D. Case studies

Out of a large number of potential case studies the consultant has selected nine cases which are presented below in a summary form. One may distinguish two types of cases: those which went through similar discussions as Bergen does and which performed serious comparison studies regarding different technology approaches (like several Swiss cities) and those which are representing specific technology/policy approaches (like e.g. Stockholm).

D.1 Winterthur

As early as 1996 the city of Winterthur saw a discussion regarding economical and ecological effects of the three scenarios Trolleybus, Dieselbus or Gasbus (not yet Biogas!).

![Comparison between Trolley-, Diesel and Gasbus 1996](Source: Umweltpraxis)

Picture D-1: Winterthur – comparison between Trolley-, Diesel and Gasbus 1996

Picture D-1 shows results for relative costs and environmental impact with regard to local emissions (left diagram) and global emissions (right diagram). While the left diagram is more or less still valid today (see chapter E), the rather bad evaluation of the gas bus regarding global emissions was a result of taking into account higher Methane emissions of gas buses against Diesel buses (related to assumed CH4 losses?).

The evaluation resulted in a replacement of the trolley service on line 4 by Diesel buses but trolley services remained in operation for other parts of the network. However, the discussion was going on and in 2002 a further study was delivered which now also included the biogas option (see picture D-2). This study should give an answer whether to operate line 4 further with Diesel buses, with Trolleybuses again or alternatively with gas buses.

For the trolley scenario two sub scenarios have been evaluated which looked at electricity production either by Swiss waterpower or by “European mix”. 
For the Diesel scenario the use of nearly sulphur-free “Green Diesel” and vehicles with EURO 3 technology and CRT-filters has been assumed.

For the biogas scenario it has been assumed that 100% of the biogas can be produced locally from biomass (mainly household waste). Biogas evaluation remained conservative – no additional gains were calculated regarding the avoidance of other waste disposal options.

Based on, or perhaps despite of the recommendations, the city council did decide on keeping the trolleybuses and even favoured their re-introduction on line 4 as announced in press messages (see picture D-3).
However, such re-introduction plans did finally not move forward and in 2007 a new system comparison was assigned (see picture D-4) with regard to the need to replace 21 articulated trolleybuses in 2009/2010.

The study compared the trolleybus with conventional (EURO 5 + SCRT) Diesel buses, hybrid buses, CNG buses and biogas buses.

Results from the study are used in the following chapter E.

Here follows a short summary (*italics* are used to make clear the “translation character”):

**Economy:**
*The Trolleybus is representing the most expensive alternative while the Diesel option is the cheapest. The difference is about 1.1 Mio SFR per year, the gap (=extra costs of the trolleybus) would be reduced to 0.8 Mio SFR if hybrid buses would be chosen. The gasbus was evaluated in the middle between trolley- and Diesel buses, costs being slightly higher than the hybrid option (partly influenced by the need for new tanking facilities).*
Despite of the economical result, a replacement of the trolleybus by either Diesel or Gas buses has to be seen ecologically as a step back while a continuation of the trolley operation is to be seen as combining various advantages: high customer benefits, high public acceptance, good ecological profile regarding emissions (air quality, climate and noise). The disadvantage of the CNG-buses could be eliminated theoretically by biogas but the local energy supplier (Stadtwerke Winterthur) had been raising the problem of availability in enough quantity!

Picture D-4: Winterthur – comparison between Trolley-, Diesel and (Bio-)Gasbus
(Source: Infras/EMPA/Stadt Winterthur)

Based on the new study results the city of Winterthur did decide for the trolley option (see picture D-5). The summarised argumentation was that Diesel buses despite of their ecological improvements, further increased costs for trolleybuses and lower operational costs are not able to compensate the local ecological advantages of the trolley!
Both the political decision and the study results are remarkable in comparison to the earlier study which was clearly favouring the Biogas-option and also in comparison to the decision taken in Basle (see D.3).

**D.2 Bern**

With regard to the need to replace 32 articulated Diesel buses in 2006, the Swiss city of Bern has been evaluating from 2004 a future fleet strategy for the bus network which up to then had been consisting of Trolleybuses and Diesel buses.
The comparison was made between Diesel buses with EURO 4 standard (available from 2006) and CNG-buses with EEV-standard.

The decision was to replace Diesel buses by Biogas buses, reasoned by a feasibility study for the gas option, operational evaluations and general political and societal considerations (see pictures D-6 and D-7).

The evaluations resulted in no major advantages for a CNG option against a Diesel option but with clear ecological advantages regarding CO2 if biogas would be used instead of natural gas. The Bern decision pro Biogas/CNG, as also visible from picture D-7, was clearly based on image, energy policy aspects and the wish to support the local biogas production.

The decision was also dependent on the possibility to establish a financing framework to cover the extra costs involved and to make the CNG/biogas option cost neutral for BERNMOBIL against the Diesel option both with regard to investment and operation costs (see picture D-8). This includes liberation of biogas from the mineral oil tax since 1st July 2008.

Bern’s energy supplier ewb has (so far!) contractually secured the supply of 1 Mio kg biogas per year and has therefore also participated in the construction of a new bio gas factory linked to ara bern’s sewage water plant (the third biggest in Switzerland). The total capacity of the new biogas facility is about 6.35 Mio Nm³ (about 5 Mio kg) per year which certainly would allow to operate more biogas buses in the future.
Picture D-7: BERNMOBIL’s comparison including general political aspects
(Source: BERNMOBIL)

Picture D-8: BERNMOBIL’s contractual / financial framework for the gasbus project
(Source: BERNMOBIL)
The introduction phase for the new technology has been reviewed and results have been published (see picture D-9).

Here follows a short summary (*italics* are used to make clear the “translation character”):

When looking back, problems with the tanking facility proved to have been underestimated. The location of the tanking facility within a housing area presented additional problems. Availability problems in the start phase have been compensated by Diesel buses but only 15% of all disturbances have been linked to gas-specific reasons. The average consumption of the gas buses in Bern was given with +30-35% compared to Diesel buses. Biogas production can be seen as a win-win situation due to production from organic substrate (mainly food waste). Emission reduction for CO2 is about 2000t/year, NOx emissions are about 10% of the Diesel buses with EURO3, PM is at 4% of the Diesel buses – it is acknowledged that Diesel technology has been improved since and that a comparison with EURO V buses would be different. Public acceptance of the gas bus introduction has been very good.