This is the published version of a paper presented at BIWAES 2015 - Biennial International Workshop Advances in Energy Studies 2015: Energy and Urban Systems.

Citation for the original published paper:

In:

N.B. When citing this work, cite the original published paper.

Permanent link to this version:
http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-173642
On the road:
non-fossil fuel deployment for the public bus fleet of Sweden
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Abstract

The public transport sector in Sweden has set a target to run 90% of its total vehicle-kilometers on renewable fuels by 2020, and double its market share in the long term. The focus of this paper is the adoption of renewable fuels in public bus fleets. Data for all 21 Swedish counties were gathered and analyzed, mapping the bus fleets’ condition in relation to renewable fuel deployment, CO₂ emissions and energy efficiency. The main factors affecting fuel choices in the bus fleets were investigated through a survey among environmental managers and transport planners at regional public transport authorities. The analysis highlights the challenges implied in the rapid shift that regional bus fleets are undergoing to adopt renewable fuels and reduce emissions. Political will and procurement have been strong success factors in facing these challenges. The survey indicates the stakeholders’ interest to switch to electricity for city routes, while biodiesel and HVO are preferred for longer routes. When it comes to how fuel choices are made, environmental factors seem to be prioritized, while the barriers identified are mainly economic and political.

1. Introduction

Sweden has set an ambitious goal to have a fossil-free vehicle fleet in 2030, in line with the CO₂-emissions neutral target by 2050 (Regeringskansliet, 2013). The public transport sector aims to run 90% of its total vehicle-kilometers on renewable fuels by 2020 (SKL, 2014). Biodiesel, biogas, ethanol and electricity from renewable sources are accounted as renewable fuels. Furthermore, the public transport sector aims to double its market share in the long term, and the volume of travel on public transport by 2020. While significant actions are needed to reach these targets, this is also a great opportunity to rethink public transport solutions and to improve both energy and service efficiency. However, there is currently lack of systematic policy analyses for the Swedish public transport sector that needs to be addressed (Nilsson et al., 2013).

The focus here is on the adoption of renewable fuels in public buses. Bus is the most common means of public transport in Sweden (52% of the total passenger boardings in 2013), and it is offered by all regions (Trafikanalyse, 2014). The status of the Swedish public bus fleet in relation to the aforementioned 90% target for renewable fuels varies regionally, with the national average reaching 58% in 2014 (Svensk Kollektivtrafik, 2015). Thus there is still a long way to go before Sweden reaches carbon neutrality in the public bus fleet. How do present policy initiatives affect renewable fuel deployment? Which are the main factors affecting fuel choices?

In this paper, data on public bus fleets are gathered for all 21 Swedish counties. These data were analyzed in order to map the bus fleets’ condition in relation to renewable fuels deployment, CO₂ emissions and energy efficiency, and to better understand the reasons behind broad regional variations. The main factors affecting fuel choices in bus fleets were investigated through a survey aimed at environmental managers and transport planners at public transport authorities, as well as transport service companies. Through the analysis, we identify best practices and lessons for developing successful strategies for renewable fuel deployment in public bus fleets.
2. The organization of Swedish public transport

Under the new Public Transport Act (Lag (2010:1065) om kollektivtrafik) that was enacted on January 1st 2012, new regional public transport authorities (PTAs thereof) were formed. The PTAs are responsible for the development of public transport systems in their respective region. The PTA is organized either as a federation or a committee of local authorities together with the County Council, for better co-ordination with other aspects of social planning.

The PTAs issue regional transport provision programs, which set the basis for issuing public service obligations for all regions, even where public transport services are not of commercial interest (Svensk Kollektivtrafik, 2014). The public transport services provision is up to 95% subject to procurement. The Swedish Public Transport Association (Svensk Kollektivtrafik – SK thereof) has issued a common sector standard for procurement of public bus services, named “Bus 2014-common sector functional requirements for buses”. The standard includes requirements for safety, passenger comfort, information, communication etc. The environmental requirements are set in more detail in a separate sector standard, titled “Environmental requirements in connection with transport procurement”. Representatives from PTAs, transport operator companies, bus manufacturers and other stakeholders are involved in the development of these standards, which are issued by SK.

3. Regional mapping of non-fossil fuel deployment in public bus fleets

Information regarding environmental performance and other bus fleet characteristics is found in the FRIDA database (FRIDA miljö- och fordonsdatabas), which gathers official statistics for public buses in all 21 counties of Sweden. The web-based database was developed by Nordic Port in cooperation with SK and the transport service operators report the information to the PTAs who are responsible for curating FRIDA. The increase of vehicle kilometers run on renewable fuels has been impressive in the past few years, rising from a total share of 8% in 2007 to 58% in 2014. Biodiesel is currently leading among renewable fuels (33.7%), followed by biogas (17.2%) and ethanol (7.2%). Electricity has currently a very small share (0.3%), since electric buses are only in demo stage (only 7 reported). A significant increase trend for renewable fuels can be observed starting around 2010, which was the year when the first common sector standard was introduced. The even higher growth rates after 2012 could be credited to the boost given to procurement with the creation of PTAs in 2012, as well as the dissemination of new bus technologies.

Data on regional fuel mixes for buses are shown in Figure 1. Generally, higher renewable fuel shares are noticed in the South. Biogas is dominating in specific regions (e.g. Skåne, Västmanland) where investments on gas infrastructure and local production of biogas have been promoted. It can be observed that achievements vary across the country, and not only densely populated regions with large bus transport volume perform well in terms of renewable fuel deployment. In Figure 2, only 4 regions surpassed 50% renewable fuels in 2012, while in 2014 the number increased to 9, showing the rapid growth of renewable fuel use in bus fleets.

Thus, although there is an indication of a north-to-south axis for renewable fuel deployment trends in bus fleets, there is no strong correlation of population density or...
bus transport volume to the share of renewable fuels in the fleet. This places political will and strategic planning in public transport as very important factors affecting renewable fuel deployment, provided that limitations due to, for example, climatic conditions are overcome through alternative fuel choices and improved technologies.

Figure 1: Map of (i) the 21 Swedish regions, (ii) fuel mix per region, and (iii) share of vehicle kilometers run on renewable fuels - public bus fleets in 2014 (Svensk Kollektivtrafik, 2015)

Figure 2: Renewable fuels share (%) on vehicle kilometers run by Swedish public bus fleets per region for the years 2010, 2012 and 2014 (Stockholm Läns Landsting, 2011; Svensk Kollektivtrafik, 2015)

Analyzing the environmental data on bus fleets, a steady decrease on CO₂ emissions per vehicle kilometer is observed at national level from 2007 to 2013 (see Figure 3). However, this is not the case for energy use, as energy efficiency values have remained relatively stable. Moreover, when counting CO₂ emissions and energy use per passenger kilometer, emission levels are stable and energy use seems to be
increasing (see Figure 3). The statistics per passenger kilometer are directly connected to occupancy rates and average trip lengths. These numbers are only estimations made by the PTAs, so they should be considered with caution (Tom Petersen, personal communication, 12 January 2015). However, both figures imply the need for higher occupancy rates and more efficient vehicles in order to reduce energy use, especially in future scenarios with higher transport volume.

The statistics on emissions and energy use vary significantly among regions. In the Västra Götaland region, gas buses consume 36% more fuel than diesel buses (Hanna Björk, personal communication, 20 January 2015). So in regions with a larger share of biogas-driven buses, there is higher energy use, though also lower CO\textsubscript{2} emissions since the global Warming Potential (GWP) is lower for biogas than biodiesel (Hallberg et al., 2013). Energy use is also affected by the balance between city and regional traffic. From data provided for the region of Gävleborg (93% of buses are diesel), fuel efficiency for city routes was 14% lower than for regional routes (Claes Forsberg, personal communication, 17 February 2015).

Figure 3: CO\textsubscript{2} emissions and energy use per vehicle kilometer and per passenger kilometer (national level, from 2007 to 2013) (Svensk Kollektivtrafik, 2014a; Trafikanalys, 2015-personal communication)

4. Fuel options for Swedish bus fleets: survey results and best practices

Input from stakeholders of the public transport sector was sought in order to understand the reasons why specific fuel choices are being made, as well as barriers and drivers to increasing renewable fuel deployment. Survey research methods, as in Sapsford (2007) were used, with an anonymous electronic questionnaire and personal interviews with straightforward note-taking. The sampling pool was environmental managers or persons working with strategy and planning at each one of the regional PTAs. Furthermore, the questionnaire was sent to the environmental managers of large transport service companies and representatives of the Swedish Bus and Coach Federation (Sveriges Bussföretag). The questionnaire was sent to 35 persons. In total, 19 persons responded the survey, thus the response rate was 55%.

The results from the survey and the personal interviews conducted show that public transport stakeholders are strongly interested in electricity as a fuel option for buses. The survey respondents mentioned a variety of demonstration projects for electric buses happening in several regions, e.g. Stockholm, Västra Götaland, Skåne. When asked about the most attractive fuel alternative in the foreseeable future, the
respondents placed electricity first (6 responses). Biodiesel from rapeseed oil (RME), which is the most common type of biodiesel currently used in Sweden, was second, together with biogas (5 responses). Finally, 4 replied that HVO (Hydrogenated Vegetable Oil) is the most attractive fuel option. HVO’s performance is similar to conventional biodiesel, but has significantly lower lifecycle GWP (Arvidsson et al., 2011).

The survey also shows the importance of biodiesel, especially in scarcely populated regions, where infrastructure for electricity or biogas may not be profitable. Biodiesel is quite a flexible fuel, which is used in ordinary diesel motors without modifications. It must be noted that, at the moment, electricity can only be seen as an alternative for city traffic while the natural choice for regional routes has usually been biodiesel. Currently transport service operators tend to choose biodiesel, unless another fuel is specifically procured by the PTAs. For regions that have already invested in a specific fuel, either biodiesel or biogas, the survey shows that the majority of PTAs wish to continue investing in the same fuel, in addition to the introduction of electricity as the main choice for city routes. In some cases, although biogas is currently the main fuel used, electricity or biodiesel are identified as more attractive in the future. The reason for this is the lower fuel efficiency of gas-driven vehicles compared to diesel, and the difficulties of securing the biogas supply.

Figure 4.a shows the responses indicating the main factors that affect fuel choices for bus fleets, as seen by the PTAs. Environmental aspects, such as emission reduction potential and energy efficiency, are a priority, as well as infrastructure needs and fuel availability. Lower noise was also a factor, as well as investments needed for specific vehicle technologies, as the latter make fuel switch more difficult. Political priorities are seen as a barrier in a context that requires long-term strategic commitment from the PTAs. Finally, climate conditions affect fuel choices, especially in the colder Northern parts of Sweden, where some fuels are not an option due to freezing points.

Costs are what most of the respondents classify as the biggest barrier to increasing renewable fuel deployment in public bus fleets (see Figure 4.b). Uncertain policy conditions are also high in the response list, because the policy background on renewable fuel taxation and incentives is unclear at the moment, which hinders or delays new investments. Costs, infrastructure and current contracts with transport operators tie PTAs to specific fuels. Low population density leading to longer average trip lengths is also a barrier to increased renewable fuel use in buses.
Most of the respondents indicated that the common sector standards for procurement are followed by the PTAs of their region (59%). However, in the most populous regions of Sweden, e.g. Stockholm or Västra Götaland, the PTAs set even higher requirements than the common sector standards. SK’s standard already has different levels of ambition for the requirements on procured bus services, thus giving flexibility to each PTA to design strategies that are realistic in specific regional conditions. For example, the high requirements on emissions reduction and energy efficiency set by Västra Götaland, will lead transport operators to opt for hybrid buses to improve the fleet’s environmental performance (Hanna Björk, personal communication, 20 January 2015). Municipalities are also important, as they can develop more ambitious strategies and invest in new technologies independently. For example, the Skellefteå and Umeå municipalities in the Västerbotten region invest in biogas and electricity respectively, and have achieved much higher renewable fuel deployment than the aggregate for the region of Västerbotten, which only has 6% renewables in total (Bianca Byring, personal communication, 24 February 2015). Similarly, the municipality of Eskilstuna has set a requirement on biogas in procurement for city traffic since 2002 (Peter Dädeby, personal communication, 4 February 2015).

The respondents agree on the success of transport service procurement as the most important instrument to promote renewable fuel deployment in bus fleets. Strategic decisions for local biogas production and promotion of biogas in the bus fleets through procurement (especially in Southern Sweden) has also been a strong driver, even if usually local biogas supply is not sufficient to cover all the fleet needs. This is especially observed during winter when natural gas is used as a complement. Knowledge transfer and effects of economies of scale in introducing renewable fuels and new bus technologies can help curb barriers, as has been observed in the case of Stockholm (Johan Böhlin, personal communication, 4 February 2015).

5. Conclusions

The analysis highlights the challenges implied in the rapid shift that regional bus fleets are undergoing to adopt renewable fuels and reduce emissions in Sweden. Political will to pursue the decarbonization of public transport has pushed the goals higher in a successful combination with fuel tax exemptions that made deployment feasible. Procurement requirements for public transport services are adjusted regionally, and thus the PTAs have freedom to cooperate with transport operators in designing strategies and adapting to regional preferences and conditions.

Environmental factors seem to be prioritized when fuel choices are made. There is a strong indication of switching to electricity for city routes, due to low emissions, higher energy efficiency and low noise that would improve urban environments. The future challenge for PTAs and municipalities will be to secure increased supply of electricity from renewable sources for their buses. For regional routes where longer fuel range is needed, biodiesel and HVO are preferred. The barriers to increasing renewable fuel penetration are mainly economic and political. A combination of ambitious procurement requirements with economic instruments can help alleviate these barriers. Long-term tax exemption policies are needed, especially in the case of HVO. The introduction of environmental bus premiums could also have significant effects, especially for fully electric and hybrid buses.
Acknowledgements

The authors would like to thank f3-The Swedish Knowledge Centre for Renewable Transportation Fuels for funding this study. We are grateful to the respondents of the survey, especially the ones that were interviewed personally.

Bibliography


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2 http://www.svenskkollektivtrafik.se/Global/forubbling.se/dokument/NY-Avtalsprocessen/Milj%C3%B6krav_buss_20131218sv.pdf (In Swedish)
3 http://frida.port.se/hemsidan/default.cfm