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FACTORS THAT INFLUENCE THE DEVELOPMENT OF BIOGAS

Report from an f3 project

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THE SWEDISH KNOWLEDGE CENTRE
FOR RENEWABLE TRANSPORTATION FUELS

PREFACE

This project was funded by the Swedish Knowledge Centre for Renewable Transportation Fuels (f3). The f3 Centre is a nationwide centre, which through cooperation and a systems approach contributes to the development of sustainable fossil-free fuels for transportation. The centre is financed by the Swedish Energy Agency, the Region Västra Götaland and the f3 Partners, including universities, research institutes, and industry (see www.f3centre.se).

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SUMMARY

Sweden is one of the leading countries in the development of upgraded biogas for use in the transport sector. The introduction of a new vehicle fuel is complex since the production, infrastructure, and vehicle fleet has to be simultaneously developed. The aim of this report is to evaluate the barriers and drivers for increased production and use of upgraded biogas. The implications for the future development of the biogas system are also analysed.

It is likely that investment support schemes, like LIP and KLIMP, have been important in the construction of new biogas production facilities and infrastructure. The exemptions from energy and carbon dioxide taxes have also been important, both for producers and gas vehicle owners. These exemptions will most likely continue, which is important for the continued growth of upgraded biogas.

According to a proposal ”on the deployment of alternative fuels infrastructure” put forward by the European Commission (2013), policy measures to support the development of infrastructure for alternative fuels like biogas are considerad within the European Union. However, it is a challenge to determine the preferable extent and configuration of this infrastructural network. The study of the development presented in this report indicates that it may not be necessary to construct a comprehensive network of pipelines for methane to devlop the market. The biogas volumes will – in Sweden and elsewhere – still be quite small in the near future and it is possible to achieve a biogas development without an available methane gas grid, though an already existing grid may be beneficial for the development.

Biogas vehicles are supported by exemption from vehicle tax and reduced fringe benefits tax, but it is difficult to predict whether this is enough for the further expansion of biogas as a transportation fuel. Biogas chains from production to use, as well as other chains for pure and high-level blends of biofuels, will probably need further specific incentives to compete with fuel-efficient diesel vehicles. If biogas should be promoted further, support that enable biogas vehicles to compete with the alternatives in terms of life cycle economy is likely to be a key issue.

SAMMANFATTNING

Sverige har tagit en ledande position i utvecklingen av uppgraderad biogas i transportsektorn, men simultan utveckling av produktion, infrastruktur och fordonsflotta är en komplicerad process. Syftet med rapporten är därför att utvärdera barriärer och drivkrafter för ökad produktion och användning av biogas i transportsektorn.

Investeringsstöd, som LIP och KLIMP, har varit viktiga för byggandet av ny produktion och infrastruktur för biogas. Befrielsen från energi- och koldioxidskatt har också varit viktig i det sammanhanget och dessutom för ägare av gasfordon. Skattebefrielsen kommer troligtvis att fortsätta, vilket är viktigt för utvecklingen för biogas.

Enligt EU-kommisionens förslag (Proposal of the European Parliament and of the council on the deployment of alternative fuels infrastructure, 2013) övervägs politiska styrmedel för att främja utvecklingen av alternativa bränslen såsom biogas, vilket kan ha en positiv effekt för utvecklingen av biogassystemet. Det är dock inte uppenbart hur en sådan infrastruktur ska se ut och vilken geografisk täckning den bör ha. Den utredning som presenteras i den här rapporten antyder att det kanske inte är nödvändigt med ett omfattande nätverk av rörledningar för metan för att utveckla marknaden. Biogasvolymerna kommer att vara relativt små inom överskådlig framtid och det verkar vara möjligt att uppnå en utveckling av biogassystemet utan ett tillgängligt nätverk av rörledningar, även om ett redan existerande nätverk kan ha en positiv inverkan på utvecklingen.

Gasfordon stöds av befrielse från fordonsskatt och reducerat förmånsvärde, men det är svårt att avgöra om detta räcker för att användningen av biogas i transportsektorn ska öka. Gasfordon samt fordon för andra höginblandede alternativa drivmedel kommer förmodligen behöva ytterligare styrmedel för att kunna konkurrera med bränslesnåla dieselbilar i miljöbilssegmentet. Om biogas i transportsektorn ska stöttas ytterligare, behövs ekonomiska incitament som förbättrar den totala kostnaden över livscykeln för fordonet i jämförelse med andra alternativ.

1 INTRODUCTION

Biogas from anaerobic digestion is one alternative for replacing fossil fuels in the transport sector. Biogas produced from organic waste can reduce carbon dioxide emissions in the transport sector and methane emissions from waste while the digestate can be used to replace fossil fuel based fertilizer. It is, therefore, mentioned in several frameworks for environmental sustainability, for example, EU renewables directive (EU, 2009) and the Swedish quality goals for the environment (Environmental Protection Agency, 2012).

The technology for anaerobic digestion has been around for a long time; first as a means of waste treatment but the more recent focus is the dual purpose of waste treatment together with production of a renewable fuel. In Sweden, biogas is commonly used in the transport sector and Sweden has taken a leading role in this development. Germany, Switzerland and the Netherlands are also developing this sector and several countries, for example, Pakistan, Italy, and USA, use fossil methane in the transport sector. In the EU, most of the biogas is used to produce heating and electricity. Germany produces around 60% of the biogas in the EU and the fast development is driven by generous feed in tariffs for electricity produced from biogas.

The introduction of a new vehicle fuel is a complex process, since the production, infrastructure and vehicle fleet has to be simultaneously developed. The aim of this report is to evaluate the barriers and drivers for increased production and use of upgraded biogas in Sweden. The implications for the future development of the biogas system are also analysed.

1.1 METHOD

Scientific publications and official reports were used to compile drivers and barriers for the development of upgraded biogas. Legislative and governmental documents provided the details for the regulations and policy measures. The study has a Swedish focus and organisations mentioned in this report are Swedish unless stated otherwise. A geographical study was used to analyse the influence of the availability of a natural gas grid. The biogas development in a region with a natural gas grid was compared to that in a region without natural gas grid. These two regions also have the main part of the biogas production and use (Swedish Energy Agency, 2012a): the south west of Sweden (3 180 000 inhabitants) including the counties of Skåne, Halland and Västra Götaland and the region of Mälardalen (3 742 000 inhabitants) including the counties of Stockholm, Uppsala, Västmanland, Örebro, Södermanland and Östergötland (Figure 1) (Statistics Sweden, 2013). Both regions are in a Swedish context densely populated and therefore have considerable amounts of biodegradable waste and many car owners as well as public transport vehicles. They also have financially strong local energy companies and local ambitions on sustainability and renewable energy.

Figure 1. The studied regions and the approximate location of the natural gas grid on the west coast.

2 PRODUCTION

In 2011, the Swedish biogas production reached 1.47 TWh and this was produced in wastewater treatment plants (43%), landfills (18%), co-digestion plants (28%), industrial waste treatment plants (9%), and farm-scale plants (1%) (Swedish Energy Agency, 2012a). The production increase during 2005-2011 has mainly occurred at co-digestion and industrial waste treatment plants and this trend will likely continue. Landfilling of organic waste is banned in Sweden and the main segment of the wastewater treatment sludge is already used for biogas production. There is a large biogas production potential from agricultural residues, but the farm-scale production is developing slowly and is in many cases not feasible to produce up-graded biogas for transportation at small-scale remote biogas plants. There is already today a competition for substrates with a high biogas yield, which may increase substrate prices and transportation distances. These substrates may earlier have been retrieved for free or even provided an income in the form of waste handling fees.

Biogas for the transport sector is still a developing industry and the production and distribution is more complex and expensive than for conventional fossil fuels. Biogas is, therefore, in need of policy measures to reach out to the vehicle fuel market.

Biogas is exempted from energy and CO_2-tax if it is used for heating or motor vehicles and fulfils sustainability criteria, as defined in Sweden (Swedish code of statutes, 1994; Swedish code of statutes, 2010a). The tax exemption is considered a powerful incentive for renewable vehicle fuels, though expensive in terms of tax losses (National Audit Office, 2011). A quota system is therefore considered, where the exemption from energy tax is removed for low-level blended biofuels and a certain share of renewable fuels has to be sold at fuel stations. This mainly affects drop-in fuels while the tax exemption for high-blend fuels, like biogas, remain (Ministry of Enterprise, 2013). The continuation of the tax exemption is important for current and future biogas producers and also biogas customers.

Production support of €0.023 per produced kWh of biogas in farm-scale biogas production from manure has been suggested (Swedish Parliament, 2012). The motivation is that methane emissions to the atmosphere are avoided when manure is treated with anaerobic digestion. If this proposal is passed, there might be an expansion of farm-scale biogas production. However, as mentioned above, it is not always feasible to utilize biogas from farms in the transport sector.

2.1 INVESTMENT SCHEMES

Investment schemes for biogas technologies have most likely been important for increasing the biogas production volumes and they are summarized in table 1. Local investment programme (LIP) and climate investment programme (KLIMP) supported local projects for reducing energy use and greenhouse gas emissions in Swedish municipalities. The investment support for production, infrastructure and use of biogas has replaced them as the main investment scheme. This scheme is planned to continue during 2013-2016. The rural development programme for 2014-2020 will likely allow even further increased grants for farm-scale biogas production (Board of Agriculture, 2012).

Table 1. Investment schemes for biogas

Investment support scheme	Grant	Total biogas grants
Local investment programme (LIP) and climate investment programme (KLIMP) *	-	70 m€ 1998-2008
Investment support for projects regarding production, infrastructure and use of biogas **	45% of the costs or max. 2.9 m€	24 m€, 2010-2012. 39 m€ in the budget for 2013-2016
Rural development programme, support for farm-scale biogas production ***	30% of costs or max. 0.2 m€	- , 2009-2013

* Environmental Protection Agency (2009)
** Swedish code of statutes (2009); Swedish Government (2012), Swedish Energy Agency (2012)
*** Board of Agriculture (2012)

2.2 REGULATORY FRAMEWORK

Regulations surround the construction and operation of biogas facilities. Permissions according to the act on planning and construction (Swedish Code of Statutes, 2010b), the act on flammable and explosive goods (Swedish Code of Statutes, 2010c) and the environmental code (Swedish Code of Statutes, 1998) are needed before construction, each one administered by a separate authority. During operation, reporting of sustainability criteria (Swedish code of statutes, 2010a) and ensuring quality on digestate used as fertilizer are needed. Standardization and simplification of these frameworks may lead to more small-scale biogas production plants. Regulations on waste handling in different sectors may be a means of increasing biogas production in many countries. In Sweden, the total ban on landfilling of organic waste has been an important factor behind the development of biogas production from municipal solid waste. The EU landfill directive (European Comission, 1999) probably has had a similar effect.

3 DISTRIBUTION

The availability of biogas is crucial when considering buying a biogas vehicle. Filling stations are available in the south of Sweden up to the level of Stockholm, and mainly in the region of Mälardalen and the Southwest region of Sweden (Vehicle Gas Association, 2012). Biogas is injected in the natural gas grid running along the southwest coast of Sweden. Some filling stations are located next to the production facility, though in many cases transport is needed to connect the production and market. One such example is in the region of Mälardalen, where there is a high demand for biogas in the Stockholm area, while most of the production potential is located in the surrounding region.

Methane has a low volumetric energy density (kWh/m^3); for example, one litre of petrol corresponds to 4 litres of compressed biogas at 200 bar (CBG) or 1.7 litres of liquefied biogas (LBG). The energy for compression and refrigeration together with the low energy density brings about high costs for storage and distribution. Biogas can be transported with lorries (as CBG or LBG), in the natural gas grid, or in a dedicated biogas grid. Three main factors influence the preferred means of transport: biogas volume, transport distance, and available infrastructure.

Transport of CBG with lorries has a relatively low start-up investment cost, but the variable cost increases with longer distances and larger gas volumes (Börjesson et al., 2012). LBG on lorries, on the other hand, is economically and energetically more favourable over longer distances (200-300 km) (Benjaminsson and Nilsson, 2009), but a larger volume of biogas is needed to motivate the higher investment cost of the liquefaction process. A dedicated biogas pipeline can provide cost competitive and energy efficient transport when the biogas volume is high, for example 1 TWh biogas/year could motivate a pipeline at both short and long distances (Benjaminsson and Nilsson, 2009). This is, however, not likely in the near future since the total production of upgraded biogas in Sweden was around 0.7 TWh in 2011 (Swedish Energy Agency, 2012).

3.1 INFLUENCE OF AN AVAILABLE NATURAL GAS GRID

The available natural gas grid mentioned in section 1.1 is another distribution option. Biogas mixed with natural gas is sold as vehicle gas and the natural gas grid provides back up and covers the vehicle gas demand that cannot be supplied by biogas. This back up can also be provided by stand-alone LNG terminals. Injection in the natural gas grid brings about costs for compression, grid access, and propane addition to adjust the energy content to that of the grid. The cost is not increasing with the transport distance and for distances over 80 km it is cheaper than lorry transport (Benjaminsson and Nilsson, 2009).

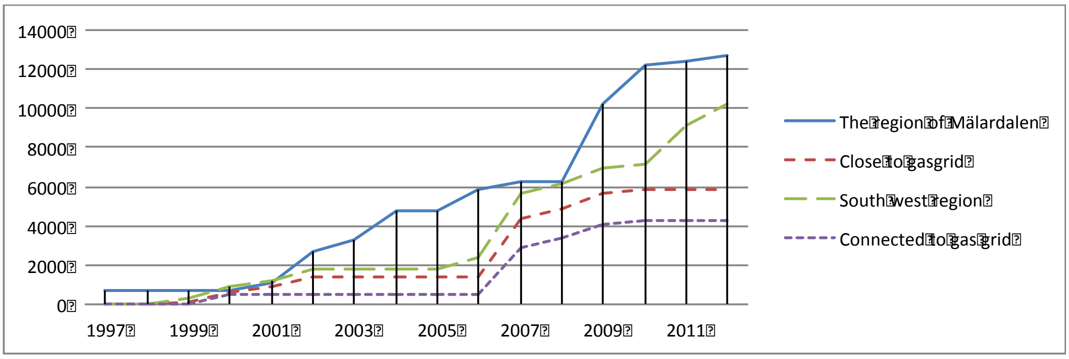

Figure 2. upgrading capacity (Nm3 raw gas/year). Upgrading facilities in the south west of Sweden (with NG grid) and in the region of Mälardalen (without NG grid). Based on: IEA (2013) and geographical data and the location of the natural gas grid from E.ON (2013).

Since the natural gas grid most likely facilitates the distribution of biogas, a natural question to ask is whether the access to the natural gas grid has had any major influence of the development of production and use of biogas. A comparison on built upgrading capacity for biogas reveals that it is possible to achieve production and utilisation of upgraded biogas without access to the NG grid (Figure 2). The region of Mälardalen has achieved a large growth in upgrading capacity without grid connection and a large part of the upgrading capacity in the southwest region has also been built without grid connection. It is also clear that production facilities close to the gas grid (in the same municipality) are not necessarily connected to the gas grid. Hence, from the collected data about the development of biogas in Sweden, it may be deducted that a natural gas network neither has been a prerequisite, nor even a driver, for the development of upgraded biogas in the Swedish transport sector.

However, availability of a gas grid has probably been positive for the facilities connected, since it connects a production facility to a large market and NG acts as backup when the biogas demand exceeds the production. Börjesson et al. (2012) concluded that an available natural gas grid could be positive for the development of biogas use in the transport sector. It is, in any case, difficult to motivate an extension of the natural gas grid with the positive influence on biogas, based on the information gathered in this report. An extention has to be motivated by the intention to use more natural gas and with the understanding that it will be very challenging to replace all the natural gas with biogas in the future grid.

Part of these unexpected results may be due to the fact that investment support schemes have supported the development of infrastructure for biogas. Investment support is today given mainly to developing distribution technologies like LBG to bring them to the market (Swedish code of statutes, 2009). The European Commission has proposed a plan for supporting infrastructure for alternative fuels in the transport sector like hydrogen, methane and electricity (European Commission, 2013). Infrastructure is a key issue for the development of biogas and an extension of the infrastructure will definitely facilitate the production and use of biogas.

3.2 FILLING STATIONS

In order to increase the availability of renewable fuels, an obligation to provide renewable transportation fuels at filling stations was instated in Sweden 2005 (Swedish Code of Statutes, 2005). Since this mainly resulted in the construction of ethanol pumps, a financial support for construction of CBG pumps, and other fuels except ethanol, was established (Environmental Protection Agency, 2012). This led to construction of more CBG pumps, though the effect was smaller than expected. Filling stations has also been included in the investment schemes mentioned in section 2.1.

3.3 A COMMON BIOGAS MARKET

Vehicle gas is today a heterogeneous market due to regional differences in supply and demand. This means uncertainties for both producers and customers. Connection to a larger gas grid, like the natural gas grid, could even out these differences and create a more stable market. The common market may to some extent be created by the so-called green gas principle, which allows biogas to be sold in a virtual grid of unconnected actual grids. Biogas and natural gas is taxed separately even if they are co-distributed (Swedish Code of Statutes, 1994). Technically, this is achieved with a contract between a producer and a buyer, stating that the buyer's outtake of methane is pure biogas although it actually is a mixture including natural gas. This legislation applies even for unconnected grids, creating a virtual network for biogas and natural gas, though it only applies to mixed grids, with both biogas and natural gas, and not to grids designated only for biogas (Swedish Tax Agency, 2012).

4 BIOGAS USE IN THE VEHICLE FLEET

Pure biogas can be used in an Otto engine and a mixture of biogas and diesel can be used in a dual-fuel Diesel engine. The Otto engine is suitable for passenger cars, light transports and buses, whereas the dual-fuel diesel engine is more suitable for heavy long distance transports, since it benefits from a driving pattern with small variations and steady engine operation. Liquefied biogas, mentioned in section 3, can increase the energy storage capacity and enable long distance heavy transports without an extensive need for refuelling. During 2011, 6.8% of the fuel used in the Swedish road transport sector was classified as renewable, and 12% of this was biogas (Swedish Energy Agency, 2012b). Today, biogas is mainly used in buses and commercial cars, for example taxis and delivery vehicles. 76% of the newly registered biogas cars are located in the counties of Stockholm, Västra Götaland and Skåne (Transport Analysis, 2013). This is also where most of the vehicle gas filling stations are situated (Vehicle Gas Association, 2012) and where 50% of the Swedish population is living.

The total life cycle vehicle economy is one of the most important factors in the process of buying a car (Eppstein et al., 2011; Ozaki and Sevastyanova, 2011), but another factor that may influence the choice of fuel is environmental concern among certain vehicle buyers. The purchase cost, taxes and fuel economy are factors that influence the total cost. The purchase cost for biogas vehicles compared to other vehicle types are available in Table 2. The comparison is based on three different car models, each available with engine technologies for the different fuels presented in the table. It shows that biogas vehicles are available at the same price level as conventional cars, but the biogas alternative is the most costly of the presented alternatives.

Table 2. Cost comparison between other fuel technologies and biogas for specific vehicle models.

Vehicle type	% Higher cost for corresponding biogas vehicle
Diesel	Around 4% *
Gasoline	0-30% *
Ethanol	11-26% *
Conversion to biogas	€ 4000-5200 **

* Volvocars (2012), Volkswagen (2012), Opel (2012)

** Alexander (2012)

In Sweden, biogas is the least expensive vehicle fuel on energy basis, approximately 10-15% cheaper than petrol and just below the diesel price (Vehicle Gas Association, 2012). The price gap is decreasing and only 4 years back the difference was 30% (Vehicle Gas Association, 2012). The difference in fuel price may lead to a lower life cycle cost for biogas vehicles than for petrol vehicles, especially for vehicles with a long yearly driving distance. Diesel vehicles are, however, generally more energy efficient than biogas vehicles. The fuel consumption for biogas vehicles is varying, but can be up to 70% higher than that for diesel vehicles (Volvocars, 2012; Volkswagen, 2012; Opel, 2012). Hence, when the total costs are added, the life cycle costs are likely to be higher for biogas cars in comparison with diesel cars. For heavy transports, it is also difficult for biogas to compete with diesel vehicles in terms of fuel economy, robustness and availability of filling stations.

Incentives are in place to even out some of the cost differences between cars using renewable fuels like biogas and cars using conventional fossil fuels, and they are summarized in Table 3. The definition of clean cars in Sweden often refers to the Act on Road Traffic Taxes (Swedish Code of Statutes, 2006). The incentives for vehicles have mainly been exemption from taxes or some form of clean car bonus. The exemption from energy and CO_2 taxes is the major reason why biogas prices are relatively attractive in Sweden.

Table 3. Incentives for clean cars.

Incentive	Definition	Duration
Exemption from vehicle tax during 5 years. Up to €600/year. *	Euro 5 vehicles. Biogas vehicles emitting <150 gCO_2/100 km, diesel and petrol vehicles emitting <95 gCO_2/100 km. Heavier cars are allowed to emit more according to the formula: 95+0,0457*(kerb weight-1372).	2013-
Exemption from vehicle tax, previous definition. *	Euro 5 vehicles. Biogas vehicles using <9.7 m^3 biogas /100 km (≈190 gCO_2/100 km), diesel and petrol vehicles emitting <120 gCO_2/100 km.	2010-2012
Clean car bonus of €1200. **	Similar to the previous definition for exemption from vehicle tax, above.	2007-2009
Special clean car bonus of €4600. ***	Euro 5 or 6 and emitting <50 gCO_2/100 km. Mainly affecting hybrid and electric vehicles.	2012-
Reduction of fringe benefits tax, up to 40% below the level for corresponding vehicle using fossil fuel. ****	Plug-in hybrid electric vehicles and vehicles using energy gases other than liquefied petroleum.	2010-
Local incentives like free parking or exemption from congestion fees	Local definitions	-

* Act on road traffic taxes (2006)

** Transport Agency (2009)

*** Transport Agency (2013)

**** Act on Income Tax (1999)

According to Figure 3, the total sales of clean cars (according the clean car definition at that point in time) are increasing, while the sale figures for biogas are steady or in a slight decline. The figure also shows that the gas vehicle sales increased around 2009.

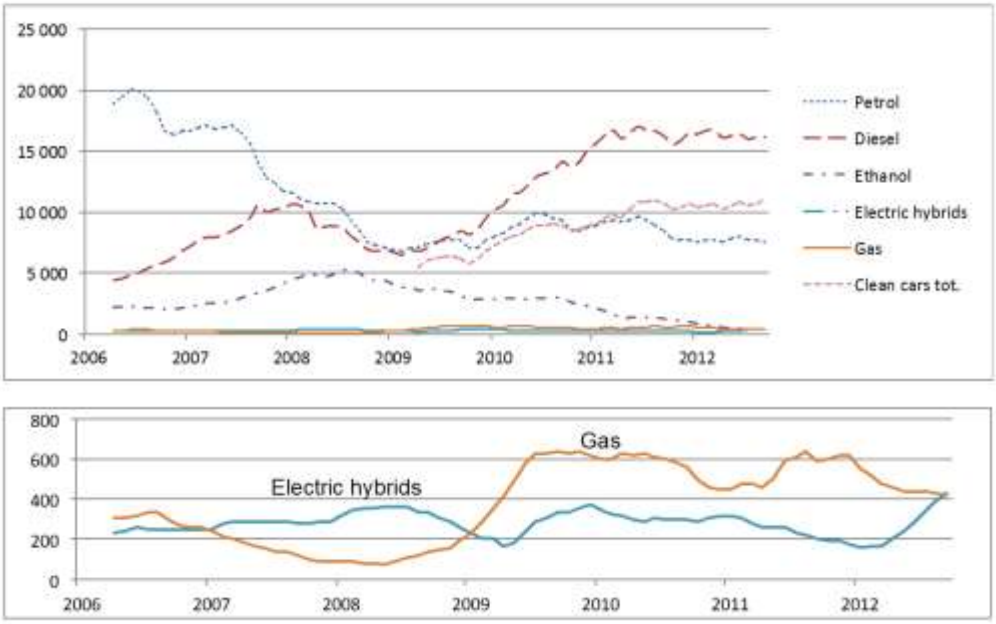

Figure 3. Monthly vehicle sales in Sweden based on all newly registered passenger cars in Sweden, not only clean cars (above) (Transport Analysis, 2012). The sales for gas and electric hybrids are magnified in the below diagram.

The main fraction of the newly registered clean cars is fuelled by diesel. The sales of diesel cars have increased dramatically during recent years, probably because of the clean car incentives supporting efficient diesel vehicles. With the current engine technology, fuel and vehicle prices it is difficult for biogas cars to compete with diesel cars in total life cycle cost. This is comprehensible, since the clean car incentives apply to both technologies and there are in some parts of the country problems with availability of filling stations for biogas. From an environmental perspective, it is positive that the clean car incentives are increasing the energy efficiency in the transport sector with efficient diesel vehicles, but problematic that they do not significantly increase the share of renewable fuels in the road transport sector. It is also contradictory that the current clean car definition allows heavier vehicles higher CO_2 emssion levels (Swedish Code of Statutes, 2006), see table 3. Heavy vehicles with efficient diesel engines still consume large amounts of fossil energy and emit considerable amounts of CO_2.

However, there is one incentive – the reduction of fringe benefits tax – that applies to gas vehicles but not to diesel vehicles. This is an important factor for public/company cars and 75% of the biogas vehicles in Sweden are actually owned by a corporate body, which includes both public services and private companies. Other reasons for a corporate body to buy a biogas vehicle are: that the environmental profile created by biogas cars is attractive for many companies, that public procurement rules often demand an environmental profile of cars, that planning of refuelling is easier since the operation route/area is known or that the possible long yearly driving distance is making the cheap biogas attractive. For the public sector, the aforementioned factors also affect the choice of cars and public procurement is used as a policy measure to aid the long term-term transition to renewable fuels and energy efficient vehicles (Swedish Code of Statutes, 2009). Public procurement is in this way used for demonstration of new technologies and to support an early market. It has been evaluated as a successful measure and it has not increased the life cycle cost of the vehicle fleets (National Audit Office, 2011).

Local and regional initiatives are also important to encourage the use of biogas vehicles and examples of such initiatives are the exemption from parking and congestion fees. The prior exemption from congestion fees in Stockholm for clean cars was likely a good reason for buying a clean car. Nevertheless, as mentioned above, this often means an efficient diesel car that not affects the use of renewable fuels in the city (Lindfors et al., 2009).

For heavy-duty vehicles, there is no national clean vehicle definition and no real state-initiated incentives in Sweden. There are local definitions and policy instruments in for instance Gothenburg, where these are used to limit the negative impact of heavy transports on the city environment. The main governmental support for renewable fuels in heavy-duty trucks is financial support to demo projects, like the Clean Truck project and the BiMe Trucks project (City of Stockholm, 2012; BiMe Trucks, 2013).

5 CONCLUDING DISCUSSION

Sweden is a leading country in the development of upgraded biogas in the transport sector due to incentives covering the whole chain from production to use, as summarized in figure 4. However, biogas production in general is more supported in, for instance Germany where the growth in production has been rapid during the last decade (German Biogas Association, 2013). The amount of upgraded biogas in Sweden is at a steady increase, while the total biogas production is developing slowly, see figure 4. In the regions with biogas development the demand for biogas often exceeds the supply of biogas, and the difference is covered by natural gas. It is difficult to analyse the effect of a separate factor on the biogas production increase, since it is a complex situation and there commonly is a time lag of one to four years between an investment decision and the production start (Environmental Protection Agency, 2009; Zinn, 2013)).

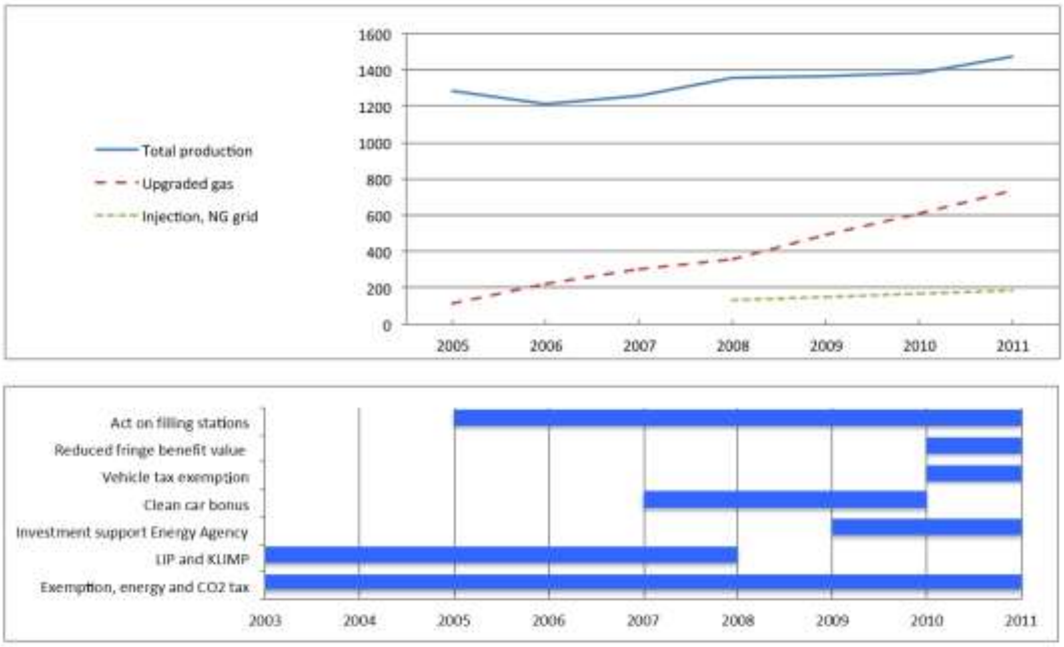

Figure 4. Development of biogas production in Sweden (GWh) in relation to policy instruments. (Swedish Energy Agency, 2012a).

It is likely that LIP and KLIMP has been important in the construction of new biogas production facilities and infrastructure. The exemption from energy and carbon dioxide tax has also been important, both for producers and gas vehicle owners, but recent uncertainties over the continuation of this exemption have likely stifled the biogas development. When this report is written it is most likely that the tax exemptions continue, which will affect the production and use of upgraded biogas positively. It is also important to remember that there are limitations on the amount of easily recoverable substrate suitable for co-digestion facilities. The suggested support for methane emission reductions in farm-scale biogas production will probably increase the biogas production. To what an extent this biogas could be used in the transport sector is limited by factors, such as, distance to biogas infrastructure, investment costs for upgrading, and internal needs at the farm. The infrastructure is today relatively well developed in some parts of the country. If the EU implements the framework for infrastructure for alternative fuels, the infrastructure for biogas in Sweden is likely to develop even further. Though, it is a challenge to determine an optimal configuration of such a developed infrastructure, since the population density in large parts of Sweden is low. As discussed in Chapter 3 it may not be necessary to construct a comprehensive network of pipelines for methane. The biogas volumes will still be quite small in the near future and it is possible to achieve a biogas development without an available gas grid for methane.

One question of importance for the development of biogas in the Swedish transport sector is the future of specific support directed at different parts in the chain from production to use of biogas. As shown in this report, biogas needs further incentives to compete with fuel-efficient diesel vehicles and the circumstances are in this respect similar for other pure and high-level blended biofuels. Since the infrastructure is a higher obstacle for biogas than for most liquid biofuels, the most efficient targets for support of biogas are many cases linked to the infrastructure. However, if biogas should be further supported as a transportation fuel, it is also important to evaluate where biogas is a suitable alternative and direct the policy instruments thereto.

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