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POLICIES PROMOTING BIOFUELS IN SWEDEN

An f3 synthesis report

Kristina Holmgren, IVL Swedish Environmental Research Institute Ltd &

Chalmers University of Technology, Division of Heat and Power Technology,

THE SWEDISH KNOWLEDGE CENTRE
FOR RENEWABLE TRANSPORTATION FUELS

PREFACE

This report was written as part of a course in Environmental Economics and Policy Instruments at the University of Gothenburg. It aims at summarizing the policy instruments introduced to directly affect the production and use of biofuels in Sweden. Since Sweden is part of the EU also EU policies were included. There are additional policy instruments which affect the production and utilization of biofuels in a more indirect way that are not presented here. The economic analysis in this paper is limited and could be developed from the information presented in order to draw further conclusions on necessary changes in order to reach set targets.

CONTENT

1 INTRODUCTION

The search for alternative fuels replacing the petroleum products in the transport sector began already four decades ago. There were and still are many reasons for wanting alternatives: high and volatile prices of oil; uncertainty of supplies; uncertainties related to reliance on supply from politically unstable regions; raised awareness of environmental damages etc. (Sterner and Coria, 2011). Many of these reasons still hold although the environmental concern and especially the concern for climate change are given most attention today.

Biofuels have been recognised to be one of the key solutions for reducing the greenhouse gas emissions from the transport sector. For quite some time there have been national and international (EU-level) policies promoting biofuels and this has indeed led to significant increase in production. During the last five years concerns have been raised about the actual societal and environmental benefits of the significant rise in biofuel production and utilisation. Two of the most intriguing concerns are:

- The actual savings of greenhouse gas emissions compared to conventional fossil alternatives
- The impact of increased prices of raw material for the production and competition for food and feed purposes

The first concern regarding emissions savings is caused by several things and could be associated with e.g. the question of direct and indirect land use and land use change and inefficient and fossil fuel dependent production units. Increased production of crops for biofuels could cause direct or indirect land use changes, e.g. deforestation, and in such cases there might be no net reduction of emissions compared to conventional fossil alternatives (Fargione et al., 2008, Searchinger et al., 2008). The second concern about raw materials being used for the production of biofuels competing with food purposes peaked in 2008 when corn prices rose drastically. One of the causes for the steep rise in prices were said to be the increased corn ethanol production in the US. This debate has thus cooled down and according to Sterner and Coria, 2011 the debate in 2008 about food versus fuel prices was much exaggerated.

After these concerns were brought into the light more hope has been set for 2nd generation biofuels that are based on waste products and non-food crops (see, Appendix 1 for definition of the different generations of biofuels). It has long been known that there is not enough biomass, nor land to grow sufficient biomass with current technology, to replace all fossil fuels. Technical analysis show that it is considerably more efficient to replace coal or oil in industrial or power and heating applications with biomass than to substitute for transport fuels. Azar et al., 2003 show that if cost optimizing and taking opportunities in other sectors in to account, the transport sector will be one of the last sectors to make a transition away from fossil fuels.

In this paper current policies applied for the promotion of biofuels in Sweden are described and a discussion on problems and potential improvements is given. Special emphasize is given to the question whether policies should distinguish between 1st and 2nd (or 3rd) generation biofuels.

2 AIM AND SCOPE

The aim of this paper is to describe the current policy instruments applied in Sweden for promoting biofuels ant to make a comparison of supply and demand side instruments and what effects they have had (in cases where the instruments have been in place for some time) or could have. As background a description of the current use and production of biofuels in the Swedish transport sector is given.

The paper also discusses the difference between 1st and 2nd generation biofuels briefly, with focus on the rational for policy instruments making a difference between the two categories.

2.1 POLITICAL FRAMEWORK

Sweden has set several goals that require instruments for increasing the use of renewable fuels in the transport sector; by 2030 the transport sector should be independent of fossil fuels and by 2050 there should be no net emissions of GHG to the atmosphere from Sweden. However, there are also several goals set on the EU level that strongly influences the development of the policy instruments and actions taken to promote biofuels in Sweden, the CAP (common agricultural policy) reform, the 2003 Biofuels Directive and the 2008 Climate and Energy Package including among other things the Renewable Energy Directive (RES-Directive) (Bureau et al., 2010).

The goal set in the RES Directive, that each member state should have at least 10% renewable fuels in the transport sector by 2020, is followed up in Sweden by calculations performed by the Swedish Energy Agency. The Energy Agency conclude (in preliminary calculations) that according to the calculation rules of the Directive (where different weight is given to different biofuels depending on what kind of biomass that is used in the production) Sweden had 9.8% renewable fuels in 2011. Thereby it is not unlikely that Sweden will fulfil the 2020 target already in 2012 and some argue that there is a need for a more stringent target in order to speed up transition.

3 THE SWEDISH BIOFUEL MARKET

There has been a strong increase in energy utilisation in the Swedish transport sector for several decades. Between 1970 and 2009 the energy utilisation in the Swedish transport sector rose by 70%. In 2011, 94 TWh were used for transportation and 93% of this was used for road traffic. The use of biofuels constituted ~6 TWh (6.3%). The Swedish biofuel market is dominated by three different fuels; ethanol, biodiesel and biogas, which in 2011 amounted to 2.5 TWh, 2.7 TWh and 0.7 TWh respectively. The use of ethanol has stagnated, whereas the use of biogas and biodiesel still increase rapidly (SEA 2012a). In Figure 1, the development of the use of biofuels in Sweden is presented. During the period 2005-2010 the total energy use in the transport sector was quite stable and the same is true if only looking at road transports, although some inter-annual variation can be seen (SEA 2012a).

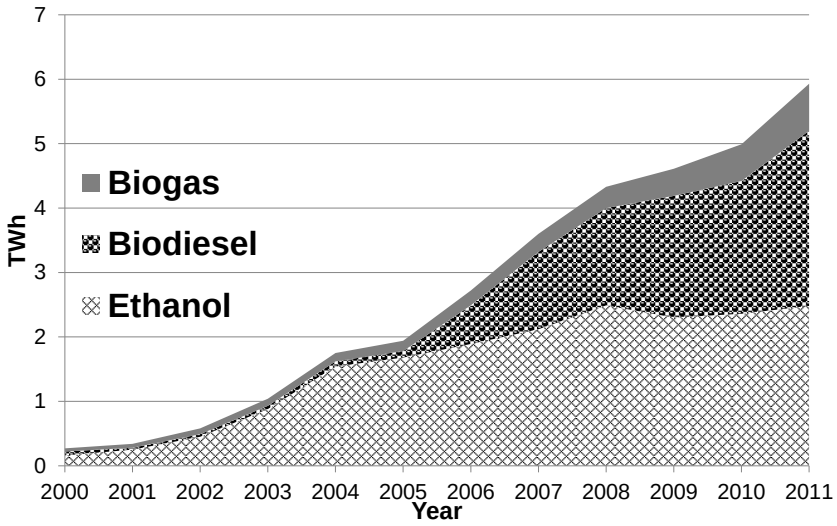

Figure 1 *Use of biofuels in the Swedish transport sector. (Sources: SEA, 2012a, SEA, 2009a)*

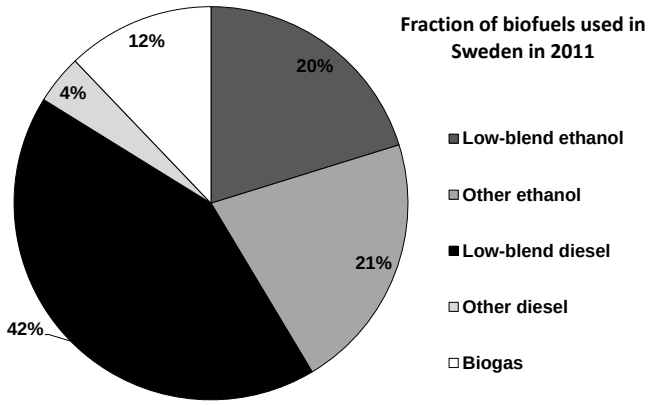

Figure 2 *Renewable fuels in the Swedish transport sector in 2011.(Source: SEA, 2012a)*

Ethanol was the first biofuel to enter the market in larger volumes and there are mainly two uses in Sweden, either as a low-blend (5%) in gasoline or as a high-blend, in E85 (85% ethanol and 15% gasoline). In 2011 approximately half of the used ethanol was used as E85 whereas the other half was used as low-blend (Trafikverket, 2012). Over 95% of the gasoline sold in Sweden contains the low blend (5%) of ethanol (SEA, 2012a).

Sweden is the seventh largest ethanol importer in the world and historically most of the imports came from Brazil. In 2009, 90% of the ethanol used in the Swedish transport sector was imported. However, during the last years imports from Brazil have declined and the imports from EU have increased. In 2011 85% of the ethanol used in Sweden was produced either in Sweden or other EU countries. The Swedish Energy Agency finds several possible explanations to this, the harvests in Brazil have been poor, Swedish exemptions from energy tax for biofuels has during 2011 required that the fuel fulfils the sustainability criteria. Since the sustainability criteria were recently enforced in the EU might have come further with the certification than actors outside the EU (SEA, 2012b). There are two ethanol production units in Sweden; Agroetanol´s installation in Norrköping which is based on fermentation of cereals and that has a production capacity of 1.24 TWh (210 000 m3) ethanol and SEKAB´s pilot installation in Örnsköldsvik which

is based on processing of lignocellulosic raw material (mainly residues from the pulp and paper industry) with a capacity of 65 GWh (11 000 m^3) ethanol.

In the Swedish case biodiesel is a collective name for FAME (fatty acid methyl ester) and HVO (hydrogenated vegetable oil). HVO is a hydrocarbon very similar to diesel which makes it possible to blend in unlimited amounts (as long as specifications of cold properties are met). HVO was introduced at the Swedish market in 2011. In 2011, 295 million litres of biodiesel was used in Sweden, most as low-blend in diesel (80% of the used diesel has a low-blend (5%) of FAME). There are a number of biodiesel producers in Sweden, mainly small scale, and there are only two large scale producers: Perstorp in Stenungsund, with a capacity of 160 000 tons RME annually and; Ecobränsle in Karlshamn with a capacity of 50 000 m^3. Together these two units have a capacity of ~2.1 TWh. According to the Swedish Energy Agency, 60% of the biodiesel used in Sweden during the last two years was also produced in Sweden (SEA, 2011b). Starting in 2010, there is also the crude tall oil production at the SunPine unit in Piteå where crude tall oil is produced from black liquor (by-product from pulp industry). The crude tall oil is further processed (hydrogenated into HVO and blended) at the Preem refinery in Gothenburg to a low-blend (10-22%) diesel. The fuel, called "Evolution diesel" came on the Swedish market in 2011. The capacity of crude tall oil production in Piteå is 100 000 m^3 annually.

The biogas in Sweden is produced in 230 anaerobic digestion units. In 2010 the production of biogas in Sweden was approximately 1.4 TWh (SEA, 2011c). There are several areas of use for the biogas and in order to be used as a transport fuel it needs to be upgraded. Approximately 44% of the produced biogas in 2010 was upgraded. Raw material for the production is food wastes, sewage sludge, manure, food industry wastes, slaughter house wastes, energy crops and other (landfills) (Rydberg et al., 2010, SEA, 2011c). Biogas is mainly a local fuel, often used in local systems such as bus-fleets. The supply side does not always satisfy the demand, which leads to either natural gas being used instead, or gasoline (in hybrid cars). There is no import of biogas to Sweden but potentially it could be imported if the natural gas net was used for the distribution (Tolke et al., 2011).

Estimates of the potential production capacity of Swedish biogas indicate that there is a potential for biogas produced via anaerobic digestion of 10-15 TWh and a potential for biogas (SNG, synthetic natural gas) produced via gasification possibly as high as 40 TWh. Biogas production via the gasification can use woody biomass as raw material, but so far there are no commercial units for this. In Gothenburg a demonstration plant of biomass gasification is under construction and the plant will gasify woody biomass (pellets or woodchips) and process it to bio-SNG that can be fed directly to the natural gas net. The capacity of the demonstration plant will be 20 MW in phase I and an additional 80 MW in phase II. E.ON is also planning for a full scale unit in Landskrona or Malmö with a capacity of 200 MW (1.6 TWh) in 2016.

The large increase in biofuel use last years in Sweden was mainly due to increased amounts of biodiesel/HVO and biogas. However, recent reports indicate that many biogas projects are being postponed. The reason is said to be that there are no longer any KLIMP-grants. So far KLIMP-grants[1] have accounted for 25% of investment costs for anaerobic digestion units. The industry (e.g. energy companies) claims that the willingness to pay for biogas is not high enough (Miljöaktuellt 2012-04-18).

[1] KLIMP = Klimatinvesteringsprogram (Swedish) climate investment program. For an explanation see the section in this paper on Climate investment program.

4 POLICY INSTRUMENTS IN SWEDEN IMPACTING THE USE OF BIOFUELS IN TRANSPORT SECTOR

In this section both national and EU instruments are described. In general the EU rules are formulated in directives which the member states should turn in to national law.

4.1 DEMAND SIDE INSTRUMENTS

In this section instruments impacting the demand side are described.

4.1.1 EU directives and goals

In the Biofuel Directive (EC, 2003b), guiding targets are set for the transport sector aiming at increasing the share of biofuels used in the transport sector, claiming that biofuels should constitute 2% of total energy use in the sector by 2005 and 5.75% in 2010. In association to this directive there was also the Energy Taxation Directive (EC, 2003c) which allows member states to grant tax reductions or exemption on biofuels. In the Renewable Energy Directive (RES Directives) (EC, 2009a) there is now a binding target (equal for all member states) of 10% use of renewable fuels in the transport sector by 2020. In order to be accountable as renewable fuels, the sustainability criteria outlined in the directive must be fulfilled. It is also necessary to fulfil the sustainability criteria in order to enjoy other support such as tax-exempts or subsidies.

In addition the Fuel Quality Directive (FQD), (EC, 2009b) strongly influences the potential use of biofuels by setting limits to how much blending of biofuels into diesel and gasoline that is allowed. According to this directive (which was to be implemented by 2010-12-31) it should be allowed to blend 10 % into gasoline and 7% vol. into diesel (previously the limits for both fuels were 5% vol.). Further, according to the FQD, fuel suppliers in the union should reduce GHG emissions by 6% per energy unit until 2020. For the latter target only the selling of biofuels fulfilling the sustainability criteria set in the RES Directive could be accounted for.

4.1.2 The Swedish tax exempt for biofuels

In Sweden there is both a carbon tax and an energy tax on fuels. The energy tax is determined individually for each fuel and is not proportional to the energy content of the fuel. The carbon tax is proportional to the carbon content of the fuel. Liable fuels are all fossil fuels but there is an exempt from energy tax on natural gas used as vehicle fuel. In addition there is also a tax relief for diesel MK1.[2] Biofuels (including ethanol, biogas, RME/FAME) are exempted from both energy and carbon tax (RFR, 2009). Table 1 presents the current tax level for vehicle fuels in Sweden.

Table 1 ***Energy and carbon tax in Sweden for vehicle fuels in 2011. Source (SEA, 2012b)***

Fuel	Energy tax	Carbon tax	Total tax
Gasoline, MK1	3.06 SEK/l	2.44 SEK/l	5.50 SEK/l
Diesel, MK1	1.524 SEK/l	3.017 SEK/l	4.541 SEK/l
Natural gas	0 SEK/m^3	1.581 SEK/m^3	1.581 SEK/m^3

[2] MK1 = miljöklass 1. This is the environmental classification of the most environmentally friendly fuels according to the Swedish fuel classification system.

Since 1995 the Swedish government has a pronounced possibility to decide on tax reliefs and tax exemptions for biofuels. The purpose is to contribute to the technological development of more environmentally friendly fuels in order to, among other things, reduce GHG emissions. In 2011 the Swedish National Audit Office performed an audit of the tax exemption for biofuels in Sweden and according to it, the tax reduction (of CO_2 and energy tax) for biofuels is the single most important instrument for increasing the amount of biofuels in Sweden (SNAO, 2011). However, the main conclusion drawn by the SNAO is that the tax exempt for biofuels contributes to reaching the climate objective set by the Swedish parliament but not at a reasonable cost. It has been necessary to increase the use of biofuels but it is a relatively expensive way to reduce GHG emissions. Further the SNAO states that the tax exemption has been necessary for creating the market for low-blends of biofuels in gasoline and diesel.

The tax exempt has not been a general exempt but decided upon based on individual applications sent in by fuel suppliers (who are the ones that pay the tax). The decisions have mainly been short term (one to two years at a time) and not always granted on the same reasons (SNAO, 2011). The SNAO claims that the tax exempt has not had a significant effect on technology development nor can it be claimed as technology-neutral, due to low transparency and inequity in treatment of companies.

One thing that complicates the procedure of granting tax exempts is that the EU State aid rules prohibit overcompensation. Overcompensation takes place when a tax reduction or exempt makes the biofuel cheaper than the fossil (conventional) fuel it replaces. In order to be allowed to grant tax exempts Sweden has agreed to submit annual reports to the EU and thereby the tax exempts are approved. Currently there is an approval from the EU that Sweden can continue with this exempt until 2013, an approval that possibly could be prolonged but not longer than until 2020 (SNAO, 2011).

4.1.3 Mandatory blending rates

In the spring budget proposition (Regeringen, 2012), it is suggested that from 2014 there will be a quota regulation on the blending of diesel and gasoline, requiring 10% of ethanol in gasoline and 7% of FAME in diesel. The main reason to introduce a quota regulation is that, due to the EU State aid rules that prohibit overcompensation, it will be very difficult to keep the tax exempt for the low-blend fuels and in addition it is costly as the utilisation increases. The tax exempt for E85 and other high-blend fuels should however remain. Further it is suggested that there should be a tax exempt for up to 15% HVO in diesel.

4.1.4 Indirect instruments

The instruments below indirectly impact the demand for biofuels by increasing the demand for vehicles that use alternative fuels.

Environmental car premium

In 2007 the environmental car premium was introduced in Sweden with the aim of increasing the incentives for buyers to choose environmentally friendly vehicles. The premium was only paid to private persons. The premium amounted to 10 000 SEK (~1100 €). In 2009 the premium was replaced by a tax exempt for environmental cars during their first five years.

By January 1st, 2012, the Swedish government introduced a new super-green car rebate (super environmental car premium) of a maximum of 40 000 SEK (~4400 €) per car. The specification of a "super environmental" car is that they should fulfil the latest EU exhaust gas standard and should not emit more than 50 g CO_2/km. The subsidy is available both for private persons and companies. There is a limited time frame and budget set for the subsidy.

Congestion tax - exempt for environmental cars

In Stockholm a congestion tax was introduced in 2006 but environmental cars were exempted from the tax obligation. However, part of the exempt was abolished in 2009 and it will be abolished for all cars by August 1st, 2012. The exempt has been very important for the registration of new environmental cars in the Stockholm region (RFR, 2009).

CO2-based vehicle tax

In 2006 a CO_2-based vehicle tax for new cars was introduced (the former vehicle tax was based on vehicle weight). The tax has a fixed part and a variable part that is directly dependent on the amount (grams) of emitted CO_2 per kilometre. The variable part is higher for diesel driven vehicles than for gasoline driven. Vehicles that run on other fuels, such as ethanol, natural gas or biogas, have a lower tax rate than conventional vehicles.

Standards for car producers

Initially it was suggested as a voluntary agreement for car manufacturers in the EU but in 2008 it was introduced as a binding target that, car manufacturers should reduce the average CO_2 emissions for new sold cars. The target is set at max 130 g CO_2/km by 2015 and 95 g CO_2/km by 2020. This instrument drives technology towards more fuel efficient cars or towards cars which run on renewable fuels.

Reduced taxable value for fringe benefits

In Sweden there is a reduced taxable value for fringe benefits for environmental cars, which is why these have been chosen to a higher degree as firm´s cars (Rydberg et al., 2010). Currently the reduction is limited to 16 000 SEK/yr (~1800 €/yr). New rules for 2012 make it more advantageous for electric vehicles (or hybrids) that can be charged from the grid, or gas-driven cars.

Free or reduced parking fees

In approximately 40 municipalities in Sweden there have been reduced or free parking fees for environmental cars during the last couple of years. However, due to the rapidly increasing number of environmental vehicles many municipalities have now abolished this advantage (Sprei, 2009).

Authorities should mainly use environmental cars

Since 2009 there is a regulation stating that 100% of cars bought or leased by Swedish authorities should be environmental cars.

4.2 SUPPLY SIDE INSTRUMENTS

In addition to the demand side instruments there have also been a number of instruments introduced by the Swedish government in order increase the supply of biofuels and renewable fuels in the transport sector.

4.2.1 The "Pump Law"

In 2006 the so called "Pump law" (Pumplagen) was introduced which requires filling stations (of a certain size) to provide renewable fuels. Due to costs (the government has estimated the cost for installing a gas pump to 4 MSEK whereas the cost for installing an ethanol pump is 0.2 MSEK) this law was most beneficial for the ethanol pumps which grew significantly in number and there has been subsidies amending the "Pump law" granting subsidies to filling stations installing biogas pumps or other than ethanol renewables (RFR, 2009). However, the governmental subsidy is limited to 30% of the 3.8 MSEK that constitutes the additional cost for a gas pump. The limited grant and

remaining cost difference between ethanol and gas pump costs has resulted in a limited use of the grant. There is no grant given for ethanol pumps.

The introduction of the "Pump law" has led to an increase in the number of filling stations providing alternative fuels from 385 (10%) in December 2005 to 1610 (50%) in September 2009. 90% of the renewable pumps are E85 pumps. The consequences of the law have not been technology neutral and could possibly have a negative impact on the development of other renewable fuels (RFR, 2009).

4.2.2 Obligations for fuel suppliers to reduce GHG emissions

In the Fuel Quality Directive (EC, 2009b) there is a requirement for fuel suppliers to report and to reduce greenhouse gas emissions by up to 10% on a life cycle basis by 2020 (compared to 2010 level). There are three possible ways of fulfilment:

- Increase the use of biofuels, alternative fuels and reduction in flaring and rejection at site of production
- To reduce emissions by applying CCS (carbon capture and storage) or electrical vehicles
- To buy CDM credits

4.2.3 Climate investment Programmes (KLIMP)

The Swedish government's support to Climate Investment Programmes (KLIMP = klimatinvesteringsprogram) is a tool for reaching the Swedish climate objective as formulated in the Swedish climate strategy in 2002. KLIMP has enabled municipalities and other local actors to receive grants for long-term investments that reduce GHG emissions. The grants have been administrated by the Swedish EPA (SEPA) and money has been granted for the period 2003-2008 (there was also a predecessor called LIP (local investments programmes) in the period 1998-2002). In total 1.8 billion SEK were granted and a summary of what kind of projects that were granted money show that 660 MSEK (37% of totals) were given to biogas projects. (RFR, 2009) conclude that 330 MSEK of the 660 MSEK were granted to production and upgrading installations for biogas. Another 120 MSEK were granted to biogas systems for vehicle use (mainly pump stations and gas pipes) and 25 MSEK were granted for investments in gas vehicles (buses and personal cars). 110 MSEK were granted to projects related to the collection and handling of waste before the fermentation step. No more KLIMP grants have been given since 2008 and the accomplishment of the programmes will be finalized in 2012.

4.2.4 Other investment grants

In 2008 the Swedish government decided on a new grant for energy technology which aims at stimulating the use of climate-efficient energy technology that is not yet commercially competitive. Biogas is mentioned as one such example.

4.2.5 Grants for R&D

The Swedish state has also granted money for demonstration and commercialization of new energy technologies. A program called "Second generation biofuels and other energy technology" containing 875 MSEK was administrated by the Swedish Energy Agency. The following projects related to second generation biofuels have been granted money:

- Full scale demonstration unit for production of lignin from chemical pulp mill (in Mörrum)
- Gobigas – demonstration unit of gasification of woody biomass with production of bio-SNG (methane) in Gothenburg (20 MW phase I)

- Chemrec black-liquor gasification with production of methanol and DME at chemical pulp mill in Örnsköldsvik (Domsjö fabriker).

The black-liquor gasification has significant potential. If all pulp and paper mills in Sweden would have this process, it has been estimated that there is a potential of replacing 50% of the fuel for heavy vehicle transports in Sweden. (Carlson and Antonsson, 2011). However, this would require significant amounts of (bio)fuels to replace the energy needs of the pulp and paper processes.

Two other projects in Sweden involving second generation biofuels that also have received at least some financing from the Swedish Energy Agency are:

- SEKAB ethanol pilot plant in Örnsköldsvik where ethanol from cellulose, via hydrolysis, is produced.
- SunPine production of crude tall oil in Piteå which is sent to and finally upgraded by Preem refinery to Evolution Diesel (mixture of fossil and renewable diesel).

4.2.6 Common agricultural Policy CAP

During the period 2003-2008 there was a premium for energy crops grown outside set-aside land according to the CAP (EC, 2003a). This premium more than doubled the total area used for energy crops, but was abolished in 2009 (EC, 2009a). The reason for the abolishment was that there was no longer considered to be a need for a specific support for energy crops, mainly due to the strong demand for these products on the international markets and the establishment of binding targets for bio-energy in total fuel by 2020. Before the premium was introduced in 2003 there had been some establishment of energy crops on the mandatory set-aside land (which allowed for production of non-food crops) (Bureau et al., 2010).

4.2.7 Import tolls for biofuels

For import to the EU, ethanol produced in a third country is associated with a toll of 10.2€/hl (denatured) and 19.2€/hl (un-denatured). This toll is kept since the product is defined as an agricultural product. Sweden has managed to get an exempt for the import of Brazilian ethanol where the product instead is defined as a chemical product and the toll to be paid is only ~0.25€/hl. However, in order not to violate the EU state aid rules of overcompensation Sweden forces suppliers to import ethanol to be used for low-blending at the higher toll rate in order to get the tax exempt. Ethanol to be used in E85 or ED95 can still be imported at the lower toll rate and get the tax exempt (SEA, 2011a). In 2011 the EU decided that Sweden can apply the lower import toll for ethanol for at least the coming three years.

5 DISCUSSION

Sweden is, and has been for many years, a net importer of biofuels. However, a transition to 2nd generation biofuels could change this since Sweden has significant biomass resources for the production of biofuels based on woody (lignocellulosic) biomass. In addition some of these production technologies could take advantage of already existing industry (pulp and paper, refineries etc.).

The EU goals set for increasing the amount of renewable fuels in the transport sector in Sweden for 2020 seems to be met well in advance. One conclusion of that could be that instruments introduced in order to stimulate the increased utilisation have managed to do so. According to (SNAO, 2011) the tax exempt has been very important. Several other sources state that blending or utilization standards are effective in creating or expanding the biofuel industry e.g. (UNCTAD, 2009). However, the latter could also result in negative effects such as: increased prices of agricultural commodities or lowering demand and thereby prices of conventional fuels

It is important not only for the fulfilment of GHG reduction targets but also for the development of biofuels that the oil price is kept at a high level. According to an estimate by the IMF in 2007 most biofuels would be cheaper to produce than fossil ones with an oil price exceeding 120 $/barrel (Carriquiry et al., 2011). A high oil price might reduce the need for specific support for biofuels and help reduce rebound effects caused by instruments like vehicle standards.

The policy instruments introduced so far, such as fiscal incentives (taxes) and consumption mandates (blending mandates), have in general not differentiated between the 1st and 2nd generation biofuels except in some cases at EU level. The policy regime should be revised to account for the relative merits of different types of biofuels. One example of differentiation made by the EU for 1st and 2nd generation biofuels is that contributions of 2nd generation biofuels, other biofuels, and electric cars, are credited with a multiplier of 2.5 towards the target of 10% for renewable energy used in transport. Policy instruments could be used to differentially incentivize the production pathways according to their contribution to pre-established goals. This is also emphasized by the Swedish Energy Agency in their report on quota requirements for fuel suppliers (SEA, 2009b). Carriquiry et al. argue that policy-makers should offer different levels of support to different biofuels and that the capacity of biofuels that simultaneously advance multiple policy goals should be considered when designing incentive mechanisms (Carriquiry et al., 2011). Having an integrated approach combining rural development, climate change and energy provision is reasonable when formulating the policy framework for 2nd generation biofuels.

In the conclusion of the report that evaluated the "Pump law" (RFR, 2009), it is stated that further measures should be directed towards long-term predictable instruments focussed on increasing the incentives for consumers to choose vehicles that use renewable fuels. It is also important to put effort into actions that are directed towards production and distribution of renewable fuels. One specific area pointed out is the supply and distribution of biogas that could be developed more.

Policy instruments could help accelerate the transition from 1st to 2nd generation biofuels. A general conclusion is that future instruments should distinguish between 1st and 2nd generation biofuels, directly or indirectly, so that fuels with a high level of sustainability benefit more. According to IEA 2008 it is crucial that policies are designed in order to promote the development of the most advantageous biofuels and discourage production of "bad biofuels". IEA also highlights the importance for basic R&D and deployment to improve the competitiveness of the preferred pathways.

My conclusion is that if the main objective is to reduce the GHG emissions from the transport sector, additional instruments and incentives should also be in focus. Some examples are:

- Incentives for consumers and firms to choose alternative transportation modes that are less energy and GHG emission intense (i.e. take the bike instead of the car, take the bus or public transport instead of the car, go by train instead of air or car, join a car pool instead of buying a private car etc.)
- Incentives to choose vehicles that are less energy intensive, hence more fuel efficient. Today there are some incentives in this direction but they could be stronger.

Further, it is important to keep the mix of instruments as simple as possible. This in order to be sure that the mix of instruments steers towards the most environmentally friendly choices. A significant part of the transport sector is constituted by private persons and hence their choices are important. If the decision making picture is too complex there is a significant risk that actors will not make the most logical choices.

Demonstration and commercialization as well as research and development are still important for both 2nd and 3rd generation biofuels. Some argue that due to the limitations of 1st but also 2nd generation biofuels, more emphasize should be given to 3rd and 4th generation that potentially could be produced in systems with a much lower requirement of land area.

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APPENDIX 1. Definition of 1st, 2nd and 3rd Generation Biofuels

There is no general definition, but commonly used is something like the definition given in the table below. The table is based on several sources but mainly on (SNAO, 2011) based on collaboration between European Commissions Joint Research Centre, EUCAR and CONCAWE.

Table 2 Explanation of division of biofuels into the different generations.

	Definition based on raw material and examples	Definition based on technology
1st generation	Based on sugars and vegetable oils found in arable crops or animal fats or other residues from e.g. food industry.	Commercially available technology
	Examples: Ethanol from sugarcane, cereals, sugar beets etc. FAME based on rapeseed oil.	
2nd generation	Based on lignocellulosic biomass or woody crops, residues or wastes agriculture and forestry.	Technology for implementation or in pilot scale production
	Examples; DME based on black liquor, Hydrogenated oils, FAME from new plants/crops.	
3rd generation	Based on algae or other biomass.	Technology at research stage
	Examples; many different fuels can be produced from algae e.g. biodiesel. Hydrogen is often regarded as a 3rd gen. biofuel due to the immature technology of both production and utilization.	

One specific feature of the biofuels based on algae is that the biomass does not require land area for the production. Algae can be grown in waters and hence does not compete with other land uses.