BEST
BioEthanol for Sustainable Transport

SUPPORTED BY THE EUROPEAN UNION

Promoting Clean Cars

Case Study of Stockholm and Sweden

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This report is produced within the European project BEST - Bioethanol for Sustainable Transport.

BEST deals with the introduction and market penetration of bioethanol as a vehicle fuel, and the introduction and wider use of flexible fuel vehicles and ethanol cars on the market.

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Preface

The BEST project (Bioethanol for Sustainable Transport) deals with the introduction and market penetration of bioethanol as a vehicle fuel, establishment of infrastructure for supply and fuelling of bioethanol, and the introduction and wider use of ethanol cars and flexible fuel vehicles on the market.

During the project more than 10,000 ethanol cars and 140 ethanol buses will be put into operation and E85 and E95 fuel stations will be opened.

Low blends with petrol and diesel will be developed and tested. Through this, the participating cities and regions aim to facilitate a market breakthrough for ethanol vehicles and bioethanol and to inspire and obtain followers.

Participating cities/regions are: Biofuel Region (SE), Rotterdam (NL), Somerset (UK), Basque Country, Nanyang (China), Madrid (ES), La Spezia (IT), Sao Paolo (Brazil) and Brandenburg (DE). Co-ordinating City is Stockholm (SE). Industrial partners are Ford Europe, Saab Automobile and several bioethanol suppliers.

The project is co-financed within the 6th framework; Sustainable Energy Systems/Alternative Motor Fuels: Biofuel Cities.

This particular report has also received additional funding from the Swedish Energy Authority (Energimyndigheten).

When it comes to introducing clean vehicles and fuels, to date Stockholm has come the furthest in Europe. Strategic work, since 1994, and the use of various incentives have been applied in order to push for a market breakthrough for clean vehicles and fuels. In this report, the work with clean vehicles and fuels and especially the incentives used both on a national level in Sweden and on a local level in Stockholm has been evaluated. The report is also filled with facts and figures describing the impressive development in Sweden and Stockholm within the field of clean vehicles and fuels.

Eva Sunnerstedt and Björn Hugosson at the City of Stockholm, Environment and Health Administration have been project managers for this report.

The report has been written by Sirje Pädam with much help from Svante Berglund and Ida Örtegren, all from WSP Analysis and Strategy in Stockholm.

Stockholm in January 2009

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Summary in English

In 2005 there was a significant increase in sales of alternatively fuelled vehicles in Sweden. This can be partly explained by the introduction of significant financial incentives such as exemption from congestion charges in Stockholm. In 2008 sales of clean cars grew at a record pace, in comparison to other European countries. One third of all cars sold in Stockholm and a quarter of all cars sold in Sweden were alternatively fuelled vehicles. Low-CO_2 petrol and diesel vehicles also enjoyed record sales in Stockholm and Sweden in 2008.

In this report, the work of the multi-year project Clean Vehicles in Stockholm and national policies in Sweden are used as a case study. The case study follows the developments of clean cars and alternative fuels during the time period 1994-2008 and those measures and incentives that have been used in order to encourage the use of clean cars. The impact of incentives on clean cars have been studied in statistical analyses and qualitative assessments in order to assess how different factors influence the market development of clean vehicles. One reason for this is that relatively little is known about the mechanisms behind the diffusion of clean vehicles, and about the impact of different activities and incentives to promote the choice of a clean car. Another reason is that increased knowledge will help to design future polices, and meet national and European Union goals for alternative fuels and vehicles.

Ranking the impact of various incentives has been one central theme of the analysis. Another concerns policy recommendations based on the lessons learned by the Clean Vehicles in Stockholm project. A third issue has been to consider the relevance of the S-curve for predicting technology introduction of clean cars.

Statistical analyses indicate that exemption from congestion charges in Stockholm has been the most important incentive. Its impact increased sales of alternatively fuelled vehicles by about 23 percent in Stockholm County in 2008. Low relative prices for renewable fuels between January and October likely had a similar positive impact on sales. Free parking incentives influenced the number of clean cars to a lower degree. A national purchase subsidy of SEK 10,000 promoted sales, but significantly less. This incentive has mainly affected sales of petrol and diesel powered low-CO_2 cars.

In a survey of recent clean car buyers in the City of Stockholm, households report their desire to reduce their own environmental impact as the most influential factor when choosing a clean car. Lower operating costs and exemption from congestion taxes are ranked next and these two factors are equally important. The purchase rebate and free residential parking are of relatively low importance. Company car drivers respond that the lower employee benefit tax assessed to a clean company car is the most influential factor for choosing a clean vehicle. Environmental performance is rated as the second most influential and the exemption from congestion charges is ranked third by company car drivers.

Incentives that reduce operating costs seem to be stronger than incentives affecting purchase price. The most effective incentives seem to be those that offer the largest monetary gain or those that drivers experience frequently, such as exemption from congestion charges. Another observation is that incentives that introduce a privilege for clean cars are stronger than incentives that attempt to “even out” differences between clean cars and their conventional counterparts.

The experience of Stockholm and Sweden clearly shows that it is possible for a city to influence the market spread of clean cars. It is important that the city leads by example, but achieving effects beyond municipal administrations requires co-operation with strategic public and private partners and constructive dialogue with national government authorities. There is a need to work systematically and to have a long run commitment. It is essential to include both vehicle supply and fuel infrastructure as critical components of city policies. It is also important to adapt policies to changing circumstances.

Monetary incentives are an important part of an overall policy to promote clean cars, but these incentives will not have a significant impact until clean cars have performance and reliability comparable to a conventional car. It is important to distinguish between a pre-market phase and a market development phase. The pre-market phase requires so-called preparative incentives while the

market development phase calls for incentives that stimulate markets. These preparative incentives include measures promoting vehicle supply and fuel distribution, as well as activities to identify and remove legal barriers and tax disadvantages. Monetary incentives introduced at this stage will likely have a weak impact at this stage. Powerful incentives in the pre-market phase instead address the lack of vehicles and model diversity, missing fuel infrastructure and punishing taxes or absent regulations.

In the market development phase monetary incentives and reliable information become powerful tools. It is also important to keep track of the development of vehicle supply and supporting infrastructure (refuelling network and vehicle repair and service). Information is generally perceived as an incentive with limited impact, but cannot be neglected. In order to reach potential buyers, cities must identify and select target groups. Companies providing transport services and other companies with large fleets are expected to be represented in these target groups. There are many options for cities to work actively with market expansion. Potential activities include guidance regarding green procurement, influence via networking etc.

	Type of incentive
Pre-market phase	Identification and removal of legal barriers and other disincentives Support for development of refuelling infrastructure Promotion of clean vehicle introduction
Market development phase	Joint procurement and other actions to increase vehicle supply Dissemination of reliable information about clean vehicles and fuels Activities to encourage target groups to replace conventional vehicles with clean vehicles (consider investment grants) Market expansion activities (green travel and car policies, green procurement) Support for development of refuelling infrastructure Monetary incentives

By the end of 2008 the share of clean vehicles in the Swedish vehicle stock was approximately 5 percent. This is a significant share in the Swedish market, where vehicle turnover is slower than for example in the United States and most European countries. While the Swedish market seems to have reached the market take-off phase, it is not yet at a self-sustaining growth level. Our understanding of the complex dynamic interactions between consumer considerations, vehicle supply and refuelling infrastructure is still at a very early stage and needs to be developed in order to use the S-curve for predictions about when markets reach self-sustaining growth.

An especially interesting result of this study is that incentives affecting operating cost seemed to be highly effective and the eminent discontinuation of these policies is expected to lead to a sharp drop in clean vehicle sales. Previous studies of car buying behaviour have argued that consumers tend to ignore operating cost when making purchase decisions. Stockholm’s experience suggests that the influence of operating costs in all types of car buying behaviour deserves further study.

Sammanfattning på svenska

Under 2005 ökade miljöbilsförsäljningen markant i Sverige. Detta kan delvis förklaras av att betydelsefulla ekonomiska incitament såsom undantag från trängselskatt infördes. Under 2008 var försäljningstillväxten fortsatt rekordhög, även i jämförelse med andra europeiska länder. Alternativbränslebilarna utgjorde 25 procent av nybilsförsäljningen i Sverige och 33 procent av försäljningen i Stockholm. Försäljningsrekord registrerades även för energieffektiva bilar med låga CO_2-utsläpp.

De mångåriga aktiviteterna i projektet Miljöbilar i Stockholm används tillsammans med politiskt tagna beslut i Sverige som en fallstudie. Fallstudien följer utvecklingen av miljöbilar och alternativa drivmedel under perioden 1994-2008 samt de åtgärder och incitament som införts för att främja användningen av miljöbilar. Incitamentens påverkan på användningen av miljöbilar har studerats genom statistiska analyser och kvalitativa bedömningar i syfte att analysera hur olika faktorer påverkar markandsspridningen av miljöbilar. En av anledningarna bakom detta är att relativt lite är känt om mekanismerna bakom spridningen av miljöbilar och om hur olika aktiviteter och incitament främjar valet av miljöbil. En annan anledning är att ökad kunskap kommer att komma till nytta för framtida åtgärder för att nå nationella och EU målsättningar om alternativa drivmedel och fordon.

En av de centrala frågorna i analysen är rangordningen av de olika incitamentens påverkan. En annan frågeställning är vilka policyrekommendationer som kan dras baserade på lärdomar från Miljöbilar i Stockholm. En tredje fråga som har behandlats är S-kurvans relevans för att förutsäga teknikintroduktionen av miljöbilar.

Statistiska analyser indikerar att undantag från trängselskatt har varit det viktigaste incitamentet. Dess inverkan ökade försäljningen av miljöbilar i Stockholms län med cirka 23 procent under 2008. Under januari till oktober har de låga priserna på förnyelsebart drivmedel relativt bensin haft en liknande positiv inverkan på miljöbilsförsäljningen. Incitament med gratis boendeparkering påverkade antalet miljöbilar i mindre grad. Miljöbilspremien om 10 000 kronor främjade försäljningen, men i avsevärt mindre grad. Premien har huvudsakligen påverkat försäljningen av bränslesnåla bilar.

I en undersökning om nyblivna miljöbilsägare i Stockholms stad anger privatpersoner att deras vilja att minska sin egen miljöpåverkan är den mest betydelsefulla faktorn vid val av miljöbil. Näst viktigast rankas lägre drivmedelskostnader och undantag från trängselskatt, båda värderas som lika viktiga. Miljöbilspremien och gratis boendeparkering värderas som relativt oviktiga. Förmånsbilister säger att lägre förmånsskatt är den mest betydelsefulla faktorn vid val av miljöbil. Egen miljöpåverkan rankas som näst viktigast, och på tredje plats rankas undantag från trängselskatt.

Incitament som minskar driftkostnader verkar ha större betydelse jämfört med incitament som påverkar inköpspriset. De mest betydelsefulla incitamenten är sådana som har stort ekonomiskt värde och sådana som bilister påverkas av ofta. En annan observation är att incitament som ger privilegier för miljöbilar är starkare jämfört med incitament som verkar för att ”jämna ut” skillnader mellan miljöbilar och konventionella fordon.

Erfarenheter från Stockholm och Sverige visar tydligt att det är möjligt för en stad att påverka marknadsspridningen av miljöbilar. Det är viktigt att staden leder genom exempel, men för att påverka bortom den kommunala organisationen krävs samarbete med strategiska offentliga och privata partners samt en konstruktiv dialog med statliga myndigheter. För att nå resultat är det nödvändigt att arbetet är systematiskt och långsiktigt. Det är av största betydelse att både fordonsutbud och infrastruktur för drivmedel inkluderas som avgörande komponenter i stadens åtgärder. Det är också viktigt att anpassa åtgärdernas inriktning efter rådande omständigheter.

Ekonomiska incitament är en viktig del i en övergripande policy för att främja miljöbilar, men incitamenten har ingen särskild påverkan förrän en miljöbil kan jämföras med att köra en vanlig bil. Det är viktigt att särskilja mellan en förberedande fas och en marknadsutvecklingsfas. Den förberedande fasen kräver så kallade förberedande incitament, medan marknadsutvecklingsfasen behöver incitament som stimulerar marknader. Bland de förberedande incitamenten återfinns åtgärder som främjar fordonsutbud och distribution av drivmedel, liksom aktiviteter som syftar till att

identifiera och ta bort hinder i lag och beskattningsregler. Ekonomiska incitament kan introduceras i denna fas, men deras påverkan kommer att vara svag. Kraftfulla incitament i den förberedande fasen riktar sig istället på bristen av variation av fordon och modeller, brist på tankställen samt bestraffande skatter eller saknat regelverk.

I marknadsutvecklingsfasen är ekonomiska incitament och tillförlitlig information kraftfulla verktyg. Det är också viktigt att hålla reda på utvecklingen av fordonsutbudet och stödjande infrastruktur (nätverk av tankställen och service av bilar). Information uppfattas generellt som ett incitament med begränsad påverkan, men det kan inte negligeras. För att nå potentiella köpare måste städer identifiera och välja ut målgrupper. Företag med transporttjänster och andra företag med stora bilflottor förväntas vara representerade i dessa målgrupper. Det finns många möjligheter för städer som arbetar aktivt med marknadsutvidgning. Möjliga aktiviteter är rådgivning i grön upphandling, påverka genom nätverkande etc.

	Typ av incitament
Förberedande fas	Identifikation och borttagande av hinder mot miljöbilar Stöd till utveckling av tankstationer Skapande av förutsättningar för introduktion av miljöbilar
Marknadsfas	Gemensamma upphandlingar och andra aktiviteter som ökar utbudet av miljöbilar Spridning av trovärdig information om miljöbilar och drivmedel Riktade aktiviteter till utvalda målgrupper för att uppmuntra dem att byta ut konventionella fordon mot miljöbilar (överväg investeringsstöd) Aktiviteter som skapar förutsättningar för en marknadsexpansion (grön rese- och bilpolicy och grön upphandling) Stöd till utveckling av tankstationer Ekonomiska incitament

I slutet av 2008 var andelen miljöbilar av det totala antalet fordon i trafik cirka fem procent. Detta är en betydande andel av den svenska marknaden, där utbytet av fordon är långsammare än i exempelvis USA och de flesta europeiska länder. Hursomhelst är det inte möjligt att konstatera att marknaden har nått en sådan nivå att den är självgående. Förståelsen för den komplexa, dynamiska integration mellan konsumenters avvägningar, tillgång till fordon och infrastrukturen av tankställen är fortfarande i ett tidigt stadium. Denna förståelse behöver utvecklas för att genom S-kurvan kunna förutsäga när marknader når en självgående tillväxt.

Ett särskilt intressant resultat av denna studie är att incitament som påverkar driftskostnaderna verkar ha en hög verkningsgrad och att den kommande avvecklingen av ett flertal incitament förväntas leda till en betydande minskning av miljöbilsförsäljningen. Tidigare studier av bilvalsbeteende visar att konsumenter tenderar att förbise betydelsen driftskostnaderna när de köper bil. Detta förordar fortsatta studier av betydelsen av driftskostnader vid bilval.

1 Introduction

Since 1994 the City of Stockholm has run a Clean Vehicle Project through the Environment and Health Protection Administration. *Clean Vehicles in Stockholm* acts as an umbrella for various projects promoting clean vehicles and renewable fuels. A wide range of methods have been used, such as: market incentives, dissemination and awareness-raising (newsletters, seminars etc), joint procurement, investment support, infrastructure development and use of environmental criteria in procurement.

The introduction of clean vehicles began with replacement of conventional vehicles in the city fleet. This work led to a number of complementary activities in order to reduce market barriers such as the lack of clean vehicles, missing fuel infrastructure, punishing taxes and absent regulations. During the 1990s the first steps of market preparation had been taken and in 2000 the city introduced information activities targeted towards private companies to help them choose clean vehicles. As a result of a joint procurement activity initiated by the city in 1998, Ford launched its Focus Flexifuel in Sweden in 2001. Flexi fuel vehicles can run on any blend of petrol and ethanol, up to 85 percent ethanol as in the most common available blend, E85. The same year the city began offering subsidies to companies who invested in clean cars.

In 2005 there was a significant increase in sales of alternatively fuelled vehicles. This can be partly explained by the introduction of significant financial incentives such as free residential parking in Stockholm City in May 2005 and exemption from congestion charges beginning in January 2006. The market penetration of clean cars was further magnified by the introduction of permanent congestion charges in August 2007 and national government subsidies of SEK 10,000 offered to private buyers of clean cars. In 2008 sales of clean cars grew to record levels, also in comparison to other European countries. Between January and October 32 percent of all cars sold in Stockholm were alternatively fuelled vehicles. In comparison to other European cities Stockholm has achieved remarkable developments.

1.1 Purpose

The purpose of this assessment is to study factors that influence the market spread of clean vehicles. One reason for this is that relatively little is known about the mechanisms behind the diffusion of clean vehicles, and about the impact of different activities and incentives to promote the choice of a clean car. Another reason is that increased knowledge will help to design future polices and reach European Union targets including the proposed goal of a ten percent bio-fuel share in European transportation by 2020. (COM 2008 19). The activities in Stockholm and Sweden are used as a reference point of this study. Since policies in Stockholm have been related to the concept of the so-called S-curve it is also important to consider the relevance of the S-curve for predicting technology introduction of clean cars.

1.2 Method and Disposition

This assessment has been divided into three parts:

1. Summary of data and activities
2. Statistical analyses of incentives
3. Complementary assessments

The first part is reviewed in Chapters 2 and 3. Data on developments during the time period 1994-2008, are based on data on sales of clean vehicles and fuels in Stockholm and in Sweden. Chapter 3 includes a chronological summary of activities and policies that have been used to increase the number of clean cars in Stockholm and in Sweden. In order to form a base for recommendations to other cities, this chapter analyzes activities applied at different phases of market growth.

Statistical analyses to estimate the impact from incentives for clean vehicles are reported in Chapter 4 and complementary analyses are carried out in Chapters 5 and 6.

Chapters 7 and 8 offer conclusions and recommendations.

1.3 The S-curve

The S-curve describes the development of markets for many new technologies, including computers and mobile phones. When new technologies are first introduced to the market, most consumers are reluctant to purchase them. The product is considered too unusual, or unproven. The market is dominated by so-called "early adopters" which are buyers with a special interest in new technologies or in the particular qualities of a specific technology (such as lower environmental impact). Slowly, the volume of product in the market increases, new suppliers enter the market and the technology continues to develop. Market barriers including high purchase price, missing information or perceived shortcomings in quality diminish and demand increases, prompting producers to add new models to the market. When the new product has reached wider availability and the market has reached a so called acceptance level or critical mass, mainstream consumers begin to be interested in it. Having reached this level of wider acceptance, market share begins to increase rapidly until it reaches a maximum penetration and is considered a mature product offering.

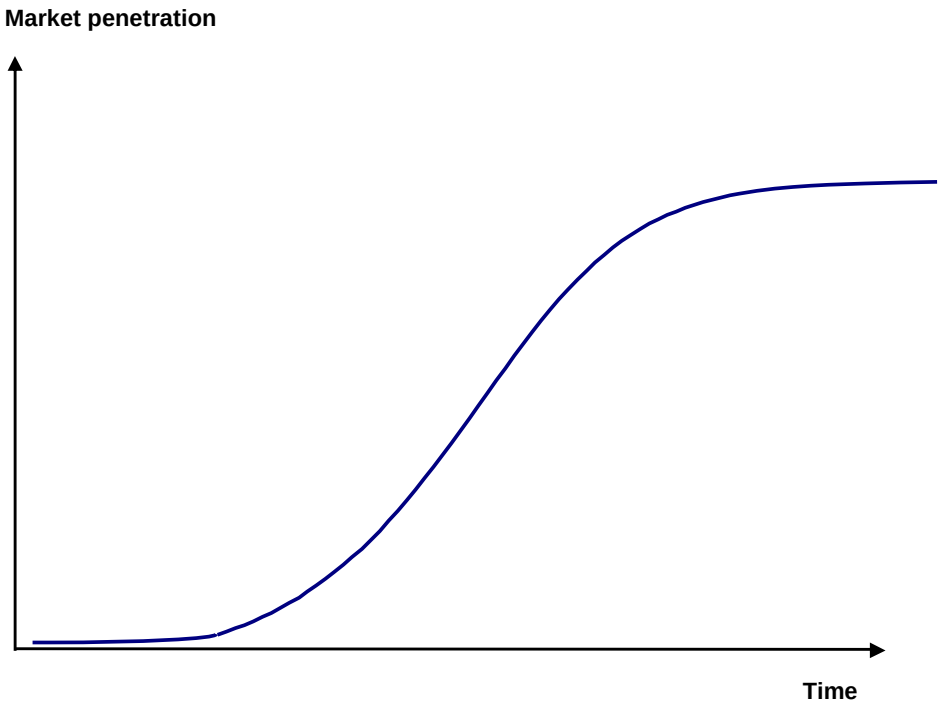


Figure 1 S-curve showing the relation between time and market penetration of new technology

In order to hasten developments, above all by encouraging a swifter exchange of vehicles, Stockholm has used a wide range of methods. These have had the intended effect of shifting the S-curve to an earlier acceptance of clean vehicles. When the market reaches critical mass growth will become self-sustaining and incentives can be phased out.

1.4 What is a Clean Vehicle?

What is a clean vehicle? There is no simple answer to this question. In the mid-1990s the City of Stockholm adopted a definition of clean cars stipulating that clean cars run on renewable fuels (including electricity). In 2005 the Swedish Government adopted a definition of clean cars, which focuses on energy consumption. This definition requires low fuel consumption regardless of whether the cars run on alternative fuels or conventional fuels. The Government definition was adopted by the City of Stockholm in May 2007 with an addition that includes mini vans run on renewable fuels.

Table 1 Various definitions of clean vehicles

	Definition
Adopted by the City of Stockholm in Mid-1990s	A clean vehicle is a motor-driven vehicle which meets Class 1 (best environmental class) requirements and which uses renewable fuels (including electric vehicles). These vehicles should also have a recycling plan. This means that new conventional vehicles that meet Class 1 standards and can be driven on both fossil and renewable fuels, are classified as clean vehicles depending on which fuel they use.
Refinement adopted by the City of Stockholm in 2002	Clean vehicles shall refer to vehicles with a total weight less than 3,500 kg that belong to any of the following categories: • Electric vehicles of any model year • Hybrid vehicles running on petrol and electricity of model year 2000 or later Vehicles of Class 1 that are: • Bifuel vehicles predominantly using biogas • Fuel-flexible vehicles (FFV) predominantly using ethanol (for example E85)
Adopted by the Swedish Government in January 2005	Clean vehicles are passenger cars, with a maximum of four seats plus the driver's seat and sets different requirements depending on whether the vehicle runs on alternative or conventional fuel: **Alternatively fuelled vehicles and electric vehicles** The energy consumption for an alternative fuel vehicle may not exceed the energy equivalent of 9.2 litres of petrol/100 km, 8.4 litres of diesel/100 km or 9.7 cubic metres of LPG/100 km. Common alternative fuel vehicles are flexible fuel vehicles (normally ethanol, E85 and petrol-fuelled) and bifuel (normally biogas/natural gas and petrol-fuelled). The vehicles should primarily be refuelled with renewable ethanol fuel (E85 for flexible fuel vehicles) or biogas (bifuel). An electric car is considered to be a clean vehicle if it is placed in environmental class Mk EL and has an electric energy consumption that does not exceed 3.7 kilowatt hours /100 km. **Low-CO_2 (fossil fuel operated) vehicles** A vehicle run on fossil fuels can be classified a clean vehicle if the carbon dioxide emissions are below 120 grams/km. For vehicles with diesel engines, emissions of particulate matter must be below 5 mg/km. In practice this means that vehicles run on diesel must be equipped with a particulate filter in order to be classified as a clean vehicle. (SFS 2004:1364) and (SFS 2006:1572)
Government definition adopted by the City of Stockholm in May 2007, with the following addition	In addition to government definition: Passenger cars/mini-vans with a minimum of five seats in addition to the driver's seat are considered clean if equipped with either of the following technologies: A) Passenger/mini-van run partially or entirely on electricity. B) Passenger car/mini-van equipped with technology to operate totally or partially with fuels other than petrol, diesel or LPG. Vehicles with compression ignited engines must meet the particulate requirements for environmental class 2005PM according to the listings in SFS 2006:1572. Vehicles run on electricity (Category A) must be of environmental class Electricity or Hybrid. Vehicles with alternative fuels (Category B) must be run with a fuel mixture in which the alternative fuel is predominant, calculated on the fuel's energy content. It must be classified for environmental class 2005/2005PM or higher.

Although different definitions of clean cars now overlap for passenger cars, regulations and incentives still apply to different groups of vehicles. There is, on the one hand, the reduced tax assessment value for clean vehicles owned by companies including hybrid electric cars and cars that can run on alternative fuels (biogas, ethanol (E85), and electricity). On the other hand, the clean car subsidy of SEK 10,000 includes both these groups of vehicles with some restrictions regarding fuel consumption, but also petrol and diesel cars with low CO2 emissions. When there is a need to distinguish between these two groups of vehicles, we use the term *alternatively fuelled vehicles* for hybrid-electric vehicles and vehicles that can run on alternative fuels, and *low-CO2 cars* for petrol and diesel vehicles emitting a maximum of 120 g/CO_2 per kilometre and in the case of diesel cars are equipped with a particulate filter.

As low-CO2 cars were only included in the clean car definition by 2005, the term clean cars (or clean vehicles[1]) in most cases denote only alternatively fuelled vehicles, electric and electric hybrid vehicles, leaving out low-CO_2 cars. Non-private cars are owned by a company (or the public sector) and are either *company cars* or *business cars*. A company car (*förmånsbil* or *tjänstebil* in Swedish) denotes a car used by an employee for both work-related and private purposes, while a business car denotes a car in use for work-related services only.

In this report prices are quoted in Swedish kronor (SEK). For most of the period of the study one Euro has been approximately equivalent to 9 SEK. Since the second half of 2008 the Euro has increased in value and the exchange rate of Euro is now (beginning of 2009) over 10 SEK.

[1] The words ”car” and ”vehicle” are used interchangeably as synonyms for denoting passenger cars.

2 Developments 1994-2008

This chapter reviews available data about clean vehicles during the period of study 1994-2008. There is no single accurate data set of clean vehicle and fuels. The data presented here are collected from various sources.

2.1 New Registrations of Clean Vehicles

Data concerning new registrations of biogas and flexible fuel passenger cars were in many cases wrongly registered as petrol cars in official statistics until 2004. Some data prior to 2005 has been based on personal interviews with people involved in clean vehicles projects. However, most early data has been collected from written sources produced by clean vehicle projects. BilSweden produces data on new registrations of low-CO_2 cars in Sweden since 2005 and since 2006 for Stockholm County.

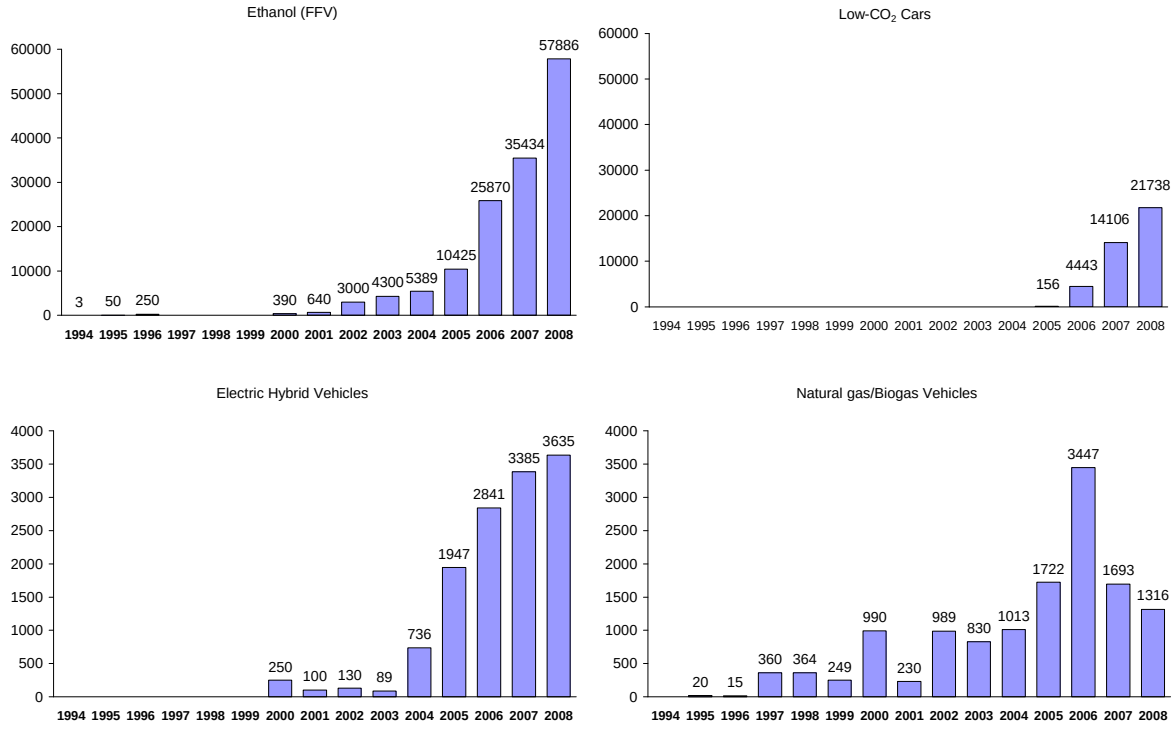


Figure 2 New registrations of clean passenger cars (Sweden) Sources: SCB, Bilsweden, Svenska gasföreningen

Swedish sales of flexi fuel vehicles (FFV) and low-CO_2 cars have grown rapidly during the past few years. Biogas vehicles show a scattered development. Volvo's withdrawal of its V70 Bi-fuel in late 2006 has significantly affected new registrations negatively. Sales of electric hybrid vehicles grew rapidly between 2004 and 2007, but tapered off in 2008. The slump in hybrid registrations in the early 2000's was due to delays in the delivery of the Toyota Prius. 2006 stands out as the year when sales increased dramatically for all types of clean cars.

In 2008 total sales of passenger cars were about 254,000. Clean cars represented one third or about 85,000. Flexi fuel vehicles were the most popular, with sales of about 60,000, which is close to 70 percent. Low-CO_2 vehicles account for about 25 percent of all clean cars in Sweden in 2008.

Regional sales data is missing until 2000. From 2001-2004, the market growth of clean vehicles in Stockholm County was similar to that of Sweden. However, a distinct positive shift occurred in 2005, see figures below.

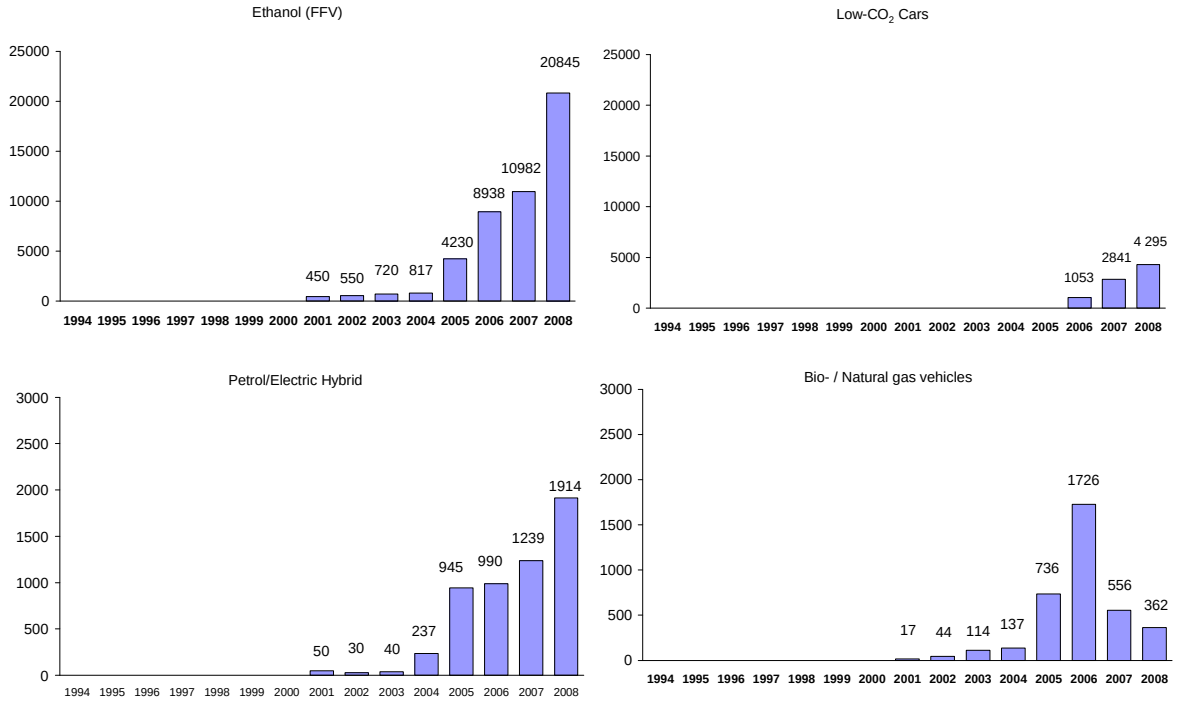


Figure 33 New registrations of clean passenger cars (Stockholm County) 2001-2008 Sources: Clean Vehicles in Stockholm (MIS), SCB, Svenska gasföreningen, Bilsweden

Stockholm County typically accounts for around 25 percent of national new car sales. Stockholm's share of clean cars in Sweden has fluctuated considerably. During the period 2002-2004, Stockholm County had low shares of national clean car sales and clean cars were under-represented in the Stockholm market. Since 2005, the share of clean cars has been higher than 25 percent and consistently above the national average for clean car sales.

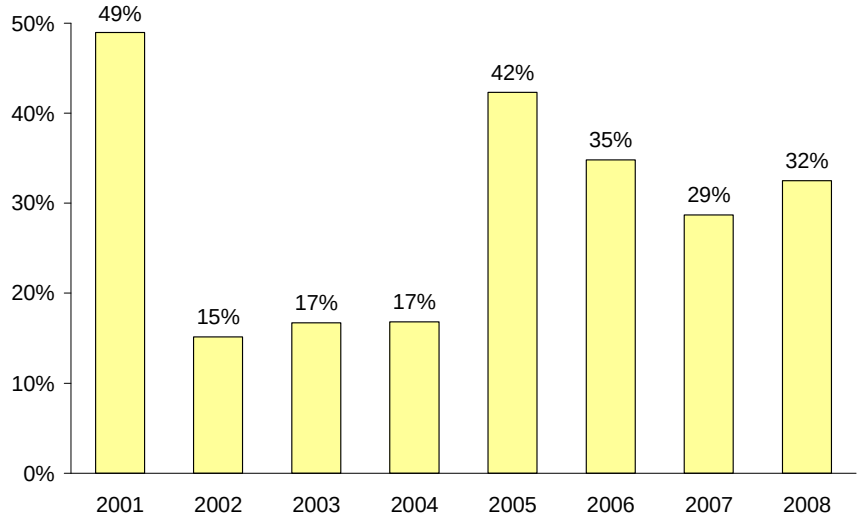


Figure 4 Stockholm County's share of national clean cars sales, 2001-2008

Clean cars including low-CO_2 vehicles represented 33 percent of passenger car sales in Sweden and 39 percent in Stockholm in 2008. Alternatively fuelled vehicles made up 25 percent of sales in Sweden and 33 percent of sales in Stockholm.

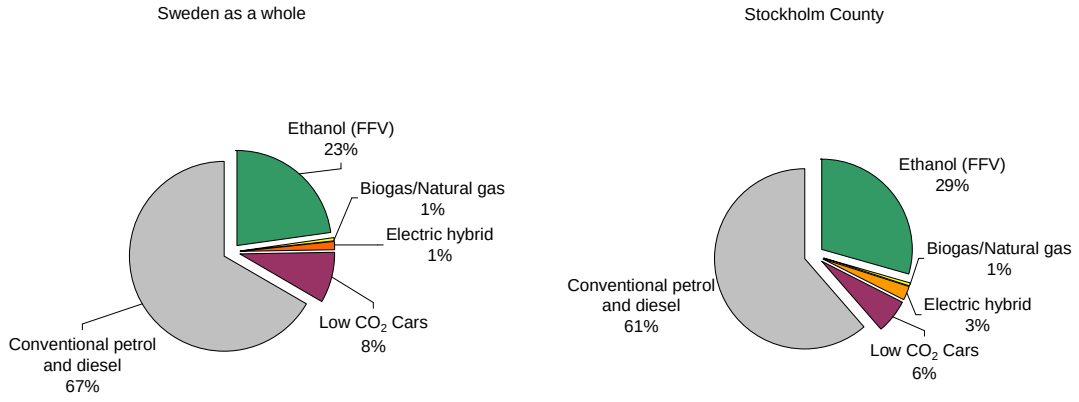


Figure 5 Share in new registrations in Sweden and in Stockholm County 2008. Source: BilSweden

2.2 Stock of Clean Vehicles

There are also data gaps regarding clean vehicle stocks, i.e. the number of cars in use. However, since project documentation has been more rigorous regarding stocks than sales, it is possible to present a longer time series. While official statistics were corrected on flexible fuel and biogas passenger cars in 2005, it is still not possible to identify low-CO_2 vehicles in official statistics. The data presented here on low-CO_2 vehicle stocks has been collected by the clean vehicle website (miljofordon.se) and by the project Clean Vehicles in Stockholm.

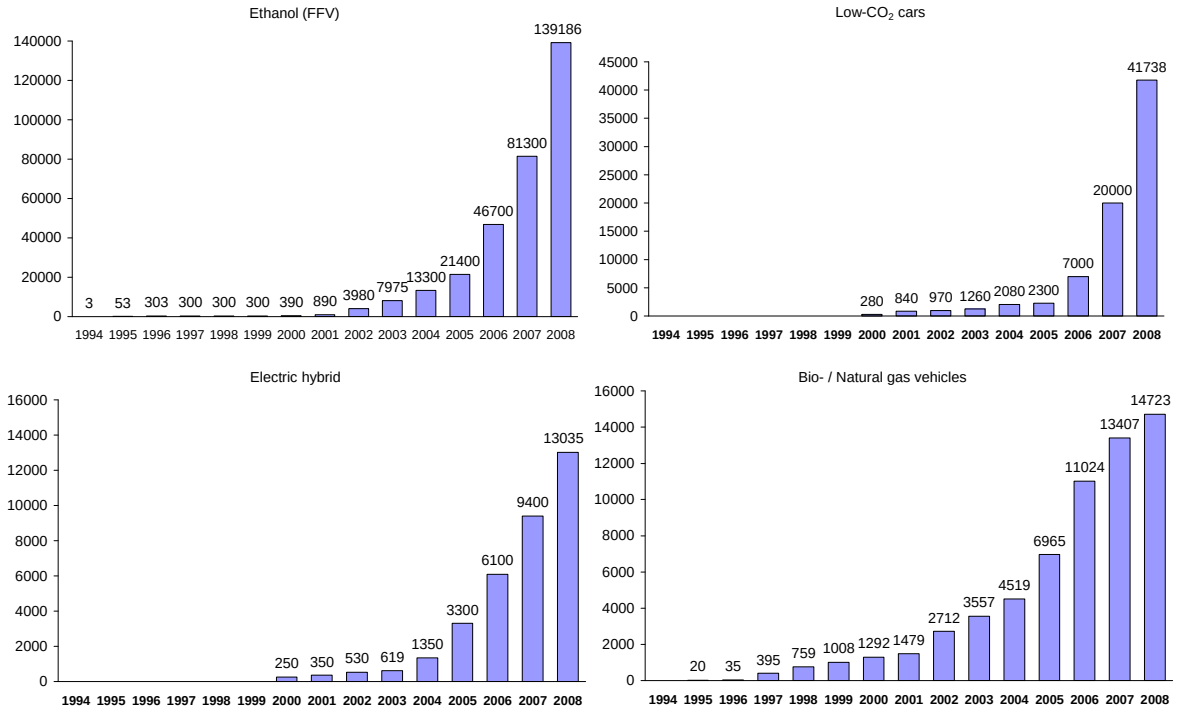


Figure 6 Stock of clean passenger cars (Sweden) Sources: SCB, Miljöfordon.se, Svenska gasföreningen, BilSweden, 2008 (equals stock 2007 plus new registrations 2008)

The four different kinds of clean vehicles represented above have been growing exponentially over the past four to six years. In 2003 the share of clean cars was 0.3 percent of the Swedish vehicle stock. In 2008 the share of alternatively fuelled vehicles was 4 percent and the share of clean cars (including Low-CO_2-vehicels) was 5 percent.

Clean cars are more prevalent in Stockholm than in the rest of the country. Stockholm County accounts for 18 percent of Sweden's stock of passenger cars but over a third of Sweden's FFV's, a quarter of all biogas vehicles and low-CO_2 cars, and over 40 percent of electric hybrids. FFV's are most popular, with 50,000 registered in Stockholm in 2008. In 2008, the share of alternatively fuelled vehicles in Stockholm County was about 6 percent and the share of clean cars (including Low-CO_2-vehicels) was about 8 percent.

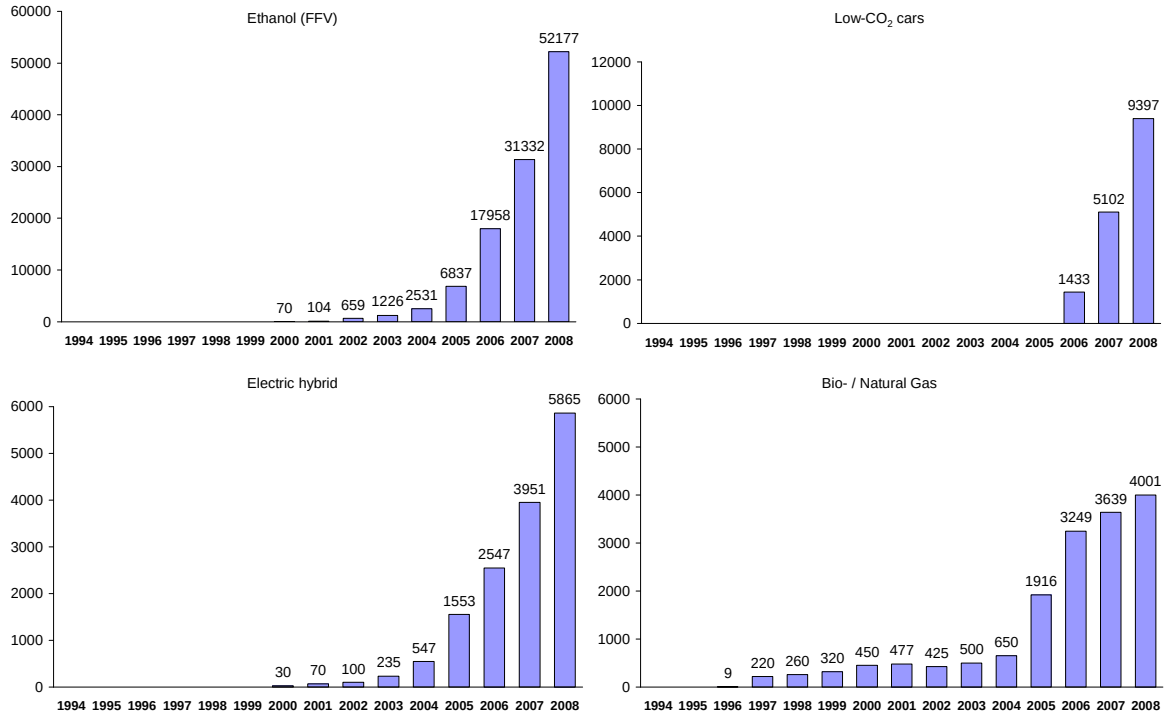


Figure 7 Stock of clean passenger cars (Stockholm County) Sources: SCB, Clean Vehicles in Stockholm, Svenska gasföreningen, BilSweden, 2008 (equals stock 2007 plus new registrations 2008)

2.3 Supply of Car Models

The availability of a variety of clean car models is essential for market growth. In 1994 and 1995 there were only three car models available: two electric cars with battery drive only and the Ford Taurus FFV (using ethanol and petrol) in Sweden. The Ford Taurus FFV could only be leased. Biogas vehicles became available on the Swedish market in 1996 and the first Toyota Prius electric hybrids arrived in Sweden in 2000. One year later, pure electric cars where withdrawn from the market. Cars that fulfil national low-CO_2 standards were introduced in 2005. The low-CO_2 cars are all compact cars with petrol and diesel drive, but their number has been growing significantly from 2006 and onwards. The table shows the top 10 models in 2008 and their first registration month.

Table 2 Top ten models of alternatively fuelled vehicles and their first registration. Source: BilSweden

Car model	Size	Month and year of first registration
1. Volvo V70 Flexifuel	Large	November, 2007
2. Saab 9-3 Biopower	Compact	February, 2007
3. Volvo V50 Flexifuel	Mid-size	December, 2005
4. Saab 9-5 Biopower	Mid-size	July, 2005
5. Ford Focus Flexifuel	Compact	Arrives in Sweden in 2001, new model variety in 2004
6. VW Golf Multifuel (FFV)	Compact	November, 2007
7. Toyota Prius	Mid-Size	Premiere in Sweden in 2000, new model variety 2004
8. Peugeot 307 Bioflex (FFV)	Compact-Mid-size	August, 2007
9. Skoda Octavia E85	Mid-size	December, 2007
10. Volvo C30 Flexifuel	Compact (Small coupe)	January, 2007

Among top ten, all models except the Prius electric hybrid car are flexible fuel (ethanol/petrol) vehicles.

The figure below shows the total number of clean vehicle models available on the Swedish market. Note that sales show significant growth of FFVs in 2002, the year after the introduction of the second FFV model. Other jumps in FFV sales are in 2005, 2006 and 2008. In 2005 the number of available models grows from three to six, and perhaps more importantly the three new models were introduced by Sweden's two leading brands Saab and Volvo. The number of biogas models fell in 2007 and 2008. A corresponding downward trend is obvious in sales figures. Electric hybrid sales grow significantly between 2004 and 2005. This is probably related to the introduction of the new Prius. Increase in sales contiues in 2006 when Honda and Lexus introcude their electric hybird models. The causal relationship is more difficult to determine but is likely bidirectional; growing markets encourage automakers to offer new models, and new models encourage consumers to purchase clean vehicles.

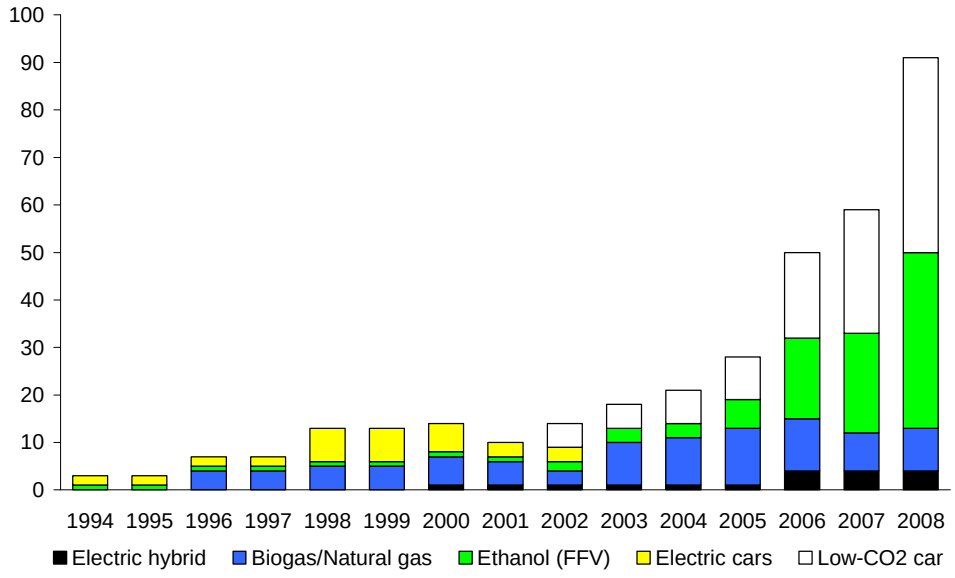


Figure 8 Number of clean car models on the Swedish market. Source: Konsumentverket

2.4 Refuelling Infrastructure for Alternative Fuels

There are about 3,500 refuelling stations in Sweden and about 1,400 of them supply alternative fuels. Most of them, about 1,300, supply E85 (85 percent ethanol and 15 percent petrol). Only 90 refuelling stations supply methane gas: 41 sell natural gas and 49 sell biogas.[2] Refuelling infrastructure supplying E85 has grown rapidly since the introduction of the renewable fuel obligation: from 305 in 2006 to 1,293 in November 2008. This obligation ("the pump law") requires refuelling stations of a certain size to supply at least one alternative fuel. The number of biogas and natural gas pumps has grown from 62 to 90 during the same time period (2006-2008). The figure below shows this development. The dominance of ethanol as the preferred option taken by fuel providers to fulfil the national requirement is quite easily explained. Installation of an ethanol pump requires an investment of approximately 350,000-400,000 SEK, while a biogas pump costs ten times that amount. The fact that refuelling stations can apply for subsidies for installing biogas stations (up to thirty percent of the additional cost) has so far not affected ethanol's position as the most-widely available alternative fuel on the Swedish market.

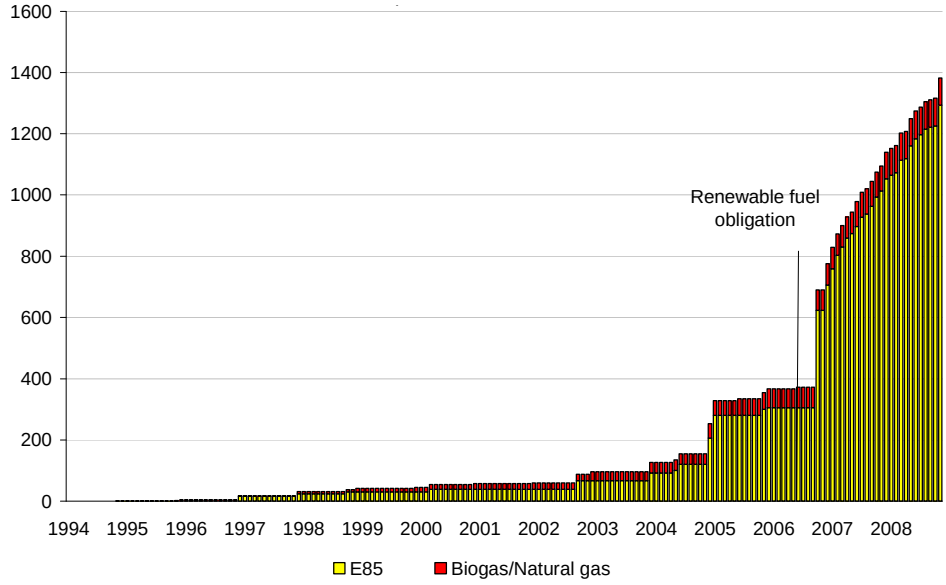


Figure 9 The number of refuelling stations supplying alternative fuels, Annual data 1997-2006, monthly data 2007-2008. Sources: Svenska gasföreningen, Clean Vehicles in Stockholm OK/Q8 and SPI

2.5 Sales of Alternative Fuels

Sales of E85 have grown dramatically from about 1,000 m^3 per month in 2005 to about 20,000 m^3 per month in 2008. In November 2008 the price of petrol fell and at the same time as the price of E85 increased, which reduced sales by one half, see figure below.

[2] Figures correct as of 30 November 2008.

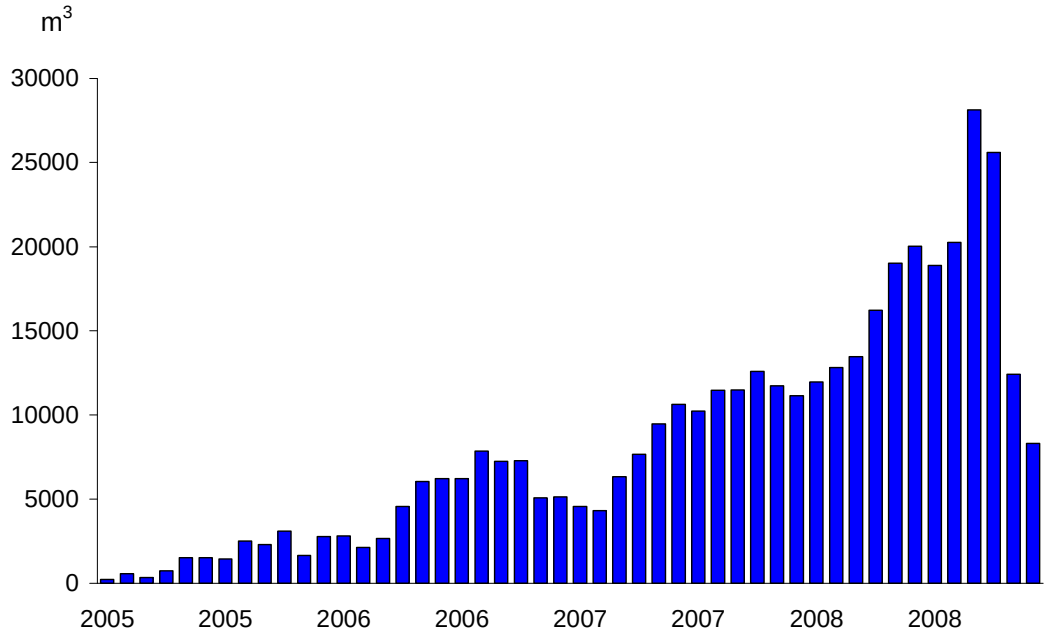


Figure 10 Sales of E85, m^3 in Sweden January 2005-December 2008: Source: SPI

While sales of ethanol have grown rapidly during recent years, consumption of natural gas and biogas as vehicle fuel has increased at a more modest pace. It is interesting to note that consumption of biogas in vehicle fuel surpassed that of natural gas in 2006, see figure below.

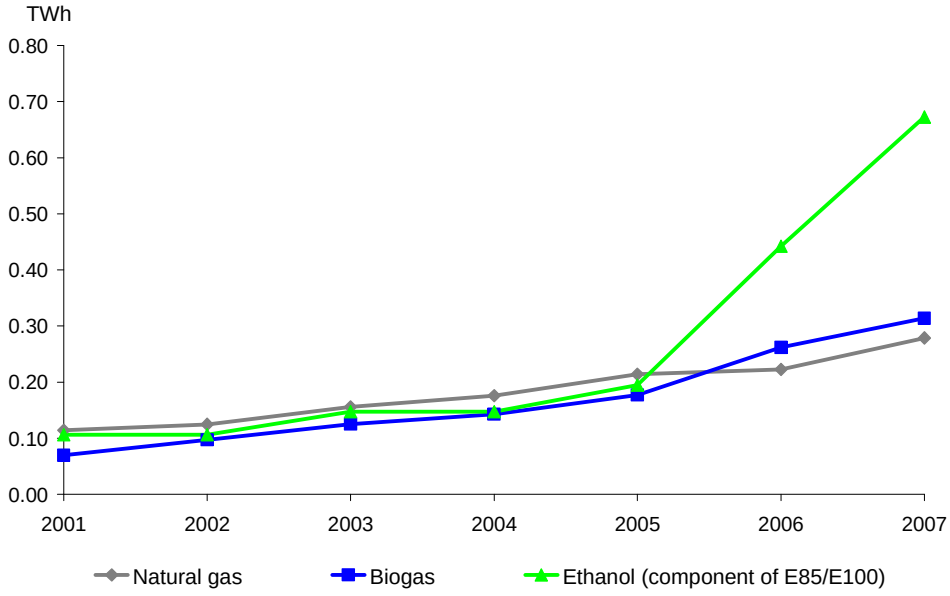


Figure 11 Annual Sales of natural gas, biogas and ethanol (E85-E100 blends) in Sweden, TWh Source: Svenska gasföreningen and STEM ES 008:02

2.6 Purchase Prices

Purchase prices for alternatively fuelled vehicles are higher than prices of conventional vehicles. The additional price for a hybrid electric vehicle is about SEK 70,000 and that of a biogas/natural gas vehicle is about SEK 30,000. This means additional costs of about 40 and 15 percent respectively. The price difference of a petrol car and an ethanol petrol car is significantly less, between zero and five percent. The Swedish National Tax Board has published data on the additional purchase price of alternatively fuelled vehicles since 2002, see table below. This information is and has been used by the Swedish National Tax Board when calculating the reduced tax for company cars. There is no corresponding price premium for low-CO_2 cars.

Table 3 Additional purchase price of alternatively fuelled vehicles SEK (VAT included).* Source: National Tax Board

	Hybrid/electric	Biogas/Natural gas	FFV
2002	60,000	35,000	5,000
2003	60,000	47,000	5,000
2004	64,000	47,000	5,000
2005	63,000	30,000	6,500
2006	63,000	30,000	6,500
2007	72,000	30,000	12,000
2008	72,000	30,000	10,000

*Note: Values are rounded since they are a base for determining the reduction of the tax assessment value of company cars.

The alternatively fuelled vehicles available on the Swedish market have a purchase price premium of about 30 percent for hybrid cars, ten percent for biogas cars, and five percent for an ethanol FFV.

Second hand markets started to develop in the early 2000s, but price estimates were difficult because the base for comparisons was still very small. (Blomberg, 2003) It was possible to draw conclusions only about battery electric cars, electric hybrids and biogas vehicles. The battery cars had lost 40 percent more in value than a comparable conventional vehicle; electric hybrids were valued 8 percent less and biogas vehicles 10 percent less than a comparable conventional car (*Ibid*.). In 2006 there was no difference in value loss between a conventional Ford Focus and FFV Ford Focus. In January 2008 buyers were prepared to pay slightly more for a second hand Ford Focus FFV than a second hand Ford Focus petrol car, see table below. Although this is based on a limited owner survey, it does indicate that FFV-owners are no longer disadvantaged in the second hand market.

Table 4 Percent retained value after three years compared to purchase price
Source: Trendsetter 2006, Clean Vehicles in Stockholm 2006 and Clean Vehicles in Stockholm 2008

Model	2004	2006	2008	
			40,000 km	80,000 km
Toyota Corolla petrol	75%	83%*	-	-
Toyota Prius (electric hybrid)	50%	75%*	71%	65%
Volvo petrol	63%	64%	67%	61%
Volvo Bi-fuel (biogas/petrol)	55%	57%	63%	57%
Ford Focus petrol	-	71%	70%	62%
Ford Focus FFV (ethanol/petrol)	60%	71%	72%	64%

*Note: The comparison concerns a Toyota Corolla that has been driven 15,000 km less than the Prius.

Since FFV's use more fuel when run on E85 than on petrol, the relative price of E85 needs to be sufficiently lower than petrol to make E85 a preferred option. Therefore "petrol equivalent" prices are more useful when comparing ethanol and petrol prices. The red lines in the figure below show petrol

equivalent prices of E85 calculated to reflect higher fuel consumption of 30 to 40 percent. In 2005 and during the time period April 2006-October 2008 the petrol equivalent price of E85 was less than petrol, see figure below.

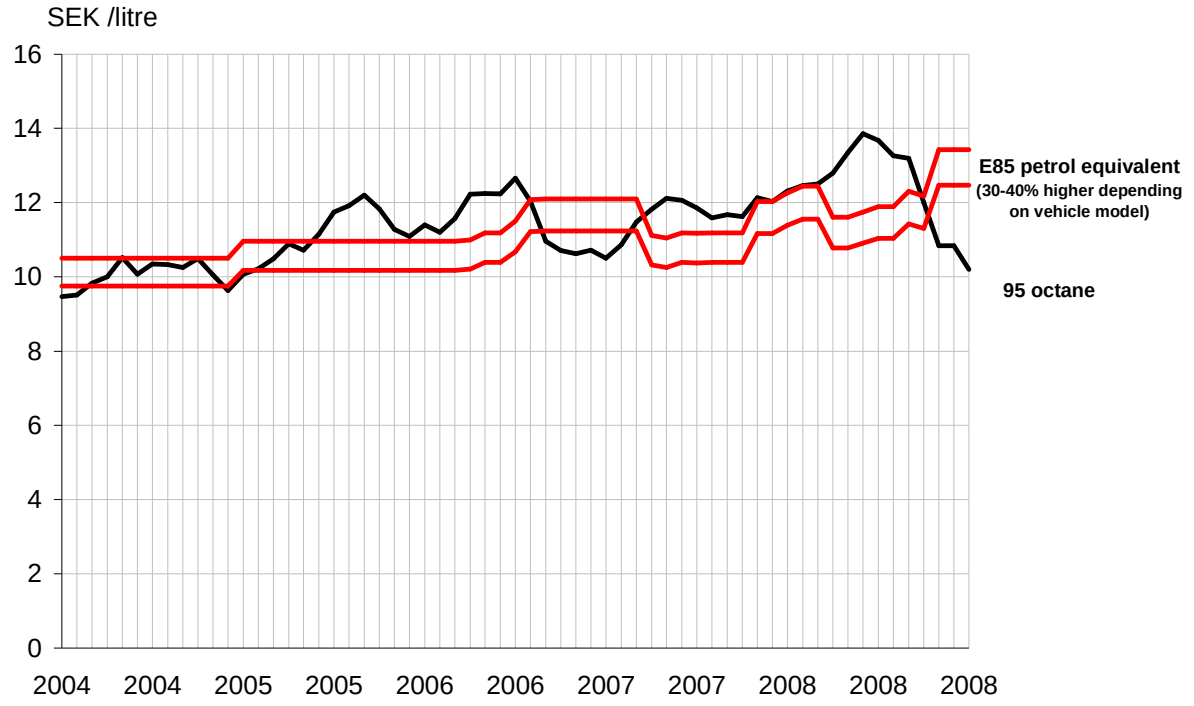


Figure 12 The price of petrol (lead free 95 octane) and the price of E85, monthly averages Source: Statoil

3 Activities

This chapter provides an overview of activities and policies in Stockholm and in Sweden and describes measures that have been in use to increase the number of clean cars. In order to form a base for recommendations to other cities, an analysis is carried out by classifying activities in different phases in relation to market growth. The figure below shows introduction dates of incentives and the development of clean vehicle registration in Sweden. For a description of incentives, see Appendix.

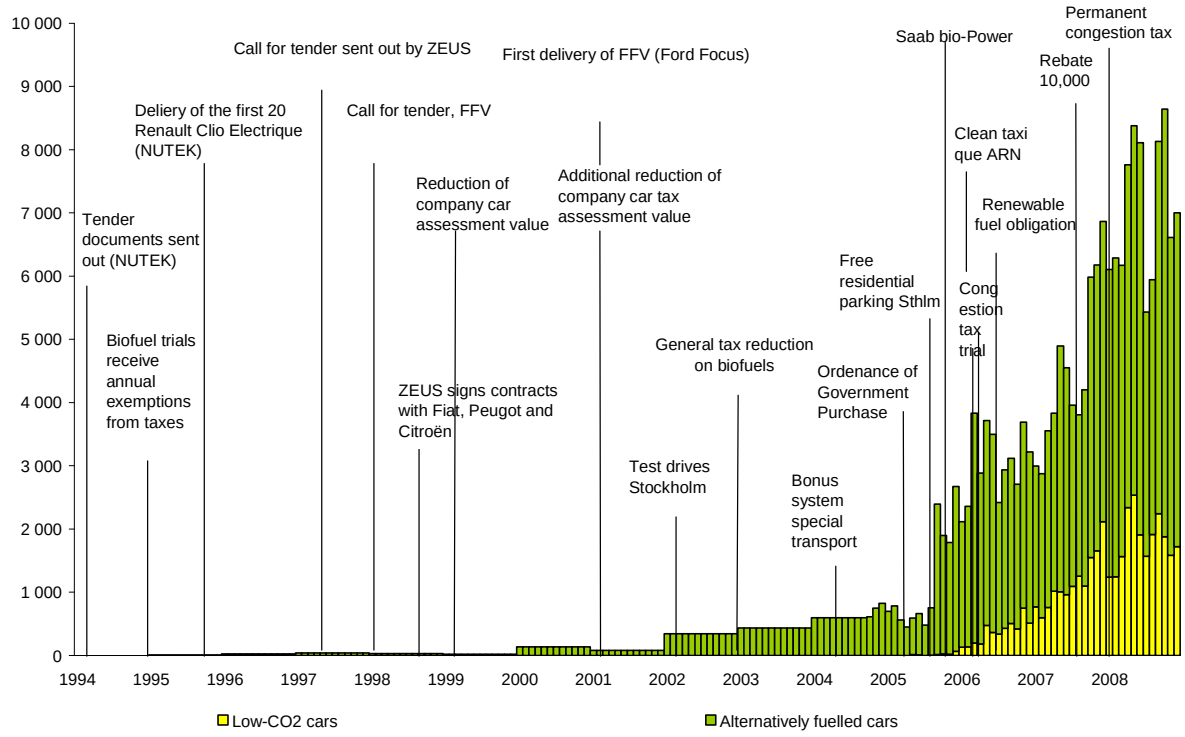


Figure 13 Incentives and new Clean Vehicle registrations in Sweden 1994-2004 annual data, October 2004-December 2008 monthly data. Source: Environment and Health Administration, City of Stockholm, Data from General Agents, Statistics Sweden and BilSweden

3.1 Clean Vehicles in Stockholm

Clean Vehicles in Stockholm was established in 1994 and acts as an umbrella for diverse projects promoting clean vehicles and renewable fuels. A wide range of methods have been used, such as: market incentives, dissemination and awareness-raising (newsletters, seminars etc), joint procurement, investment support, extension of infrastructure, driver incentives and use of environmental criteria in the City's own vehicle and transport services procurement.

Stockholm leads by example. One of the first decisions in 1996 was to replace 300 of 1,500 municipal vehicles with clean vehicles. The 2010 target is that 100 percent of the municipality's cars will be clean vehicles fuelled with at least 85 percent renewable fuels.

The City Council has ordered that Stockholm's administrations and companies shall, except in special cases, always procure clean vehicles and be fully compensated for the additional costs of acquiring clean vehicles.

The extensive activities of the Clean Vehicles project in Stockholm have positively influenced the introduction of several national incentives, including the rebate on clean company car assessment value, the general tax reduction on biofuels and the congestion tax exemption.

3.2 National Policies

National policies supporting clean vehicles and fuels have been implemented by different administrations and ministries. Early policies only concerned fuels. Research on alternative motor fuels has received continuous governmental funding since 1975. From the beginning of the 1990's government R&D has been mainly targeted towards ethanol. (Grahn, 2004) Electric and hybrid vehicles were the focus of a national research programme in the 1990s. However, general legislation concerning clean vehicles did not appear until the late 1990s. The first definition of clean vehicles appears in company car tax legislation in 1999. A new definition was proposed by the Swedish Road Administration in 2004 for state purchases of clean vehicles. The definition was adopted by the Swedish government in 2005 and requires low fuel consumption regardless of whether the cars run on alternative fuels or conventional fuels.

3.3 Activities in Relation to Market Phases

This section describes the activities of Clean Vehicles in Stockholm and its partners and developments in Sweden during the time period 1992-2008. The section is structured according to the staircase of the BEST project, se figure below.

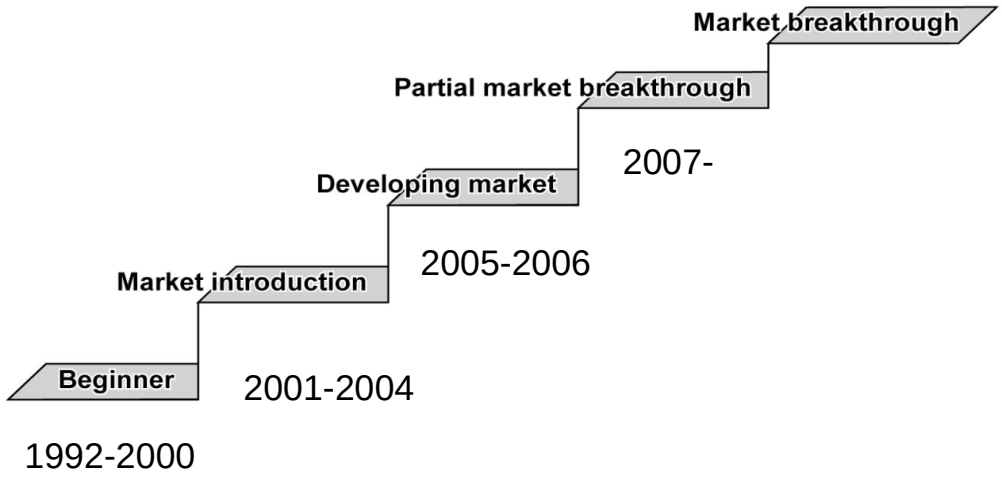


Figure 14 Developments in Stockholm according to the staircase of the BEST project

3.3.1 Beginner

The beginner phase is a stage prior to market introduction. In this phase there are very few or no clean vehicles available, fuelling infrastructure is underdeveloped and there is a very low level of knowledge about clean vehicles, but activities are beginning to correct these shortcomings. Evaluating Stockholm's experiences, it is possible to say that the beginner phase stretches over the period 1992-

2000. The beginner phase starts by the national electric car procurement, in which Stockholm was represented by its fleet management.

In the case of Stockholm, the beginner phase has been divided into two sub-phases: the first period includes strategy formulation and preparation of future activities, including application of the ZEUS project. This sub-phase stretches from 1992 to 1996. The second sub-phase is characterised by operational work, which to a large degree coincides with activities of the ZEUS project (Zero and low Emission vehicles in Urban Society). The table lists main developments in Stockholm and Sweden during the beginner phase.

Table 5 Activities of Clean Vehicles in Stockholm and developments in Sweden 1992-2000

Stockholm	**1992-1996**
	City Fleet Management (MFO) engages in national demonstration project of electric vehicles in 1992
	Clean Vehicles in Stockholm starts in 1994
	Stockholm adopts a strategy decision to support three alternative vehicle technologies: electricity/hybrid, ethanol and biogas (Action programme from 1996)
	Stockholm sets a goal to replace 300 vehicles in its own fleet (of a total of 1,500 vehicles)
	Stockholm engages electricity company and municipal water works in construction of fast charging network, and biogas production and distribution.
	1996-2000
	Clean Vehicles in Stockholm acts as the lead partner in the EU-project ZEUS engaging 8 European cities 1996-2000
	Joint public procurement of electric vehicles (ZEUS)
	ZEUS cities work with identifying barriers to alternatively fuelled vehicles
	Stockholm initiates a procurement process to increase the number of FFVs (ethanol/petrol) on the Swedish market with support from the Swedish Delegation for Sustainable Technology in 1998
	Stockholm puts main focus on own fleet, but includes a limited number of non-municipal external partners
	Partnership with clean vehicle programs in other Swedish cities: Stockholm, Gothenburg and Malmö
Sweden	**1992-2000**
	Government funded (KFB) demonstration programme of electric and hybrid vehicles 1993-2000
	1992-1995 National authority (NUTEK) co-ordinates electric vehicle procurement (Stockholm participates via fleet management, MFO)
	The first Ford Taurus FFV's is supplied for leasing by private entrepreneur "Carsteds bil" in 1994.
	The consumer co-operative fuel supplier OK/Q8 promises to build E85 pumps in cities with at least ten flexible fuel vehicles.
	First deliveries of the Renault Clio Electrique in 1995 to partners of NUTEK procurement, including Stockholm, Gothenburg and Malmö.
	Company car taxation of alternatively fuelled vehicles becomes equivalent to conventional cars in 1999

In order to encourage clean vehicles, Stockholm commits itself to activities within two main fields: fuel supply and demonstration vehicles. Electricity, biogas and ethanol fuels and related were the focus of Stockholm's fuel supply activities. Since market activities concerning ethanol were largely managed by private entrepreneurs, the city concentrated on electricity and biogas infrastructure. The private entrepreneurs included Carstedt's bil supplying Ford Taurus FFV for leasing and the action of the consumer co-operative chain OK, which accepted a proposal from their members to provide one E85 pump for every 10^{th} ethanol flexi-fuel vehicle in use in each town where OK were represented. (see Ramjerdi and Brundell-Freij, forthcoming in 2009).

During the beginner phase a biogas production plant and refuelling station were set up in Stockholm in co-operation with Stockholm Water Company (Stockholm Vatten). For electric vehicles recharging stations were provided in co-operation with the then municipal electric company Stockholm Energi.[3]

The ZEUS project started in 1996, main activities of Stockholm are shown in the box below.

Vehicles	Fuels	Systems & Equipment	City planning and infrastructure
222 vehicles (cars vans, light trucks), 6 hybrid buses. 3 biogas waste trucks. 1 biogas fuelled biogas distribution truck	Biogas and ethanol and electric hybrids	Infrastructure for electric and biogas vehicles	Electric vehicles in car pools and rental companies, transportation system study

Box 1 Actions of Stockholm within the ZEUS-project Source: KFB 1998

On the initiative of Stockholm, five cities in the ZEUS project joined together in a common public procurement effort. The cities pooled a large order and were able to negotiate competitive prices. A European wide tender invitation to vehicle manufacturers was published in the Official Journal in February 1997. Basing the joint tender on lessons learned from previous experience with pure electric vehicles, e.g. large unexpected costs due to battery problems, the cities specified risk-free agreements such as battery leasing option as a requirement for vehicle purchases. The cities together bought some 200 electric vehicles and an additional 150 went to buyers outside the ZEUS project at the same competitive price.[4] This was the first European-wide joint tender and its major achievement was to convince producers to offer electric vehicles in two parts: vehicle purchase and battery lease.

The vehicle market was limited during this phase. In late 1990's Volvo offered one biogas vehicle and it was possible to import biogas vehicles from Germany and Italy. However, these vehicles could not automatically be approved due to extra requirements on gas tanks because of colder climate in Sweden. Each manufacturer had to show that the gas equipment could handle minus 40 degrees centigrade. Electric cars were bought via NUTEK and ZEUS procurements. Since the single flexi fuel car (Ford Taurus) available in Sweden could only be acquired with a leasing contract, the city worked to improve the supply of vehicle models running on ethanol and petrol, and initiated a procurement process with support from the Swedish Delegation for Sustainable Technology in 1998.

By testing clean vehicles in their own fleets, cities learned more about the new technologies and many legal and institutional barriers became obvious. Work with identifying these barriers stands out as another important part of the ZEUS project. However, overcoming barriers requires actions on the national level in most cases. Therefore, overcoming the identified barriers, Stockholm started co-operating with the other two Swedish major city regions Gothenburg and Malmö who were engaged in the national programme on electric vehicles, via KFB (The Swedish Transport & Communications Research Board).

One important achievement in reducing legal barriers was the change in the standard assessment values for company car taxation in 1999. The promise to change the assessment value of company cars was made by the Minister of Environment at a conference on clean cars which was organised by Clean

[3] In 1998 Stockholm Energi merged with a private energy provider. This partially owned municipal company was named Birka Energi and was fully acquired by Fortum in 2001.
[4] For a detailed review of the ZEUS procurement program see ZEUS (2000)

Vehicles in Stockholm in co-operation with the cities of Gothenburg and Malmö. Before the change, clean vehicle drivers received a disadvantageously high tax, since the assessment value is based on purchasing price. In 1999 company car tax on clean vehicles was set equivalent to a comparable conventional car. This meant that Renault Clio Electrique received the same tax value as a conventional Renault Clio. Before the change, the electric car was taxed about three times as high as the conventional car.

The Swedish Electric and Hybrid Vehicle Research and Development and Demonstration Program administered by KFB ended in 2000. However, finalisation of the program also meant that there was an end of government subsidies to buy electric vehicles. One important conclusion of the programme was that there is an urgent need to develop safety and infrastructure standards to support the introduction of clean vehicles. Several research projects, organisations and other stakeholders helped provide documentation and draft legislation to the Swedish government to remove this market hinder.

3.3.2 Market Introduction

Market introduction becomes possible when major obstacles have been overcome. Developments during the time period 2001-2004 characterise this phase. The number of vehicle models is still small, but with the introduction of Ford Focus FFV and Toyota Prius it becomes possible to buy clean vehicles on the regular market. In 2002 Stockholm begins targeting information to a selected group of private companies.

Table 6 Activities of Clean Vehicles in Stockholm and developments in Sweden 2001-2004

Stockholm	**2001-2004**
	As a result of Stockholm's procurement initiative a new flexi fuel vehicle, the Ford Focus Flexi Fuel had world premiere in Sweden in January 2001.
	Stockholm receives national LIP funds for subsidies to support exchange to clean vehicles in the city fleet
	Stockholm is the lead partner of the EU project Trendsetter 2002-2006. One theme focused on clean vehicles and renewable fuels, including both passenger cars and heavy vehicles.
	Trendsetter include activities to increase clean vehicle use in private companies (seminars, information, test driving and purchase subsidies)
	Network was initiated among companies that participated in Trendsetter demanding "at least one clean car" in their company fleet.
	AGA (gas supplier) takes over biogas distribution in Stockholm and agrees to double infrastructure from 4 to 8 biogas refuelling stations.
	Stockholm county government starts paying a bonus to clean taxis used in special transportation services in Feb 2004
Sweden	**2001-2004**
	The Toyota Prius hybrid electric vehicle arrives in Sweden in 2000
	Company car tax assessment value rebate to clean cars introduced in 2001
	The web-page www.miljofordon.se is launched by three cities (Stockholm, Gothenburg and Malmö) in co-operation in 2003

The procurement initiated by Clean Vehicles in Stockholm in 1998 led to the launch in 2001 of Ford's Focus Flexifuel, which got a Swedish pre-order of 3,000 cars, and which cost some 500 Euro less at launch than the gasoline-only model.

In order to locate a sufficient number of buyers that resulted in the launch of the Ford Focus, Stockholm had to split the common procurement process into three phases.

1) The first step was a market study to gauge out the interest among 10,000 enterprises and public institutions with potential buyers. Another market survey looked into what vehicle models were already on the market and the price for them.

2) The second step was an information campaign and the forming of a buyers' consortium.

3) The last step was the procurement itself, which was a European wide tender invitation to vehicle manufacturers.

During the market introduction phase Stockholm was the lead partner of the European Trendsetter project engaging five cities between 2002 and 2006. Clean Vehicles and Fuels was one of the themes, including city fleet activities commercial traffic and heavy-duty vehicles.

In Stockholm, the Clean Vehicle project was involved in demonstration of clean vehicles in the city fleet, marketing activities and measures to provide additional infrastructure for renewable fuels. Although Stockholm had introduced clean vehicles in the city fleet in the 1990s, their number was decreasing. After the entire municipal fleet was outsourced to a private leasing company in 2002, purchase decisions were decentralized. This led to less focus on clean vehicles. Investment grants financed by the government (LIP-programme) and via the Trendsetter project were used to lower the cost for purchasing clean vehicles. The city also arranged seminars and information activities in order to encourage city administrations, especially procurement officers, to choose clean vehicles. Furthermore, a test fleet of clean cars was set up together with the car industry.[5] This way, potential company buyers, including procurement officers could try different types and models of clean cars free of charge.

Apart from the work that was carried out to encourage city administrations to choose clean vehicles, Stockholm introduced market activities directed to private companies in order to influence them to choose clean vehicles instead of conventional vehicles. The work started with two market studies. These studies resulted in an assessment of the market potential of clean vehicles and a communication strategy.

The purpose of Stockholm's external market activities was to raise the awareness of clean vehicles in private companies. Media was invited to the events that were carried through. Journalists were supplied with research results and news in general. The following activities were carried out:

1. Establishing a company register

2. Production of information materials

3. A campaign directed to media and companies including seminars, press releases etc

4. A program offering companies the opportunity to test a clean vehicle for free for one week

5. Information and education aimed at vehicle retailers

6. Investment grants defraying additional purchase cost as an incitement when buying a clean vehicle

7. Direct contacts and advice to companies

8. Support to parallel activities in other organizations such as seminars

In order to improve information on clean vehicles Stockholm, in co-operation with Gothenburg and Malmö, put up the website www.miljofordon.se , partly financed by the Trendsetter project.

A network called "At least one clean vehicle" was created in 2003. Members were companies in Stockholm that have at least one clean vehicle in their fleet. The initiative was taken by the Swedish Television and was strongly linked to Trendsetter activities. A press conference was arranged where the director of the Swedish Television as well as four other managers signed an agreement to "join the Trendsetter project" as well as the Clean Vehicle Network committing them to purchase at least one clean vehicle.

[5] Participants included: Toyota Center, Bilia (major Volvo dealer), AB Wilhelm Kindvall (Ford dealer) and Svenska Bil (Opel dealer).

The Clean Vehicles in Stockholm project initiated a meeting with the Minister of Finance in order to discuss introduction of a general tax reduction on biofuels. This meeting resulted in a promise from the minister to take this into consideration and from January 2003, tax on biofuels was reduced until the end of 2012.

Trendsetter also included activities to increase the number of biogas refuelling stations. An agreement was negotiated between AGA (major gas company) and Stockholm Water Company with support of the Environment and Health Administration which gave AGA the right to buy, sell and distribute all biogas produced by Stockholm Water Company with the exception of a certain volume reserved for biogas buses operated by the local public transport company, SL. Suitable locations for four new stations were studied and decided.

3.3.3 Developing Market

In 2005 there is a significant increase in the sales of alternatively fuelled vehicles. Developments are triggered by the congestion tax trial in Stockholm that started in January 2006. In 2005 several new models appear on the market. Swedish car manufacturers introduce their market leading models with ethanol/petrol drive: Saab 9-5 Biopower and Volvo V50 Flexi fuel.

Companies offering transport services begin to exchange their fleets. All large car rental firms start buying clean cars. Taxi companies are among the pioneers, triggered both by monetary incentives (special service bonus and investment grants), the priority queue at Arlanda airport and consumer demands from companies with travel policies demanding clean taxi trips. Congestion charges did not influence taxi companies since all taxis were exempted during the congestion charge trial. The ordinance regarding government vehicle purchases introduces new public sector buyers to the clean vehicle market in 2005.

Table 7 Activities of Clean Vehicles in Stockholm and developments in Sweden 2005-2006

Stockholm	**2005-2006**
	Stockholm introduces free residential parking for clean vehicles in May 2005
	Stockholm introduces free commercial vehicle parking permits for clean vehicles in May 2005
	National KLIMP subsidies were used by the city to administrate subsidies to companies - taxi, rental car firms, service vehicles
	Stockholm Arlanda airport introduces a high priority queue for clean taxis (Dec. 2005), reducing waiting time for taxi companies
	Congestion tax trial Jan-Jun 2006. The Clean Vehicle project promotes an exemption of clean cars.
	Stockholm is the lead partner of EU project BEST which focuses on ethanol vehicles and fuel (2006-2010)
	Stockholm is a partner of EU project BioGasMax which focuses on biogas infrastructure and biogas vehicles (2006-2010)
Sweden	**2005-2006**
	The Government introduces a definition of clean vehicles (not identical with Stockholm's original definition)
	Ordinance of government purchase and leasing of clean vehicles Jan 2005 (targets increasing over time)
	Obligation to supply renewable fuel at refuelling stations in April 2006. Requirements increase over time.

During the design phase of the congestion charge trial, there were discussions about potential exemptions from congestion charges. The City of Stockholm promoted an exemption of clean cars. There was opposition against exempting clean cars, largely based on practical problems, since at that time it was not possible to identify clean cars in the national vehicle register. This was because flexi-fuel vehicles running on both ethanol and petrol and biogas vehicles running on both biogas and petrol had been registered as petrol-only cars. The Clean Vehicle project provided a proposal about how to solve the shortcomings. The politicians of the City of Stockholm used this proposal in their negotiations in the parliament and with the national government.

Focus on biofuels increased in 2006 as Stockholm participated in two new EU projects focused on bio-ethanol and biogas. To a greater extent than earlier, these two EU projects concentrated attention on the whole chain of interacting stakeholders from fuels and vehicles to users. In the leaflet of the bio-ethanol project this is stated by the following:

"Not the car makers, not the filling stations, not even governments, municipalities or public bodies can make the bio-ethanol market share grow by its own. But if all these stakeholders come together, and do so in several countries at once, a breakthrough will happen." (BEST leaflet)

3.3.4 Partial Market Breakthrough

Permanent congestion taxes were introduced in Stockholm in August 2007. Market penetration of clean cars was magnified by state subsidies to private buyers launched in April 2007. Sales of clean vehicles increased rapidly, but this development cannot yet be characterised as a market breakthrough since positive feed-back mechanisms between vehicle and fuel markets on the one hand, and consumers on the other hand are still lacking.

Table 8 Activities of Clean Vehicles in Stockholm and developments in Sweden 2007-2008

Stockholm	**2007-2008**
	Stockholm adopts national definition of clean vehicles in May 2007 and adds a definition of mini vans
	Permanent congestion charges - clean cars exempted from congestion taxes originally until 2012. No exemptions for clean cars bought January 2009 or later. (Decision of national government affecting Stockholm)
	City does not prolong free parking of clean cars in Stockholm beyond December 2008
Sweden	**2007-2008**
	Purchase subsidy of SEK 10,000 to all private buyers of clean cars April 2007-December 2009. Government shortens time of subsidies to June 2009.
	Doubts about ethanol being sustainable are raised following articles in Sweden's largest newspaper, starting Dec 14 2007
	Government decision that the share of clean vehicles for national agencies' purchaseshas to be 100 percent starting from February 1st 2009
	Proposal to increase goals of clean car purchases demanding higher safety requirements of ordinance of government purchases and leasing

During the time period 2007-2008, Clean Vehicles in Stockholm has been engaged in producing and communicating information about the environmental characteristics of different motor fuels. Work also includes activities to improve biogas supply in Stockholm. In addition, Stockholm is involved in communicating Swedish experiences of clean vehicles to cities and regions in other countries.

In 2009 several monetary incentives will be discontinued. While vehicles registered before January 1st 2009 will continue to be exempt from congestion charges until July 2012, new clean vehicles will not. The free parking incentive in the City of Stockholm ends December 2008 and the purchase subsidy will be discontinued June 30th in 2009. Other incentives will still be offered, including the rebate on tax assessment value on clean company cars and tax exemption on bio-fuels.

Clean Vehicles in Stockholm has a goal that 35 percent of the total number of new car sales in Stockholm Region will be clean vehicles and that 8 percent of vehicle fuel that is sold in the region will be renewable in 2010. These goals were most probably achieved in 2008. The share of clean vehicles of new car sales was 39 percent (including petrol and diesel low-CO_2 vehicles) in 2008 and the share of renewable motor fuels was 5.1 percent in 2007.

4 Effects of Incentives on Clean Car Adoption

In this chapter, standard statistical methods are used to estimate the effect of incentives on the adoption of clean cars. The statistical analysis shows that the exemption from congestion charges for alternatively fuelled cars, the relative price of the alternative fuel (E85), free parking and the 10,000 SEK subsidy have had significant impacts on adoption of clean cars. The most important incentives are those affecting the running costs of using cars: congestion charges and the fuel price.

Two types of analyses were carried out. The first type is a time series analysis which uses monthly sales data and combines this with dates of introduction of incentives and developments of fuel prices. By combining different developments over a period of time in statistical analysis, it is possible to trace the impact of an incentive. The second type is a cross section analysis. In this analysis, data about the share of clean cars per municipality and information about how incentives vary across municipalities is used. An example is free parking for clean cars, which is offered in some cities but is absent in others. The cross section analysis investigates whether or not the share of clean cars depends statistically on local incentives.

4.1 Data

Time series data are based on monthly observations of new cars registered in Stockholm County from October 2004 until October 2008. Observations prior to October 2004 were not available. Figure 16 describes new registrations per month.

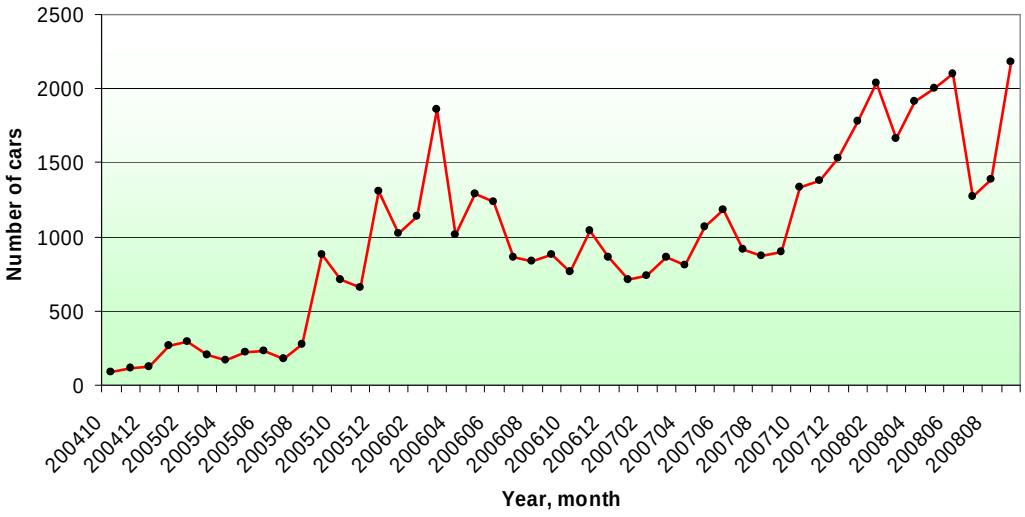


Figure 15. Number of new clean cars registered in Stockholm County by month from September 2004 until October 2008. Source: Bil Sweden, authors' calculations.

Possible factors influencing the number of registered alternative fuelled cars are purchase incentives, factors affecting running costs, and refuelling and related infrastructure.

The petrol price or the petrol price in relation to the price of the alternative fuel is expected to influence the demand for alternative fuelled cars. The vast majority of alternatively fuelled cars in Sweden use E85 and consequently the ratio of the price of petrol and E85 could be expected to be positively correlated with registration of alternatively fuelled cars, see Figure 16.

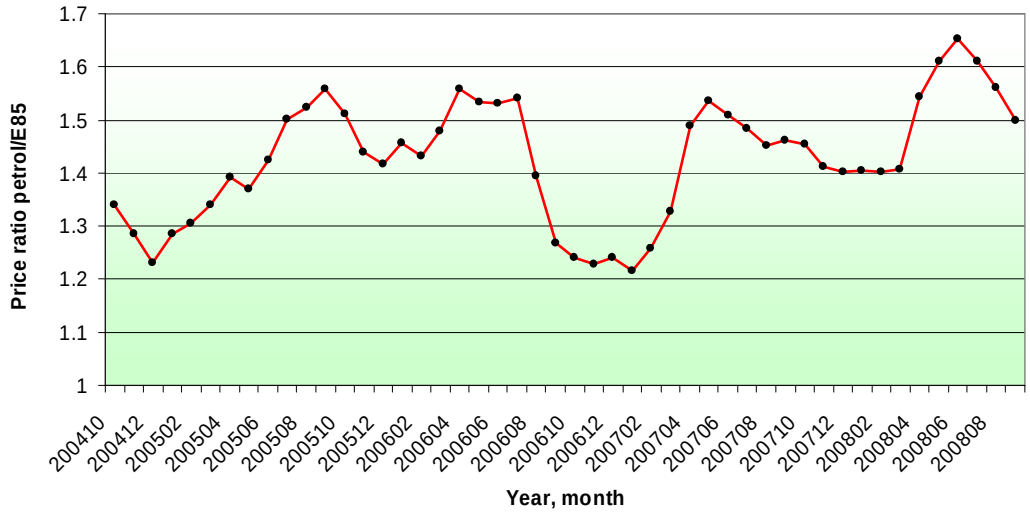


Figure 16 Price ratio of petrol and E85. Source: SPI and Statoil.

Other possible factors influencing the number of clean vehicles are the introduction of congestion charges, the congestion trial period and the introduction of the 10,000 SEK subsidy for alternative fuelled cars and low-CO_2 cars. We could also think of factors such as the number (and location) of petrol stations offering alternative fuels and the availability of models using alternative fuels of different brands as determinants.

Some of these incentives were known in advance and could be expected to have an unclear effect on car sales (i.e. the dependent variable) in time e.g. the congestion charges were decided and known before the charging started. We can thus expect that consumers started to buy cars that would be exempted from congestion charges some time before the charges took effect. We do not have an exact a priori understanding of the correct lag structure with regard to known incentives. The situation is complicated by the fact that car buyers must wait months for delivery of clean cars.

Data showing the totals of alternatively fuelled cars per municipality in 2007 (there are 290 municipalities in Sweden) is published by SIKA and has been used in the analysis of local differences. Using data on municipalities makes it possible to test if an incentive with local impact shows a significant effect. We can again think of influences from local incentives with a distinct spatial impact. Local variables we test are: free parking for clean cars, and exemption from congestion charges. Local incentives can be local in the sense that they affect those who live in a municipality, e.g. free parking in own residential area and local in the sense of congestion charges. We expect that the effects of congesting charges reach car owners in a wider geographic area than just the City of Stockholm. Therefore we test the impact of congestion charges using different spatial lags.

An important explanatory variable of private car ownership is income. However, models of car ownership usually predict the probability that a household disposes of a car and the number of cars that will be purchased, not preferences among different types of cars. High income households also tend to buy larger and more expensive cars that are not classified as alternatively fuelled. One reason to include income is that alternatively fuelled cars are a relatively new phenomenon and that high income households replace cars faster.

Another hypothesis is that introduction of new technology such as alternatively fuelled cars will be adopted faster among people with a high education level. We use the share of the adult population with a university degree. A possible problem is that education is highly correlated with income and it could thus be problematic to isolate the effect of either of the variables.

4.2 Estimation Results

4.2.1 Estimations Based on Time Series

In order to explain the variation over time of the number of registered alternatively fuelled cars an equation was fitted using OLS (Ordinary Least Squares). We controlled for trend, season (monthly) and one outlier in the data in March 2006 when SAAB released a new model. We use the explanatory variables mentioned above and dropped insignificant variables and ended up with the model presented in table 9. The introduction of the congestion charges is represented by dummy-variables (0/1).

Table 9. Estimation results using time series data. Dependent variable: The number of sold alternatively fuelled cars in Stockholm County. Control variables omitted in table.

	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-2536.03	587.18	-4.32	0.0002
Fuel price ratio	2115.07	431.72	4.89	0.0000
Congestion charges t-3	248.94	118.97	2.09	0.0456
Congestion trial t-3	352.57	92.12	3.83	0.0007
R-squared	0.917822			
Adjusted R-squared	0.870864			
S.E. of regression	199.8848			

Another segment is low-CO_2 cars. These cars are not exempted from congestion charges, but are eligible for the 10,000 SEK subsidy if bought by a private person. The low-CO_2 cars are small and relatively inexpensive, costing approximately 100,000 SEK. If we estimate the same equation, remove the variables related to congestion charges and include a dummy-variable representing the introduction of the subsidy, the influence of the subsidy becomes significant. For these low-CO_2 cars, the 10,000 SEK subsidy is a significant rebate and that is possibly the reason why this variable showed significance for this segment.

The low-CO_2 cars are rarely used by companies. In addition, the clean vehicle subsidy seems to have affected company purchases adversely by capitalising the value of the premium as lower second hand values on low-CO_2 cars by lower their second hand value by 10,000 SEK.[6]

The number of refuelling stations offering alternative fuels, free residential parking and the availability of alternative fuel models were not significant variables in our analyses. The model was also tested using national data. The same variables were significant, but these results are less precise because many incentives are local in character and cannot be argued to have explanatory power for national data.

4.2.2 Cross Section Analysis

The dependent variable in the cross section data is the share of alternatively fuelled cars in the vehicle stock per municipality in Sweden. Again we estimate an equation using OLS. The variable representing the congestion charges in Stockholm is formulated in three different ways representing the spatial incidence of the charges: a dummy-variable for Stockholm municipality, a first order spatial lag for municipalities with a common border with Stockholm and a second order spatial lag for "neighbours of the neighbours".

[6] Since the subsidy only applies to cars bought by private persons the second hand value of a low-CO_2 car falls with 10,000 SEK the moment it is bought by a company.

Municipalities with free parking for alternatively fuelled cars are represented by a dummy variable. We had three outliers in this equation: Solna just outside Stockholm where some car rental firms are registered, Trollhättan (the home of SAAB) and Skövde (where Volvo is an important employer). The estimation results are presented in Table 10.

Table 10 Estimation results for equation estimated on cross section data. Dependent variable: share of alternatively fuelled cars in municipality.

Variable	Coefficient	Std. Error	t-Statistic
Constant	0.0031	0.000862	3.62
Free parking	0.0069	0.001145	6.05
Congestion charges (Stockholm)	0.0503	0.00522	9.63
1st order neighbours to Stockholm	0.0109	0.001964	5.55
2nd order neighbours to Stockholm	0.0036	0.001869	1.92
Education	0.0691	0.007454	9.27
R-squared	0.83155		
Adjusted R-squared	0.826755		
S.E. of regression	0.005037		

Free parking for alternatively fuelled cars and exemption from congestion charges were significant in areas in and close to Stockholm. It is worth noting that the congestion charges have an effect in and in the immediate neighbourhood of Stockholm but for the second order neighbours the effect is not significant at the 95 percent level. It is somewhat surprising that the impact from congestion charges is not significant for the entire commuting region, which includes both the first and the second order neighbours.

The explanatory power of education was higher than income and education also showed higher significance[7]. If we look at income and share of alternatively fuelled cars at some detail we can confirm that areas with the highest incomes tend to have quite low shares of alternatively fuelled cars.

4.3 Simulation

Using the estimation results above it is possible to make an analysis of what would happen under alternative scenarios e.g. when the exemption from congestion charges ends or if the fuel price changes significantly.

Case 1: Exemption from congestion charges discontinued

Between January and October 2008 32 percent of all cars sold in Stockholm County were alternatively fuelled. The estimated effect from the discontinued exemption from congestion charges is that about 26 percent of sales will be alternatively fuelled cars, a sales volume decrease of about 20 percent. This result also indicates that the exemption increased clean vehicle sales in Stockholm County by 23 percent in 2008.

Case 2: A change in the relative fuel price

During 2008, until October the relative price of petrol was high compared to E85, the quotient (petrol 95 octane/E85) was about 1.5. Even if we take into account that the energy content of E85 is 30-40 percent lower than petrol it was less expensive to use E85. The relative price was thus an argument to buy an ethanol car. In November 2008 the relative price changed and the quotient became about 1.14. If we assume that this relative price remains at the November level, it will have the same effect on sales of alternative fuelled cars as the change of congestion charges: a decrease from 32 to 26 percent, i.e. a sales volume decrease of about 20 percent.

[7] If income is used separately it is also significant.

Case 3: No more free parking for alternatively fuelled cars

In central Stockholm and in some other cities it is possible to apply for free parking for alternatively fuelled cars and for low-CO_2 cars. At the turn of the year 2008/2009 this will be discontinued in Stockholm. According to our estimates the long run effect will be a decrease in the share of alternatively fuelled cars in the vehicle stock of Stockholm municipality with about 10 percent.

Case 4: Discontinued 10,000 SEK purchase subsidy for alternatively fuelled cars

The 10,000 SEK subsidy will end in summer 2009. The estimated effect will be most important for small low-CO_2 cars which are expected decrease with a little less than 10 percent (sales volume).

5 Car Buying Behaviour

The proportion of non-private new cars registrations varies in the European Union from 22 percent in Finland to nearly 56 percent in the UK (IEEP, 2006). In Sweden, household purchases make up about one half of the market of new cars and the other half is made up of company purchases. In a European perspective Sweden has a high share of company purchases together with Germany and the UK. Company purchases can be further divided into business cars and company cars. In Sweden, each group comprises approximately half of non-private new registrations. (SEPA, 2004). Business cars are vehicles that are used by companies to run day-to-day businesses while company cars refer to vehicles that are owned by a company, but used by an employee for business and private purposes. Since different considerations affect the purchase decision of these three groups it is advisable to study them separately. Unfortunately, it is not possible to break down the data that was used for statistical analyses into these categories.

5.1 Household Purchases

Several studies covering car buying behaviour report factors influencing a household's choice of car. One study, basing its conclusions on a wide review, lists the five most important factors as reliability, safety, cost (upfront investment), fuel consumption and comfort. (IEEP, 2006) Another observation is that purchase cost appears to be significantly more important than operating costs. A majority of households do not attempt to estimate, or keep track of, the running costs of a vehicle, and many appear to be unable to weigh purchase costs against running costs reliably. (IEEP, 2006)

Fisk, referring to Cao's comprehensive review, reports that price, vehicle-running costs, brand loyalty, engine power and the number of seats appear to be the most important factors for household purchases (Fisk, 2008). Although IEEP did not identify brand loyalty as an important factor, IEEP notes that many consumers choose a brand before even entering the final stages of the decision process (IEEP, 2006). The three top priorities across countries according to multi country studies are safety, price and reliability. (Cap Gemini, 2006).

Statistical analyses of the Swedish fleet (including both household and company purchases) show that the following variables significantly explain the choice of a particular car: purchase price, size, range, reliability, safety and running costs. (Transek, 2006)

When fuel consumption is considered, it is mainly for its economic, rather than its environmental, benefits. (IEEP, 2006) In addition, willingness to pay for fuel efficiency is generally low. Less than 10 percent of respondents in Western Europe say they are prepared to pay more than 10 percent extra for a fuel-efficient or alternatively fuelled car. Nevertheless, the same report notes that rapidly rising fuel prices may make fuel economy a more important purchase price factor in the future (Cap Gemini, 2008).

A car's environmental performance does not generally appear to be given high consideration, even where interviewees claim a high level of environmental concern.

5.2 Company Purchases[8]

IEEP reports a lack of literature on the subject of company car purchasing decisions (IEEP, 2006) which is remarkable since company purchases account for a significant share of new registrations. Existing studies of company buying behaviour usually divide company purchases into two different groups:

[8] Company purchases refer to all non-household purchases. Public sector purchases are included in this category as well.

- Company cars owned by a company (or the public sector), but used by an employee for both work-related and private purposes
- Business cars (or service vehicles) in use for work-related services only

The purchasing decision for company cars is often a two-stage process. The initial decision, taken on the basis of the overall objectives for the fleet, is made by the fleet manager, while the specific make and model is chosen by the company car driver. This means that personal preferences of the employee influence the choice of vehicle to some extent. The IEEP review shows that comfort, safety and style are key influences in this decision.

Company cars are generally larger than household cars in Sweden, (Transek, 2006) although Danish data show that company cars are quite similar to the private cars owned by high income households (IEEP, 2006). A hypothesis is thus that the choice of company cars resembles the car buying behaviour of high income households, which tend to be less price sensitive.

Analyses of Swedish data show that private buyers choose a car that costs about 200,000 SEK, while an average company car costs about 75,000 SEK more. Brand loyalty affects 60 percent of private choices and 70 percent of company car choices (Transek, 2006).[9]

Decision making concerning business cars seems to be simpler. This is because the process involves fewer decision makers: either solely the fleet manager or the fleet manager in co-operation with the company management. (Trendsetter, Deliverable No 12.13.1, 2001) A survey of fleet managers emphasises the importance of economic considerations. Operating costs, life costs (the total cost for the period of ownership) and capital costs feature as the three most important factors in the selection of business cars (Whelan *et al.* ,2000). However, business vehicles also need to fulfil certain requirements, including safety standards and cargo capacity. It is therefore plausible that companies restrict their choice to a certain few vehicles before entering the final stages of the decision process.

5.3 Factors Determining the Choice of a Clean Vehicle

5.3.1 Households Choices of Clean Vehicles

In order to estimate a Swedish Car-fleet Model, Transek collected data from three surveys in 2005. One stated preference study was directed to households that had recently purchased a new car (Transek, 2006). About 1,400 private buyers (700 in Stockholm, Gothenburg and Malmö and 700 in the rest of Sweden) were asked hypothetical questions about alternative car buying choices concerning purchasing price, operational costs, second hand value and fuel.

About 90 percent had replaced an old car and ten percent were buying a first car or adding an additional car to the household. The most popular brands were Peugeot, Volvo, Citroen and Toyota.

Most respondents lacked personal experience with clean cars. Only about 8 percent had been in a clean car, and only one percent had had a clean car at their disposal. In order to estimate household willingness to pay for alternatively fuelled vehicles respondents were asked questions with hypothetical choices. One example is shown in the figure below.

[9] The definition of brand loyalty is that the respondent had owned or disposed a car of the same brand as the new car.

In order to answer this question you are expected to **choose between two cars of the same brand and model that you bought**. The only way these two cars differ is given by the information below, all other characteristics are equal. The cars below might not be available today.

The differences between the two cars concern:

- Purchase price
- Fuel (petrol, diesel electric hybrid, ethanol and gas hybrid)
- Second hand value after three years

Which of the two cars would you choose?

Car 1	Car 2
Purchase price: 353,000 SEK Fuel: ethanol Second hand value: 219,000 SEK	Purchase price: 363,000 SEK Fuel: gas hybrid Second hand value: 261,000 SEK

I choose: Car 1 Car 2 The cars are of equal value

Box 2 Question with a hypothetical choice between two clean cars. Source: Transek 2006

By carrying out statistical analyses of the responses, the authors were able to deduct the willingness to pay for different kinds of vehicle characteristics. The data collected from the households showed that:

- Household car buyers are willing to pay 700 SEK for one extra horse power.
- Household car buyers are willing to pay about 12,000 SEK in purchasing price to achieve a reduction in running costs of 0.1 SEK per kilometre.
- An ethanol vehicle (FFV), otherwise identical to the car that was actually bought, is valued 20,000 SEK more than the petrol vehicle. This value added of an ethanol car corresponds to fuel costs of about 0.2 SEK less per kilometre.
- An ethanol vehicle (FFV) is valued about 25,000 SEK higher than a biogas/natural gas vehicle.
- To accept a diesel car, buyers require a price about 10,000 SEK lower than a comparable petrol car.
- The value of ethanol and biogas/natural gas vehicles depends on accessibility to fuelling stations. When about half of all refuelling stations have a given alternative fuel, buyers are willing to purchase alternatively fuelled vehicles for the same price as petrol vehicles.[10]

In a recent study in Stockholm, Fisk conducted deep interviews with owners of alternatively fuelled vehicles and owners of conventional vehicles (Fisk, 2008) and found that alternative fuel vehicle ownership is not significantly different from conventional vehicle ownership. This finding supports the assumption that the same determinants influence the choice of alternative fuelled vehicles as their conventional counterparts. Both groups report that their primary reason for owning a vehicle is either family size or the need for a car to travel to their summer house. However, while alternatively fuelled vehicle owners reported environmental performance as the most important purchase factor, conventional vehicle owners reported cost as paramount when choosing a vehicle.

Although all interviewees expressed concern for the environment, these results imply that alternative fuel vehicle owners are more conscious about the environmental impact of their choice of transport. This is supported by Fisk's finding that the only significant difference between the ownership groups

[10] This is inconsistent with the finding that buyers are willing to pay more for an ethanol car than a petrol car. According to the report, this is because the value effect of fuelling station accessibility was estimated using another statistical model.

is that conventional vehicle owners stress the fact that cars are more convenient than other means of transport.

Fisk finds that main barriers to alternative fuel vehicles include: a lack of inexpensive models, an immature second hand market and the perceived difficulty and inconvenience of taking time to find relevant information about alternative fuel vehicles.

5.3.2 Company Choices of Clean Vehicles

In a parallel stated preference study, Transek surveyed 1,400 new company car drivers (Transek, 2006). The four most popular brands among company car drivers in this survey were Volvo, Audi, Saab and BMW which together comprise about 60 percent of all new company cars. These four brands made up only 40 percent of all new household cars. This does not seem to be a result of employer restrictions. Two thirds of respondents said they were free to choose among different brands. Most drivers worked in the private sector; only two percent were public sector employees. In comparison to the average household buyer, company car drivers earned 10,000 SEK (40 percent) more per month. Company drivers' experience with clean vehicles corresponds to that of households. This study's results are similar to those of household purchasers. There are however some notable differences:

- Company car drivers are less concerned about second hand value. This is probably because the company is responsible for re-sale, not the driver. However, second hand values are in some cases reflected in employee contracts. When the employee pays the employer for using the car, a low second hand value usually implies higher costs. In the survey 45 percent indicated that the value of the benefit of using the company car was deducted from their wages.
- Perceived added value of an ethanol vehicle is lower among company car drivers, about 0.1 SEK per kilometre. One possible explanation as to why company car drivers state a lower value on fuel costs is that it is common that employers pay for fuel (about 50 percent of company car drivers have this kind of agreement). Although the company car driver is taxed for the fuel benefit covering private miles, the cost is still lower than buying the fuel. (SEPA, 2004).

Clean Vehicles in Stockholm commissioned a study to find out what kind of knowledge companies need when considering a clean vehicle, see "An unexploited potential – analysis of companies' need for knowledge to buy clean vehicle" (Trendsetter, Deliverable No 12.13.1, Nov, 2001). Deep interviews were produced with fleet managers and other stakeholders in late 2001. Several companies said they were willing to buy clean cars. However, companies lacked information needed to calculate the costs of buying and operating clean cars. In addition, the authors find that clean vehicles are associated with several uncertainties:

- Technical risks – potential buyers distrust the performance of alternatively fuelled vehicles
- Political risks – there is uncertainty about development of political conditions concerning alternative fuels and clean vehicles
- Economic risks – companies do not have information about running costs and second hand values of alternatively fuelled vehicles

The report recommends that since cost estimates are the most important basis for making a purchase decision, companies willing to pay more for the environmental benefit of a clean car need information about associated costs. In order to help companies make informed decisions, it is important to provide information about vehicle performance; future policies and vehicle costs to a group of selected companies. The tax reduction on the employee benefit value of clean company cars was argued to be a powerful incentive for companies to purchase clean cars. The report suggests that both companies and employees should be provided with information about clean cars.

5.4 Incentives Affecting Clean Car Purchase

Clean Vehicles in Stockholm conducted a survey among owners of newly registered clean cars. A questionnaire was sent to 566 households and companies in Stockholm who had purchased a clean vehicle during the period January 2008 – May 2008. The response rates were 76 percent for households and 40 percent for companies.

It is possible to distinguish three groups among the respondents:

1) Households who purchased alternatively fuelled vehicles

2) Households who purchased low-CO_2 cars

3) Employees with new alternatively fuelled company cars (no low-CO_2 cars in this group)

A majority of households (66 %) had only considered clean vehicles when planning their purchase. Among employees, the reverse was true, with most (85 %) considering conventional vehicles first but eventually opting for clean vehicles when making the purchase.

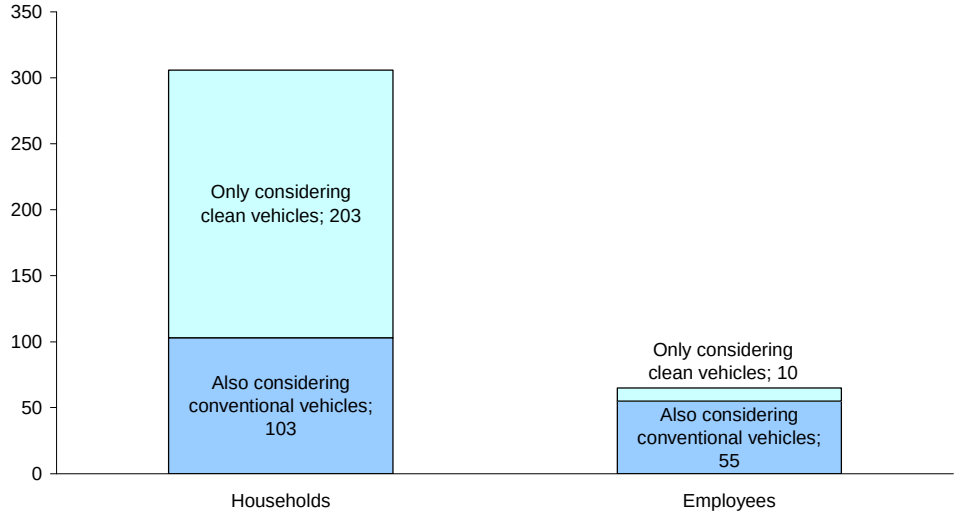


Figure 17: When you purchased your latest clean vehicle, did you also consider conventional vehicles that are not clean vehicles?

A hypothesis was that various incentives to clean cars would make it acceptable for households that earlier did not own a car to buy a clean car.

In 70 percent of cases, new clean vehicles replaced a previous vehicle. In 30 percent of cases, the clean vehicle represented an additional vehicle and two thirds of these were purchased by households which previously had no car. The share of additional cars is higher than in the 2006 stated preference studies. However, since samples vary among surveys, it is not possible to judge whether incentives for clean cars have triggered the purchase of additional cars.

Another hypothesis was that clean cars would in many cases become the second car of a household.

However, only 10 percent of the respondents claimed that the clean vehicle became an additional, second car. Neither was there a difference in second car acquisition between households buying low-CO_2 vehicles and those who bought a larger alternatively fuelled vehicle.

A majority of households (65%) chose to buy new cars instead of second-hand models (this question was not put to company car drivers). Corresponding data for conventional vehicles are missing so it is not possible to compare.

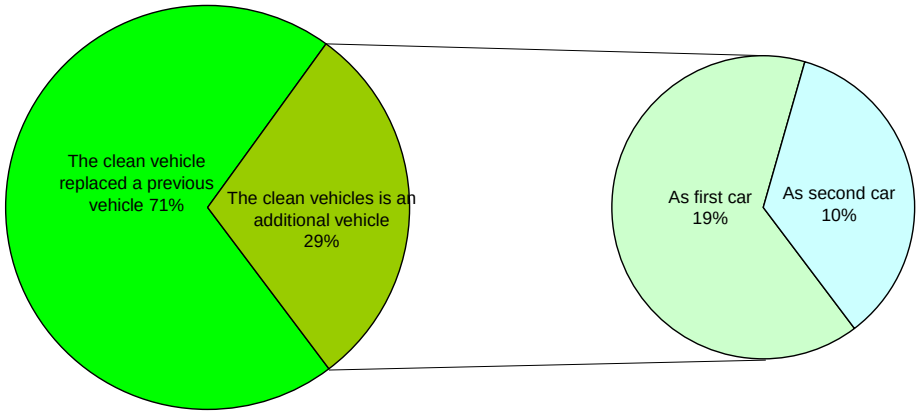


Figure 18 Additional cars as a proportion of first and second cars (total sample)

In order to find out how important different incentives are for choosing a clean car, respondents were asked to rate the importance of a number of statements. The most important factors influencing the choice of a clean car were:

1. Lower company car assessment value for clean cars
2. Desire to reduce the negative impact of driving on the environment
3. Lower fuel costs of clean vehicles
4. No congestion charge for clean vehicles

When taking uncertainties into account, the importance of lower fuel costs and exemption from congestion charges cannot be significantly separated from each other.

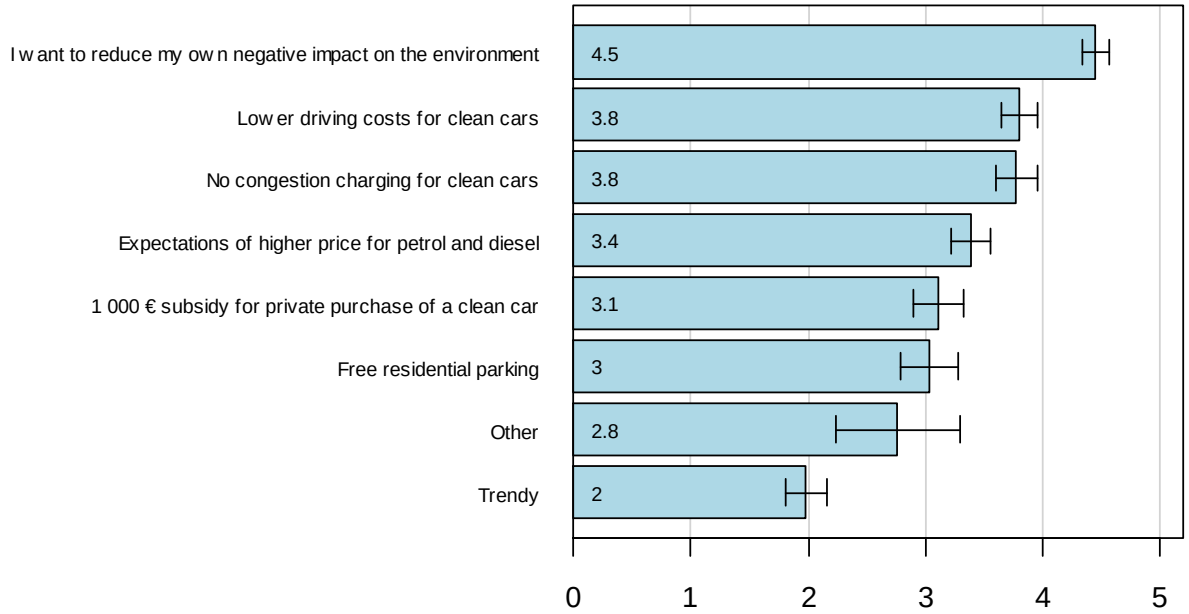
Free residential parking was either considered a critical purchase decision factor (rating it 4 (important) or 5 (very important) or not at all important (rating 1). One interpretation is that free residential parking only influences certain groups of clean vehicle drivers, i.e. those living in the city centre. In addition, among city centre residents there may be households who find it more convenient to hire a place in a parking garage rather than search for parking spaces on city streets.

The most important factors vary between households and employees. The factors also vary between households who purchased alternatively fuelled vehicles compared to those who purchased low-CO_2 cars.

The figures below show the importance of incentives for each of the three respondent groups.

Most important factors of household purchases of alternatively fuelled vehicles:

1. Desire to reduce negative impact on the environment
2. Clean vehicle's lower fuel costs
2. Clean vehicles are exempt from congestion charges



Statistical uncertainties are marked in the figure by 95 percent confidence intervals.

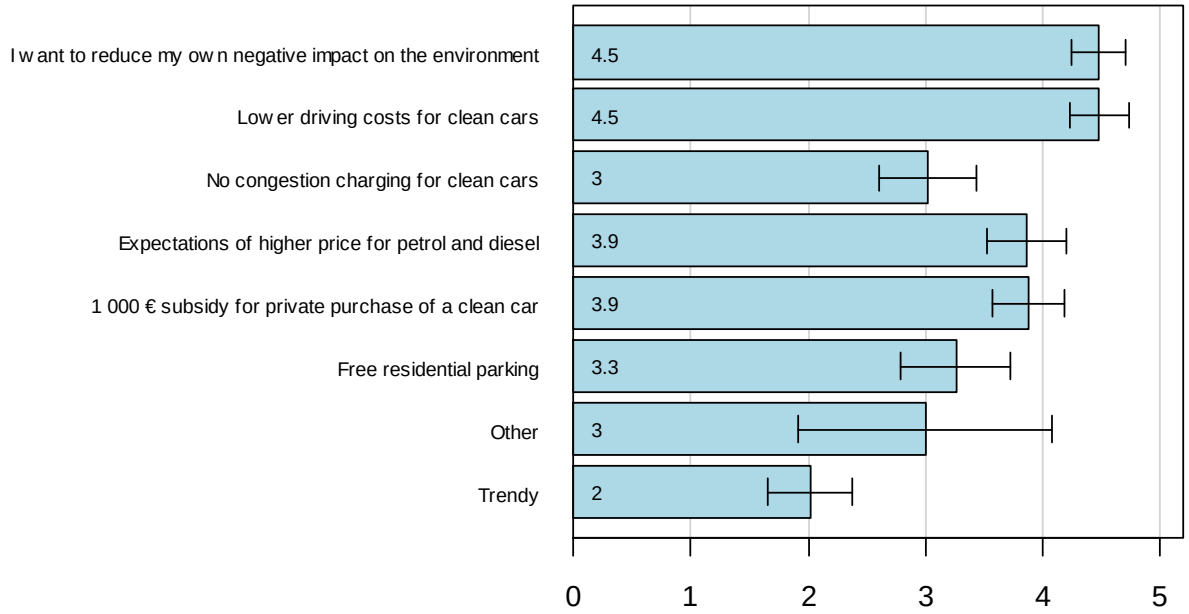
Figure 19 What significance did the following factors have on your choice of an alternatively fuelled vehicle?

As in the Fisk study reported above (Fisk 2008), households who bought an alternatively fuelled vehicle state that their desire to reduce their own environmental impact was the most influential factor when choosing a car. Lower operating costs and exemption from congestion taxes are ranked next and these two factors are equally important. The purchase rebate and free residential parking are of relatively low importance. Even expectations of rising prices on petrol and diesel are considered more important than these two incentives.

Environmental performance and fuel economy are regarded as the two most influential factors for choosing a low-CO_2 car. The purchase rebate and expectations of rising fuel prices are rated as second most important factors followed by free residential parking. Since low-CO_2 cars are not exempted from congestion taxes, it is surprising that this exemption has influenced the choice of vehicle. The explanation might be that there were discussions about extending the exemption to low-CO_2 vehicles implying that some respondents may have made their choice based on such expectations.

Most important factors of household purchases of low-CO_2 cars:

1. Desire to reduce negative impact on the environment
1. Clean vehicle's lower fuel costs
2. Expectation of rising gasoline/diesel prices
2. Clean vehicles rebate (SEK 10,000, about Euro 1,000) for new vehicle purchases

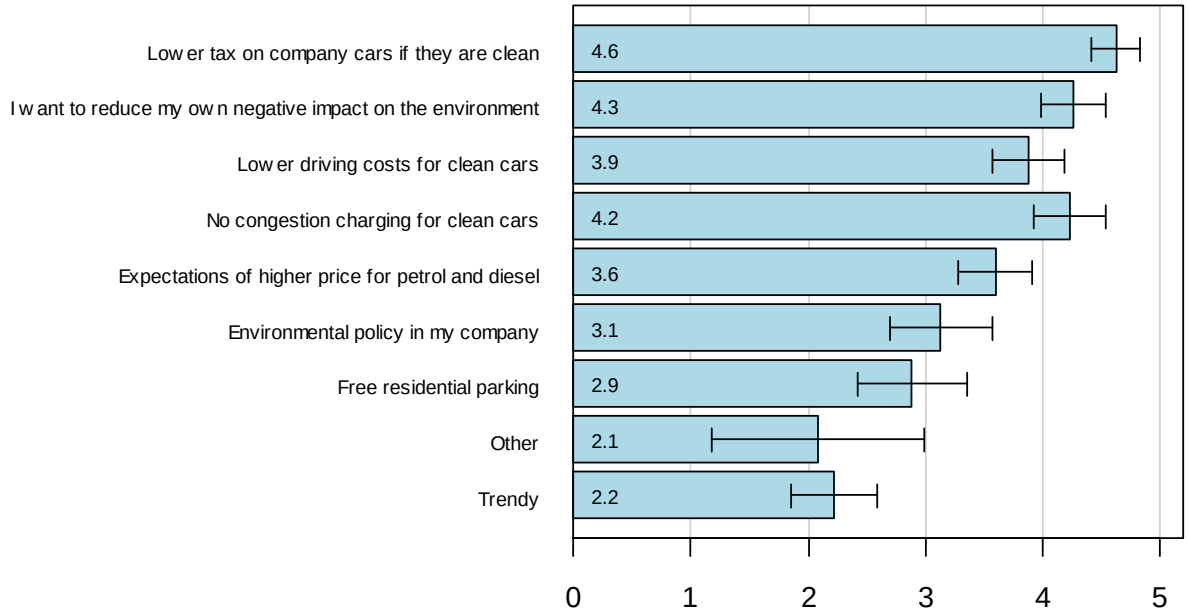


Statistical uncertainties are marked in the figure by 95 percent confidence intervals.

Figure 20 What significance did the following factors have on your choice of low-CO_2 car?

Most important factors of employees' choice of alternatively fuelled company cars:

1. Lower company car assessment value on clean company cars
2. Desire to reduce negative impact on the environment
3. Clean vehicles are exempt from congestion charges



Statistical uncertainties are marked in the figure by 95 percent confidence intervals. Employees were not asked about the clean vehicle rebate.

Figure 21 What significance did the following factors have on your choice of company car?

The lower tax value of a clean company car is the most influential factor for choosing a clean vehicle among drivers of company cars. Environmental performance is rated as the second most influential and the exemption from congestion charges is ranked third. However, due to relatively few responses, there are wide confidence intervals.

In order to find out whether company policies influence the importance of different factors, the results were tabulated according to whether or not a clean vehicle is required by the company policy. The results show very little difference between responses, see figure below.

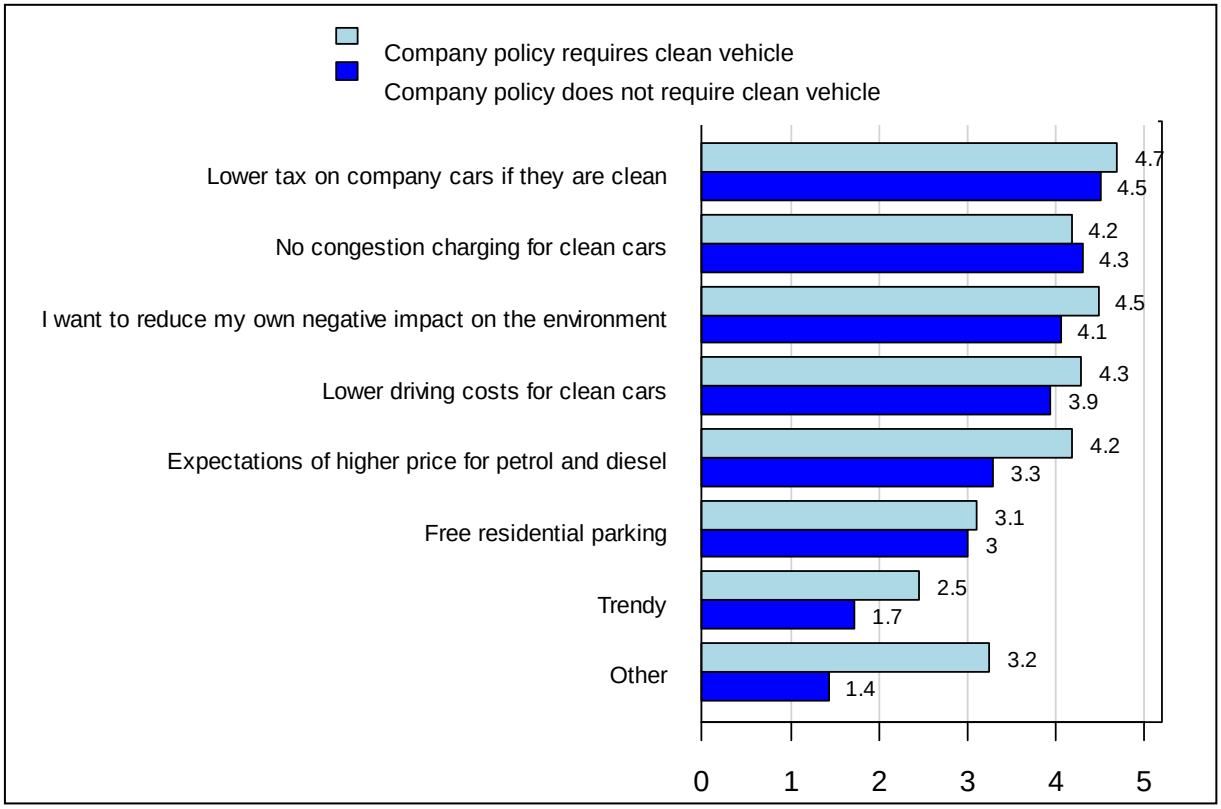


Figure 22 Answers to questions in relation to the influence of company policy on vehicle choice (only company survey)

5.5 Summary

The review of studies shows that the main differences in car buying behaviour are found between households and non-private buyers. However, the choice of a company car resembles that of a household car in some respects. Generally employers are less price sensitive than households and tend to choose larger cars.

The three most important factors influencing the choice of a car appear to be reliability, safety and price. Functional characteristics and brand loyalty also seem to have a large influence, possibly being the first step in the decision making process and restricting the choice to a sub-set of a brand or a certain function. Other influential characteristics are fuel economy, comfort and size.

Households and companies are willing to pay more for an alternatively fuelled vehicle. Those who have bought a clean car report that environmental performance was the most influential factor of their choice of vehicle. Exemption from congestion taxes and lower fuel costs are the most influential incentives for clean car purchases among private car buyers. Lower tax assessment value for a company car is the most important factor for company car drivers.

Incentives that reduce operating costs seem to be stronger than incentives affecting purchase price. This is in contrast to studies of car buying behaviour where purchase prices are reported to be influential while most people do not bother to consider or calculate operating costs. This deserves further study and may indicate that consumers are becoming more aware of operating costs. If this is the case, it is an important finding and a significant guide for future policy development.

Combining the findings of the statistical analysis and the questionnaire produces the following ranking of incentives, listed from most to least important:

1. Reduction of tax value of clean company cars
2. Low relative prices on alternative fuels
2. Exemption of clean cars from congestion taxes
3. Free parking
4. Purchase price subsidy

6 Qualitative Analysis

The background hypothesis of this study is that the market spread of clean cars follows an S-shaped development pattern and more importantly, that it is possible to hasten developments by introducing incentives. The statistical analysis supports the hypothesis that monetary incentives speed developments. Together with the survey of recent buyers of clean cars, the previous chapter suggests a ranking of incentives. This ranking covers only monetary incentives, and leaves out other incentives that have been in use during the period of study. The aim of this chapter is to further assess the importance of all types of incentives that have been implemented in Stockholm and in Sweden.

6.1 Generalized Cost Approach

Generalized costs are the sum of monetary and non-monetary characteristics of making a trip and widely in use in transport economics for studying trip choices, and can also help assess the market spread of clean vehicles, see WSP (2007).

Typical variables affecting the costs of a trip include cost, time, quality and acceptance. In the introductory phases of an S-shaped market penetration sequence, several barriers slow technology diffusion. It is possible to describe the barriers to clean vehicles according to the variables of the generalized costs. For example, when there is limited experience with a new technology, acceptance tends to be low. The tree diagram below illustrates the connection between potential barriers that influence a driver, a car buyer or a fleet manager.

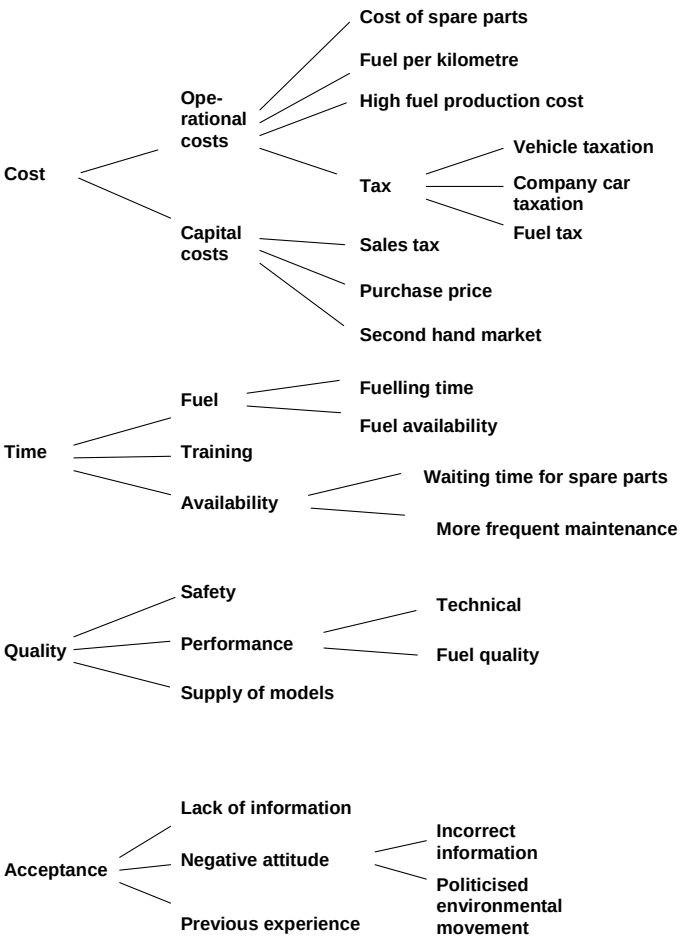


Figure 23 Classification of barriers to clean cars, based on how they affect generalized costs

6.1.1 Monetary Incentives

There are several monetary barriers to clean vehicles. Clean cars are generally more expensive than conventional cars. An underdeveloped second hand market reduces second hand values at a faster rate than for conventional cars. Operational costs tend to be high either because of high fuel costs or high taxes relative to conventional cars.

Several incentives have been in use to reduce monetary barriers to clean cars, see lists below. In the lists below S refers to Stockholm and N to national incentives. When possible, there is an estimate of the approximate monetary value of annual savings.

Operational Costs

- S: Bonus system for clean vehicles used for special transportation services including transport for disabled persons – Potential earnings SEK 27,000 if the vehicle is used for special transportation services half of the time.[11]
- S: Free residential parking and commercial/utility parking for clean vehicles – Maximum savings SEK 7,200.
- N: Lower fuel taxes on biofuels. Based on relative prices between petrol and biofuels savings of SEK 3,000-4,000 for drivers using 1,500 litres petrol (August 2008 prices).[12]
- N: Exemption from vehicle taxes (electric and electric/hybrids) – about SEK 1,500.
- N: Lower assessment value on company car tax – About SEK 4,000 for an FFV and SEK 8,000 for hybrid electric and biogas vehicles.
- N: Exemption from congestion taxes – Annual savings for frequent drivers about SEK 7,000 an average daily payment of SEK 28.[13].
- N: Carbon differentiated vehicle taxes – Annual savings vary from SEK 500 to SEK 4,500.

Capital Costs

- S: Public procurements (intended to provide sales volumes high enough to lower purchases)
- S: Investment grant – a one time payment of SEK 10,000-30,000 on company purchases
- N: Clean vehicle premium – a one time payment of SEK 10,000 to private purchasers

Monetary Value and Frequency

The bonus for special transportation services has the highest annual monetary value of the above incentives, implying that it is a strong incentive. At the same time, this incentive is targeted to a limited group of transporters, mainly taxi companies with a specific contract with Stockholm County Council, thus restricting its reach.

The highest monetary values are associated with investment grants, and that of the clean vehicle premium, which is of approximately equal monetary value. Nevertheless, the surveys indicate that monetary incentives that reduce operational costs (free residential parking, congestion taxes and the lower assessment value of company car taxes) may be more influential than incentives that reduce capital costs. One reason might be that there is a stronger reaction to frequent incentives. Exposure to Stockholm's congestion taxes occurs at every passage. Residential parking and company car taxes involve monthly savings, while the purchase rebate is a one time reward.

[11] Average annual taxi mileage 60,000 km multiplied by 0.5 and the bonus of SEK 0.9/km.
[12] This estimate is based on market prices and does not take into account the whole saving from tax reduction.
[13] Average daily payment based on estimate by Eliasson (2008).

The congestion exemption is more powerful than free parking

The combination of time savings and monetary savings seem to have reinforced the effect of the exemption from congestion charges.[14] On the other hand, this does not appear to be the case for the free residential parking incentive. The time spent required to find a free parking space might be valued more highly than the cost of parking in a garage. If this is true, offering designated parking places for clean vehicles would have a larger impact than offering parking for free. Another reason for the relative ineffectiveness of free residential parking as an incentive is that it affects a limited group of drivers. In late 2008 here were about 135,000 free passages in and out of the congestion tax area with alternatively fuelled vehicles during an average day, while about 6,000 vehicles had free residential parking permits. Free parking would become more powerful if larger groups of drivers were eligible for it. However, experience from Gothenburg shows that such a policy may have serious side-effects. Allowing free parking to all drivers of clean cars stimulates driving and may lead to a shift from public transport to private transport.

Monetary incentives can even out cost differences between clean cars and conventional cars such as a purchase price premium. Other monetary incentives introduce privileges for clean cars, such as the exemption from congestion charges. A drawback of the purchase price premium and other subsidies is their potential to give rise to negative side-effects. For example, car dealers tended to increase prices by the value of the subsidy when the Swedish Government introduced the clean vehicle premium.

There have been no incentives to stimulate the development of a second hand market. However, the growing market demand for clean vehicles has increased their second hand value. A significant change seems to have occurred a few months prior to the congestion tax trial that began in January 2006. As noted, anticipation of this privilege may well have increased the demand for alternatively fuelled vehicles.

6.1.2 Time Saving Incentives

The main time barrier relates to the availability of refuelling and service infrastructure. Other time barriers may include longer waiting times for spare parts and possibly a need for training in case clean cars require different driving skills. The incentives in this category concern the development of refuelling infrastructure, service network and when appropriate, training. Other time saving incentives concern privileges for clean cars, including the clean taxi queue at Arlanda airport, exemption from payments for congestion charges and free parking.

The incentives under the heading availability refer to time saving features of monetary incentives. As noted above, the combination of saving money and saving time, make monetary incentives potentially more effective. The separate taxi queue gives priority to clean taxis at Arlanda airport. By shortening waiting times at the depot for clean taxis, these taxis receive a market advantage and they can earn more money.

The list below shows time reducing incentives that are, or have been in use in Stockholm (S) or in Sweden (N).

Fuel

- S: Production of biogas (increasing fuel supply)
- S: Public private initiatives to distribute biogas
- N: Subsidy to refuelling stations for supplying other renewable fuels than E85
- N: Obligation to supply renewable fuel

[14] Time savings may not be very large for those who have joined the automatic congestion payment system.

Availability

- S: Separate taxi queue for clean vehicles
- S: Exemption from congestion charges and free parking

It has not been possible to measure the time saving incentives in a meaningful way. However, if the distance to a refuelling station for alternative fuel is too great, car buyers will decide that there is no point in acquiring a flexi-fuel or a biogasvehicle. Fuel availability is necessary rather than optional in order to achieve a successful market introduction of clean vehicles. Several incentives have been applied in Sweden for increasing the number of renewable refuelling stations. However, using legal requirements to increase supply may have potential negative side-effects. The Swedish renewable fuel obligation has been criticised for imposing large costs on small refuelling stations in the country side and for leading to an ethanol lock-in effect because it costs much less for refuelling stations to fulfil the obligation by supplying E85 instead of supplying biogas or other renewable fuels. In order to reduce the ethanol lock-in effect, the government introduced subsidies in 2007 for refuelling stations supplying other renewable fuels than E85 (primarily biogas).

6.1.3 Improving Quality

Quality barriers could include low safety in cars and/or refuelling sites and poor vehicle performance. We have also chosen to classify the narrow supply of models as a quality barrier because few models increase the risk that consumers cannot find cars of the quality they prefer.

All of these aspects are to a large extent characteristics controlled by vehicle producers. Swedish experience shows that several low-CO_2 cars and alternatively fuelled vehicles did not pass the strictest safety requirements defined by one of Sweden's largest insurers.[15]

Safety

- N: Safety standards adapted to alternative fuel characteristics (such as underground gas tanks)

Performance

- N: Technology procurement to improve driving range of electric cars (NUTEK 1994)
- N: Standardisation of alternatively fuelled vehicles (via KFB financed programme)

Supply of Models

- S: Joint procurements

Applying standards and requirements via legislation can overcome some quality concerns. Joint procurements have proved to be powerful tools for increasing the supply of alternative fuel vehicle models. All four joint procurements that have been finalized (see, Appendix) have increased the supply of clean vehicles in the Swedish market. In principle, procurements can also stimulate technology development as a tool to improve vehicle performance. The national procurement of electric cars in 1994, aimed at both improving vehicle supply and stimulating technology development, achieved only the former goal. The buying consortium had to accept a lower driving range than originally specified in technology specifications. (Trendsetter, Deliverable 12.11.1, December 2005).

[15] Folksam (2007) One of the largest insurance companies in Sweden has defined a crash-safe car as a model earning five stars in Euroncap's crash test and also offering anti-skid systems, seat belt reminders and an effective whiplash protection

6.1.4 Improving Acceptance

Only a very small share of consumers are so-called "early adopters." These consumers differ from the majority by being devoted enthusiasts. The majority of consumers are reluctant to purchase new technologies until they are more established in the market. Surveys of potential buyers have shown that low acceptance of clean cars is often based on erroneous perceptions about clean vehicles such as perceived technological risks, i.e. technological failure of clean cars. (Trendsetter, Deliverable No 12.13.1, Nov, 2001) In this particular case, distrust was due either to a lack of information about technical performance or to previous negative experience with early vehicles in the 1990's. In order to attract other groups of consumers than early adopters, it is important to provide them with information.

Information

- S: Information dissemination: Newsletters, seminars, consulting

Attitude

- S: Press releases and media representation at seminars

New Experiences

- S: Test drives and loaner programs
- Riding in a clean taxi

Incentives that increase acceptance have been widely used by Clean Vehicles in Stockholm. In order to provide accurate information and to reduce the impact of past experiences the project arranged seminars and consulting, and offered test driving to potential buyers. The city targeted its activities towards private companies with sizeable business fleets (e.g. car rental firms, newspapers) and companies providing transport services (e.g. messenger companies and taxi).

Attitudes and popular knowledge about clean cars is to a large extent based on media reports, which in several cases has been inaccurate. One example is an article in Sweden's largest daily newspaper declaring that a crashed Toyota Prius may become a death trap because of electric shocks spreading from the car wreck. (Dagens Nyheter, December 14th 2003). This incorrect statement was later dismissed by the Swedish Rescue Services Agency.[16]

Clean Vehicles in Stockholm has had an active approach to public relations, inviting journalists to events and supplying them with research results and news in general. The experience is press releases regarding monetary incentives for clean cars have been followed by positive and accurate reporting. The best media penetration was achieved by the company subsidies administered by Clean Vehicles in Stockholm.

6.1.5 Spread of Demand for Clean Vehicles

The categories of generalized costs do not cover all measures and strategies applied by Clean Vehicles in Stockholm. An additional class of incentives promote market expansion.

Market Expansion

- S: Replacing conventional vehicles with clean vehicles in the City fleet
- S: Development of the "at least one clean car" - network
- S: Green procurement requirements, City of Stockholm
- N: Ordinance regarding official purchase and leasing of clean vehicles

[16] See http://www.miljorapporten.se/article.jsp?article=10760). *(IN SWEDISH)*

- N: Travel policy (requirements that rental cars and taxis used by national government offices and agencies are clean vehicles)

The process of market expansion began in the 1990s when Stockholm began to replace the conventional vehicles in its own fleet with clean vehicles. This activity increased the city authorities' knowledge about clean vehicles and identified barriers. The other incentives listed above have in common that they increase the demand for clean vehicles as public authority fleet cars, but also companies supplying goods and services (messenger services, craftsmen and goods transports) and personal transportation services (taxi, rental cars). It has not been possible to systematically assess the influence of these incentives. However, demands from large private and public customers with green travel policies and by hotels requiring clean taxis for their customers seem to have had a strong impact on taxi companies.

6.1.6 Summary

Frequency and monetary value influence the effectiveness of incentives. Incentives that introduce a privilege for clean cars are stronger than incentives that attempt to "even out" differences between clean cars and their conventional counterparts. Some incentives seem to be necessary, implying that they must be in place in order for incentives for market stimulation to produce results. These necessary incentives include provision of supporting infrastructure such as refuelling facilities and standards requiring a certain quality standard.

The table below summarizes the additional generalized costs of a clean car and the associated additional benefits from incentives. The frequency column anticipates how often a clean vehicle driver "experiences" the incentive.

Table 11 Additional costs and additional benefits of a clean vehicle

Additional costs	Additional benefits (annual value)	Frequency
	Environment	Continuous
Purchase price: additional SEK 0-70,000	Purchase subsidy SEK 10,000 (not annual)	Once
Underdeveloped second hand market		
High sales tax (no sales tax in Sweden)	Sales tax rebate on clean vehicles	Once
High production cost of bio-fuels	No tax on bio-fuels SEK 3,000-4,000 (Aug. 08)	Weekly
Vehicle taxation (weight/purchase price)	CO_2 based vehicle taxation, SEK 500-4,500	Annual
Low fuel availability		
Higher service costs/more service		
Extra inspection		Annual
Brand and model (if not first choice)		
Lower safety		
Lack of information		
	Free parking SEK 7,200	Monthly
	Congestion tax SEK 7,000	Daily
	Rebate on company car taxation (saves money) SEK 4,000-8,000	Monthly
	Market advantage (clean taxi queue, clean delivery and clean rental cars)	

In the absence of incentives the only additional benefit of a clean vehicle is its environmental performance. Environmental considerations were reported as more important than exemption from congestion charges in the survey of recent clean vehicle buyers, see Chapter 5.4. However, surveys about car buying behaviour in general do not note environmental performance as an important factor, see Chapter 5.1.

6.2 The Importance of the Early Period

In the 1990's, clean cars were essentially unknown and unproven. This early period can be characterised as a pre-market phase. Clean cars were not sold by ordinary car dealers, there was no service network and legislation in some cases actually punished clean car purchase and use. Buying a clean car involved many risks. Only a small number of devoted enthusiasts with a special interest in environmentally friendly cars drove clean vehicles. The additional costs of clean cars were higher in the 1990's and the introduction of the most powerful incentives described above might well have failed to produce similar results in the 1990's as they did in 2006 and 2007.

6.2.1 Reducing Barriers

Stockholm's experience suggests that testing and demonstrating vehicles in the city fleet is a useful way to identify barriers to alternatively fuelled vehicles in particular. Real world tests improve understanding of how clean vehicles function in everyday situations and identify taxes and legislation that impose restrictions on their use. When tests of functionality indicate positive results, demonstration activities can lead to the certification of new technology or reforms of punishing taxes and regulations.

Co-operation with private sector partners has proved fruitful in reducing barriers such as the lack of refuelling infrastructure. City activities may include provision of a fuel production plant, financing infrastructure and planning sites. Fuel providers with little or no operations in petroleum production are not surprisingly generally most inclined towards this type of co-operation.

The high production costs of bio-fuels are reflected in high fuel prices. Unless prices of alternative fuels become comparable to the prices of fossil fuels, the spread of clean vehicles will remain limited. Therefore, it seems to be particularly important that fuel taxes do not discriminate against bio-fuels. Efficient fuel taxes would consider internalisation of externalities, reflecting the social cost of a fuel rather than its purchase price. During a transition period there are motivations for reducing the tax of alternative fuels to an even lower level.

Low acceptance is often related to fears associated with an unproven technology. It is therefore necessary to test alternative technologies and alternative fuels in order to prove that the risk of explosions and fires, or the magnetic fields in clean cars are not different from what can be expected with conventional fuels and vehicles.

6.2.2 Long Run Commitment

The main lesson of the Clean Vehicles in Stockholm project is that success takes time: this project has been operating for fifteen years. Data on clean vehicles show that the turning point in vehicle sales did not occur until 2005, 11 years after the start of the project. The duration of most other projects are significantly shorter e.g. many EU projects are 4-5 years. Long run commitment seems to have been a key factor for achievements so far. Another contributing factor is low turnover of personnel; there is a core team continually working with promotion of clean vehicles. While market conditions including dramatic oil price hikes and the introduction of congestion charges became favourable for clean cars across Sweden, their higher penetration in Stockholm bears witness to the effectiveness of a long term program.

6.3 Implications of the S-curve

Bosshardt *et al* (2008) caution against using estimates of S-curves for policy purposes. S-curves with different outcomes show a similar behaviour at the beginning see figure below. New technologies may succeed or fail, but it is not possible to distinguish success or failure in the starting phase. S-curves provide valuable descriptions of past developments, but their usefulness is low for predicting how to choose among different technologies. Neither is it possible to accurately determine that a new product has reached wider availability and market growth has become self-sustaining.

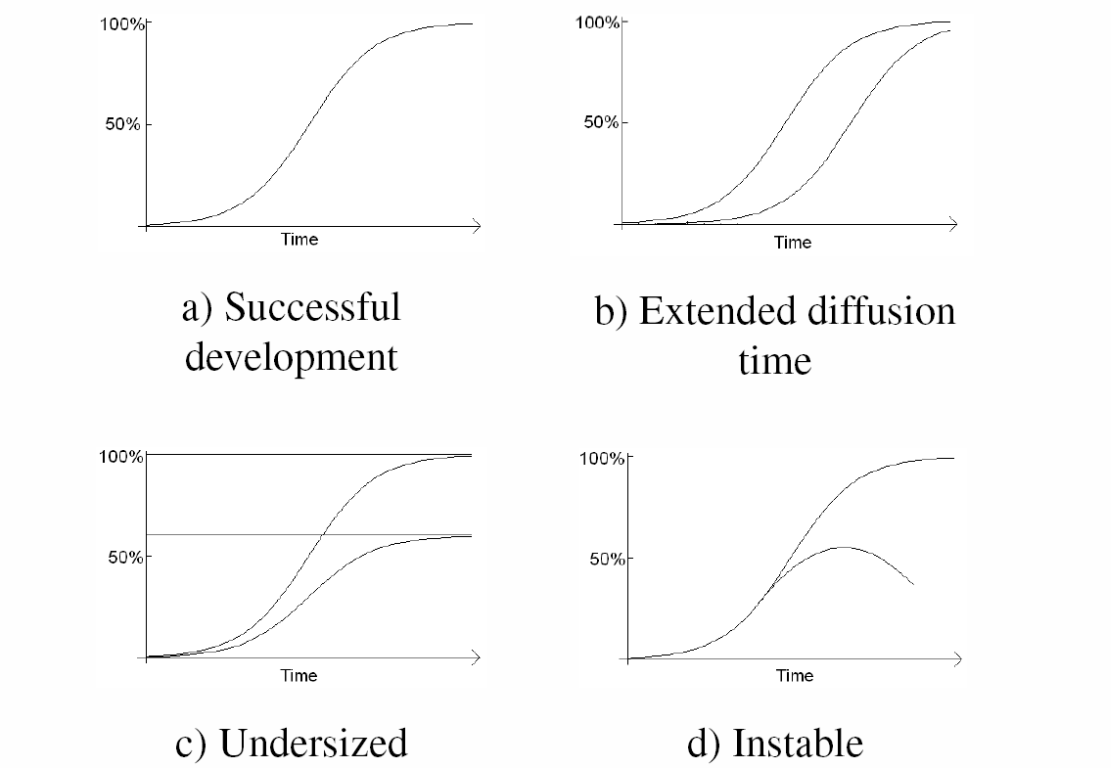


Figure 24 Four different development paths Source: Bosshardt et. al. (2008)

In order to reduce the risk of selecting an undesirable technology, experience suggests that governments should set policies that are directly related to objectives. This consideration has been considered in most policy choices. The first definition of clean vehicles included all renewable fuels and electricity. However, commitment to a broad range of technologies may not be cost effective since support to different technologies requires a large range of activities and numerous resources.

6.3.1 Target Groups

While the S-curve is not a tool for predicting whether a technology is a success or a failure, observations concerning adoption underlying the S-curve are helpful for identifying target groups.

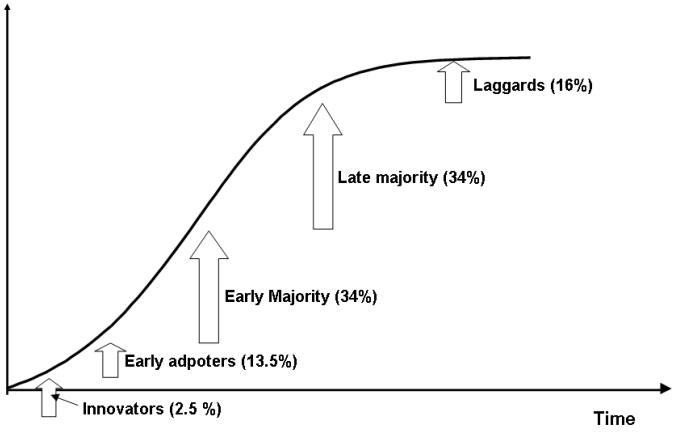


Figure 25 Adoption of technology by different groups of consumers

S-curves manifest the cumulative result of the behaviour of distinct consumer groups, and policy is therefore most effective when matching incentives to the preferences of these groups. In the pre-market phase, the primary focus needs be on replacing a small number of vehicles. Cities with devoted clean vehicle projects could replace a limited number of vehicles in the city fleet for testing purposes. It is useful to co-operate with other partners who test vehicles, but the choice should be limited to devoted pioneers, technology innovators who are prepared to cope with possible difficulties. Majority consumers are more easily discouraged by bad experiences with test vehicles. These devoted enthusiasts may have a special interest in environmentally friendly cars or in new technologies in general. Note however that these two types of innovators may have radically different model and performance preferences.

If tests produce encouraging results, markets can begin to develop among target groups including innovators and early adopters. Identifying target groups will typically require a market study among company buyers. Households are generally difficult to approach, in part because they tend to be more price sensitive. In addition, the private purchase process is more complex. Companies replace their vehicles at a much faster rate and the purchase process of business cars involves relatively few decision makers. Also, companies may see a goodwill or public relations value to owning and operating cleaner cars that may offer them a comparative advantage among competitors. However, not all fleet managers will be willing to purchase clean cars, particularly if they are concerned about their reliability. The target group of potential buyers needs to be selected among fleet managers identified through interviews or questionnaires. Companies providing transport services (taxi companies, messenger services) and companies with sizeable business fleets (e.g. car rental firms, newspapers) are expected to be represented in these target groups.

6.3.2 Dynamic Market Interaction

Monitoring only the sales of clean vehicles is of little help for determining when growth will become self-sustaining. In a forthcoming article Ramjerdi and Brundell-Freij (forthcoming 2009) following Struben (2008) argue that the market growth of clean vehicles depends on the dynamic interaction of multiple markets. In order to determine the diffusion dynamics of clean vehicles it is important to identify the relevant markets and their interactions.

In their case study of the E85 growth in Sweden, Ramjerdi and Brundell-Freij identify three primary markets: consumer considerations, vehicle supply and refuelling infrastructure. *(ibid)* Positive consumer considerations will translate into increasing sales of alternatively fuelled vehicles, while growing sales stimulate vehicle producers to supply new models. Use of alternative fuels depends on the availability of refuelling infrastructure and on motives for consuming alternative fuels. Unless these three markets interact via reinforcing feedback mechanisms growth cannot become self-sustaining. The statistical analysis in Chapter 4 indicates that sales of alternative vehicles would be substantially smaller in the absence of several current incentives, implying that incentives can reinforce relevant market interactions.

Market interactions can also have negative feedback effects on vehicle or fuel technologies. For example, the supply of new biogas and electric hybrid models and biogas refuelling developments has slowed over the past two years. It is possible that the so called ethanol lock-in effect is slowing down developments on these complementary markets.

6.3.3 The Swedish S-curve for Clean Vehicles

By combined actions of Clean Vehicles in Stockholm and government policies the Swedish “S-curve” for clean vehicles has arguably shifted to an earlier path than otherwise. Monetary incentives have been an important driving force. Although environmental considerations remain the main reported motivation for choosing a clean vehicle, the majority of car buyers do not report environmental considerations as a major purchase decision factor. This suggests that most drivers of clean cars are innovators and early adopters on sales.

An important privilege for drivers of alternatively fuelled vehicles is the exemption from congestion charges in Stockholm. In 2008 the exemption increased clean vehicle sales in Stockholm County of 23 percent. Low prices of renewable fuels between January and October likely had a similar positive impact.

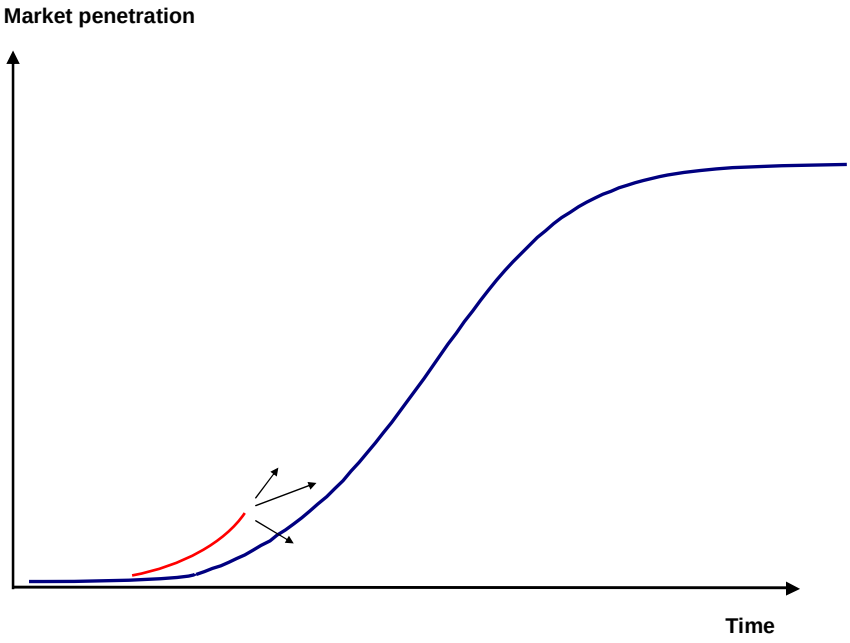


Figure 26 Supposed impact of incentives on the Swedish S-curve for clean cars

By the end of 2008, clean vehicles comprised approximately 5 percent of the Swedish vehicle stock and 8 percent of all vehicles in Stockholm. This is a significant share in the Swedish market, where vehicle turnover is slower than for example in the United States. In 2009 several monetary incentives will be discontinued. It is, however, not possible to conclude that the market has reached self-sustained growth level. Our understanding of the complex dynamic interactions between markets is still at a very early stage. As noted above the S-curve cannot be used for predictions about the future path.

7 Conclusions

The experience of Stockholm and Sweden clearly shows that it is possible for a city to influence the market spread of clean cars. Cities can act as catalysts with activities that reach beyond their municipal administrations. This requires co-operation with strategic public and private partners and constructive dialogue with government authorities. In order to achieve results there is a need to work systematically and to have a long run commitment. It is essential to include both vehicle supply and fuel infrastructure as critical components of city policies.

Monetary incentives are an important part of an overall policy to promote clean cars, but these incentives will not have a significant impact until the performance and reliability of a clean car is comparable to that of a conventional car. When assessing the strength of incentives it is, therefore, important to distinguish between a pre-market phase and a market development phase. The pre-market phase requires so-called preparative incentives while the market development phase calls for incentives that stimulate markets. These preparative incentives include measures promoting vehicle supply and fuel distribution, as well as activities to identify and remove legal barriers and tax disadvantages. If monetary incentives are introduced at this stage, their impact will be weak. Powerful incentives in the pre-market phase instead address the lack of vehicles and model diversity, missing fuel infrastructure and punishing taxes or absent regulations.

The combined actions of Clean Vehicles in Stockholm and government policies sales of clean vehicles in Sweden have arguably resulted in a more rapid market development than otherwise expected. Monetary incentives have been an important driving force in the latter stages of market development. An important privilege for drivers of alternatively fuelled vehicles is the exemption from congestion charges in Stockholm. The statistical analyses show that this exemption increased clean vehicle sales in Stockholm County by 23 percent in 2008. Low prices of renewable fuels between January and October likely had a similar positive impact on sales.

In a survey of recent clean car buyers in the City of Stockholm, households report their desire to reduce their own environmental impact as the most influential factor when choosing a clean car. Lower operating costs and exemption from congestion taxes are ranked next and these two factors are equally important. The purchase rebate and free residential parking are of relatively low importance. Company car drivers respond that the lower employee benefit tax assessed to a clean company car is the most influential factor for choosing a clean vehicle. Environmental performance is rated as the second most influential and the exemption from congestion charges is ranked third by company car drivers.

The statistical analyses and the buyers' survey find that low relative prices for alternative fuels and exemption from congestion taxes are the two most effective incentives. For drivers of company cars, the reduction of benefit taxes for clean vehicles is the most important incentive. These three incentives affect operating costs and provide frequent rewards to drivers of clean vehicles. Offering free residential and free commercial parking to clean vehicles includes the same mechanisms, but the analyses show that they are not as effective as the three aforementioned. One reason is that this incentive affects a limited group of drivers. Free parking would become more powerful if larger groups of drivers are included. However, experiences from Gothenburg show that such a policy may have serious side effects. Offering free parking to all drivers of clean cars stimulates driving and may lead to a shift from public to private transport. Consumers seem to respond to continual reminders of the rewards of a clean car choice, implying that vehicle tax rebates most probably have lower impact than offering free parking.

Purchase price subsidies are a one time reward affecting capital costs. The recent Swedish clean vehicle subsidy to private buyers was tested in the statistical analysis. The incentive was only statistically significant for low-CO_2 cars (petrol/diesel), and even for this segment was ranked lower than many other incentives. Purchase price subsidies can have both positive and negative side effects. Purchase price subsidies were reported positively by the Swedish media which helped raise awareness

about clean cars. At the same time, subsidies require significant amounts of public funds which put pressure on the public budget. Worse, car dealers tended to increase prices by the value of the subsidy. In addition, the Swedish clean vehicle subsidy seems to have affected company purchases adversely by capitalising the value of the premium as lower second hand values on low-CO_2 cars. Purchase price subsidies reduce capital costs and are suitable in limited cases. Paying subsidies to selected target groups will reduce the risk of market wide side-effects and puts less pressure on public funds.

By the end of 2008, clean vehicles comprised approximately 5 percent of the Swedish vehicle stock and 8 percent of all vehicles in Stockholm. This is a significant share in the Swedish market, where vehicle turnover is slower than for example in the United States. It is, however, not possible to conclude that the market has reached self-sustained growth level. Our best estimate is that the market for clean cars in Stockholm, and perhaps also in Sweden, has reached the developing market phase and may also manifest a partial market breakthrough.

Our understanding of the complex dynamic interactions between markets is still at a very early stage and needs to be developed in order to use the S-curve for predictions about when markets reach self-sustaining growth. Nevertheless, the S-curve concept can help policymakers identify target groups and craft incentives appropriate to each type.

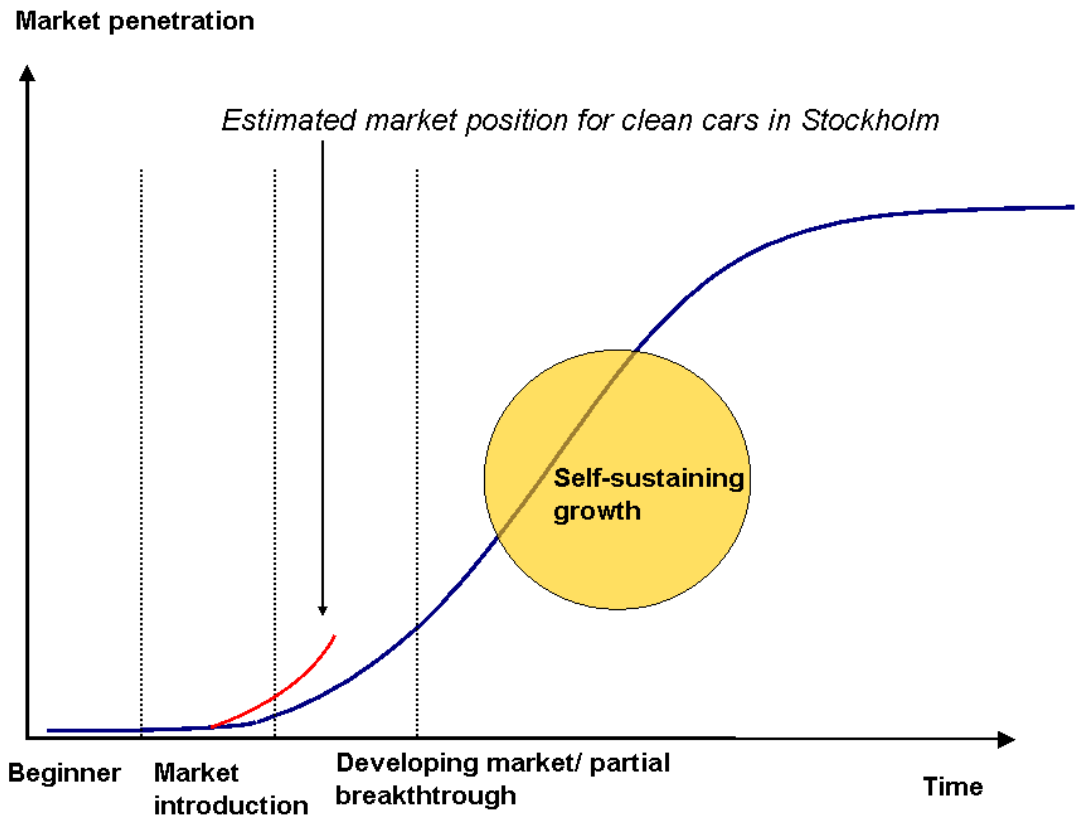


Figure 27 Estimated market position for clean cars in Stockholm

8 Recommendations

Stockholm appears to have passed the primary phases of market development and the clean vehicle markets seems to have reached partial market breakthrough in 2007. Public policies in Stockholm and developments in Sweden have also been analysed statistically and qualitatively and the results of these analyses form the basis of recommendations to other cities. These suggestions about how to design a strategy for creating a market for clean vehicles focuses on city actions, the choice of strategic partners and the selection of market segments during different stages.

Since actions and strategies need to adapt to developments, these recommendations relate to the different phases used to categorise developments in Stockholm and Sweden. The market of clean vehicles can be said to go through the following phases before it becomes self-sustaining:

- Beginner
- Market introduction
- Market development and partial market breakthrough
- Market breakthrough

8.1 Beginner

At the outset cities need to focus on creating or promoting the supply of vehicles, fuel provision and fuel infrastructure. Cities should recognise that their clean vehicle strategy is a long run commitment. It is also important to prepare for the next stage by identifying and reducing legal barriers. In order to identify barriers it is essential to test and demonstrate vehicles in real world situations, but putting large numbers of vehicles into operation is neither feasible nor desirable at this stage.

It is not uncommon for projects to run into difficulties during the beginner stage. General difficulties include high purchase costs, technical problems, an underdeveloped refuelling network, difficulties with fuel supplies, requirements such as double inspections and tax disadvantages. Project management and project partners need strong commitment to its goals.

In the pre-market phase, the city primarily needs to focus on replacing a restricted number of vehicles in its own fleet. It is useful to co-operate with other partners who test vehicles, but the choice should be limited to devoted pioneers who are prepared to cope with possible difficulties. The number of vehicles is of secondary importance until barriers have been overcome. It is much more important to co-operate with strategic partners, including other cities, fuel producers and providers. Other key partners include vehicle suppliers, service providers and test centres.

The city needs to collect information and experiences from its own fleet managers, test drivers and partners in order to identify complicating circumstances. These experiences should be documented and communicated to relevant actors at the national, regional and local levels.

In order to promote fuel distribution, there is a need to identify strategic partners, including producers, providers and retailers and to initiate co-operation. To some extent market mechanisms can help cities develop refuelling capacity. Existing infrastructure for petrol and diesel can be converted to supply liquid fuels including ethanol and RME at a relatively small cost. Cities will need to identify existing fuel suppliers interested in committing themselves to supply alternative fuels. In Sweden the consumer co-operative chain OK became the pioneer in providing E85. The chain had no own interests in oil fields and accepted a proposal from their members to begin providing one pump for every 10^{th} flexi fuel vehicle. Infrastructure for biogas is much more costly and cannot use existing motor fuel infrastructure. However, cities connected to a natural gas network are in a good starting position and the natural gas supplier can be a strategic partner. Partnership to provide biofuels can develop stepwise. The first step covers provision of natural gas refuelling facilities for vehicles. The next step

includes blending natural gas with biogas. Sewage treatment plants may be important producers of biogas. They need to be recognised as strategic partners for developing biogas production.

Joint procurements have proved to be a powerful tool when vehicles are missing or when the cost of existing clean vehicles is high. Buying in bulk together with other cities can raise volumes to a level at which producers can offer lower purchase or lease costs and in Sweden this led to the introduction of new clean cars to the market. Market research to find available vehicles among car dealers and general agents should be carried out before engaging in joint procurement.

Since there is a need to develop interaction between vehicle sales and fuel supply it is advisable to try to find ways to co-operate with car producers or general agents and fuel suppliers.

In short, the recommendations for the beginner phase include:

- recognition that a city strategy for clean vehicles and fuels is a long-term commitment
- demonstration of a limited number of clean vehicles in real world situations
- information collection in order to document barriers to clean vehicles and actions to reduce them e.g. by communication to concerned actors
- promotion of fuel distribution by co-operating with strategic partners relevant to the city context
- actions in order to promote market introduction of clean vehicles

8.2 Market Introduction

The transition between the pre-market phase and the market development phase is difficult to distinguish. One important signal of this transition is that driving a clean car is in all relevant aspects identical to or better than driving a conventional car. Regulations are in place and car dealers supply a variety of models. Clean cars may still be more expensive to purchase, their second hand value lower, and accessibility to alternative fuels disadvantageous, but apart from these possible drawbacks the performance and reliability of a clean car is close to or comparable to a conventional car.

Monetary incentives and reliable information become powerful tools in the market development phase. It is also important to keep track of the development of supporting infrastructure including networks for refuelling and vehicle service. The city will need to intensify its work with vehicle supply and continue supporting fuel market developments. At the same time market introduction phase adds new actions to the agenda. This is when cities should begin to work externally in order to convince early adopters to choose clean vehicles instead of conventional vehicles. There is a need to identify target groups, encourage them to buy clean vehicles and provide them with reliable information about the costs and specifications of clean vehicles.

Launching a popular existing model as an alternatively fuelled vehicle has a positive impact on sales of clean vehicles. In order to achieve this, cities may consider initiating a joint procurement process. As a first step, it is advisable, to conduct a market study to gauge interest among potential buyers parallel with a market survey that identify vehicle models already on the market and their price. The second step should intend formation of a buyers' consortium. The final step is the procurement itself, with a tender invitation to vehicle manufacturers. The tender documents will need to specify certain requirements for vehicle performance, prices etc. It is also advisable to include safety requirements in technical specifications.

The activities that started in the beginner phase to provide fuel infrastructure should continue. New partners may need to be invited to co-operate. If developments are slow, it is worthwhile to apply for additional financing from national programmes or European funds. However, using legal requirements to increase supply may have potential negative side effects, including technology lock-in effects and financial hardship for small refuelling stations.

The city should engage in external activities to spread information and encourage other actors to replace conventional vehicles with clean vehicles. This work will require a market study to identify target groups. Households are generally difficult to approach in an early market phase, so companies should be the focus of external activities. Company buyers also represent a wide group of potential buyers. Potential buyers may be identified via interviews or questionnaires. Companies providing transport services and other companies with large fleets are expected to be represented in these target groups. Employers providing a large number of company cars represent another potential target group.

The city should invite potential buyers to seminars and distribute objective information about clean vehicles' technical performance, political conditions affecting clean cars and their financial costs. Publicly produced information is most often perceived as neutral and trustworthy. Cities are, therefore, potential providers of web resources for facts about clean vehicles and renewable fuels.

Cities can initiate clean vehicle networks and aid companies in finding partners that have already bought clean vehicles. In Stockholm market expansion developed via green travel and procurement policies in companies and in the public sector. In order to speed such developments cities can prepare template guidelines for actors who want to implement green policies. Although cities seldom have direct authority over monetary incentives other than parking, cities can propose monetary incentives to regional or national authorities.

In short, the recommendations for the market introduction phase include:

- intensification of support to develop refuelling infrastructure
- actions that help to put a popular clean car model on the market
- information provision about clean vehicles and fuels
- promotion of introduction of monetary incentives
- activities to encourage external actors to replace conventional vehicles with clean vehicles
- production of template guidelines for green procurement and travel policies
- initiation of green vehicle networks

8.3 Market Development and Partial Market Breakthrough

These phases are distinguished by positive sales developments. Interest in clean vehicles will grow among fleet managers and expertise will spread to leasing management companies. In this phase cities can reduce the intensity of external activities that aim at encouraging external target groups to buy clean vehicles such as seminars and information campaigns.

Instead, cities will need to continue monitoring developments of vehicle markets and supply of renewable fuels. This work should form a base for an analysis that identifies missing links. These missing links should become a platform for continued city actions. Actions to address missing links can be a continuation of work that started in earlier phases or concern new activities. Cities may need to intensify earlier partnerships or to find new strategic partners for co-operation.

Monetary incentives will be important part at this stage. If not yet in place, it is critical at this stage to develop a national long run strategy for clean vehicles and renewable fuels. Cities can help government policy makers evaluate and design new policies that support both vehicles and new fuels.

Information provision and development of webpages needs to continue. Targeting information for new consumer groups, including households should be considered.

8.4 Market Breakthrough

Market breakthrough with self-sustaining growth cannot be realized until there is dynamic reinforcement between consumer considerations, vehicle supply and refuelling infrastructure. There is a need to monitor developments and the interactions between these markets. However, our understanding of the complex dynamic interactions between markets is still at a very early stage and needs to be developed in order to make predictions about when markets reach self-sustaining growth. Since it is difficult to assess when growth is self-supporting, it is important to take caution when phasing out policies. Phasing out should be done in a step-by-step manner so that discontinuation does not result in major disturbances.

The future development of a clean car market in Stockholm and Sweden will continue to provide an important example for other European cities and indeed cities worldwide. In particular, the phasing out of key incentives such as congestion charge exemption will help us understand whether or not clean cars are on a path to self-sustainability or require additional support.

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Appendix

Regional Incentives Implemented in Stockholm

Joint Procurements

Pooling demand from several actors can raise order volumes to a level at which it is attractive for automakers to supply clean vehicles. *Clean Vehicles in Stockholm* has initiated or participated in several joint procurements of clean vehicles.

- National procurement of electric vehicles. Initiated by the Swedish Agency for Economic and Regional Growth (NUTEK) and led by an executive committee chaired by Stockholm MFO (Equipment and Supply Service Organisation). Pre-study in 1992 and invitation for tender in 1994, awarded to Renault. 20 Renault Clio were delivered in 1995, 100 more were supplied in 1996 primarily to municipal buyers in Stockholm, Gothenburg and Malmö.
- ZEUS (1997-1998). Five European cities in the European project ZEUS jointly procured 200 electric cars and succeeded in dramatically reducing costs from SEK 320,000 to SEK 160,000.
- Ford Focus (1998-2000). Led to world premiere of Ford Focus FlexiFuel in Sweden in 2001. Altogether 3,000 cars had been pre-ordered by the buyers' consortium led by the Clean Vehicles in Stockholm.
- Hybrid, biogas and ethanol cars (2003). The procurement resulted in competitive offerings on alternatively fuelled vehicles.
- New procurement announced by the Clean Vehicles project in 2006. Agreement with Volkswagen in 2007 to launch its Caddy model in FlexiFuel format.

Purchase Prices Rebates

Clean Vehicles in Stockholm has administered rebates on purchases of clean vehicles within the framework of various projects, including:

- 1993-2000: purchase price rebates for ca 70 electric cars in the City of Stockholm fleet, in cooperation with KFB (The Swedish Transport & Communications Research Board)
- ZEUS Project (1996-2000): Purchase price rebates ca 250 vehicles in the City of Stockholm fleet
- National funds for local governments (LIP) allocated to Clean Vehicles in Stockholm in 2000-2003: purchase price rebates for ca 300 newly-introduced vehicles in the City of Stockholm fleet, plus some external vehicles.
- Trendsetter Project (2001-2005): Purchase price rebates for 30 percent of additional cost compared to equivalent gasoline or diesel vehicle. Support to City of Stockholm fleet and external vehicles.
- National climate funds for local governments KLIMP (2005- 2007): Rebate for 30 percent of additional cost excluding VAT, maximised to 18,500 SEK for transport vehicles and 10,000 SEK for passenger vehicles. Focus on taxis but also available to delivery firms, carpools, service cars and rental cars.
- European Project, BiogasMax (2006-2010): Contribution to companies who invest in at least three biogas vehicles. Purchase price rebate is 30 percent of the additional cost of the vehicles, maximum 18,500 SEK for transport vehicles and 10,000 SEK for passenger

vehicles. Rebate expected to be given to 24 vehicles in the City of Stockholm fleet and 84 external vehicles.

– European Project, BEST (2006-2010): Rebate for 35 percent of additional purchase cost (5,000-8,000 SEK/car) for 100 ethanol vehicles in the City of Stockholm fleet.

Test drives (2000-2001 and 2002-2005)

Companies are offered the opportunity to test drive clean vehicles for one week at no cost, enabling drivers to become more accustomed to clean vehicles and helping companies determine whether or not clean vehicles meet their demands for functionality, performance, security and price. Test driving offerings to a target group of fleet managers and CEOs in a selected group of companies.

Green procurement, City of Stockholm (2004-)

The City of Stockholm uses environmental performance criteria when procuring goods or services that include transports. All agreements signed by the City since 2004 include environmental performance requirements.

Bonus system for clean vehicles in special transportation services (Feb 2004-)

Clean vehicles used in special transportation services (such as transport for disabled persons) receive an extra bonus of 0.9 SEK/km (prior to 2006, 0.45 SEK/km) if they use at least 80 percent renewable fuels.

Separate taxi queue for clean vehicles (December 2005-)

The airport authority at Stockholm-Arlanda Airport wants to help consumers choose clean taxis and has given clean vehicles the priority in the airport waiting queue. This reduces waiting times for taxi companies, enabling them to conduct more journeys and increase profits. In 2008, it was decided that all taxis visiting the airport must be clean vehicles in 2010, although the definition of clean vehicles has not been finalised.

Free residential and commercial/utility parking for clean vehicles (2005-2008)

Clean vehicle owners (using the City of Stockholm's definition of a clean vehicle) can apply for free residential and commercial/utility street parking.

– Residential parking:

Registered owners of clean vehicles are eligible for free residential parking in the city centre, reducing their costs by up to 40 SEK/day or 600 SEK/30-day period.

– Commercial/utility parking permits:

Company service vehicle permits for parking near temporary workplaces are eligible for free parking. Such permits otherwise cost 8500 SEK/year.

– Commercial/utility parking mini:

This permit is available to those whose work requires parking and re-parking several times per day in different locations and costs 1200 SEK/30-day period for conventional vehicles. For clean vehicles, this charge is waived.

National Incentives

Lower fuel taxes (1995-2012)

All alternative vehicle fuels (except electricity) are eligible for tax rebates of vehicle fuel taxes including a CO_2 tax and a tax on the energy content of the fuel. VAT is added to all types of fuel.

Compared to the energy value of petrol, FAME, biogas and ethanol receive a 100 percent tax rebate, natural gas and LPG propane receive a rebate of about 80 percent.

Initially, EU rules prevented the Swedish Government from reducing taxes on biofuels except those used for trial purposes on an annual basis. Between 1995 and 1998, the Government freed biogas and ethanol from taxes on an annual basis. The announcement of the EU Biofuel Directive in 1999 enabled exemption of taxes during longer periods. The first long-term decision concerns the period 2003-2008 and the exemption has been extended until 2012.

Tax exemption for electric/electric hybrid cars (1995-2006)

A five-year grace period from annual vehicle registration tax was introduced in 1995. The tax exemption applied to new passenger cars, light-commercial vehicles, and buses classified as electric vehicles and electric hybrids. This policy was replaced by the CO_2-based vehicle taxes introduced in October 2006. Vehicles already in the tax exemption scheme were not affected.

Rebate on company car assessment value (1999-2011)

Employees who use a company car for private travel (including commuting) are taxed for this benefit according to the purchase price of the vehicle. Drivers of clean vehicles, which typically have a higher purchase price than comparable conventional vehicles, paid higher taxes on their company cars. To correct this disincentive to clean car use, the national government lowered assessment values for clean cars to the same level as comparable petrol-fuelled vehicles in 1999. Additional reductions were allowed from 1 January 2002 until 2007 and the incentive has been extended until 31 December 2011. The fuels and techniques affected, as well as the reductions of tax assessment values in relation to a comparable petrol-fuelled vehicle are summarised below.

- E85: 20 percent, maximum SEK 8,000 per year
- Natural gas and biogas: 40 percent, maximum SEK 16,000 per year.
- Hybrid-electric or electric: 40 percent, maximum SEK 16,000 per year.
- Propane LPG: same level as a comparable petrol-fuelled vehicle

Ordinance regarding official purchase and leasing of clean vehicles (2005-)

The Ordinance (SFS 2004:1364) entered into force on 1 January 2005 requires that at least half of the passenger vehicles purchased or leased by government authorities during a calendar year be clean vehicles. On 1 January 2006 the minimum requirement was increased to 75 percent and on 1 January 2007, increased again to 85 percent (SFS 2006:1572). According to a Government decision in January 2009 the share of clean vehicles has to be 100 percent starting from February 1st 2009.

Exemption from congestion charges (Jan-July 2006 and Aug 2007-July 2012)

A congestion charge trial was produced between January and July 2006 and made permanent in August 2007. The charge affects Swedish-registered vehicles entering and leaving Stockholm's inner city Monday-Friday between 06:30 – 18:29. The maximum charge is 60 SEK per day and there is no congestion charge on weekends or national holidays. Vehicles driven with biogas, ethanol, electricity, synthetic gas, methane, methanol, natural gas or hydrogen are exempt until 2012. There will be no exemption from congestion charges for cars sold and registered after the 1 January 2009. Alternatively fuelled vehicles registered before 1 January 2009 will exempt until 30 June 2012.

Obligation to supply renewable fuel (April 2006-)

Since December 2005, fuel stations that sell more than a certain volume of fuel are required by law to offer pumps with renewable fuels. This law is applied in five stages and began on 1 April 2006. It is

estimated that by 2010, 70 percent of all refuelling stations in Sweden, and one hundred percent in Stockholm, will be required to offer an alternative fuel.

Carbon differentiated vehicle taxes (October 2006-)

Carbon differentiated vehicle taxes for light-duty vehicles (1/10 2006 –): Basic tax at 360 SEK per year for all light duty vehicles. An additional tax is paid per gram CO_2 exceeding 100 g/km. This per gram tax is 15 SEK for petrol driven vehicles. For diesel vehicles gram tax is 52.5 SEK/g CO_2 and for vehicles using alternative fuels (in this case ethanol, E85, natural gas or biogas) the tax is 10 SEK/g CO_2.

Carbon differentiated vehicle taxes for heavy-duty vehicles vary between SEK 100 - 20,000. A new level of classification will be introduced on 1 October 2009.

Clean vehicle premium (SEK 10,000 cash rebate) (1/4 2007-30/6 2009)

To encourage individuals to purchase low-CO_2 cars and alternatively fuelled cars, the Government introduced a Clean Vehicles Rebate of 10,000 SEK in 2007. The rebate is available to private individuals who purchase a new clean vehicle and keep it for at least six months. Rebate payments were halted on 19 May 2008, because the original budget of 100 million SEK had been paid out. In July 2008, the Swedish government decided to provide an additional 240 million SEK for clean vehicle rebates in 2008. Rebates will be available until summer 2009.

Subsidies for refuelling stations supplying renewable fuel (31/12 2008-31/12 2009)

Since 2006, all large refuelling stations have been obliged to provide at least one renewable fuel. The majority of fuel stations have chosen to supply ethanol E85 since this is by far the least expensive alternative. This measure aims to stimulate establishment of biogas fuel stations. Planning and construction cannot begin until a decision on support has been made. According to the original plan, construction must begin no later than 31 December 2007 and be completed no later than 31 December 2009 to receive support. However, there were delays in initiating activities in 2007 and the Government decided to increase the permitting start time for installations until 31 December 2008.