of industrialization implies a high demand for energy,

especially if the structure consists of industries that consume large amounts of energy. Examples of such industries are the forest product industries and the steel industries. There are certain industrial structures that are favourable for bioenergy because they produce by-products that can be used as biofuels. The industrial structures are especially; the forest-, the farming- and the food industry.

Forest product industry

The paper industry (paper-mills, pulp-mills) and sawmills are the main branches within the forest product industry. The industry is closely related to the biofuel industry as they share the same raw material, techniques and certain knowledge. By-products from the forest product industries can be used as biofuels, but also for production of particleboards and plywood. From sawmills are the main by-products bark, wood chips and sawdust. The bark is often used internally as fuel for drying sawed timber. Wood chips and sawdust are in general distributed to the market were it is used by the paper industry in the production of paper, by the particular board industry and for biofuels. Biofuel by-products are either used direct as a fuel in district heating plants or as a raw material in production of refined biofuels. By-products from the paper industry are often used internally in the industrial process. There are two different techniques for making paper chemically and mechanically. It is especially in the chemical process quantities of biofuel by-products are produced, mainly black liquor. It consists of a mix of lignin and chemicals (Svebio, 2004).

Biofuel by-products are also produced in logging operation, when supplying the forest product industry with raw material. The wood residues mainly consist of branches, stumps, tops and smaller trees. In order to cost-effectively gather wood residues it is important to adjust the cutting operation, for a selection of the residues (Bengt Hillring, 2003).

Countries that have a forest product industry consequently have opportunities to use by-products for biofuel production. There are however a competition of available by-products. Thus, low competitions of the available by-products strengthen the possibilities for biofuel production, because large quantities of raw material get available. While a harder competition between the biofuel-, the paper- and the particle board industries restrict possible production.

Agriculture Industry

There are several different biofuels and raw materials for production of biofuels produced in agriculture, both as main products (energy crops) and as residues. Energy crops can be divided into the groups; crops for combustion, plants for fermenting to alcohol and crops whose seeds are rich in oils. Crops suited for combustion are mainly wood crops, but also grain and energy grass. Woody crops produced in agriculture are fast growing trees, such as poplar, salix, willow and others. Fermentation is an anaerobic biological process in which sugars are converted to alcohol by micro organisms. Plants from agriculture that can be used for alcohol production through fermentation are among other sugar cane, corn, cassava, sweet potatoes and wood. Seeds from plants which seeds are rich in oil can be crushed to yield vegetable oil. Vegetable oils can be combusted directly in a diesel engine, either pure or blended with diesel. There are several examples of vegetable oils used as transportation fuel. For example Coconut oil in the Philippines, palm and castor oil in Brazil, sun flower oil in South Africa and RME from rape in Europe. Both residues from plants and animals can be used for

production of bioenergy. Residues from plants are mainly straw and surpluses of food commodities, see food industry. Animal waste is mainly used for production of biogas (Godfrey Boyle, 2000).

A well-developed agriculture industry creates possibilities for a cost-effective production of biofuels, because the industry can transfer reliable techniques, infrastructure for farming, machines, equipments etc. The industries consequentially create possibilities for an increased production of biofuels. Agriculture products that are suitable for international trade are especially those produced directly for energy purposes and refined products like ethanol and vegetable oils. Examples of products that not are suited for trade are, most obvious biogas, but also straw is not likely to be traded due to a relative low energy density.

Food industry

The food industries produce by-products that can be used as biofuels. Examples of biofuels from the food industry are residues from almond-, olive-, rice-, sugar- and wine production. The use of by-products for energy production is very suitable, because alternative field of application are limited. By-products are in some cases utilized as energy source on a local level; hence not all are available for international trade.

Surpluses of by-products from the food industry imply possibilities for increased domestic consumption and international trade, because raw material is available to relative low costs. A potential barrier is increased competition of available by-products, which would cause increased prices.

Power plants type and location

The design of the energy infrastructure in a country influences the possibilities for biofuel consumption because different energy solutions are more or less suited for co-firing, conversion or replacement of biofuels. Energy infrastructures that are not suitable for an increased use of biofuels are especially hydro power plants and nuclear power plants. The main reason is that very large investments have been made and financed, which makes them economical profitable over a long period of time. Others energy sources that are not suitable are e.g. wind and solar, mainly because there are very low variable costs, when the plant are installed and financed. The only variable costs needed to operate wind and solar plants are maintenances costs.

Power plants that use fossil fuels are however suitable for converting and co-fire with biofuels mainly because the same incinerators also can be used for biofuels. It is especially coal power plants that are suited because coal has the same handling characteristics as biofuels. The fuels similarity enables use of existing techniques and equipments for handling the fuel. Coal power plants are also adapted for receiving large quantities of solid fuels often transported by ships, which also is the case for biofuels.

The distribution of heat in district heating systems is another structure suited for replacement and conversion to biofuel. Experiences from Sweden were most cities has district heating systems originally based on oil has successfully been replaced with biofuels (Bo Hektor & Erik Ling, 2004). One reason that biofuels are suitable for combustion in district heating system is biofuels relative low energy density. This makes biofuels suitable because less energy is needed to make heat compared to power.

2.3.4 Technical aspects and Development

There is an ongoing technical development in the society and in the industry, as well as in the bioenergy sector. Development can with other words be seen as tearing down barriers, and creating incentives and also driving forces for international use and trade. However, new technology does not become a driving force until it is implemented.

There are two different types of development: adjustments/improvements of existing activities and innovations. Adjustments and improvements of existing activity result in an increased effectively and thereby reduced costs. Elements and operations that are of interest of adjustment and improvement are combustion techniques, equipment for handling biofuels, shipping fleet etc. Innovations are creating something new, which results in alternative solutions. Innovations related to biofuels can e.g. be new types of biofuels and new techniques for production of biofuels.

2.3.5 Policy measures on the energy market

Policy measures set the conditions for the energy structure in a country. There are several measures that influence the production and use of renewable energy and biofuels, e.g. supporting incentives for production of renewable energy and environmental legislation. Policy measures are in the study divided into the following groups: economical incentives, agreement and legislation.

Economical incentives

Taxes, subsidizes and contributions have traditionally been the main policy incentives on production and use of energy. Besides control the development they have also been used for fiscal reasons. Taxes have the two purposes to influence the development and also contribute to the state finances. Subsidizes are used to support production and construction of plants that would not take place without the support. The motivation for this type of support is to support domestic industry or any form of energy, generally renewable energy sources. There are two main types of subsidizes used, direct capital subsidizes and subsidized loans. Distributions of capital through fees to contributions between producers and consumers are another way to control the market. No net balance contributes to the state finances with this type of measures.

When the environment and the climate issue became important, new measures had to be taken, which had to work independently of every country's rules and energy polices i.e. on the markets conditions. Market based measures differs from conventional incentives, in the way that it do not generate revenues to the state, and do not create expenditures. Emissions trading[4] are an example of market based measures with the purpose to regulate the emissions of greenhouse gases. There are also other e.g. the electricity certificate in Sweden, which imply that the consumers need to consume a certain amount of renewable electricity (Kungliga Ingenjörsakademin, 2003).

Agreements

Agreements between countries influence both the need of renewable energy, and supply of energy. The main international environmental agreement is the Kyoto

[4] One of three flexible mechanisms of the Kyoto protocol

protocol, which will increase the demand of renewable energy, and thereby also bioenergy. The Kyoto protocol is an international agreement between several countries with the purpose to decrease the global emissions of green house gases (GHG). According to the agreement, are countries allowed to reduce their emissions of GHG in different ways. Naturally through reduce their emissions of GHG, but also through three flexible mechanisms. The mechanisms enable opportunities to reduce emissions cost effectively in other parts of the world. This is possible because the benefit for the atmosphere is the same, wherever the action is taken. The three mechanisms are: Joint Implementation (JI), Clean Development Mechanism (CDM) and Emissions Trading (United Nations, 2003).

There are also other agreements between countries that influence the energy situation, such as bilateral agreements, free trade agreements and other collaborations. Activities like these imply that a country can be supplied with certain techniques and fuels, which makes it advantages to use a specific energy source. Such agreements are however not regarded in the study due to the limited extent. It can however be concluded that these activities influences countries energy structures.

Legislation

The policy measure legislation also influences the use and trade of biofuels, through restriction of certain activities. An example of legislation that have affected the biofuel sector is the biomass flows from the waste sector in EU, which strongly has increased in recent years, mainly due the EU's waste regulation (Bengt Hillring, 2003). Other type of legislation that affects the use of biofuels is e.g. propitiation and limited values of emissions that have affect on the environment.

3 ANALYSE OF DEVELOPMENT FACTORS

In this chapter factors related to the development of biofuel trade are discussed and compared with collected data. The purpose is to strengthen the above discussion, but also expand the discussion to the current situation. The studied factors are as above; macroeconomic factors, geographical conditions, industrial structure, technical aspects and development and policy measure on the energy markets.

3.1 Indications from macroeconomic factors

There is a close relationship between GDP and energy consumption, as discussed earlier. The GDP can accordingly indicate the energy need in a country, and the GDP-growth indicates the future need. The GDP, GDP per capita and the GDP-growth of the studied countries can be seen in Table 3, below.

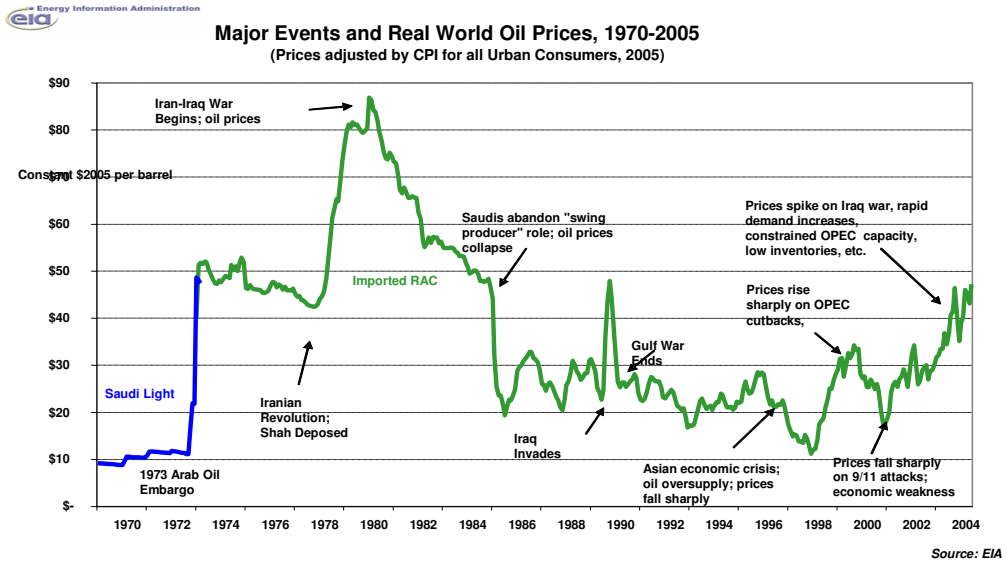
Table 3: GDP, GDP per capita and GDP-growth in selected countries

Nation	*GDP(billion)*	*GDP(*1000)/inhabitant (Central Intelligence Agency, 2005)*	*GDP-growth (estimated) (International Monetary Fund, 2005)*	
Year	*2004*	*2004*	*2005*	*2006*
Brazil	*$1492*	*$8.1*	*3.3%*	*3.5%*
Canada	*$1023*	*$31.5*	*2.9%*	*3.2%*
Finland	*$151.2*	*$29*	*1.8%*	*3.2%*
Netherlands	*$481.1*	*$29.5*	*0.7%*	*2.0%*
Norway	*$183*	*$40*	*3.1%*	*3.3%*
Sweden	*$255.4*	*$28.4*	*2.6%*	*2.8%*

From previous discussion and table 3, does it appear that Canada and Norway have the highest need of energy per capita followed of the industrial countries Finland, Netherlands and Sweden. Brazil has a relative low GDP per capita, which indicates that they have a lower need of energy. The GDP-growth indicates an increased demand in all countries, especially in Brazil, Canada and Norway.

Another important macroeconomic aspect is the development of the oil price. The development of the international oil price can be seen in figure 1. It can be interpreted from the figure that the oil price is increasing, which implies an increased need of renewable energy and biofuels. Another interesting aspect from the figure is the heavy fluctuations of the price, which cause an uncertainty for consumers of oil. This uncertainty is not an issue for consumers of biofuels, because the price has not fluctuated that much in the past.

Figure 1: Development of the oil price (Energy Information Administration, EIA)



In close relation to the oil price are the cost of transportation due oil is the main fuel used for international transports. The most competitive mean of transportation is ships followed by trains and trucks, according to previous estimation. It is however not always possible to transport the fuel with ships because of limited access to the sea and ports. If it is possible to ship biofuels by boats the transportation cost is not a barrier no matter what distances due to low costs for shipping biofuels. If it is not possible to transport the biofuel by ships, transportation costs can restrict international trade. All the studied countries have access to sea and ports, which makes it possible to effectively transport the fuel over long distances.

The last discussed macroeconomic aspect is trade restrictions. Two types of trade restriction are used on biofuel products; tariffs and quotas. Both restrictions imply that the consumer needs to pay a higher price for the fuel. Quotas also imply that a maximum amount is allowed, which probably can decrease investments in biofuel technology. Trade restrictions differ from country to country and on different commodities. It is therefore hard from a general point of view to describe, which biofuels and which countries that are affected. However, as mentioned earlier quotas is in general used on agriculture products, and thereby certain biofuels. In order to improve the conditions for biofuel trade, it is important to encourage free trade.

3.2 The Task 40's countries geographical conditions

The geographical conditions in a country heavily influence the consumption and production of biofuels, but also the possibilities for international trade. The

considered geographical conditions in the study are; land productivity, population density, area and the access to infrastructure/transportation.

Brazil is likely to have the best growing conditions with a tropical climate, while the others are assumed to have a bit lower land productivity. Canada, Finland, Norway and Sweden are assumed to have equally good productivity due they are located approximately on the same latitude. Netherlands are assumed to have a bit higher productivity then previous mentioned countries, but lower then Brazil due to Netherlands latitude location. A prerequisite to produce biofuels is to have available land for production. The measure used to study available land is population density, which can be seen in Table. Netherlands has a very high density of population, which implies that there is a high competition of available land and the high demand of energy. It is consequently likely that Netherlands will have to import biofuels in the future. All the other countries have available land and therefore have the possibilities to become suppliers in the future.

Table 4: Population density in selected countries

Country	*Density of population [inhabitants / km^2]*
Brazil	*21*
Canada	*3*
Finland	*15*
Netherlands	*395*
Norway	*14*
Sweden	*20*

In order to utilize the production possibilities in a country it is of great importance that the infrastructure is adapted for cost effective handling and that the ports are easy accessed. An adjustment of the infrastructure for biofuel handling can be problematic due to several parties with different goals are involved and because it is also a matter of long term investments. Governmental financing is likely to be limited because of short-term goals and other priorities, especially in developing countries. Investments from private interested parties are also likely to be limited because they lack capital and that large investment in specific sources results in less flexibility. Large investments, which cause less flexibility, are problematic due companies end up in a bad negotiation position.

3.3 Analyses of the industrial structures

The industrial structure and the design of the energy infrastructure influence both the need of energy and the conditions for production of biofuels. A high level of industrialisation in general requires a high need of energy, especially if the structures consist of industries that consume large amounts of energy. Certain industrial structures implies good conditions for production of biofuels, mainly because the existents of know how and the fact that certain industries produce by-products that can be used as biofuels. The industrial structures are the forest product industry, the farming industry and the food industry.

All studied countries have an industrial structure that positively can influence the development of bioenergy, e.g. a farming industry. Brazil, Canada, Finland, Norway and Sweden all have a significant forest product industry, which produce by-products that can be used as biofuels. The current utilization of by-products differs in the studied countries, e.g. is there a high utilization in the Nordic countries. While in Canada the utilization is less and there are available surpluses of by-products that can be used for production of biofuels.

As mention earlier the energy infrastructure influence the possibilities for biofuel consumption due different solutions are more suited for co-firing, conversion or replacement with biofuel. A detail description of the situation in the studied countries can be found in the presentation of each country, in chapter 4. The different situation can briefly be summarized as Brazil already has a high supply of renewable energy, but there are also coal power plants in use. The power plants do however mainly use charcoal, which are originating from biomass. In Canada the main energy supply (80%) comes from the fossil fuels, petroleum, natural gas and coal, while only 6 % comes from biomass. The remaining parts originate from hydro- and nuclear power. Finland's supply of energy comes from a combination of fossil fuels, hydro, nuclear, and biofuels. Finland produces a considerable amount of energy from biomass, ca: 20%. In Norway the main energy supply comes from the domestic resources: hydro power and fossil fuels. Netherlands are supplied with energy from a combination of several energy sources. They also import a considerable amount of energy/electricity. Netherlands are unique because they are dependent of imported energy due to the small size of the country and the very high population density. In Sweden the major energy sources are biomass, fossil fuels, hydro power and nuclear energy.

The possibilities to increase the domestic use of bioenergy differ between the members in Task 40. All countries consume considerable amounts of fossil fuels, which partly is possible to convert to biofuels. It is especially coal power plants that appropriate to convert or co-fired with biofuels. Countries that use coal are: Brazil, Canada, Finland and Netherlands. Canada, Finland, Norway and Sweden both produce considerable amounts of energy from hydro power, which not are likely to be replaced by biofuels. Neither are nuclear energy, which at the moment is used by Canada, Finland and Sweden. Altogether does it seem that Canada, Finland and Netherlands have an energy infrastructure that is most suited for conversion or replacement of bioenergy.

3.4 The effect of technical development and innovations

Technical development and innovations will be a key factor for the future need and demand of energy, and thereby also the future production and consumption of biofuels. It is however impossible to predict, which developments and improvements that will occur and how they will influence the future biofuel market. It can however be concluded that technical developments and innovations within the biofuel industry positively will influence the development of biofuels due to an increased effectively and effectiveness and thereby reduced costs. There are several examples of developments and innovations, which has contributed to an increased use and trade of biofuels, e.g. has Netherlands developed techniques for co-firing biofuels in coal power plants, which has proven to be a very successful combination. There are also several examples of ongoing research programs in the country reports e.g. in Canada were they have both research push and pull programs.

3.5 The effect of policy measures on the energy market

Countries use many different policy measures in order to promote renewable energy and biofuels, as mentioned earlier. In general are industrial countries using supporting policies for renewable energy (FAO, 2005). The effects of different incentives proved to been different in various cases, partly due to the nature of other factors, partly due the fact that the institutions related to the incentives were

different. Because there are several different measures used to control the market and the different effects of those, will there not be a comparison of specific measures. It can however be concluded that policy measures have a great influence of use and trade of biofuels. Specific measures used to control the energy market in the studied countries can be seen in the presentation of each country in chapter 4.

Instead of comparing specific policy measures, a comparison of the commitment against the Kyoto protocol will be done. The commitment shows a comprehensive picture or tendency of future policy measures. As can be seen in Table 5, are Canada, Netherlands, and other countries within the EU obliged to heavily decrease their emissions of GHG, while Brazil, Finland, Norway and Sweden don't need to decrease their emissions. It is therefore assumed that powerful policy measures that promote renewable energy will be used in Canada and Netherlands. According to the protocol is it also possible to reduce emissions through the flexibility mechanisms, therefore it is likely that reductions will be done also in the other countries. In order to cost effective reduce the emissions of GHG.

Other policy tendencies are most likely an increased legislation due to an increased knowledge and awareness of the environment, which will enlighten the need of sustainable products. A successful example is the waste legislation within the European Union.

Table 5: Commitments against the Kyoto Protocol (United Nations, 2003)

Country	*Reduction of GHG [%] compared with 1990 in the*
Brazil	*No reduction commitments*
Canada	*- 6 %*
EU	*- 8 %*
Finland	*0 %*
Netherlands	*- 13%*
Norway	*+ 1 %*
Sweden	*+ 4 %*

4 COUNTRY REPORTS

This chapter contains a summary presentation of factors relevant to this study based on the country reports, submitted by participating countries. The complete country reports are presented on the website:
www.fairbiotrade.org > Country Reports by T40

4.1 Brazil

Brazil has a tradition of both extensive production and use of biomass. The country has good conditions for large-scale production of biomass, i.e. land availability, adequate weather conditions, no special constraint regarding labour, domain of technology and the existence of know how. At the moment Brazil is the largest producer of sugarcane in world, last production season the production reached 389 million tons. Renewable energy corresponds to a significant share in Brazil's energy matrix. In 2003, 43 % of the energy supply was covered by renewable, biomass accounted for 29,9 %. Brazil also have an extensive international trade with biofuels were ethanol is the most traded product, but also other biofuels e.g. charcoal, pellets, chippings (Arnaldo Walter, Paulo Dolzan & Erik Piacente, 2005).

4.1.1 The development of production and trade of biofuels in Brazil

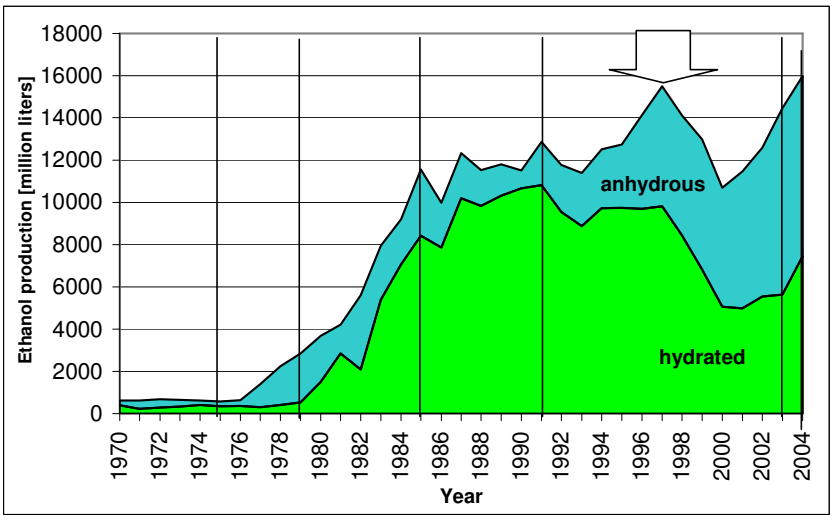
Brazils development of production and use of biofuels mainly ethanol is closely related to the alcohol program PROALCOOL. The program is considered the largest commercial biomass program in the world. The PROALCOOL started in 1975, with the purpose of supporting production of anhydrous[5] ethanol that could be blended with gasoline. The main reason was to decrease Brazil's dependence of imported oil. The decision was also influenced by frequent problems due to the excess of sugar production and strong variations in the international price.

The program have since it started gone through different stages, the first lasted until the second oil chock in 1979. The program then enlarged to also support production of hydrated[6] ethanol. The third phase took over in 1985 and during that phase opposition was reinforced due to decline of international oil prices and the heavy subsidies given to inefficient alcohol producers. The fourth phase started 1990 with an ethanol supply shortage that deeply impacted the supplier's credibility, leading to a drop in sales of neat ethanol cars. This however changed, 2001, due to large price differences between ethanol and gasoline. In 2003 the invention of the flexi-fuel vehicles replaced neat ethanol cars; a flexi-fuel vehicle has the advantage that it can run on both ethanol and gasoline.

The effect of the PROALCOOL can be studied in Figure 2, which shows the evolution of the ethanol consumption in Brazil. The four phases can be identified through the vertical lines (Arnaldo Walter, Paulo Dolzan & Erik Piacente, 2005).

Figure 2:.Ethanol consumption in Brazil 1970-2004 (Arnaldo Walter, Paulo Dolzan & Erik Piacente (2005), s. 7, see MME(2003) and DATAGRO (2004))

[5] Anhydrous ethanol must be blended with another fuel to be used in an engine
[6] Hydrated ethanol can be used directly without being blended with other fuels

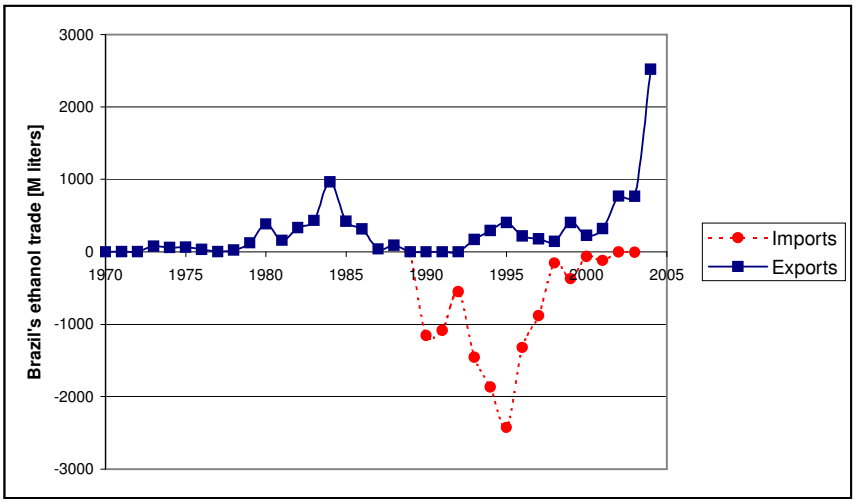


Development of the ethanol trade

Trade with ethanol began already in the seventies, the trade were however mainly oriented for beverage production and industrial purposes. Recently trade for fuel purposes has enlarged, and after 2000 have the trade increased steadily. Figure 3 shows Brazil's ethanol trade and how it has been developed since 1970. The heavy import during the 1990's was partly caused by a supply shortage of ethanol in 1990-91, and partly by the fact that the international sugar markets were favourable for exports in 1993-1997, which resulted in an import of ethanol that matched the fuel demand.

Since 1990s the producer has explored a strategy to induce more flexibility into the industry, shifting production from alcohol to sugar and vice versa according to market opportunities (Arnaldo Walter, Paulo Dolzan & Erik Piacente, 2005).

Figure 3: Brazilian exports of ethano l(Arnaldo Walter, Paulo Dolzan & Erik Piacente (2005), s. 10, see MME (2003) and DATAGRO (Nastari, 2004))



4.1.2 Current trade with bio fuel to and from Brazil

The most important biofuel in 2004 were ethanol, the total export reached 2.5 billion litres. The ethanol was mainly exported for fuel purposes, but also for beverage production and industrial purposes. The destinations of Brazil's export have until 2004 been India (23.1%), USA (20.2%), South Korea (10.2%), Japan (9.2%), Sweden (8%), Jamaica (6.3%), The Netherlands (6.2%), Mexico (3.5%) and Costa Rica (3.2%).

There are also trades with other biofuels to and from Brazil. In 2003, 0.4 PJ charcoal was exported. The export was for small users, packed and certified as environmentally friendly. There has also occurred importation of charcoal in south of Brazil, from neighbouring countries, like Paraguay etc. Pellets have been exported from southeast of Brazil to North America. The exported quantities amount to 10.000 tones up until the end of 2004. Wood chips are exported mainly to Asia, where it has been used for many applications, such as paper and the pulp industry, brick and ceramic, energy and other uses. The exported chips are supplied both from forest residues as well as whole trees. There has also been a direct export of wood chips to Europe were the chips has been used to supply electric and heating plants. The wood chips have been made of acacia trees and barks of eucalyptus and pinus. The total export of wood chips reached 3 PJ in 2004 (Arnaldo Walter, Paulo Dolzan & Erik Piacente, 2005).

4.1.3 Analyses of Brazil's biomass production and trade

According to Brazil's country report there are several factors that can help to explain Brazil's biofuel situation, regarding consumption, production and international trade. The most fundamental factor behind Brazil's extensive production and trade, are most probably the very good conditions for production with land availability, adequate weather conditions, no special constraint regarding labour, domain of technology and the existence of know-how. There are also powerful domestic policy measures, which support consumption and production of biofuels. The main incentive is the extensive alcohol program PROALCOOL. Brazil is however also heavily influenced of international politics and agreements due to their large-scale export of ethanol. International policies and agreements in different countries both support and restrict possible trade of biofuels. Examples of measures that restrict trade are e.g. measures in USA, which are protecting the US ethanol market due the interests of domestic corn producers. Therefore are the opportunities for export limited to USA. Examples of measures that create an incentive for trade and consumption of ethanol is e.g. a directive in the EU (The green paper on security of supply), which obliges the use of a certain amount of renewable energy in traffic- fuels (e.g., 2% in 2005 and 5.75% in 2010).

Another important force behind the ethanol export is flexibility in the sugar cane production, which enables opportunities to maximize the outcome of the production of sugar canes. The producers are shifting the production between sugar and alcohol depending on market opportunities. The flexibility can in cases when the production is oriented against alcohol act as a driving force for production and trade, but it can also act the other way around.

4.2 Canada

Canada is a country rich in natural resources; available resources for energy production are among other fossil fuels resources hydro resources and biomass resources. In 2000, 6 % of Canada's primary energy was from biomass. Projections for the next couple of decades are a biomass share of 6-9 %. Energy from biomass was produced in form of heat generation, combined heat and power, gasification, pyrolysis, landfill gas, ethanol from grain and cellulose (Doug Bradley, 2005).

4.2.1 Policy Settings in Canada

There are different governmental instrument used to promote renewable energy and bioenergy, especially two different governmental programs are used to direct promote bioenergy: technology push and market pull. Technology push programs encompass basic research, applied R&D, demonstration and pre-commercialization. Market pull programs support utilization of bioenergy technologies. Other governmental measures that support bioenergy have been listed by Doug Bradley in the Canadian country report and are seen below (Doug Bradley, 2005):

- Renewable Energy Deployment Initiative (REDI)- Originally a 25% incentive toward purchase of certain biomass combustion systems, this program is being phased down to 15% and then 10% by the end of the REDI program in 2007.

- A one-time capital contribution of $78 million toward the construction of new ethanol capacity, announced in February 2004

- Incentives for industrial-scale bio-diesel plants

- The Renewable Power Production Incentive (RPPI) announced in the 2005 federal budget is the newest and potentially most effective policy support for bioenergy. Designed to stimulate the installation of up to 1500 MW of renewable non-wind energy, it will pay 1¢ per KWh of production in the first 10 years of operation.

There are also other initiatives that promote all renewable energies, such as measures for reduction of GHG and national targets of 1.4 billion liters of ethanol and 500 million liters of renewable diesel by 2010.

Although there are several programs in place to promote bioenergy, consensus in the market place indicates that programs are directed only to small, specifically targeted projects, and that prior to the RPPI program just now being implemented there is little real support for commercial bioenergy capacity (Doug Bradley, 2005).

4.2.2 Biomass resources

Canada is one of the world's largest pulp, paper and lumber producers. From pulp- and sawmills surpluses of biomass by-products is produced, including bark, sawdust and shavings. The surplus from the industry has deceased since pulp mills and saw mills increasingly have used by-products as fuel to reduce the cost of using fossil fuels. In little more than a decade, the forest products industry has become Canada's leader in renewable energy use. In addition cogeneration companies have bought by-products to produce steam and electricity (Doug Bradley, 2005). The estimated available surplus of mill residues from the forest product industry in the different provinces 2004 can be seen in Table 6 below.

Table 6: Mill Residue Inventory (Doug Bradley (2005), see Doug Bradley &Brian McCloy (2004))

Province	Residue production annually [metric Dry ton (Dt)]	Residue surplus annually [Dt]	Bark Piles [Dt]
British Colombia	6554	1815	-
Alberta	2406	481	-
Saskatchewan	580	164	*2900*
Manitoba	225	13	-
Ontario	2602	121	6712
Quebec	6669	100	*5652*
New Brunswick	1373	0	*257*
Nova Scotia	601	13	148
PEI	24	1	*0*
Nfld & Labrador	195	30	*19*
Total	21229	2738	15688

A biomass resource with a huge potential related to the forest product industry is residues from logging operations. The Canadian forest industry harvests 192 million m^3 of wood annually, and at present forest floor residues is not used in large extent for energy purposes. The total potential of forest floor biomass is estimated to 20 million Dt(Doug Bradley (2005), see Susan M. Wood and David B. Layzell (2003)).

Another large potential biofuel source is forests that have been infested of the Mountain Pine Beetle (MPB). There are a massive infestation of the (MPB) in Canada covering over 7 million hectares, which has caused damage and mortality to trees in the province British Colombia (BC). These trees are a potential source of biofuel. It is estimated that approximately 27 million Dt (at 400kg/m3) can be used as biomass for energy (Doug Bradley (2005), see Susan M. Wood and David B. Layzell (2003)).

Other biomass resources available in Canada as bioenergy are agriculture residues, livestock waste and municipal solid waste. Available agriculture residues for energy purposes have been estimated to 173 M Dt (oven dry-tonnes), equivalent to 309 TJ annually. Waste from livestock available for energy in Canada are 58 Mt, which represent a biogas potential of 3.2 billion m^3 pa, or a heating value of 65 M GJ. Although, is this energy mainly intended to supply farms and their requirements. Approximately 23 Mt of municipal solid waste is generated annually in Canada, of which 19 Mt wet or 15 Mt dry is a combustible fraction, equivalent to

224 TJ energy. Most of the MSW is land filled, though some small communities have limited incineration programs (Doug Bradley, 2005).

Table 7: Unutilized Biomass Volumes in Canada

Unused Resources	*Quantity Million Dt*
Forest Floor Residues	*20*
Mountatain Pine Beetle Fibre	*27*
Livestock Waste	*58t*
Agricultural Residues	*18*
Total	*123*

4.2.3 Use of biomass resources in Canada

Biomass resources are mainly refined to BioOil, ethanol and wood pellets in Canada. Large-scale production of BioOil and Ethanol is in the initial phase, therefore are the products not yet exported. The potential is however significant due to Canada's great biomass resources. Wood pellets are produced and refined in large scale industries both for domestic consumption and export to both Europe and USA.

BioOil

Production, utilization and properties of BioOil have been observed by Doug Bradley in the Canadian country report, and are presented below. BioOil from pyrolysis of wood is a brown, free-flowing liquid compromised of highly oxygenated compounds and has a density of 1.2 kg/litre. With fast pyrolysis biomass waste is rapidly heated in the absence of oxygen, vaporized and then condensed into liquid fuel. Its heating value is 40% of diesel by weight and 55% by volume. It can be stored, pumped and transported like petroleum products and can be combusted directly in boilers, gas turbines and slow to medium speed diesels for heat and power (Doug Bradley, 2005).

Canada is regarded as a leader in BioOil technology and BioOil development. There are three systems at an advanced stage:
- Dynanmotive Energy Systems- Uses a patented fast-pyrolysis process that converts forest and agricultural residues such as bark, sawdust and sugar cane bagasse into liquid BioOil, and focusing on modular plants of 100, 200 and 500 metric ton per day (tpd).
- Ensyn Corp- Uses its core technology (Rapid Thermal Processing or RTP™) to transform carbon-based feedstocks, either wood "biomass" or petroleum hydrocarbons, to more valuable chemical and fuel products.
- Ontario Ministry of Natural Resources- is undertaking a bio-refinery pilot to develop and test mobile 50-tpd BioOil units to convert harvest waste in Northern Ontario to liquid BioOil (Doug Bradley, 2005).

The BioOil industry is young and still developing, thus it has not been any trade with commercial BioOil. It is likely that there will be an export of BioOil to Europe due the European market offers significant incentives for use of renewable energy. The export could reach 400.000 tonnes in 2008 and be doubled within four years (Doug Bradley, 2005).

Ethanol

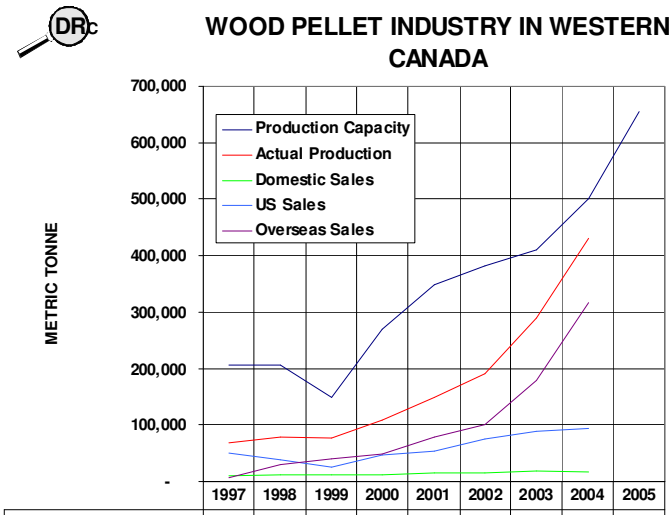
Production of ethanol reached 238 million litres in 2004. Almost all production was from grain except 17 million litres of wood based ethanol. The production from

grain is expected to increase due to the federal governments has announced financial support to the construction of seven new ethanol plants with the capacity to produce over 720 million litres annually. Policies by the provinces supporting ethanol are expected to result in additional capacity, which will bring production over 1 billion litres. In addition, the company Lignol innovations of BC anticipates commercial production of ethanol from woody fibre in 2006. Lignol claims that it will have the lowest production cost for ethanol. If it is successful Lignol may be able to make use of extensive supplies of mill residues and mountain pine beetle fibre in BC to manufacture meaningful amounts of ethanol. The ethanol produced initially is expected to be used within Canada, thus little will be available for export (Doug Bradley, 2005).

Wood pellets

Wood pellets production has reached 600.000 metric tones, but recent capacity expansions will allow production of 755.000 metric tones. The primary source is the available surpluses of mill residues, but also the huge potential from MPB affected stands is a possible source. The historical development of the wood pellet industry in western Canada can be studied in figure 4.

Figure 4: Wood pellet industry in western Canada(Doug Bradley, 2005)



	1997	1998	1999	2000	2001	2002	2003	2004	2005
Production Capacity	205,0	205,0	150,0	270,0	350,0	380,0	410,0	500,0	655,0
Actual Production	68,00	80,00	77,00	110,0	150,0	190,0	290,0	430,0	
Domestic Sales	10,00	12,00	12,00	13,00	16,00	16,00	20,00	18,00	
US Sales	51,00	38,00	25,00	47,00	54,00	74,00	90,00	95,00	
Overseas Sales	7,000	30,00	40,00	50,00	80,00	100,0	180,0	317,0	

The primary market for companies with close proximity to ocean ports in BC, and Mctara in Nova Scotia is Europe, while companies in the provinces Alberta and Quebec export largely in to USA. The Canadian pellets production, production-capacity and export can be seen in Table 8 (Doug Bradley, 2005).

Table 8: The Canadian pellets production and capacity (1000 tonnes pa) (Doug Bradley, 2005)

Manufacturer	*Province*	*Capacity*	*Production*	*Exports*	*Key Market*
Pellet Flame Inc	*BC*	*100*	*60*	*-*	*Europe*
Pinnacle Pellet	*BC*	*-*	*-*	*-*	*Europe*
Premium Pellet	*BC*	*200*	*120*	*108*	*Europe*
Princeton Co-Generation Corp, expansion Mat 2005	*BC*	*75*	*60*	*6*	*Europe*
Armstrong	*BC*	*50*	*50*	*-*	*Europe*
Pacific Bioenergy Corp	*BC*	*140*	*130*	*124*	*Europe*
Dansons-Vanderwell	*Alberta*	*80*	*40*	*32*	*USA*
Energex	*Quebec*	*-*	*-*	*-*	*-*
Advanced Wood	*New Brunswick*	*10*	*10*	*-*	*USA*
Shaw Resources	*New Brunswick*	*20*	*20*	*-*	*-*
Mactara	*Nova Scotia*	*80*	*80*	*80*	*Europe*
Total		*755*	*600*	*350*	

The production capacity will probably increase heavily the next years. In the province BC, alone the production capacity could reach 1.000.000 tones in two years and 1.500.00 within three years. The rate of the pellets industry expansion is hinging on a number of key factors including according to Doug Bradley: license to use pine beetle infested wood at reasonable price, lower cost for railing pellets to the coast, sustained low ocean freight rates and new loading facilities (Doug Bradley, 2005).

The greatest opportunity for pellet export is from BC, the potential is huge due a large surplus of mill residues. In central Canada production capacity is not near ocean ports and thus is largely intended for USA. Nova Scotia on the East Coast has very little mill residues available for additional capacity and province is not currently predisposed to use forest floor waste. In Quebec, reduced wood harvesting will put pressure on the current demand for mill residues; however there is an opportunity to manufacture pellets from the large amount of unutilized forest slash. Plants in Quebec would also be near the port of Montreal. However, the use of forest floor biomass is still an environmental question and is not yet supported (Doug Bradley, 2005).

4.2.4 Barriers to increased Production and Trade

Domestic and International barriers for increased trade of biofuels has been listed in the Canadian country report by Doug Bradley. Even if the possibilities for an increased production and export are huge in Canada are there several barriers that can restrict a possible expansion of the industry. Below follows a list from the

Canadian country report of the recognized domestic and international barriers in Canada.

Domestic

The Canadian bioenergy industry has been faced with a number of domestic economic, social and infrastructural barriers to production and export, including:

1. Until recently, the **availability and low cost of energy,** including fossil fuels and grid electricity, compared with much of the rest of the world. Now, sharply higher thermal energy and electricity prices in Canada will likely induce the production and use of biomass locally.

2. **Awareness** of biomass energy as an option. With the exception of forestry and energy companies, the populace is largely unaware of biomass as an option for heating or power. Solar and wind power options are perceived by the public as cleaner for the environment.

3. **Lack of capital** financing. In many remote communities the use of biomass to reduce fossil fuel costs would be viable, but capital to convert the system is not available.

4. **High capital costs** for installation.

5. **Small**, **widely separated biomass sources**. In many regions, forestry and energy companies have absorbed the larger pools of residue from pulp mills and sawmills for cogen. Now forest floor and other sources are being considered to enhance supply options.

6. **Availability and cost of biomass.** – With traditional sources of biomass largely dried up and increasing demand for biomass, this commodity formerly hauled away at no charge now demands a price.

7. **Undeveloped supply chains** for biomass. Forest floor biomass harvesting is only at the trial stage, and cost-effective supply chains have not been developed.

8. **2-year payback** requirements for energy investments by the forest industry. Heavy offshore competition and an uncertain future for pulp mills and sawmills dampen willingness to spend capital on non-core business, such as energy. Most forestry companies have had a 2-year payback requirement for over 20 years.

9. **Lack of domestic markets** for pellets, BioOil and ethanol. Markets do exist for pellets and ethanol in Canada, but they are small. Increased pellet capacity requires export markets, and the same is thought to be true of BioOil initially. The domestic market for ethanol is anticipated to absorb production increases.

10. **Lack of access to the grid** for power production. The bureaucracy created for provincial power utilities has been slow to change and allow new power into the grid at a fair price, however this is beginning to change.

11. **M**arginal and **complex domestic government incentive programs**. Most programs have been targeted at small installations and have caps that make them ineffective for large projects. Often the administrative effort to get an incentive is not worth the effort to apply for it.

12. **NGO misinformation on bioenergy**. The populace and NGOs have not been supportive of bioenergy projects because of long-held beliefs on particulate emissions common in outdated bioenergy installations. For example, the Greater Vancouver Regional District prohibits the use of biomass unless emissions are less than the natural gas option, without taking into account GHG emissions considerations. Ontario does not permit combustion of municipal waste.

13. **No national standards for pellets**. Canada has no national standard for wood pellets, however the BC Pellet Fuel Manufacturers Association is attempting to establish such a standard based on the Swedish, Austrian and other standards.

14. **Risk of change in Kyoto carbon accounting.** While biomass neutrality is expected to be maintained for Kyoto accounting, it is unclear what impact adding the managed forest, including slash, will have on carbon crediting.

15. **I**mplementation **Climate Change Initiatives**. Implementation of the Large Final Emitter System and of the associated Offset Trading System will tend to promote domestic use of biomass (Doug Bradley, 2005).

International trade

While pellet trade with Europe is in full swing, there are many barriers to enhanced trade in pellets and other biofuels, including:

1. **Indirect trade barriers** for import in certain areas of Europe. For example, the UK is promoting domestic supply of biomass and restricts subsidies if the imports exceed certain limits, resulting in almost no trading of pellets into the UK. Consequently, no receiving facilities exist for large size vessels.

2. **No common standard for pellets.** Some countries in Europe have pellet standards, some have none, and even those that have are different. A common standard is preferred, and it is understood that this initiative is underway.

3. **High Freight Costs.** A sharp increase in shipping costs in 2003 made trade between Canada and Europe difficult. Biomass power facilities require an uninterrupted supply of feedstock, and Canada was often considered a supplier of last resort to absorb uncertainties. It is important to establish a supply chain with consistent freight costs.

4. **BioOil an unknown product.** Research has been underway on applications and there are many proven uses in research, but there is not enough production of BioOil yet and it needs to be tested commercially.

BioOil is now being produced and tested commercially in a combustion gas turbine at the Ontario plant.

5. **Special Freight Conditions.** Unlike other fuels, BioOil has a density of >1 and a low PH, and therefore may need specific transportation requirements(Doug Bradley, 2005).

4.2.5 Analysis Canada

Canada exports large quantities of wood pellets to Europe and US, which can be explained by several reasons, including: available surpluses of biomass resources for production of wood pellets, knowledge and infrastructure to handle biofuel, access to ocean ports and a relative immature domestic market.

The potential of exporting biofuels from Canada is huge due large unused biomass resources. Export of wood pellets is likely to increase the coming years due increased production capacity. In a longer perspective Canada can also become a major exporter of BioOil and ethanol. The production capacity of both fuels is at the moment increasing from low levels. Initially the production is devoted for the domestic market, but in a longer perspective Canada can have the capacity to supply the world market of these fuels due the very large available biomass resources.

4.3 Finland

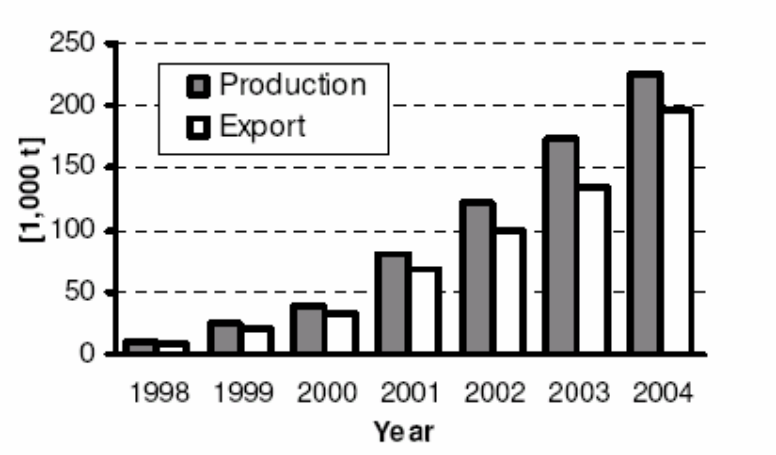
Finland trade with large quantities of biomass, the main flow of biofuel is through indirect trade. Looking at the overall picture Finland is a net importer of biofuels, however if only studying direct trade Finland is an exporter (Jussi Heinimö & Tapio Ranta, 2005).

4.3.1 Development of Finland's trade with biofuels

Procurement of raw material to the forest product industry represents the largest biomass flow, through indirect import. The Finnish forest product industry has a great deal of experiences in raw wood importation. During the period between 1990 and 2004 the annual raw wood import increased from 6.0 million m^3 to 17.4 million m^3. In 2004, imported raw wood corresponded to 23 % of total utilized raw wood in the forest product industry. Russia was the major exporter, provided 80 % of the imported wood, followed by the Baltic countries, which provided with 13%.

Production of wood pellets at an industrial level started in 1998, and production has increased rapidly ever since, se figure 5. In the beginning production was founded only for export. This has however changed in recent years, and the domestic consumption of wood pellets has increased. In 2004, Sweden, Denmark and the Netherlands were the main importer of wood pellets from Finland (Jussi Heinimö & Tapio Ranta, 2005).

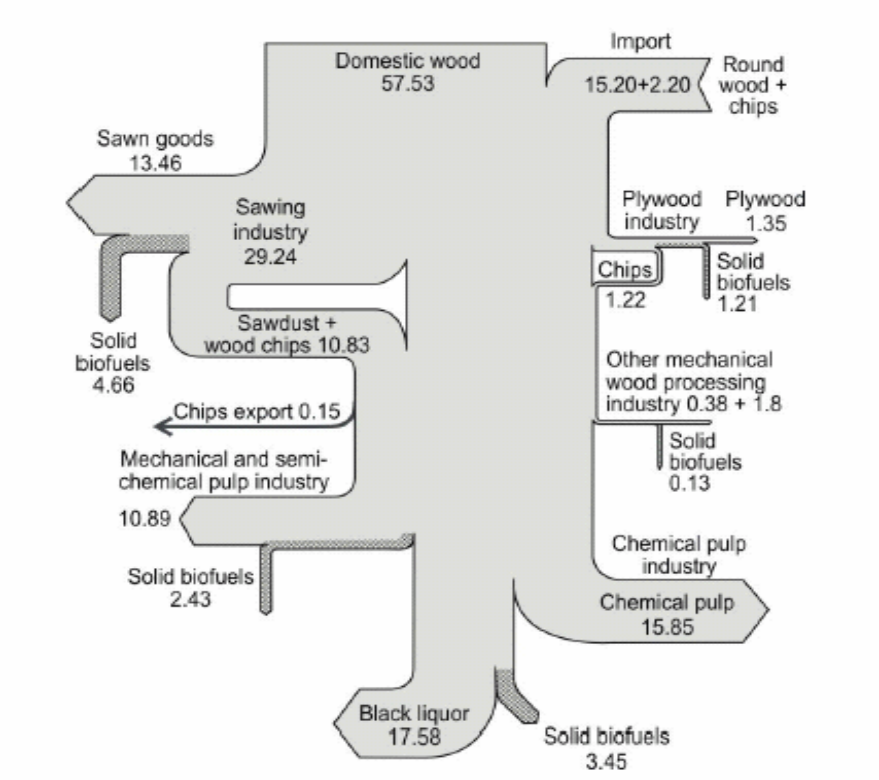
Figure 5: Wood pellets production and export volumes in Finland. (Jussi Heinimö & Tapio Ranta, 2005)



4.3.2 Current trade with bio fuel to and from Finland

The major flow is imported through indirect trade of the forest product industry as mentioned earlier. However, a large part of the imported wood ends up in energy production or is converted into by-products. The flows of biomass in the Finnish forest industry 2004 is estimated and illustrated in Figure 6 (Jussi Heinimö & Tapio Ranta, 2005).

Figure 6: Wood flows in the Finnish forest industry, 2004.



The total import 2004 was estimated to 60.4 PJ, and the total export to 10.9 PJ. A major part 55.8 PJ came through indirect trade, and 4.4 PJ through direct trade. Of the exported biofuels, were 8.5 PJ direct trades and 2.4 PJ indirect trades. The estimated of import and export volumes to Finland in 2004 can be studied in Table 9 below.

Table 9: Export and import balance of biofuels in Finland, 2004 [PJ] (Jussi Heinimö & Tapio Ranta, 2005)

Table 9	*Import*	*Export*	*Net flow*
Direct trade:			
Wood pellets	*0*	*3,4*	*-3,4*
Peat pellets	*0*	*0,4*	*-0,4*
Energy peat	*0,2*	*0,2*	*0*
Fuel wood	*0,9*	*0,1*	*0,8*
Wood residues	*1,2*	*0*	*1,2*
Tall oil	*2,1*	*4,4*	*-2,3*
Indirect trade:			
Round wood	*50,7*	*2,0*	*48,7*
Chips	*5,2*	*0,4*	*4,8*
Sawdust	*0,1*	*0*	*0,1*
Total	*60,4*	*10,9*	*49,5*

4.3.3 Development of biofuel in Finland

Finland's energy policy has the objectives to ensure the availability of energy, to maintain competitive energy prices, and to meet international emission commitments. There is an action plan for renewable energy sources in Finland with the goals (see also Table 10) to increase the use renewable with 50% by 2010, compared with 1995. The action plan does not state a clear opinion of biofuels as traffic fuel; however is the preliminary target 3.1 PJ in 2010. The EU directive green paper on security and supply has set a target of 5,75 %, which approximately corresponds to 10.5 PJ.

Table 10: Realized energy use in 2004 and government targets for 2005 and 2010, by type of renewable energy source, PJ (Jussi Heinimö & Tapio Ranta, 2005)

Source of energy / year	*2004*	*2005*	*2010*
Traditional firewood	*44*	*50*	*54*
Forest chips	*19*	*22*	*38*
Black liquor	*158*	*143*	*154*
Solid processing residues	*81*	*80*	*84*
Wood-based total	*302*	*295*	*330*
Hydro power	*53*	*49*	*52*
Other renewables	*11*	*15*	*30*
Renewables total	*366*	*359*	*412*

Measures to implement energy policies in Finland are energy taxation, tax relief, production subsidies and funding of research and development projects. Generally, the Finnish financial incentives to utilize biomass in energy production are at a quite moderate level compared to other EU countries that apply considerably stronger financial measures. In addition the support system of bioenergy has been almost constant for several years (Jussi Heinimö & Tapio Ranta, 2005).

4.3.4 Forces and key issues for international trade with biofuels

The main direct biofuel flow is export of wood pellets, which mainly is explained of differences in policy incentives between Finland and other countries. The differences cause a relation were wood pellets end-users abroad have higher capacity to pay than Finnish customers. Policy incentives that differ are especially taxation of fossil fuels in heat production and subsidies for electricity from biomass.

Three key issues for Finland's for future international biomass trade have been stated in the Finnish country report.

1. The development of indirect trade with biomass due by-products from the forest industry is the major source of bioenergy and biofuels.
2. The development of fossil fuel prices or the energy taxation of fuels used in heat production. A higher price would result in an increased domestic consumption of pellets.
3. Future consumption of biofuels used in traffic. If the EU target of 5,75 % is implemented, how much can be produced by domestic raw materials and how much import is needed (Jussi Heinimö & Tapio Ranta, 2005).

4.3.5 Comments about Finland

Finland is a net importer of biomass; the import is however mainly intended for the forest product industry. If comparing only direct trade with biofuels; then Finland is a net exporter of biofuels. The export mainly consists of wood pellets and tall oil, which originates from the forest product industry. The biofuel industry is well developed in Finland, and the utilization of available biomass resources for biofuel is high. Both by-products from the forest product industry and from cutting operation are used for production of biofuels.

It is likely that Finland will increase their domestic use of biofuels due to policy incentives. It is therefore assumed that the export will decrease and the biofuel will be used whiten the country. The future production is however closely related to indirect import of biofuels, which is controlled of factors not directly related to biofuels. These factors are outside this reports extent, and will therefore not be studied in this report. Because of this it is hard to predict the future development of biofuel production in Finland. Thus, assuming the indirect import will be the same then it is likely that the export will decrease.

4.4 Netherlands

Biofuels are an important energy source in Netherlands energy matrix, especially for production of electricity. Biofuels in Netherlands consist of liquid fuels, agro residues, unrefined biofuels and by-products from the agriculture and food industry.

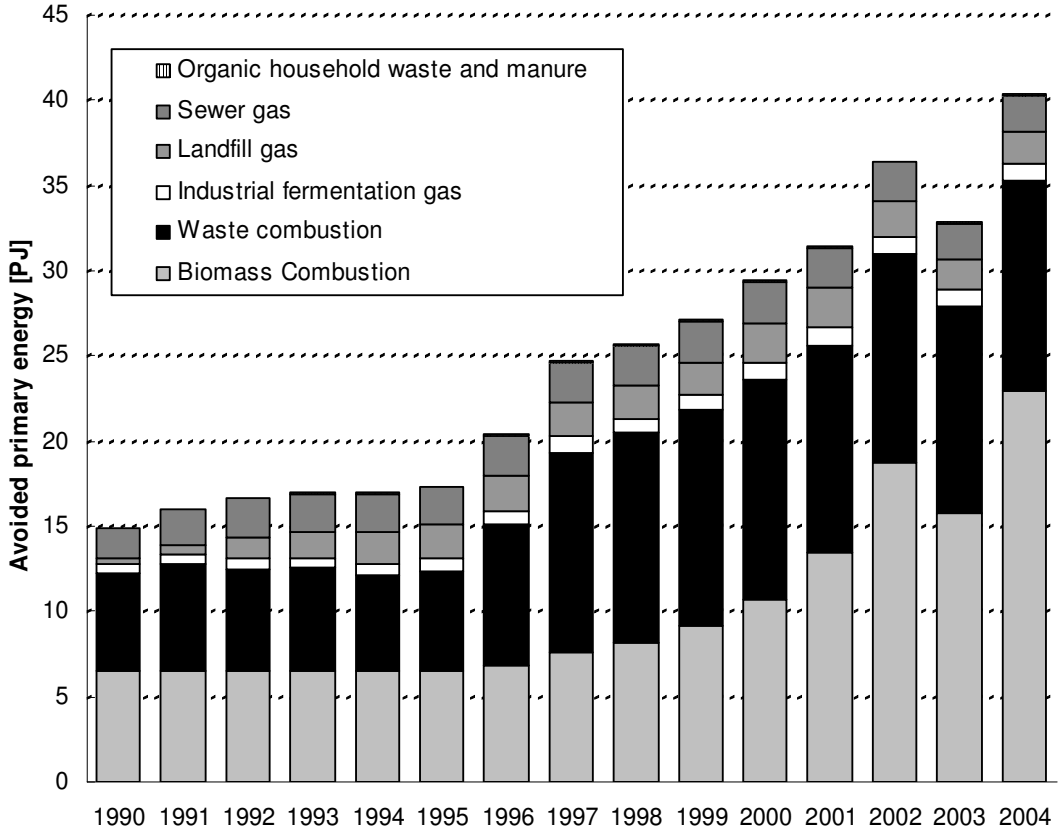
4.4.1 Development of the trade and use of biofuels in Netherlands

The production of renewable energy has considerably increased in Netherlands the last five years, as a result of police measures. This has also involved an increased use of bioenergy. The main market deployment policy instruments that have been used are fiscal measures/investment subsidiaries and feed-in tariffs/tax exemptions. The fiscal measure Energy Investment Deduction (EID) allows investments in certain technologies to be deducted from taxable profit up to a percentage of investment costs in the first year. There have been two tax exemptions systems in the last five years first a Regulation Energy Tax (RET), which is an energy levy on electricity and gas consumption by small and medium size customers. Energy from renewable sources was exempted from this tax in the period between 2000 and 2004. The RET system had to be phased out mainly because it caused high amounts of imported electricity. In the period 2003-2004 the RET were replaced by a feed-in tariff system (MEP). The MEP tariff is paid to the producer of renewable electricity, who feed in on the Dutch electricity grid (Martin Junginger & André Faaij, 2005).

The different biofuels and techniques that are and have been used in Netherlands are Municipal Solid Waste (MSW)- combustion, co-firing in coal and natural gas plants, biomass plants and biomass digestion. The MSW- combustion was the main biofuel source in Netherlands in 1990, the production of both electricity and heat from waste combustion increased until 1997. The contribution from the combustion has since then remained more or less stable at about 12 PJ. The municipal waste are produced in Netherlands and don't influence the international trade of biofuels.

In 1990 Dutch energy companies began to co-fire biomass and coal, mainly waste such as paper sludge and demolition wood. Power companies' combusted specific types of fuel, in particular demolition wood and sewage sludge. The reason was a surplus of these fuels rather than a demand for renewable energy. In the beginning the focus was on experimenting with small amounts of biomass. In the late 1990s, the focus shifted towards larger amounts of biomass and permanent co-firing. After 2000, production companies intensified their co-firing activities, the main reason being a covenant between the power producers and the Dutch Ministry of the Environment, signed 2002, and the increasingly high RET-tax exemption (and later on MEP feed-in tariffs for co-firing clean biomass). The biofuel that are used and have been used in co-firing plants, are to large extent imported to Netherlands. Fuels that are used in the plants are pellets, biofuels from the food industry, wood chips, waste wood, vegetal oils and derivates. There are also a number of combustion plants that only use biomass as fuel in Netherlands. The biomass plants contribute with 13 PJ of energy. All biomass combustion plants are fuelled by local biomass, and consequently don't affect the international trade with biofuels. Biomass digestion is also used in Netherlands, the contribution of energy correspond to 0.03 PJ. The production is expected to increase strongly to 0,3 PJ over the next years. Digestion plants are using domestic fuels and don't affect the international trade with biofuels. The development and use of different types of bioenergy in Netherlands can be studied in the Figure 7.

Figure 7: Production of electricity and heat from biomass in Netherlands



4.4.2 International trade with biofuels in Netherlands

There are no official static's on exact volumes and sources of the traded biofuel to and from Netherlands, as this information is treated as confidential. There are however estimated figures presented in Netherlands County report, which are presented below.

There are both an import and an export of biofuels, mainly an import. In 2004 the total import was 20.2 PJ, while 13.4 PJ was exported. At the moment there are no trade with biological motor fuels to and from Netherlands. There is however an import of the liquid biofuel; bio-oil, the import reached 15 PJ in 2004. Netherlands also imports by-products from the agriculture and the food industry. The total import of by-products reached 0.9 PJ. The fuel originated from different countries, according to Essent, the largest user of biomass in Netherlands. Approximately 30 % of the imported biomass originates from North America, 25% from Western Europe 20% from Asia and the remaining from Africa, Eastern Europe, Russia and South America (Essent 2005). According to the port of Rotterdam and several biomass traders, biomass pellets mainly originated from South Africa, North America (mainly Canada) and South America (e.g. Chile and Brazil), while agriculture residues were imported from Malaysia, Thailand and Mediterranean countries.

The exported biofuels are principally different kinds of wastes. Two-thirds of the volume is from contaminated waste wood, demolition wood etc. Most of this material is exported to Germany and Sweden.

An overview of Netherlands international trade with biofuels 2003 and 2004 can be studied in Table 11 and 12.

Table 11: Import of biofuels to Netherlands

Import	*2003*		*2004*[7]	
	kton	*PJ*	*kton*	*PJ*
Wood pellets and other wood streams	*80*	*1,4*	*420*	*6,3*
Agro residues	*55*	*0,9*	*-*	*-*
Bio-oil	*5*	*0,2*	*90*	*3,4*
Others (Bone meal, paper sludge etc.)	*0*	*0*	*15*	*0,15*
Total	*140*	*2,5*	*525*	*9,85*

[7] (The exact composition of biomass fuels used in 2004 in coal power plants were considered confidential by some power producers. The number presented are (rough) estimates)

Table 12: Biofuels exported from Netherlands

Export	*2002-2003*		*2004*[8]	
	kton	*PJ*	*kton*	*PJ*
Construction & demolition waste (wood waste)	*430*	*6,6*	*419*	*6,4*
Remaining fraction from construction & demolition	*503*	*4,5*	*475*	*4,3*
Paper/plastic fraction from household waste	*151*	*2,0*	*147*	*1,2*
Pellets from RDF	*107*	*1,5*	*76*	*1,1*
Others	*449*	*0,4*	*372*	*0,4*
Total	*1639*	*15,1*	*1489*	*13,4*

4.4.3 Driving forces behind Netherlands trade and use of biofuels

Netherlands environmental- and energy policies strongly promote use of renewable energy and biofuels. The main policy driver for import of biofuel is the feed-in tariff on electricity production and for export it is a levy on using combustible material for landfills and difficulties to obtain permits for co-fire contaminated wood waste.

The imported biofuel is almost 100% used in Dutch co-fired power plants. Until 2000, Netherlands barley imported biofuel at all. The import has since then strongly increased due a covenant between the power producers and the Dutch Ministry of the Environment, and the RET-tax exemption (later replaced with the MEP feed in tariffs).

The main exported biofuel or two-thirds of the total exported volume is from contaminated waste wood, demolition wood etc. The trade can be explained by that combustion of contaminated waste is problematic, because of the strict air emissions levels and problems with obtaining emissions permits. To landfill with a combustible material in Netherlands a high tax has to be paid. It is however allowed to export waste if 50 % or more are used for any useful applications, e.g. as material or fuel. Given the relatively large waste combustion capacity in Germany and relatively low waste tariffs, the export levels have risen strongly from 2001 onwards, when the tax on landfills was introduced in the Netherlands.

4.4.4 Barriers for trade and use with biofuels in Netherlands

Several different barriers for use and trade of biofuels have been identified in Netherlands country report. The Dutch Biomass Action Plan has listed general barriers for a further market diffusion of biomass in Netherlands.

- Financial support for energy from biomass
- Acquiring permits for new biomass energy plants
- Absent knowledge on biomass with local authorities and consumers
- Absence of a clear definition of sustainable biomass
- Availability of biomass and absence of a level playing field

Biomass traders in Netherlands have also listed a number of barriers and expectations in Netherlands country report.

[8] All export data on 2004 is based on total export volumes, and the assumption that the share for use as fuel was the same as in 2002-2003.

• *Competition with application as fodder production or food production* - In case of a strong increase in combustion of agro-residues, scarcity of fodder products may occur , and thus a price increase. Also, the fodder industry sees the feed-in tariff for electricity from biomass as an indirect subsidy for agro-residues. On the other hand, also the fodder market is subsidized.

• *Increasing international competition* - Some traders expected a growing demand for cheap biomass streams in the mid-term (5-10 years) in developed countries, but also in developing countries (local production for local use).

• *Reluctance to use new biomass streams* - Power producers are generally reluctant to experiment with new biomass streams, e.g. bagasse or rice husks. As these streams often do not have the required physical and chemical properties, power producers are afraid to damage their installations, especially the boilers. On the longer term, the limited ability to use different fuels may lead to a restricted availability of biomass fuels.

• *Immature market* - Due to the small size of the biomass market and the fact that biomass waste streams are a relatively new commodity, the market is immature and unstable. This makes it difficult to include a risk for long-term, large-volume contracts. One trader estimated the current upper boundary for wood pellets of approximately 100 €/ton may significantly increase in the near future due to increasing demand and lacking capacity on the supply side to satisfy this demand.

• *Lack of significant volumes and associated professional logistics* - In order to achieve low logistics costs, larger volumes need to be shipped on a more regular basis. Only if this is assured, the there will be investment on the supply side (e.g. new biomass pellet factories).

• *Lack of commitment of the Dutch government and energy producers* - Large volumes can only be achieved, if the demand side (i.e. power companies) commit themselves to largescale use. Given the current problems with obtaining emission permits and the missing financial security for co-firing biomass, this commitment is currently too small.

• *Import restrictions* - As some biomass streams have not been imported before, so far no specific import regulations exist. Also, most residues streams that contain (traces of) starch are considered potential animal fodder, and are thus subject to EU import levies. For example, rice residues (e.g. rice husk) containing 0-35% starch are levied 44 €/ton (i.e. about 3.1 €/GJ) (Birkhoff, 2005). For denaturated ethanol of 80% and above. The import levy is 102 €/ m^3 (i.e. about 4.9 €/GJ), i.e. quite substantial amounts compared to general biomass prices (compare to figure 7). Other biomass streams such as wood pellets are not taxed.

4.4.5 Analyse of Netherlands

Netherlands is a net importer of biofuels, which partly can be explained by lack of domestic resources and limited possibilities for domestic large-scale production of biofuels. Due the high density of population, together with their knowledge and experiences of trade and shipping, and partly due favourable conditions of co-fire biofuels in coal power plants. The consumption is also strengthening of policy measures that promote use of renewable energy, e.g. the feed-in tariffs.

4.5 Norway

The Norwegian experience of trade with biofuels is limited, mainly because the market for biofuels is immature. The lack of development on the Norwegian market can partly be explained by low prices on alternative energy, which causes bad conditions for use and trade with biofuels with missing logistics, few actorsS and a limited capital market. At the moment Norway has no international trade of biofuels (Havar Risnes, 2004).

Norway's biomass input to the energy sector are currently approximately 15 TWh annually, approximately half is used in traditional wood firing. However, the Norwegian government has the ambition to increase the use of renewable energy in heat production; the goal is to increase the production with 4 TWh within 2010 (O. Hetland & B. Otterstad, 2004).

The future market potential in Norway is significant; the biomass potential on "close to commercially sound" basis is about 10TWh (Havar Risnes (2004), s. 1, see Risnes et. Al (2003)).

4.5.1 Barriers and key issues for further development in Norway

The Norwegian market for biofuel is immature, which partly can be explained by low prices on alternative energy. This situation creates bad conditions for use and trade with biofuels, with the limiting factors:

- Missing logistics
- Few actors
- A limited capital market

4.5.2 Measures to develop the Norwegian market and trade

In order to increase the competitiveness of biofuel in Norway, it is concluded that governmental actions primarily should be directed towards measures, which can contribute to market growth, both on short and long term.

Consumers of bioenergy in Norway require increased fuel supply flexibility through international trade and an increased market transparency. This is crucial on short terms to reduce the economic risks. To further reduce the risk a market place for financial and physical trading is wanted. A market place has the potential to increase future cost efficiency (Havar Risnes, 2004).

4.5.3 Analyse of Norwegian Trade

The Norwegian market is partly limited due low prices on alternative energy, missing logistics, few actors and a limited capital market, And partly due an unsuitable energy infrastructure with a low need of new energy sources. Because Norway produces large amounts of energy in hydropower plants and has large resources of fossil fuels.

At the moment Norway has no international trade with biofuels. The potential for export is however large due Norway has unused resources of biomass and a forest product industry that produce by-products. In addition Norway has access to ocean ports and fjords to transport biofuels effectively. It is therefore assumed that Norway in a near future will start to export biofuels.

4.6 Sweden

Sweden is an important actor on the international bioenergy market, with a long history of trading biofuel and biomass. At the moment Sweden is a net importer of biofuels, but has the capacity to become an exporter.

4.6.1 Development of the Swedish trade

International trade of biofuel to and from Sweden started in the period 1975-1990 with small-scale import of cheap bio waste, mainly from the food industry. The biofuel could compete with coal in a direct prize comparison. In 1990 the import increased when access to a new source of cheap biofuel in the Baltic States was opened. Import also increased from Germany and Holland because of stricter rules for wood waste handling, which resulted in a flow of cheap recovered wood to Sweden (Bo Hektor & Erik Ling, 2004).

4.6.2 Biomass Flows to and from Sweden

The official statistics is a poor source of information for biomass import. Biomass is imported under different definitions and it is often mixed with other categories of products. This is especially true for wood in unrefined forms.

The current international trade is mainly import of wood products. The total import 2004 was roughly 92.3 PJ. An essential part was imported from the Baltic States and Russia through indirect import of round wood and chips. The total indirect import was 59 PJ, thus were the remaining 33.3 PJ imported through direct import. Unrefined biofuels from the Baltic's and Russia correspond to 26 PJ. Pellets are mainly imported from Estonia, Latvia and Canada. The total amount of imported pellets corresponded to 1.3 PJ in energy, it should also bee noted that Sweden exported 0.03 PJ pellets.

Sweden also imported motor fuels, namely 200.000 m3 of ethanol from southern Europe's wine industry and Brazil's Sugar industry. The ethanol is either used as low mix, 5 % in petrol or as ethanol fuel with 85 % mix of ethanol.

Other biofuels that were imported to Sweden was tall oil and residues from the food industry to an amount of 6 PJ (Bo Hektor & Erik Ling, 2004).

4.6.3 Development of future trade

The Swedish government has recently introduced two instruments that probably will affect the future use and trade with biofuels. The instruments are electricity certificates and tradable emission rights. It is especially likely that the process industry will increase their use of biomass fuels and thereby also their import.

4.6.4 Driving forces in Sweden

There are several strong driving forces behind the extensive Swedish trade. Recognized forces in Sweden are:

- Differences in policy incentives
- Cost structure
- Incentive from a procurement perspective
- Incentive from a sourcing perspective(Bo Hektor & Erik Ling, 2004)

Differences in policy incentives and the international cost structure
Governments in Sweden have for a long time worked for a higher share of renewable energy in the country. This has been done through incentives focusing on the energy market, which have resulted in an increased demand for renewable energy and thereby also biofuels. The incentives for use of biofuels in Sweden were earlier higher than in exporting countries, which made it favourable to import biofuels from these countries. The current governmental incentives on production and use of energy in Sweden can be studied below:

Carbon dioxide taxes - Tax on fossil fuels,

Energy tax – Tax on fuels, the tax rate are individually set dependent on the fuel properties. Bio fuels don't normally have to pay this tax, except tall oil. The reason is to protect the chemical industry within the country.

Sulphur taxes – tax on fuel which contain sulphur, e.g. coal, oil and peat.

Tax on nuclear power – A power tax on nuclear power plants.

Renewable certificates – Imply that a share of the consumers' electricity have to be renewable.

Emission trading – the possibility to by and sell rights to emit GHG (Kungliga Ingenjörsakademin, 2003).

Incentive from a procurement perspective
From a procurement perspective there are a number of factors that are positive for import and act as force for an import of biofuels:

- Competitive fuel costs
- Risk distribution
- Negotiation power

Incentive from a sourcing perspective
There are also aspects of import that are positive from a sourcing perspective. The aspects are:

- Synergies with the import timber and pulp logs
- Fulfilling sourcing agreements in an efficient way (Bo Hektor & Erik Ling, 2004)

4.6.5 Barriers in Sweden

There are three types of barriers identified for Swedish trade. The identified barriers are:

- Technical barriers – has to do with problems to describe and measure quality and energy content in an efficient way. In some cases especially when it comes to ethanol but also with pellets it can be problematic to obtain a product of high enough quality.
- Shipping related barriers – are cost driving aspects of shipping biomass for energy. Harbour facilities are often not equipped in fashion that

enables cost efficient handling of the products. In addition to that there are no real shipping fleet ready and design to take on the shipping of biomass for energy.

- Quotas – European and Swedish import of ethanol is regulated with quotas that of course limit the possible import (Bo Hektor & Erik Ling, 2004).

4.6.6 Analysis of Sweden

Sweden is a significant actor on the international bioenergy market. Swedish companies trade with large quantities of biofuels and biomass annually, and have done that for a long period of time. At the moment Sweden is a net importer of biofuels, but has the capacity to become a net exporter. There several factors that has contributed to Sweden's strong position in the biofuel market. Among other policy measures that promote bioenergy and other renewable energy sources, a significant forest product industry and a suitable energy infrastructure with district heating systems. It is also likely that Sweden has had relative low barriers or obstacles for use of biofuels, which has contributed to this positive development.

5 DEVELOPMENTS OF FUTURE USE AND TRADE

In previous analyses it has appeared that the global demand of biofuels is projected to continue to increase rapidly in the future, see chapter 5.1. A prerequisite for an extensive global increased consumption of biofuels is however that biofuels can be supplied to competitive costs. In order to do so international trade is needed from regions with good conditions for production and trade to regions in need of energy and suited for import. At the moment are international trade with biofuels not that extensive, but it is increasing rapidly. An important reason that international trade have been restricted is that there are obstacles and trade barriers, which restrict possible trade and use (see 5.2 Barriers for international trade with biofuels). In order to improve the conditions for trade and use, it is important that the identified barriers are reduced, but also that the rationales and driving forces behind existing trade is strengthened. In section 5.3, has rationales and driving forces behind existing trade from the studied countries been identified. The need of bioenergy and international trade of biofuels differ between the studied countries. In section 5.4 are previous analyses put together for each country, in order to predict the individual biofuel development in each country.

5.1 General indications for a growing global demand of biofuels

The global demand of biofuels will most likely be much more intensified then current in a near future, several factors indicate a development like this. The most fundamental factors are a growing global demand of energy, an increased awareness and knowledge of the environment, and the fact that conventional energy resources are running dry. The growing global demand of energy is trigged of a global economical growth. According to the International Monetary Fund will the real world GDP grow 4, 3 % 2006, and continue to grow the coming years. The improved awareness and knowledge of the environment has caused an increased demand of renewable energy; a concrete example of this is the Kyoto Protocol, which mainly is a result of the green house effect. Simultaneously, are conventional energy resources running dry, which results in an increase competition of the remaining available resources. Increased competition implies a higher price, which is the case for oil (see chapter 3.1; figure 2). Higher prices on alternative energy sources enhance biofuels ability to compete, which naturally is an incentive for consumption of bioenergy. Other factors that are likely to increase biofuels ability to compete with other energy sources are technical development and innovations due to an increased efficiency and effectiveness.

5.2 Barriers for international trade with biofuels

In this section barriers and the restricting factors will be analyzed, identified barriers are:

- Insufficient spreading of existing technique, which causes lack of technical skills.
- Institutional obstacles and problems.
- Lack of knowledge and uncertainty.
- The absence of entrepreneurs.
- Resistance from other interested parties, both through direct and indirect resistance.
- Lack of global professional logistics

5.2.1 Insufficient spreading of existing technique, which causes lack of technical skills

Biofuel has the capacity to be a competitive and favourable fuel or resource in several countries. This is however limited due that the most competitive technique is not used in different processes, which cause a low profitability and thereby less investments and use of biofuels. The insufficient spreading of existing techniques both limits possible exports and import.

5.2.2 Institutional obstacles and problems

There are several institutional barriers for biofuel trade and use. Institutional obstacles can be divided into barriers that direct restrict trade and indirect barriers, which restrict production and consumption of biofuels. Identified factors that direct restrict trade are the trade restrictions: tariffs and quotas due the costs of trade increase. Biofuels that especially are influenced by these restrictions are those within the agricultural rule systems. The restrictions do however differ from country to country and what type of products that is intended. Examples from country reports of direct trade restrictions are quotas on import of ethanol to Sweden/EU and import of biofuel residues that contain starch to the EU. Another example is export of ethanol to USA from Brazil, which is limited obviously to protect the interest of corn producers and related ethanol producers.

Indirect institutional obstacles and problems are measures that affect the production or consumption of biofuels, and thereby possible trade. There are several examples of this in the country reports: legislation, permissions, governmental support for utilisation of domestic biomass resources, protecting of competing industries and existing jobs or lack of strategic investments in biofuel facilities etc. An example of indirect barriers is experienced by Canada with regard to export to certain areas of Europe for example to the UK where the support systems in reality discriminate large-scale import of biofuels.

5.2.3 Lack of knowledge and uncertainty

Lack of knowledge and information about biofuel trade and use cause an uncertainty, which restrict possible trade. There is an uncertainty in several fields, e.g. measure and describe quality and energy content, handling contaminated residues and effects of combustion. Biofuel is defined as a fuel produced directly or indirectly from biomass (Swedish Standards Institute, 2004), within this definition is there room for several fuels with different properties and chemical structure etc. Further, are not all biofuels are homogeneous and specific biofuels are not identical, e.g. can various pellets have different moisture- and ash contents. The various biofuels with various properties need different knowledge of combustion, handling, storage etc. and comprehensive and new information and data are needed. Extreme examples of a biofuel with different properties are municipal solid waste, which contain various amounts of biomass and other substances. Other factors that cause uncertainty are related to the fact that biofuels are relative new products on the international market.

In the country reports have Netherlands and Sweden identified lack of knowledge and uncertainty as a barrier for trade and use of biofuels. Power producers in Netherlands are reluctance to experiment with new types of biofuels e.g. bagasse and husks. The main reason is that the fuels do not have the required physical and chemical properties. There is also an experienced uncertainty because that the market for biofuels is immature and unstable due to the small size of the biomass market and the fact that biomass waste fuels are relative new products. This makes it difficult to include a risk for long-term, large-volume contracts. In Sweden technical barriers have been identified, which have to do with problems to describe and measure quality and energy content in an efficient way. In some cases especially when it comes to ethanol but also with pellets it can be problematic to obtain a product of high enough quality

The experienced uncertainty will probably decrease with additional experience and knowledge of new types of fuels. It is however of great importance that information is exchanged between countries in order to rapidly decrease the uncertainty. An action to decrease uncertainty could be to develop international standards for biofuels.

5.2.4 The absence of entrepreneurs

The need of new alternative energy sources is increasing, especially renewable. The potential in a global increased consumption of biofuels is therefore great, as biofuels are an economical competitive and environmental friendly alternative. However, as mentioned elsewhere in this report , bio-energy being a new and vulnerable industry suffers generally from lack of institutions, e.g. for financing, education and logistics especially with regard to international trade. Entrepreneurs and small and medium sized enterprises often lack resources to overcome these deficiencies, which may restrict their possibilities to grow and to exploit their specific opportunities. Generally this may harm and slow down a sound global development of bio-energy.

5.2.5 Resistance from other interested parties, both through direct and indirect resistance

There are stakeholders that have an interest in limiting the use and trade of biofuels, especially competitors of the raw material and companies that produce and use

other types of energy sources. But also a few NGOs resist bio-energy trade claiming that the risks for negative social and environmental effects are not fully controlled. There are also a few countries that indirect resist trade through protecting domestic production of biomass and other natural resources. The resistance can be practiced in different ways e.g. lobbying, support and strategic investment in other energy sources.

Biomass is mainly used as raw material in the industrial sectors agriculture, energy, food and forest. A global increased use of biomass for energy would imply a higher demand and thereby more expensive biomass. It is therefore competing industries of biomass resources is likely to make resistance. Examples of resources used for several purposes besides biofuels are e.g. by-products from the sawmill industry, which also is used by pulp mills and the particle board industry. Another example is fodder, which also is used in the agriculture as food and in the food industry as grain. Companies that are in a direct competition with biofuels are mainly energy companies that have made investments in a certain technology, and supplier of alternative fuels. For examples are companies that use and trade with coal and gasoline likely to make resistance due their fuels can relative easily be substituted of biofuels

5.2.6 Lack of global professional logistics

In order to stimulate international trade the total logistics system need to become more effective. An increased efficiency and effectiveness would imply that new biomass sources would be profitable for production and trade. The logistics costs are closely related to infrastructure and transportation systems. The most favourable mean of transportation are ships; therefore it is an advantage if the biofuel sources and consumers have access to sea and ports. If it is not possible to ship biomass, the second most favourable mean of transportation are trains followed by trucks. An adaptation of infrastructure for trade can however be problematic due to the allocation of the costs, but also because it is very large investments over a long period of time. Governmental investments can be limited because short term goals and other priorities, especially in developing countries. While private investment opportunities often are restricted by institutional rules and by reluctance to commit capital into long-term investment in projects in which at least partly are controlled by political decision makers. Nevertheless long-term investments in infrastructure of governments would be an interesting support measure and an incentive for an increased international trade with biofuel.

Netherlands and Sweden have experienced that lack of professional logistics are restricting international trade of biofuels. Netherlands experiences that in order to lower the logistics cost, larger volumes need to be shipped on more regular basis. Lower logistics cost would imply that there would be investments on the supply side in Netherlands. In Sweden has several cost driving aspects for shipping biofuels been identified. Harbour facilities are often not equipped in fashion that enables cost efficient handling of the products. In addition there are no real shipping fleet ready and designed to take on the shipping of biomass for energy.

5.3 Driving forces and rationales behind existing trade

Below follows a description of recognized driving forces and rationales behind existing trade with biofuels. Different factors can in combination influence trade, which will be enlightened with examples from the Task 40 countries, country reports. The identified forces are:

- Raw material/biomass push
- Market pull
- Utilizing the established logistics of existing trade
- Incentives and support institutions
- Technical Developments and innovations
- Entrepreneurs and innovators
- Unexpected opportunities

5.3.1 Raw material/biomass push

Biomass push arises when there are available surpluses of biomass resources in a country. A surplus on the domestic market imply that an greater return can be found in the international market, hence international trade from countries with a surplus of biomass resources. Surpluses can either be produced or emanate from unused resources. In order to large-scale produce biofuels to competitive costs, suitable conditions are needed with low labour costs, good growing conditions and available land. Other important aspects are knowledge and experiences of forestry and/or agriculture. Unutilized resources that can cause a push are among other forest resources and by-products from the agriculture-, food- or forest product industry. Prerequisite to make these resources available for production and use of biofuels are especially ability, knowledge and an efficient handling.

Raw material/biomass push has been a contributing factor behind Brazil's export of ethanol, pellets and wood chips, and Canada's export of wood pellets. Producers in Brazil are shifting production between alcohol and sugar depending on market opportunities. A high profitability for production of alcohol and ethanol has lead to this push strategy. Brazil also exported small volumes of wood chips and wood pellets with this strategy. Wood pellets are produced of forest and sawmills residues, which is the cheapest and the most abundant source of biomass available in the country. While wood chips is produced of acacia trees and bark of eucalyptus and pines. In Canada are there available surpluses of biomass mainly by-products from sawmills and available biomass from mountain pine beetle infested stands.

5.3.2 Market pull

Market pull arises when there is a deficit of available biomass resources or energy, which consequently cause a force for import of the missing resources. Market pull are a driver in countries suitable for biofuel combustion and in need for energy, especially in countries with a limited capacity to produce biofuels. Appropriate countries for biofuel combustion are those with an energy infrastructure suited for biofuels i.e. countries that generate electricity from fossil fuels especially coal and those that distribute heat in district heating systems. Factors that in general restrict domestic production are high labour costs, limited land productivity or lack of available land.

A deficit of biofuel resources has been a force behind Netherlands import of biofuels due to a combination of factors, among them, suitable power plants for combustion of biofuels, policy incentives and limited possibilities for large-scale production of biofuels. The market pull in Netherlands for import is facilitated by a very suitable structure of the leading big utilities. This makes efficient transport and

handling possible and leads to low costs compared to users in other countries where these conditions are less favourable.

5.3.3 Utilizing the established logistics of existing trade

Large quantities of biofuels are traded between different countries in form of indirect trade, especially in Northern Europe Also other types of integration has supported biofuel trade, such as common use of ports and storage facilities, organizational integration and other factors that have kept transaction cost low in the initial phase. Indirect traded products are mainly round wood and pulp chips utilized by the forest product industry, but also biomass products for the agriculture- and the food industry.

An example of integration with other industries is the business transaction a reciprocal buy[9], which is acting as driving force when biofuels is used as payment in the contract for sale.

5.3.4 Incentives and support institutions

Effects of incentives and support institutions based on political decisions have increased the strength of driving forces and trigged an expansion of biofuel trade. The rationales of political incentives and support institutions are among other to reach environmental goals, to reduce risks of disturbance in the supply, support domestic industries and use of domestic resources. Incentives and institutions differ between countries, which has caused different conditions for use and production of biofuels. The force arises due differences in incentives between countries, which result in a flow of biofuels from low to high incentives countries.

Political measures used to promote bioenergy, can be divided in taxes, subventions, contributions, market based measures, agreements and legislation. The effect of different incentives proved to be different in various cases, partly due to the nature of other factors, partly due the fact that the institutions related to the incentives were different. It seems obvious that institutions fostering general and free markets, e.g. CO_2 taxes on fossil fuels are more successful then specific and time restricted support measures.

The country reports give several examples of incentives and support institutions. Some examples of measures that have trigged the development of bioenergy are; Brazil's creation of the alcohol program-PROALCOOL, which have been a contributory factor to the fact that Brazil has become one of the major ethanol producers in the world. The introduction of policy measures investment subsidiaries and tax exemptions in Netherlands, which has increased the production of renewable energy. Sweden has for a long time worked for an increased use of renewable energy with the measures: CO_2 tax, energy tax, sulphur taxes, tax on thermal power and renewable certificates.

A major global policy measure that will affect the futures policy incentives is the Kyoto protocol, with the objective to reduce the global emissions of GHG. Industrial countries have committed to reduce their emissions in the period 2008-2012, through reduction and the flexible mechanisms (JI, CDM and Emissions trading). Governments has already begun the work with reducing emissions, e.g. in

[9] A reciprocal buy is a business transactions were the seller is paid partly or entirely with products.

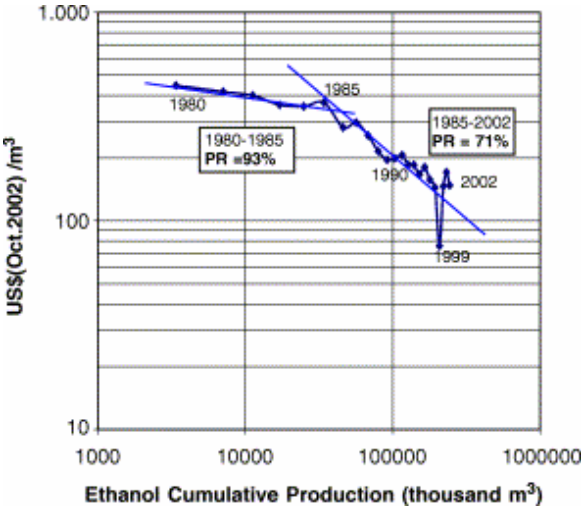
the EU were emission of GHG is controlled according to protocol, since first of January 2005. The main reasons are to acquire useful experience and to cost-effectively reach the committed reductions (Statens Energimyndighet, 2004). The Kyoto protocol will stimulate an increased use and trade due an adjustment to higher share of renewable energy. The flexible mechanism JI and CDM will also trigger trade to and from new regions.

5.3.5 Technical Developments and innovations

Technical Developments and innovations has been a major driver behind international trade with biofuels. It has created new markets possibilities and increased competitiveness of existing trade. Innovations cause new possibilities for trade and use of biofuels, which can result in new trade patterns. It can also strengthen forces behind existing trade due a more cost-effective overall product. Development and improvements of existing techniques strengthen existing driving forces due to increased effectiveness and thereby lower costs.

Examples of developments and innovations that have contributed to stronger driving forces are e.g. Brazil's increased productivity in ethanol production and improvements in the loading and the unloading procedure in Sweden that have created new possibilities and increased trade (Bo Hektor, Interview – 2005-09-05). Brazil's productivity has been increased and costs have fallen due innovations and developments in both the agriculture side and the industry side. The average production yields of ethanol were 3.900 l/ha*y in the early 1980s and had reached 5.600 litres/ha* year, in 2001 (Arnaldo Walter, Paulo Dolzan & Erik Piacente (2005), see Cortez et al.(2002)). The improved productivity was mainly due to increase in agriculture yield and agriculture management, but also as a result of operation research techniques in agriculture management intensity. Also improvement of administrative measures and the use of satellite images for crops identification in cultivated areas contributed to increased efficiency and flexibility. The reduced production cost of ethanol production due development and innovations can be studied in the learning curve in figure 8.

Figure 8: Learning curve for ethanol production in Brazil (Arnaldo Walter, Paulo Dolzan & Erik Piacente (2005), see Goldemberg et al. (2004))



Another example is from Canada due to the innovation of the fast-pyrolysis process that converts forests and agricultures residues in to Bio-oil. This innovation will most likely in the future increase the supply of bio-oil, which can result in the creation of new trade patterns.

5.3.6 Entrepreneurs and innovators

In countries like Austria and Sweden, individual entrepreneurs and innovators have had a leading role for the development of bio-energy trade. It has led to a more diversified pattern compared to e.g. Finland and the Netherlands, where bio-energy is handled by large mature companies in close co-operation with public institutions. In Finland the development takes place within the forestry sector, in the Netherlands within the leading electricity utility companies (Bo Hektor, Interview – 2005-09-05).

5.3.7 Unexpected opportunities

Storms, forest fires, insect attacks etc. may lead to short-term imbalance in the supply. Technical failures and other reasons for shut down cause disturbance in the user and distribution systems. Such short term opportunities has often led to new trade patterns, some of which may remain also when the conditions return to normal. For example, the last year's hurricanes in the Eastern part of USA led to a short-term trade of wood chips to Europe. Probably this will also occur after the recent hurricanes of September 2005 (Bo Hektor, Interview – 2005-09-05).

5.4 Development of trade and use of biofuels in Task 40

It has been concluded in previous analyses that the global demand, production and trade of biofuels will increase. The development is however likely to differ between countries due to various conditions for use, production and trade. In this section will there be an analysis or compilation of the development of each Task 40 country. The analysis is based on information and discussion from "factors that influence biofuel trade", theory and the presentation of each country.

5.4.1 Brazil's future use and trade with biofuels

In recent years has Brazil's production, consumption and international trade of biofuels increased rapidly. This development is likely to continue due Brazil has very good requirements for large scale production of biofuels and both the domestic and international demand is likely to increase in the future. Brazil has as mentioned earlier very good conditions for large scale production of biofuels with land availability, adequate weather conditions, no special constraint regarding labour, domain of technology and the existence of know-how. These conditions are also strengthened of powerful policy incentives especially the extensive alcohol program, PROALCOOL. And a suitable industrial structure for production of biomass with an advanced and large scale agriculture- and forest product industry. These conditions imply that Brazilian biofuels can be produced in large quantities and to competitive costs.

It is assumed that Brazil will increase their domestic consumption of biofuels in the future. This is partly based on the fact that Brazil has a strong GDP-growth, which implies a higher need of energy. And partly due to biofuels competitiveness will increase mainly because higher prices on alternative energy. Brazil also has an

energy infrastructure that is suited for bioenergy consumption. The consumption is strengthened of domestic policy incentives that promote use of bioenergy. Brazil's consumption of biofuels is not directly influenced of the Kyoto protocol because Brazil has no reduction commitments. The Kyoto agreement can however enables opportunities through the flexible mechanisms, which can become an incentive in the future. The increased domestic use is assumed to be supplied within the country due to that Brazil can produce large quantities to competitive costs.

It is likely that Brazil will increase their export of biofuels, as the international demand will grow (see 5.1). At the moment the most significant export is ethanol. It is however likely that the export in the future also will include several other types of biofuels. The fuel will likely be exported all over the world due to Brazil has access to ocean ports. When transporting biofuels with ship the cost is not barrier no matter what distance.

5.4.2 Canada's future use and trade with biofuels

Canada is at present producing large quantities of biofuels both for domestic use and export. It is assumed that the production will increase rapidly the next years mainly because Canada has available unused biomass resources. The production mainly consists of wood pellets, which is produced of by-products from sawmills. In the near future will production also include BioOil and ethanol due to large investments has been made in production facilities. Canada has very good requirements to increase the production of biofuels; the main reasons are that there are huge amounts of unused biomass resources available, suitable geographical conditions for production, a suitable industrial structure with a significant forest product industry and policy incentives that support production of biofuels. The available unused biomass resources mainly consist of by-products from the sawmill industry and forests that have been infested of the Mountain Pine Beetle. Another potential source is logging residues, which at present not are utilized at all. Canada also has good geographical conditions for production of biomass with decent land productivity and large areas of available land, the density of population are only 3 inhabitants / km^2. Thus, the potential for increased production of biofuels to competitive costs is huge in Canada.

According to Canadian projections will the domestic use of energy from biomass increase from 6 % to 6-9 % the next decades. Several factors indicates a development like this, among other biofuels increased ability to compete with other energy sources, , an energy infrastructure suited for increased consumption of biofuels, increased demand of energy, especially renewable and policy incentives that support domestic consumption of renewable energy. Canada's energy infrastructure are suitable because a high utilization of fossil fuels, 80%, which has proved to be successful for conversion or co-firing with biofuels. Further, it is likely that Canada's need of energy will grow the next years due to a strong economical growth. Another important factor for Canada's development in this field are their commitments against the Kyoto protocol, were they has committed to reduce their emissions of GHG with 8 %. This requires extensive actions, as Canada is a developed country with a great need of energy. Canada is the studied country that has the highest GDP per capita, which is related to energy consumption. The domestic use will also be strengthened of several policy incentives that promote use of biofuels.

Canada's export of biofuels will continue to increase rapidly the next years. The main reasons are as mentioned earlier that Canada have very good conditions for an extensive production of biofuels to competitive costs. At present the main exported biofuel is wood pellets, this will however in the future most likely include BioOil. Canada has also started large scale production of ethanol; this is however mainly intended for domestic use. Canada has good requirements for exporting biofuels with experiences and knowledge of trading and shipping biomass, and access to ocean ports. It is assumed that Canada will export biofuels all over the world. However will they major export flows be heading to the big markets in the EU and the USA.

5.4.3 Finland's future use and trade with biofuels

Finland's future production of biofuels is closely related to the forest product industry as by-products are the main raw material for biofuels. Finland is net importer of biofuels; the import is however imported through indirect trade. When only studying direct trade Finland is a net exporter. The export mainly consists of wood pellets and tall oil, which originates from the forest product industry. Production of these fuels has increased rapidly, since the beginning of the century. In the beginning of this period was the main production intended for export, this has however changed and the domestic consumption has since then increased rapidly. The utilization of by-products from the forest product industry is high; both by-products from the industry and by-products from logging operations are used in the production of biofuels. Future production of biofuels is therefore closely related to the development of indirect trade of biomass, which is depending on factors outside this report's extent. Finland do however have good geographical conditions for cultivation of biomass, with a moderate land productivity and large areas of available land, the density of population in Finland are only 15 inhabitants / km^2. It is hard to predict the development of biofuel production in Finland due to the production is related to indirect trade. However, if assuming the indirect import will be constant, then it is likely that the production will be more or less same.

Finland will increase their domestic use of biofuels, partly due to biofuels increased competitiveness and partly because Finland has an energy infrastructure suited for conversion or co-firing with biofuels. This is also strengthened of policy incentives that support consumption of biofuels, and an increased demand of energy due to an economical growth in the country. Finland produces energy in coal power plants that has been proved to be suitable for replacement of biofuels. There are several measures used to promote renewable energy and biofuels in Finland, support are however on a relative moderate level compared to other countries. The Finnish government has however made an action plan for 2010, with goals of a higher domestic consumption. To reach these goals more powerful measures is required; it is therefore assumed that the Finnish government will increase those incentives. Finland has no commitments of reduction against the Kyoto protocol, but they do have committed not increase their emissions of GHG. It is therefore assumed that Finland not direct will be heavily influenced of the agreement, it do however enables opportunities for Finnish producers of bioenergy through the flexible mechanisms.

At the moment are Finland an exporter of biofuels, this is however likely to change the next years due to an increased domestic consumption. In a longer perspective do however Finland has the capacity to become an exporter due to good geographical requirements for cultivation of biomass.

5.4.4 Netherlands's future use and trade with biofuels

According to previous analysis will Netherlands heavily increase their consumption of biofuels. The consumption will however mainly be based on imported biofuels due to limited possibilities for production within the country. Thus, will Netherlands international trade of biofuels increase heavily. The production possibilities of biofuels are limited in Netherlands because of a very high population density, with 395 inhabitants / km^2. If not considering the very high population density Netherlands has good requirements for production of biofuels with good land productivity and agriculture industry that can transfer reliable knowledge and experiences etc.

The domestic increased demand of biofuels is mainly explained of policy measures, lack of domestic energy resources and a suitable energy infrastructure for biofuels. The government in Netherlands promote use of bioenergy through powerful policy measures, especially the feed-in-tariffs. The measures has significant increased the use of biofuels and renewable energy in recent years. In addition has Netherlands committed to reduce their emissions of GHG in the Kyoto protocol with 13%, which will increase the demand even more. It is likely that the reduction at least partly will be made through increased consumption of biofuels due a suitable energy infrastructure with coal power plants, lack of domestic energy resources and the fact that biofuels competitiveness will increase in the future.

The increased consumption will be based of imported biomass because of limited domestic resources. Netherlands is however well suited for trade/import of biofuels due to good geographical conditions with a relative long cost line and channels within the country, which makes it possible to transport the fuel with ships. This in combination with a well developed infrastructure for import of biofuels, with large modern ports, and long experiences and knowledge of trade and shipping.

5.4.5 Norway's future use and trade with biofuels

Norway will increase their use of biofuels as the other members of task 40. Factors that indicate an increased use of biofuels in Norway are as in the other countries among other an increased demand for energy and actions to reduce the affect on the environment. It is however likely that the enlargement of the bioenergy use will be less in Norway then in the other studied countries. The main reasons for this are that the market for biofuel is immature and that Norway has an unsuitable energy infrastructure with extensive resources of hydro power and fossil fuels.

At the moment Norway has no or very little international trade with biofuels. It is however likely that the export will increase. This is based on the fact that Norway has large available biomass resources both through by-products from the forest product industry and through standing forests. In addition have Norway suitable geographical conditions for export with access to sea and fjords to transport the fuel.

5.4.6 Sweden's future use and trade with biofuels

Sweden is a significant actor on the international bioenergy market because Swedish company's trade with large quantities of biofuels and that Sweden use large quantities of biofuels. At the moment is Sweden a net importer of biofuels,

but has the capacity to become a net exporter. According to this study will Sweden increase their production of biofuels because there are good requirements for production of biofuels with good geographical conditions, a suitable industrial structure and the existences of know-how. Sweden's suitable geographical conditions for production of biomass are facilitated of decent land productivity and large areas of available land, the density of population are only 20 inhabitants / km^2. In addition has Sweden a considerable forest product industry that supplies the biofuel industry with by-products, knowledge etc.

Sweden will also increase their consumption of biofuels due to policy incentives, increased prices on alternative energy, increased demand of energy, and a suitable energy infrastructure. Sweden has for a long time used powerful policy incentives, in order to promote use of bioenergy and renewable energy. Several measures are used among other taxes on fossil fuels, energy taxes, sulphur taxes etc. Recently has the Swedish government introduces the policy measures electricity certificates and tradable emission rights, which is assumed to increase the incentives even more. Sweden has no official reduction commitments against the Kyoto protocol in fact are Sweden aloud to increase their emission of GHG with 4%. The Swedish government has however set the goal that Sweden should reduce their emission with 4 %, so in reality is the protocol an incentive for increased use of biofuels. An increased competitiveness of biofuels would increase the use biofuels due to Sweden has a relative suitable energy infrastructure and energy mix. Sweden produce considerable amounts of energy from hydro - and nuclear power plants, which not are likely to become replaced of biofuels. They do however use considerable amounts of fossil fuel that can be replaced. In addition is Sweden distributing heat in district heating systems, which has been proven to be a successful combination with combustion of biofuels.

At the moment is Sweden an importer of biofuels, it is however assumed that Sweden in the future will become an exporter, mainly due to good conditions for production of biofuels. Another factor that can influence the development in a longer perspective is that Sweden besides biofuels has significant domestic energy resources mainly hydro, but also wind due to a long cost line, and that Sweden is producing energy from nuclear power plants. A high utilization of these resources can imply that Sweden's energy need becomes fulfilled, and that biofuels become available for export.

6 DISCUSSION AND CONCLUSIONS

6.1 Conclusions

The international use and trade of biofuels is rapidly increasing in the task 40 countries. In some of the countries has the international trade been doubled several times in just a few years, e.g. Brazil's export of ethanol and Canada's export of wood pellets. The development does however differ between the countries, which can be explained of different conditions for production, use and trade. In the study has several examples illustrated these differences, e.g. differences in policy incentives, industrial structure and available land for production of biofuels. The study indicates that international demand and trade of biofuels will continue to grow rapidly the next years mainly due to increased competitiveness of bioenergy, which is explained of several factors the most important are a growing global demand of energy, an increased awareness and knowledge of the environment, technical developments and innovations and the fact that conventional energy resources are running dry.

In the surveys of existing trade has both forces that have push and restrict trade emerged been identified. In order to enlarge current trade it is of great importance that forces that restrict trade are removed and that factors that push trade is strengthened. Crucial restricting factors that needs to be removed or lowered behind existing trade, in order to improve the conditions are:

- Insufficient spreading of existing technique, which causes lack of technical skills.
- Institutional obstacles and problems.
- Lack of knowledge and uncertainty.
- The absence of entrepreneurs.
- Resistance from other interested parties, both through direct and indirect resistance.
- Lack of global professional logistics

Rationales and driving forces behind existing trade that have been recognized in the study are:

- Raw material/biomass push
- Market pull
- Utilizing the established logistics of existing trade
- Incentives and support institutions
- Technical Developments and innovations
- Entrepreneurs and innovators
- Unexpected opportunities

The estimation of future production, use and trade of biofuels in the studied countries Task 40, show that all will increase their consumption of biofuels. The estimation however indicates that the proportions will differ between the countries. For example does the study indicate that the increase in Finland and Sweden will be lower than in Brazil, Canada and Netherlands because these countries already use considerable amounts of bioenergy. The prediction of the biofuel development in each country can be summarized as:

Brazil will increase their production of biofuels heavily the next years mainly because they have very good conditions for production of biofuels, which enables production to competitiveness cost. The increased production is intended both for domestic use and export. The domestic use will rapidly increase in Brazil due to an increased demand of energy and because alternative energy resources are assumed to become more expensive. The production and consumption is also strengthened of policy measures that support bioenergy.

Canada's production, use and export of biofuels will grow rapidly the next years mainly due to Canada has very large available unused biomass resources and suitable conditions for production of biofuels. The unused biomass resources are mainly by-products from the forest product industry and forests that have been infested of the Mountain Pine Beetle. The domestic consumption is likely to increase due to biofuels increased ability to compete with other energy sources, a suitable energy infrastructure, increased demand of renewable and policy incentives that support domestic consumption.

In Finland are the domestic consumption assumed to increase due to biofuels increased competitiveness, a suitable energy infrastructure and policy measures that support use of biofuels. The future production in Finland is hard to predict because it is closely related to the forest product industry. At present Finland is a net exporter of direct trade biofuels, this is however likely to change as Finland increase their domestic use. Finland does however have good geographical conditions for production of biomass, so in a longer perspective it is likely that they will become exporters of biofuels.

Netherlands are assumed to rapidly increase their use and import of biofuels. In Netherlands case implies increased consumption more or less the increased import because Netherlands has limited possibilities to produce biofuels due to a very high population density. The increased use and import is mainly explained of powerful policy measures, lack of domestic energy resources and a suitable energy infrastructure for biofuels.

The increased use in Norway will be on a moderate level mainly because the market for biofuels is immature and a very unsuitable energy structure with significant domestic resources of hydro power and fossil fuels. It is however likely that the export of biofuels will increase due to available biomass resources, mainly by-products from the forest product industry.

Sweden will increase their use of biofuels due to powerful policy incentives, a suitable energy infrastructure and an increased demand of energy. At present are Sweden a net importer of biofuels, they are however assumed to become a net exporter in the future mainly because Sweden have good requirements for production of biofuels with suitable geographical conditions, a suitable industrial structure and the existences of know-how.

6.2 Discussion

Thus, in the study has it been concluded that the global demand and international trade of biofuels will continue to grow the next years. It has however not been possible to exact predict the development due to the studies limited extent, lack of information and unexpected occurrences. In the study has a few crucial factors been studied, which are assumed to have a great impact on the development of

bioenergy. In reality are however production and use of biofuels affected by a huge amount of factors that not have been possible to analyse and study. For example is the development affected of the global economical growth that is influenced of a great number of factors. The crucial factors that have been studied are however enough to indicate the direction of the development. Another aspect that contributes to the inaccuracy is the various contents of each country report. Because of this has it been hard to compare and analyse the countries with each other. To get more equilateral information from the countries have I active tried to contact the countries, in order to get information that has been missing in the country reports. This work has however not always been successful, because the missing information has in many cases not been accessible. Unexpected events that can occur in the future are e.g. a war, which can influence the whole global energy system. Other events are a significant higher price on alternative energy; oil and/or an environmental disaster, which heavily would increase the demand of renewable energy and biofuels.

The positive development of biofuels is assumed to continue, which will develop biofuels into an important commodity in the world. There are however requirements that needs to be fulfilled, it is crucial that biofuels are seen as sustainable fuel. In order to achieve fair and free trade is needed. Fair trade refers to the trade in products produced under conditions that are socially, environmentally and economically responsible, and free trade refers to trade that not are affected of tariffs and other trade barriers.

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8 ENCLOSURES

8.1 Estimation of trade

This is a rough estimation/calculation of the amount of biofuels needed to be trade to EU, Japan and US. Assumptions that have been made are the following:

The countries will reduce their emissions of GHG, to the level initially negotiated in Kyoto Protocol.
50 % of the reduction is done through substituting combustion of Diesel with wood pellets.
EU needs to import 40% of the pellets, Japan 70% and US 30%.
The efficiency of energy conversion is the same for Biofuel and Diesel.

DATA:	**European Union**	**Japan**	**United States**
Emissions of GHG, 1990[10](Gg): (excluding land-use-change and forestry)	4.199.608	1.187.108	6.139.636
Reduction in %:	8 %	6 %	7%
Reduction of GHG (Gg):	335.969	71.226	429.775
Renewable energy needed (TWh): (Assuming substitution of diesel with emission factor: 270 Gg CO2/TWh)	**1.244**	**264**	**1.592**
Energy from Biofuel 50% (TWh):	622	132	796
Total mass of pellets (ton): (Assuming heating value pellets: 4.800 KWh/kg = 0,000.004.8 GWh/ton)	**129.583.333**	**27.500.000**	**165.833.333**
Imported share:	40%	70%	30%
Imported mass(ton):	**51.833.333**	**19.250.000**	**49.750.000**

[10] United Nations(2003)