# Short-Term Forecasts for the Road Vehicle Fleet

## – methodology memorandum

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# Foreword

The development of our road vehicle fleet affects the conditions surrounding future transport policy in numerous respects, as it does the conditions surrounding the fulfillment of our transport policy objectives. The documents that describe the anticipated development of the Swedish road vehicle fleet are consequently of major importance in terms of both the design of effective policy instruments for the transport sector and the government's budgetary work.

Transport Analysis has had the task of preparing yearly short-term forecasts for the development of the road vehicle fleet since 2017, a task that has been included in Transport Analysis' directives since 2022. The forecasts are delivered in tabular form in an Excel file that also includes statistics for the most recent years and projections for the current year and the next three following years. This memorandum contains a description of the methodology used in the forecasting work, including the assumptions that have served as the basis for the forecasts and for Transport Analysis' assessments. The forecasts are based on the data and information available as of April 1, 2023. The memorandum also compares forecasts from previous years with the actual results.

Mikael Levin has served as project manager for this task. The project team included Eva Lindborg, Anette Myhr, Björn Tano and Pia Sundbergh.

Transport Analysis wishes to thank the agencies and other actors who have contributed their knowledge to this work.

Stockholm, May 2023

Andreas Tapani

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# Summary

Transport Analysis has been tasked since 2017 with preparing short-term forecasts of the development of the vehicle fleet for the current year and the three following years, which means that the forecasts this year pertain to the period from 2023 to 2026. This is a methodology memorandum that explains the methods and assessments that have served as the basis for this year's forecasts. The short-term forecasts are published in a separate Excel file.[1]

Short-term forecasts are prepared for four vehicle categories, i.e. passenger cars, light trucks, heavy trucks, and buses. The forecasting work for each vehicle category consists of three steps:

1. Project the number of new registrations, vehicles off the road, and deregistered vehicles
2. Project the vehicle stock and vehicles on the road
3. Project information as to which characteristics are associated with the vehicles.

The methods used to project new registrations, vehicles off the road, and deregistered vehicles differ from vehicle category to vehicle category. In the case of new registrations of passenger cars and light and heavy trucks, we work with the help of statistically estimated models to generate the forecasts. A yearly mean value is instead used about the number of newly registered buses. The projections of vehicles off the road and deregistered vehicles are derived from assessments based on statistics and our monitoring of external factors.

The vehicle stock (vehicles on the road and off the road as of year-end) for a projected year is calculated as the number of vehicles present in the vehicle stock in the previous year plus the number of newly registered vehicles, minus those that were deregistered during the forecast year. When the forecasting work is being done, data are available regarding the vehicle stock, vehicles on the road, new registrations, vehicles off the road, and deregistrations for the preceding year. These data serve as the basis for projecting vehicles on the road for the current year. The forecasts for the three following years are then based on the forecasts for the year prior to the year to which the forecast pertains.

The short-term forecasts for passenger cars and light trucks also cover vehicle characteristics such as fuel-type breakdown, emissions class, newly registered vehicles' average carbon dioxide emissions and the breakdown of the vehicles by ownership conditions. The short-term forecasts for heavy trucks include fuel breakdown, emissions class, ownership category and weight, broken down by the number of axles. The forecasts for buses cover the same characteristics as the forecasts for heavy trucks, with the exception of ownership category.

In recent years the automotive industry has encountered difficulties with long delivery times for new vehicles, due to component shortages and supply chain problems. The delivery time problems are expected to persist throughout much of 2023, which means that there will be a time lag in terms of how quickly new vehicles sales are impacted by new conditions and assumptions. Sweden is entering a recession as of early 2023 that is believed will continue

[1] *Prognoser för vägfordonsflottan*. [Forecast for the Vehicle Fleet] www.trafa.se/etiketter/prognoser-for-fordonsflottan/

until 2025. Inflation has risen over the last year, as have interest rates, while food and energy prices have increased dramatically. In combination, these factors have had a negative impact on household purchasing power and, in turn, on interest in buying or leasing a new car. In addition, the climate bonus for passenger cars and light trucks that are EVs, or plug-in hybrids ended on November 8. Collectively these factors are leading to lower demand for new vehicles in general, and presumably to lower demand for EVs in the short term. Because of the long lead times for deliveries of new vehicles and well-filled order books for 2023, we believe that we will not see the full effects of the recession and the abolished climate bonus in 2023, but rather it will be 2024 before the shrinking demand for new vehicles is actually apparent in the statistics.

# 1 Introduction

The development of the vehicle fleet affects the conditions surrounding future transport policy in many respects, as it does the conditions surrounding the fulfillment of our transport objectives. The Swedish government needs a documentary basis for its efforts to design effective policy instruments. It is also relevant for the government to have, in its budgetary work, forecasts of how the Swedish vehicle fleet may be expected to develop over the next few years.

Against this background, Transport Analysis has been tasked since 2017 with preparing quantitative forecasts of the development of the Swedish vehicle fleet with regard to factors such as fuels, weights, and carbon dioxide emissions for both light and heavy vehicles. These projections have a short-term perspective and pertain to the current year and the next three following years.

This task has been included in Transport Analysis' directives since 2022, after having previously been assigned in the Agency's spending authorization, or as a separate assignment. All the forecasts are accessible on the Transport Analysis website.[2]

In this memorandum, Transport Analysis reports on the methods we use in the forecasting work for 2023, along with the assumptions and assessments we have made.

## 1.1 General method for preparing short-term forecasts by vehicle category

Transport Analysis prepares separate short-term forecasts for four vehicle categories, i.e. passenger cars, light trucks, heavy trucks, and buses. We prepare short-term forecasts for each vehicle category via three methodological steps:

1. Project the number of new registrations, vehicles off the road, and deregistered vehicles
2. Project the vehicle stock and vehicles on the road. The vehicle stock consists of all vehicles on the road plus all vehicles off the road.
3. Project information concerning certain characteristics associated with vehicles on the road.

The methods used to project new registrations, vehicles off the road, and deregistered vehicles differ from vehicle category to vehicle category. In the case of new registrations of passenger cars and light and heavy trucks we avail ourselves of statistically estimated models in preparing the forecasts, while for buses we make an assumption based on new registrations in previous years. The projections for vehicles off the road and deregistered vehicles are derived from assessments based on statistics and our monitoring of external factors. The forecasting methods and justifications for them are presented for each vehicle

[2] *Prognoser för vägfordonsflottan*. [Forecasts for the vehicle fleet] www.trafa.se/etiketter/prognoser-for-fordonsflottan/

category in Sections 2.1, 3.1, 4.1, and 5.1. A more detailed description of the methods used to calculate the number of vehicles on the road and project the number of newly registered vehicles is provided in Chapter 6.

## 1.2 Forecasts based on data from the Swedish Vehicle Register

Transport Analysis publishes vehicle statistics annually. These statistics contain information about the number of vehicles on the road, vehicles off the road, deregistered and newly registered vehicles, and trends over time. They also contain information about ownership, plus certain technical aspects such as fuel type. The statistics are based on data from the Transport Analysis vehicle register, which consists of the Transport Analysis road traffic register supplemented with certain ownership data obtained from Statistics Sweden's companies database. Data concerning the number of vehicles on the road or off the road refer to their status at the end of the relevant year, while the numbers of newly registered and deregistered vehicles refer to their numbers during each relevant year.[3]

The number of vehicles in the vehicle stock is currently calculated based on the latest known year, plus the projected number of newly registered vehicles minus the number of deregistered vehicles for the upcoming year, so as to derive a new vehicle stock figure. The number of vehicles off the road is then subtracted from these projected numbers to derive a forecast of the number of vehicles on the road.[4]

## 1.3 Future characterized by recession, high interest rates, and long delivery times

The last few years have been turbulent, and are characterized by major uncertainty about the future, and this is having an impact on the vehicle market. In 2020 the Covid pandemic led to major shutdowns and uncertainties about future economic development. New vehicle sales decreased dramatically as a result. A recovery began in 2021 as the pandemic became more manageable, but the longer-term effects of the 2020 reversals began to become evident in the fall of 2021. Component shortages resulting from the pandemic, heavy demand, and long lead times resulted in long waiting times and a shortage of new vehicles. The 2021 recovery stalled and was less impactful than expected.

The problems with long delivery times have stemmed from a shortage of components, mainly semiconductors, which has caused the automotive industry problems in obtaining sufficient quantities of components to manufacture the vehicles being sought. This problem was further exacerbated by Russia's large scale invasion of Ukraine in February 2022. This is a humanitarian catastrophe that has also led to major problems in terms of access to other types of components, including cables, which are manufactured in Ukraine. The war is having a number of aftereffects that could impact the automotive industry in the longer term, including

[3] Transport Analysis (2022a) *Kvalitetsdeklaration Fordon 2022.* www.trafa.se/globalassets/statistik/vagtrafik/fordon/2023/kvalitetsdeklaration-fordon-2022.pdf
[4] See equations 1 and 2 in Chapter 6.

through higher prices for a number of key metals, as well as higher prices for petrol, diesel fuel and electricity.

The long delivery times create a time lag in the system, and some time will pass before we fully see the effects of these altered economic conditions. Sweden is headed toward a recession in 2023. The climate bonus in the bonus-malus system was eliminated as of November 8, 2022, rather than gradually being phased out starting on January 1, 2023, as had originally been planned.[5] Rising energy and food costs have driven up inflation, resulting in a policy rate hike, and this combination of factors has reduced household purchasing power. There are thus a number of factors that are considered to be affecting new car sales, i.e. both in that total sales are decreasing, and that EV sales may decrease temporarily. The rapid rise in EV sales in recent years has been driven largely by the fact that private individuals have begun to buy, or perhaps most importantly, privately lease EVs.[6] As household purchasing power decreases and private leasing becomes more expensive due to the elimination of the bonus and rising interest rates, households will very likely cut back on purchasing EVs.

However, the long delivery times mean that there will be a time lag before we fully feel the effects of these changes. According to the National Institute of Economic Research's forecast, the economy will commence an upturn in 2025 and 2026, and new vehicle sales should thus start to rebound.

This year's projection of the development of the vehicle fleet may be summarized in that we believe that there will be some decrease in the number of new vehicles in 2023 in terms of both passenger cars and heavy and light trucks. This decrease will be amplified in 2024, with a gradual recovery in 2025 and 2026. Assessing the course of a recession and determining when the recovery may occur is a complex and difficult process. Estimating the societal effects of such a downturn is even more complicated, as different sectors of our society can be affected to varying degrees by a recession. The projections of what the magnitude of the decrease in registrations of new vehicles will actually be in 2023 and 2024, and of how quickly the recovery could occur, are consequently highly uncertain.

In the fall of 2023 the government will present a new climate action policy that will include proposals that Sweden must achieve its national climate objectives by 2030 and 2045, and that will delineate Sweden's undertakings vis-à-vis the EU. This will likely be accompanied by the introduction of new policy instruments to influence the vehicle fleet, which will further alter the conditions and assumptions surrounding the evolution of the vehicle fleet in the years ahead.

[5] The Swedish Government and Government Offices, *Klimatbonusen upphör den 8 november*, [The climate bonus ends on 8 November] (2022), www.regeringen.se/pressmeddelanden/2022/11/klimatbonusen-upphor-den-8-november/

[6] Transport Analysis, Transport Analysis (2022b) *Eldrivna vägfordon – ägande, regional analys och en möjlig utveckling till 2030*, [Electric vehicle ownership, regional analysis and potential development by 2030] 2022:12 (2022), www.trafa.se/globalassets/rapporter/2022/rapport-2022_12-eldrivna-vagfordon---agande-regional-analys-och-en-mojlig-utveckling-till-2030.pdf

## 1.4 Document summary

This memorandum provides a description of the methods used in the short-term forecasts. Projected tables may be found on the Transport Analysis website.[7] The chapters in the memorandum appear in the same order in which the forecasts are presented in the tables.

- Chapter 2 describes the assumptions and assessments that serve as the basis for the forecasts concerning passenger cars, and are presented in Tables PB1 to PB7.
- Chapter 3 presents the assumptions and assessments underlying the forecasts concerning light trucks (Tables LLB1 to LLB7).
- Chapter 4 presents the assumptions and assessments for the forecasts regarding heavy trucks (TLB1 to TLB7).
- Chapter 5 presents the assumptions and assessments underlying the projected evolution of the bus fleet (Tables BU1 to BU6).
- Chapter 6 presents the methods used to project the numbers of newly registered passenger cars, light trucks, and heavy trucks.

Follow-ups of last year's forecasts and the actual results used as starting points in preparing this year's forecast are presented in the chapters for each respective vehicle category, where follow-ups of forecasts and results for each vehicle characteristic may be found as well.

Our assessments of the future development of the component elements of the forecasts are described for each step in the forecasting process. Such an assessment may, for example, indicate that the evolution will follow the trend for the five previous years, or be the same as in the year before. The justification for each assessment is then provided.

[7] www.trafa.se/etiketter/prognoser-for-fordonsflottan/

# 2 Short-term forecast, passenger cars

In this chapter Transport Analysis will present the assessments and assumptions serving as the basis for this year's forecasts regarding passenger cars.[8] It will also present a follow-up of last year's forecasts based on the number of passenger cars on the road and the number of vehicles newly registered in 2022.

## 2.1 Number of passenger cars

### Newly registered passenger cars

The number of newly registered passenger cars has been projected using the ARIMA model presented in Chapter 6, and based on the National Institute of Economic Research's forecast of the evolution of Sweden's GNP and employment rate. However, the model is unable to consider the prevailing conditions in terms of component shortages and the long delivery times for new cars, with the result that we believe that the number of newly registered passenger cars will be somewhat higher in 2023 than the model indicates. It is difficult to assess just how many more passenger cars may be registered because of the long delivery times, but we have chosen to adjust the model results upward by 2% for 2023.

### Deregistered passenger cars

Scrapping is the most common reason why vehicles are deregistered, but administrative scrapping and exports of used vehicles are also included in the category of deregistered vehicles. Vehicles are scrapped mainly because they are old and have deficiencies in terms of their functionality, but also because they have been damaged in traffic accidents. Administrative scrapping means that the vehicle has not been on the road for a long enough time to enable a determination that it will not be placed into service in the near future, and the vehicle is consequently deregistered from the vehicle register. With regard to exports, Transport Analysis has noted that exports of passenger cars that can run on alternative fuels are increasing over time. This is very likely due to the fact that more favorable conditions for such vehicles are present in other countries, making it profitable to sell them abroad.[9]

Just over 264,000 passenger cars were deregistered in 2022, which is a marginal increase compared to 2021. The scrapping of cars decreased 7% in 2022, while exports increased by 18%. Transport Analysis considers that the total number of passenger cars deregistered moving forward will remain at roughly the same level as in recent years. We believe that the number of scrapped cars will decrease as a result of the recession, while the number of exported cars will remain at a high level, or even increase, as we have seen no indications that such exports will decrease in the near future. Roughly 4.1% of the stock of passenger

[8] Cars with seating for a maximum of eight people in addition to the driver are considered to be passenger cars.
[9] Transport Analysis (2017) *Export av begagnade miljöbilar and fossiloberoendet*, [Exports of used cars and fossil independence], www.trafa.se/vagtrafik/fordon/export-av-begagnade-miljobilar-6432/

cars has been deregistered over the last 10 years. The share of deregistered vehicles was significantly higher in 2018 and 2019, i.e. 4.8 and 4.9% of the vehicle stock, as a result of both the high number of scrapped cars and the high number of exported ones.

Transport Analysis' assessment is that the share of deregistered passenger cars will total 4.2% of the vehicle stock in 2023 and 2024 and increase to 4.4% in 2025 and 2026, as the number of scrapped cars is expected to increase as the recession eases. The problem in the forecast is in assessing how many used cars will be exported.

## Passenger cars off the road

Over the last 10 years the share of passenger cars off the road (out of the total vehicle stock) has remained relatively constant over time, although it has increased somewhat in recent years, by an average of 0.5 percentage points per year. However, 2020 saw a significant deviation insofar as both the number and share of cars off the road decreased, something that had not happened in over 10 years. The number of passenger cars off the road fell in 2021 as well, albeit only marginally compared to 2020. We believe that this was due to the Covid pandemic and its associated restrictions.

In 2022 the number of vehicles off the road rose again to roughly a pre-pandemic level. Transport Analysis consequently considers that the effect of the pandemic in terms of the decreased number (and share) of passenger cars off the road is behind us, and that the share of passenger cars in relation to the vehicle stock will return to a roughly pre-pandemic level. The share of passenger cars off the road is expected, as a result of the recession, to increase by 0.2 percentage points in 2023 and 2024 from the 2022 level of 21.7%. We believe that the share of the vehicle stock accounted for by passenger cars off the road in 2025 and 2026 will increase to 22.1%.

## Passenger cars on the road

Passenger cars on the road are calculated based on the latest known vehicle stock, i.e. passenger cars on the road plus passenger cars off the road. To this is added next year's projected number of newly registered cars, minus the number of deregistered cars. The projected number of passenger cars off the road is then subtracted.[10]

## Follow-up of 2022 forecast

In our forecasting work for 2022 we considered that that recovery (after the recession) in the number of newly registered passenger cars in 2020 as a result of the Covid pandemic would persist, albeit hampered by continuing component shortages. We proceeded based on the assumption that the number of passenger cars off the road or deregistered would be at roughly the same level as in previous years. However, the increase in the number of newly registered passenger cars abated in 2022, largely because of long delivery times due to component shortages among vehicle manufacturers. The result for newly registered passenger cars thus fell a bit short of our forecast. The number of deregistered cars remains at roughly the same level as the year before, while the scrapping of older cars decreased and exports of used passenger cars increased. The number of cars off the road increased again in 2022, after having fallen for two consecutive years. We thus consider that the effect of the pandemic in terms of the decreased number of passenger cars off the road is behind us. Overall this means that our forecast was largely consistent with the actual result, although the

[10] See formula 3, Chapter 6.

number of passenger cars on the road did decrease somewhat in 2022, rather than increasing somewhat, as had been projected (Table 2.1).

**Table 2.1. Forecast and results for number of passenger cars on the road, number off the road, number of new registrations, and number of deregistrations 2022.**

| | *On the road* | *Off the road* | *Newly registered* | *Deregistered* |
|---|---|---|---|---|
| Forecast | 5,049,561 | 1,339,850 | 310,205 | 259,903 |
| Results | 4,980,543 | 1,383,569 | 299,220 | 264,585 |
| Absolute difference | 69,018 | -43,719 | 10,985 | -4,682 |
| Relative difference | 1.4% | -3.2% | 3.7% | -1.8% |

## 2.2 Fuel breakdown for passenger cars

### Newly registered passenger cars by fuel type

Sales of chargeable cars have risen continuously since 2015. Initially this was due mainly to plug-in hybrids purchased or leased by companies, but the number of newly registered EVs has increased dramatically since 2020, due in large part to private individuals having opted to purchase or lease an EV. As a result of the degraded economic conditions which are believed to have reduced household purchasing power, as well as the eliminated climate bonus for chargeable cars, Transport Analysis considers that the share of newly registered chargeable cars will increase in 2023 to account for 65% of newly registered passenger cars, but then decrease by 7 percentage points in 2024. Given that it is EVs that are most affected by the climate bonus, plug-in hybrids and other hybrid technologies will be priced better relative to EVs. As a result of this, Transport Analysis believes that the number of newly registered plug-in hybrids will be somewhat higher over the entire projected period compared to forecasts for previous years.

The long lead times within the automotive industry entail that the share of newly registered chargeable cars will begin to decrease in 2024. The currently prevailing conditions may undergo significant changes before then. Market adaptations to the prevailing situation or new policy instruments/incentives for chargeable cars may emerge, which could affect the results for 2024.

### Assessment for each fuel type

**Electric:** New registrations of EVs increased by 66% in 2022 compared to the year before, accounting for 32% of all newly registered cars that year. Electricity was thus the most common fuel type, followed by petrol and plug-in hybrids. This increase is attributable to an expanded offering of EVs with greater price variation, and to the fact that private individuals have begun to opt for EVs to a greater extent, often leasing them privately.[11] Newly registered

[11] Transport Analysis (2022b) *Eldrivna vägfordon – ägande, regional analys och en möjlig utveckling till 2030*, [Electric vehicle ownership, regional analysis and potential development by 2030] 2022:12 (2022)

EVs had also qualified for an SEK 70,000 bonus. Plans had called for a reduction of this bonus to SEK 50,000 as of January 1, 2023, but the bonus was instead eliminated entirely as of November 8, 2022.[12] Sweden is at the same time headed toward a recession, with high inflation and high interest rates reducing household purchasing power.[13] We believe that the eliminated climate bonus for chargeable cars in combination with the recession will reduce the number of newly registered passenger cars in general, and that it will impact sales of chargeable cars as well. However, because of the long delivery times, there will be a time lag before these altered circumstances affect the number of newly registered vehicles. The cars registered in early 2023 were ordered in 2022. We thus consider that the actual decrease will first begin to become evident by the end of 2023, with the full impact appearing in 2024.

*New assessment for 2023:* Our assessment is that new registrations of EVs will continue to grow in 2023, and then decrease in 2024. According to our forecast, EVs will account for 46% of the passenger cars newly registered in 2023, only to fall back to 35% in 2024, and to then rebound to 42% in 2026.

**Electric hybrids:** The number of newly registered electric hybrids has grown at a relatively uniform rate since 2013. However, mild hybrids began to be registered as electric hybrids in 2019, with the result that the number of electric hybrids greatly exceeded our projection. However, we have been able to distinguish the mild hybrids from the electric hybrids since 2020, and they will thus be registered as petrol- or diesel-powered cars henceforth. There is a relatively broad offering of electric hybrids, and they are generally subject to relatively low taxes, while at the same time being considerably less expensive than a chargeable car.

*New assessment for 2023:* Transport Analysis believes that new registrations of electric hybrids are starting to reach their peak. In the long term, electric hybrids will find it increasingly difficult to meet ever-stricter emissions requirements, and we believe that the range of models on offer will become increasingly limited. Up until 2026 we believe that the electric hybrids will be present to roughly the same extent as currently, and their numbers may increase somewhat. Up until 2026 we believe that electric hybrids will account for 11–12% of newly registered passenger cars.

**Plug-in hybrids:** New registrations of plug-in hybrids have increased rapidly since they were introduced on the market in 2013. This increase was particularly significant in 2020. The number of newly registered plug-in hybrids grew by 18% in 2021. Prior to 2022 Transport Analysis' forecast indicated that the number of newly registered plug-in hybrids would decrease, as was indeed the case. The eliminated climate bonus for chargeable cars is affecting plug-in hybrids as well. However, they qualified for a significantly lower bonus than did EVs, with the result that the elimination of the bonus entails a relative price change that favors plug-in hybrids. In the first months of 2023 it would appear that it is mainly private customers who are refraining from buying a new car, while companies are ordering new cars to roughly the same extent as before.[14] Transport Analysis has previously shown that companies opt for plug-in hybrids to a greater extent than do private individuals, which

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www.trafa.se/globalassets/rapporter/2022/rapport-2022_12-eldrivna-vagfordon---agande-regional-analys-och-en-mojlig-utveckling-till-2030.pdf.

[12] Swedish Government Offices (2022).

[13] *Inflationen exklusive energi blir hög hela 2023-Konjunkturinstitutet*, [Inflation excluding energy will be high throughout 2023-National Institute of Economic Research] www.konj.se/publikationer/konjunkturlaget/konjunkturlaget/2023-03-29-inflationen-exklusive-energi-blir-hog-hela-2023.html

[14] *Privatmarknaden för personbilars dök kraftigt under årets första kvartal* [The private market for passenger cars fell dramatically during first quarter of the year] | *Mobility Sweden*, https://via.tt.se/embedded/release/privatmarknaden-for-personbilar-dok-kraftigt-under-arets-forsta-kvartal?publisherId=3236140&releaseId=3343960&lang=sv.

indicates overall that sales of plug-in hybrids may increase in the coming years,[15] albeit subject to delay because of long delivery times.

*New assessment for 2023:* Transport Analysis' assessment is that new registrations of plug-in hybrids will account for 23% of passenger cars newly registered in 2023, a figure that will then increase somewhat in 2024 and 2025, and then decrease back to 23% in 2026 as the share accounted for by EVs begins to grow again.

**Ethanol:** The number of newly registered passenger cars that can run on E85 has decreased dramatically since the record year of 2008, when nearly 60,000 ethanol cars were newly registered. Only 70 passenger cars that can run on ethanol were newly registered in 2020. Since then, a number of models that can run on ethanol have appeared on the Swedish market, primarily from Subaru and Ford, and the number of newly registered ethanol cars has increased, totaling 1,900 in 2022. Because ethanol cars are exempt from the higher vehicle taxes and the bonus-malus system, and as the price of a new car has not risen much higher than the cost of petrol-powered cars, we believe that there is still a market for ethanol cars, albeit a limited one.

*New assessment for 2023:* Transport Analysis considers that new registrations of ethanol cars will be fairly limited moving forward as well. The fact that there are a number of models to choose from does not, however, mean that we believe that the number of newly registered ethanol cars could continue to increase. Our forecast calls for 2,500 cars in 2023, followed by an increase to 3,500 in the years that follow.

**Natural gas:** Natural gas cars have accounted for 1–2% of new car sales since 2010. However, sales of natural gas cars have decreased in recent years. Transport Analysis believes that it is unlikely that sales of natural gas cars will change to any major extent over the next four years.

*New assessment for 2023:* Transport Analysis considers that natural gas cars will account for 0.7% of all newly registered passenger cars, across all projected years.

**Petrol and diesel:** In our forecasts, passenger cars are broken down into petrol- and diesel-powered vehicles when the projected number of vehicles running on alternative fuels is subtracted from the projected total number of new registrations. The breakdown between petrol- and diesel-powered vehicles has changed over time. Petrol cars dominated up until 2008, even as they lost market share. The loss in market share continued until 2012, after which time the share of petrol cars has increased relative to diesel ones.

Our forecast from 2002 was based on the assumption that the breakdown between petrol and diesel cars appeared to have stabilized compared to previous years, as changes in the malus system entailed a rapid decline in the number of newly registered diesel cars. Transport Analysis thus believed that the breakdown between newly registered petrol and diesel cars would be 64.5% petrol and 35.5% diesel in 2022, as was in fact the case. As of when this memorandum was prepared (2023-04-19), there have been no notifications to the effect that the tax levels in the malus system will be changed.

*New assessment for 2023:* Transport Analysis considers that the breakdown between newly registered petrol and diesel cars will be 66% petrol and 34% diesel in 2023, after which the share accounted for by diesel will decrease by 1 percentage point by 2026, which is consistent with the historical trend.

[15] Transport Analysis (2022b) *Eldrivna vägfordon*.

**Hydrogen:** Hydrogen-powered fuel cell cars do not constitute a technology that Transport Analysis believes will achieve a breakthrough during the projected period.

## Deregistered passenger cars by fuel type

The fuel breakdown for the deregistered vehicles is calculated based on the historical trend. In the case of passenger cars, the statistics indicate that petrol cars have accounted for between 63 and 90% of deregistered passenger cars. However, this share has decreased every year, as more and more passenger cars that run on other fuels have arrived. Transport Analysis believes that the share accounted for by deregistered petrol cars will decrease annually by 1.5% from the 2022 value of 63.4% over the entire projected period.

The share of deregistered vehicles that can run on an alternative fuel has previously been low, but as the stock of such vehicles grows and exports may be notably high, we have raised our projection of the number of deregistered alternative fuel vehicles. Exports of used EVs increased notably in 2022 compared to previous years. Transport Analysis believes that this increase will continue moving forward, with the result that our projection for deregistered EVs is set higher than in previous years in terms of both their numbers and their share of deregistered passenger cars. The forecast for electric passenger cars indicates that they will account for 2.7% of all deregistered cars in 2023, a figure that will subsequently rise to 3.3% by 2026. The forecast for plug-in hybrids indicates that they will account for 4.7% of all deregistrations in 2023, and for 6.2% by 2026. The share of deregistered natural gas cars is expected to be 1.4% in 2023, with a subsequent increase to 1.8% of all deregistrations over the entire remaining three years of the forecast.

Deregistered ethanol cars are expected to account for 3.2% of all deregistrations in 2023, a figure which will then increase to 3.8% by 2026. Electric hybrids are expected to account for 1.5% of deregistrations in 2023, a figure that will increase to 1.8% by 2026. The share of diesel cars deregistered will rise as the diesel cars on the road become increasingly older. Our forecast indicates that diesel cars will increase from accounting for 24% of the cars deregistered to 25% between 2023 and 2026.

## Passenger cars off the road by fuel type

The fuel breakdown for vehicles off the road is based on the historical trend, and on assumptions deriving thence. The number and share of passenger cars off the road has long been increasing to some extent from year to year. This trend ended in 2020 as the number of passenger cars off the road declined because of the Covid pandemic. The number of cars off the road decreased in 2021 as well, which Transport Analysis interprets as an effect of the shortage of new cars. The number of passenger cars off the road grew again in 2022, and Transport Analysis consequently considers that the effect of the pandemic in terms of the reduced number of passenger cars off the road is behind us.

The statistics indicate that the share of petrol cars among the vehicles off the road has decreased by 1–2 percentage points each year since 2009, while the share of diesel cars off the road increased by 1 percentage point per year over that same period. We believe that this trend will continue as the diesel cars in the vehicle stock age, thereby increasing the likelihood of their not being on the road. Among the alternative fuel types there are fairly few vehicles that have been off the road (barely 4% of the cars off the road in 2022 ran on alternative fuels). With respect to the alternative fuel types, we have made qualitative assessments of their anticipated evolution over the projected period, and generally we have increased their shares compared to previous forecasts. We believe that the share of vehicles off the road running on alternative fuels will increase from 4.4% in 2023 to 6.2% in 2026, with ethanol cars accounting for just over half of such vehicles.

## Passenger cars on the road by fuel type

Passenger cars on the road by fuel type are calculated based on the number of passenger cars in the vehicle stock. We add the following year's projected number of cars by fuel type, and then subtract those deregistered or off the road.[16]

## Follow-up of 2022 forecasts

The forecast of the total newly registered light passenger cars for 2022 was somewhat too high compared to the results, although there were small differences between the forecast and the results for 2022 with regard to the breakdown by fuel type. The forecast for 2022 indicated that 55% of newly registered cars would be chargeable, while the actual figure was 54%. The number of EVs was thus somewhat higher than projected, and the number of plug-in hybrids lower. The deviations for other fuel types were relatively minor, as seen in Table 2.2.

### Table 2.2. Forecasts and results for new registrations of passenger cars, broken down by fuel type, 2022.[17]

| | *Petrol* | *Diesel* | *Electric* | *Electric hybrid* | *Plug-in hybrid* | *Ethanol* | *Natural gas* | *Total* |
|---|---|---|---|---|---|---|---|---|
| Forecast | 70,569 | 38,904 | 93,837 | 26,068 | 76,776 | 2,500 | 1,551 | 310,205 |
| Results | 67,247 | 36,788 | 96,163 | 28,355 | 66,775 | 1,937 | 1,919 | 299,220 |
| Absolute difference | 3,322 | 2,116 | -2,326 | -2,287 | 10,001 | 563 | | 10,985 |
| Relative difference | 5% | 6% | -2% | -8% | 15% | 29% | -19% | 4% |
| Breakdown, forecast | 23% | 13% | 30% | 8% | 25% | 1% | 1% | 100% |
| Breakdown, results | 22% | 12% | 32% | 9% | 22% | 1% | 1% | 100% |

The forecast of the number of passenger cars on the road, broken down by fuel type, came close to the actual results (Table 2.3). With respect to the breakdown among the various fuel types for vehicles on the road, it was mainly the plug-in hybrids that were overestimated in the forecast, while the share of natural gas cars was underestimated.

[16] See formula 4, Chapter 6.
[17] The category "Other" is not reported.

**Table 2.3. Forecasts and results for passenger cars on the road, broken down by fuel type 2022.**[18]

| | *Petrol* | *Diesel* | *Electric* | *Electric hybrid* | *Plug-in hybrid* | *Ethanol* | *Natural gas* | *Total* |
|---|---|---|---|---|---|---|---|---|
| Forecast | 2,509,341 | 1,697,439 | 200,777 | 175,579 | 253,272 | 177,585 | 35,003 | 5,049,561 |
| Results | 2,485,975 | 1,667,176 | 197,709 | 173,476 | 239,531 | 178,316 | 38,086 | 4,980,543 |
| Absolute difference | 23,366 | 30,263 | 3,068 | 2,103 | 13,741 | -731 | -3,083 | 69,018 |
| Relative difference | 1% | 2% | 2% | 1% | 6% | 0% | -8% | 1% |
| Breakdown, forecast | 49.7% | 33.6% | 4.0% | 3.5% | 5.0% | 3.5% | 0.7% | 100% |
| Breakdown, results | 49.9% | 33.5% | 4.0% | 3.5% | 4.8% | 3.6% | 0.8% | 100% |

## 2.3 Emissions classes

At present, a passenger car is to be classed in Euro 6 if it meets the applicable emissions requirements and other requirements as per Table 2 in Appendix 1 to Regulation (EC) no. 715/2007 or Appendix 1 to Regulation (EC) no. 595/2009.

Our forecasts pertain to the share of the number of passenger cars on the road that are classed in emissions class Euro 6[19] and the share of passenger cars which, above and beyond Euro 6, are classed as Euro 5, electric, electric hybrid or plug-in hybrid, and how great a share thus falls into earlier emissions and environmental classes or lacks information as to the emissions or environmental class in question. A surprising number of passenger cars that are so-called mild hybrids, i.e. they derive limited assistance from a small electric motor when in operation, are registered in the ‘electric hybrid’ emissions class. As of 2022 we have consequently chosen to report the electric hybrids under emissions class 6 as well. Emissions class Euro 6 thus covers petrol and diesel cars, cars that can run on ethanol or natural gas, and electric hybrids. Negotiations are currently underway regarding the design and implementation of a stricter emissions class, Euro 7, which will likely be introduced before 2026. However, this emissions class is not factored into our forecast, as we do not know when it will be introduced.

### Forecasting method, 2023

**Breakdown by emissions class for newly registered vehicles**
In our forecasts, we proceed on the basis that all newly registered passenger cars belong to emissions class Euro 6, electric, or plug-in hybrid. Because mild hybrids are often registered in the ‘electric hybrid’ emissions class, we have chosen to include the electric hybrids in emissions class Euro 6 in the reporting on our forecasts. The breakdown of this categorization

[18] The category “Other” is not reported.
[19] In practice there are several sub-categories of Euro 6, but Transport Analysis has chosen to make its forecasts at the overall level.

is based on assumptions concerning the fuel-type breakdown in the new registrations. We presume that all vehicles that run on liquid fuels or natural gas fall into emissions class Euro 6.

**Breakdown by emissions class for vehicles off the road and deregistered vehicles**
In the case of vehicles off the road and deregistered vehicles we assume that the share of electric and plug-in hybrids is the same as in their respective fuel-type forecasts. With regard to other emissions classes, we have made our assumptions based on the historical trends. However, the statistics are limited, making the calculations relatively uncertain. We assume that the share of deregistered vehicles for which emissions class information is lacking is decreasing by 2 percentage points per year. The same assumptions apply to the vehicles off the road. We assume that the remaining share is split between emissions classes Euro 5 and Euro 6, with breakdowns of 20/80% for deregistered vehicles and 30/70% for those off the road. The reason why the share for Euro 6 is somewhat higher for the deregistered vehicles is that a large number of relatively new cars are exported each year, and they fall into emissions class Euro 6.

**Breakdown by emissions class for vehicles on the road**
The number of passenger cars on the road by emissions class is calculated in the same way as the number of passenger cars on the road by fuel type, but with the fuel types replaced by the emissions classes.

### Follow-up of the forecast for 2022

The forecast for 2022 was that 43% of all passenger cars on the road would fall into the most recent emissions class (Euro 6), as was in fact the case. We consequently see no reason to modify our forecasting method beyond possibly adjusting a few assumptions on the basis of historical trends.

## 2.4 Carbon dioxide emissions

Transport Analysis has projected the average carbon dioxide emissions (measured in grams per kilometer) for newly registered passenger cars.

These projections were previously calculated using three different methods, although we have made certain changes since 2020 because of the transition from the NEDC testing procedure to WLTP. All three methods are based on statistics regarding the average carbon dioxide emissions from newly registered passenger cars as measured in grams per kilometer.[20] Transport Analysis' statistics are based on the emissions data per vehicle recorded in the Swedish Road Traffic Register. Most vehicles that are taxed based on their carbon dioxide emissions have an emissions value recorded in the Road Traffic Register. This value is measured by the vehicle manufacturer in accordance with EU regulations.[21]

[20] Transport Analysis' statistics differ from those reported by the Swedish Transport Agency pursuant to EU Regulation 443/2009/EC and EU Regulation 510/2011/EC. The difference is that all passenger cars are included in the Transport Analysis data while, pursuant to the EU regulations, the Swedish Transport Agency eliminates mobile homes, ambulances, racing cars, police cars and other special-purpose vehicles. This difference means that the Transport Analysis statistics indicate somewhat higher carbon dioxide emissions as measured in grams per kilometer compared to the Swedish Transport Agency reporting.
[21] All statistics pertain to emissions based on the New European Driving Cycle (NEDC) test cycle. NEDC is gradually being replaced with the Worldwide Harmonized Light Vehicle Test Procedure (WLTP), but the NEDC values are still being reported for the time being.

### Forecasting method, 2023

Transport Analysis has used three different methods in forecasting the carbon dioxide emissions values for newly registered passenger cars.

- Method 1: The historical trend for each respective fuel since 2019
- Method 2: The emissions values are the same as in the year prior for each fuel type, but the average emissions are decreased as a result of a higher degree of electrification as per our forecast.
- Method 3: The historical trend since 2019 for each respective fuel, plus a shift toward more electrified vehicles as per our forecast

For a number of years we could see no decreases in emissions for the respective fuels, and consequently favored method 2. As we are now again seeing a trend toward reduced emissions for each fuel type, we believe that method 3 is the most reliable. This means that the average emissions value for newly registered passenger cars in 2023 is 54 grams, a significant decrease compared to 2022, when the figure was 70 grams. However, the average value will increase again somewhat in 2024 as a consequence of our belief that fewer EVs will be newly registered.

### Follow-up of the forecast for 2022

The average emission values for a number of fuels have not changed notably from year to year. The decrease in emissions from newly registered passenger cars has stemmed instead from a modified fuel breakdown, insofar as more and more chargeable cars have been registered. However, this trend has changed somewhat in recent years, albeit marginally. The forecast for 2022 assumed that the average carbon dioxide emissions per fuel type would decrease over the ensuing years, based on a linear trend from 2019 to 2021. The forecast for 2022 called for a mean value of 74 grams of carbon dioxide per km for newly registered passenger cars. The actual figure was somewhat lower, i.e. 70 grams. The difference between the projected value and the actual value is attributable to the fact that the number of newly registered EVs was somewhat higher than projected, and that the average emissions from the plug-in hybrids were notably reduced compared to earlier years.

## 2.5 Ownership category

Each year Transport Analysis reports statistics regarding how the number of passenger cars on the road breaks down between legal entities and private individuals. Private individuals also include those who lease a car privately. The breakdown of the number of vehicles on the road for passenger cars by form of ownership has remained stable over time. This is reflected in the projections made by Transport Analysis with regard to ownership category.

### Forecasting method, 2023

Transport Analysis continues to believe that the breakdown by form of ownership will remain largely stable over time. Transport Analysis does not deem that there are any adopted policies or external factors that will influence these breakdowns in any particular direction during the projected period. The forecast is consequently based largely on the assumption that the shares from 2022 will persist in 2023, and over the three years that follow. However, in recent years we have noted that the number of passenger cars on the road that are owned by women is slowly increasing. In light of this, we have chosen to increase the share of passenger cars on the road that are owned by women by 0.1 percentage points per year.

On the other hand, something that has changed notably in recent years is the popularity of private leasing. Roughly 7,500 privately leased cars were newly registered in 2013. That number had risen to nearly 70,000 by 2022. Transport Analysis has published a study that includes an analysis of various determining factors with regard to passenger car ownership. The study showed that there are significant differences between the factors that govern private car purchases and private leasing.[22] It is, however, not a form of ownership that is right for everyone, and Transport Analysis has found that mileage is the primarily limiting factor. The lease agreement will specify how many kilometers the car may be driven during the lease period, and more kilometers means a higher price. The standard is usually between 10,000 and 20,000 kilometers per year. People who need to be able to drive more than 20,000 kilometers per year should consequently not view private leasing as an appropriate form of ownership.

To assess how many private individuals may be presumed to be able to get by with a mileage limitation that falls within the framework of a private lease agreement, we have proceeded based on the mileage driven by private car owners. This assessment was made based on following up the reported odometer readings for passenger cars that are three years old and have undergone their first inspection. The car must also have been purchased and owned by a private individual during the three years between its new registration and inspection. Our review indicates that 56% of private car owners had odometer readings of less than 40,500 kilometers over the three year period, and could thus find it advantageous to lease a car privately. Roughly half of all newly registered passenger cars ultimately end up with a private individual. Depending on the total number of cars newly registered in a given year, this means that roughly 85,000 new cars could be leased privately each year.[23]

In 2022 nearly 70,000 of the passenger cars newly registered were privately leased, and they thus started to reach the ceiling that we believe exists in terms of the market's potential. The cost of leasing privately has increased markedly over the last year, given that interest rates have risen over the last year, and because of the elimination of the climate bonus for EVs. We consequently find that the number of privately leased cars will decrease in the coming years. This decline will be fairly modest in 2023, given the delays in new car deliveries, but it will become more apparent in 2024. However, we also believe that private leasing will start to rebound as of 2025 as a result of market adaptations, more stable interest rate levels and an economic recovery.

We consider that the share of privately leased cars will fall by five percentage points in 2023 compared to 2022. This figure will be an additional 15 percentage points in 2024, and then start to increase again in 2025.

## Follow-up of the forecast for 2022

In April 2022 we predicted that the breakdown by ownership category at year-end would be the same as for 2021. A comparison with the actual results indicates that this was an accurate assessment. The breakdown between passenger cars owned by physical persons and those

[22] Transport Analysis (2021) *Rapport 2021:*1 [Report 2021:1].
[23] Roughly half of the passenger cars newly registered during a year end up with a private individual. Of these, we believe that 56% will have been driven a limited number of kilometers such that they could have been leased privately.

owned by legal entities was the same as for the year prior (79% vs. 21%). In the breakdown between men and women we predicted that women would own 35.8% of all passenger cars on the road, while the actual figure was 35.7%. The share of passenger cars owned by legal entities that were unincorporated enterprises (sole proprietorships) was assumed to be the same in 2022 as in 2021, i.e. 48.6%. The actual figure was 47%.

# 3 Short-term forecast, light trucks

This chapter describes how the forecast for light trucks is produced. A truck is a vehicle that is configured primarily for transporting goods. Any truck with a total weight of less than 3.5 tonnes is considered a light truck.[24] The chapter also includes a follow-up of last year's forecast and results.

## 3.1 Number of light trucks

### Newly registered light trucks

The number of newly registered light trucks is presumed to be attributable to the percentage change in GNP and the number of light trucks newly registered the year before (see also Section 6.4). However, this correlation is not considered to provide a good estimate of sales in 2023. Just as in the case of passenger cars, new light trucks are subject to long delivery times. We consequently believe there to be a large number of ordered light trucks that have not yet been delivered. The model does not include them, and we have consequently chosen to deviate from its results for 2023. The assumption for 2023 affects the model's results for other forecast years, and the model is assumed to yield accurate values for those years.

The industry organization Mobility Sweden also makes forecasts of the number of newly registered light trucks. Its forecasts are made in close collaboration with its membership, based on general assessments, order status, launches of new electrically powered models, signals from the manufacturers in terms of their offerings and allocations to the Swedish market, etc. Mobility Sweden's projection for 2023 is 43,000 newly registered light trucks.[25]

Since 2006 the share of light trucks newly registered during the period from January through April has corresponded to between 27% and 42% of the sales for the year, with an average of 32%. We see no arguments to convince us that sales in 2023 will be either front-loaded or back-loaded, and thus consider that the sales from January through April will be consistent with those in an average year (32% of the entire year), giving us 40,249 newly registered light trucks.

### Deregistered light trucks

The number of deregistered vehicles is considered to equal 3.6% of the previous year's vehicle stock. As in previous forecasts, we assume that a constant share of the previous year's vehicle stock will be deregistered. The share of light trucks deregistered from the previous year's stock has fallen, i.e. from 4.3% in 2019 to 3.3% in 2022. The average for the years 2019–2022, i.e. years when new registrations were considerably lower than previously,

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[24] Swedish Transport Agency, (2022b) "*Lastbil*".[Truck]
[25] Mobility Sweden (2023) *Prognos nyregistreringar*, [Forecast new registrations] https://mobilitysweden.se/statistik/prognos-nyregistreringar.

was 3.6%. We assume that the deregistrations will remain at this level, i.e. the same percentage share as in last year's forecast.

### Light trucks off the road

The share of light trucks off the road is 26% for the entire projected period.

Over the last 10 years the share of the total vehicle stock accounted for by light trucks off the road has been between 25.8 and 27.4%. The figure has been close to 26% over the last three years. Our assessment is that the share of light trucks off the road will remain at this level over the projected period.

### Light trucks on the road

#### *Follow-up of the forecast for 2022*

The follow-up of the forecast for light trucks for 2022 indicates that the forecast of the number of newly registered vehicles was overestimated by 15%, while the number of vehicles deregistered was overestimated by 7%. The number of light trucks off the road was 4% higher than projected (Table 3.1). All in all, this resulted in our forecast for the number of vehicles on the road being too high.

**Table 3.1. Forecast and results for number of light trucks on the road, number off the road, number of new registrations, and number of deregistrations, 2022.**

| | *On the road* | *Off the road* | *Newly registered* | *Deregistered* |
|---|---|---|---|---|
| Forecast | 622,508 | 207,503 | 42,532 | 29,029 |
| Results | 608,871 | 216,427 | 36,894 | 27,116 |
| Absolute difference | 13,637 | -8,924 | 5,638 | 1,913 |
| Relative difference | 2.2% | -4.1% | 15.3% | 7.1% |

## 3.2 Fuel breakdown for light trucks

### Newly registered light trucks by fuel type

Sales of chargeable light trucks have risen continuously in recent years. This initially pertained mainly to purely electric vehicles, but a number of plug-in hybrids have also started to be registered in the last two years, although their number is still low. Transport Analysis believes that the number of newly registered chargeable light trucks will increase over the entire projected period, despite the elimination of the climate bonus for chargeable vehicles. Our assessment is that the difference in terms of annual taxes between chargeable diesel-powered light trucks combined with their lower operating costs will steer the trend toward more and more chargeable light trucks.

The operating costs for electric trucks can also be significantly lower than for diesel ones.[26] This creates incentive to purchase an electric light truck despite the elimination of the climate bonus. Light trucks are owned to a large extent by companies, which may be expected to make rationally/financially optimized choices regarding their vehicle fleet. The TCOs (Total Cost of Ownership) are compared in this context. If the TCO is lower for electric light trucks, then they will be given preference over other options with a higher TCO. TCOs can vary depending in part on how the vehicles are being used. Lower mileage means that the operating costs become more important relative to the purchase price. Studies of TCOs for electric light trucks have pointed to both higher and lower costs compared to diesel-powered light trucks.[27] One study shows that the TCOs are lower for small electric light trucks than for diesel ones, while medium-sized and large electric light trucks have higher TCOs than do the corresponding diesel-powered light trucks.[28]

As an aid in our assessment of the share of light trucks with each respective drivetrain, we have taken a look at the new registrations for 2020–2022 broken down by drivetrain and industry, weight, chassis, ownership and whether or not the vehicles were leased. The share of electric light trucks in previous years has been higher in the 2,001–2,500 kg weight class than for heavier light trucks. This difference had essentially disappeared by 2022. We interpret this to mean that relevant electric alternatives now exist for heavier light trucks as well. The share of electric vehicles for the lightest light trucks is significantly lower (0% for light trucks between 1,500–2,000 kg, and 5% for light trucks under 1,500 kg). Light trucks under 2,000 kg account for only roughly 2% of all new registrations.

**Assessment for each fuel type**

**Electricity:** The share of newly registered electric light trucks grew from 1.3% in 2018 (when the bonus-malus system was introduced) to 13.6% in 2022. The figure nearly doubled from 2021 to 2022. The share of electric light trucks in January–March 2023 was 12.7%. A number of these vehicles may have been ordered before the elimination of the climate bonus, and thus qualified for it.

When we look at drivetrains in combination with industries, we see that five[29] industries have had higher shares of electric light trucks than was the average for all three years studied. The new registrations among these industries collectively accounted for 7% of the new registrations in 2022. The average share for electric vehicles for these five industries was 31%. The highest share of electric light trucks, 41%, was found in the real estate industry. Seven industries[30] had shares of electric light trucks that were lower than the average figure for all the years studied. The new registrations among those industries collectively account for 35% of the registrations, while the share of electric vehicles among them was 10% in 2022.

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[26] Jimmy Andersson, *Succé för Mathems ombyggda trucks-nu ska 130 elektrifieras*, [Success for Mathem's converted trucks-130 will now be electrified] 2023, www.ehandel.se/succe-for-mathems-ombyggda-lastbilar-nu-ska-130-elektrifieras.

[27] Jens Hagman, *Lätta electric trucks – Försäljningen ökar men utmaningar består*, [Light electric trucks-Sales increase but challenges remain] 2022, https://omev.se/2022/02/10/latta-ellastbilar-forsaljningen-okar-men-utmaningar-bestar/.

[28] Anastasios Tsakalidis, Jette Krause, Andreea Julea, Emanuela Peduzzi, Enrico Pisoni & Christian Thiel, "Electric light commercial vehicles: Are they the sleeping giant of electromobility?", *Transportation Research Part D: Transport and Environment* vol. 86 (2020), doi:10.1016/j.trd.2020.102421.

[29] They are real estate, education, healthcare and nursing, social services, electricity, natural gas, heating and cooling utilities, and other services.

[30] They are agriculture, forestry and fishing, mineral extraction, construction, enterprises in the fields of law, finance, science and technology; public administration and defense, compulsory social security services, industry unknown, and owned by a private individual.

The share of electric vehicles among newly registered light trucks that were leased was higher than the share of those that were not leased, i.e. 15% vs. 10%, while 68% of the newly registered light trucks were leased.

It is difficult to assess the evolution of the share of electric light trucks. The industry organization Mobility Sweden finds that the share of electric light trucks will be 20% in 2023, while also reporting that 15% of those on order are chargeable. The number of models of electric light trucks offered for sale by Mobility Sweden's members in 2023 has, however, dropped to 19, as compared to 23 models the year before.[31]

*New assessment for 2023:* We believe that the share of electric light trucks will increase by four percentage points in 2023 and 2024, after which time the increase will be six percentage points per year.

**Plug-in hybrids:** Generally speaking, the number of plug-in hybrids has been extremely low, with only a few isolated newly registered vehicles per year. However, this figure did increase to several hundred newly registered vehicles in 2021 and 2022.

*New assessment for 2023:* We believe that the share of newly registered plug-in hybrids among the newly registered light trucks will increase from 0.7% to 1.2% for plug-in hybrids from 2023 to 2026.

**Ethanol:** The number of newly registered light trucks that can run on ethanol has increased markedly over the last three years. However, this pertains mainly to larger pickups, which means that the market for light trucks that run on ethanol is considered to be relatively limited.

*New assessment for 2023:* We believe that light trucks that can run on ethanol will become more prevalent during the projected period, i.e. from accounting for 4% of newly registered light trucks in 2023 to 6.3% in 2026.

**Natural gas:** Light trucks that can run on natural gas have become somewhat less prevalent in recent years. Transport Analysis does not believe that the number of natural gas-powered newly registered light trucks will increase during the projected period.

*New assessment for 2023:* We believe that the figure for natural gas-powered light trucks will be the same as the year before, i.e. accounting for 0.5% of newly registered light trucks.

**Petrol:** The number of light trucks that run on petrol has remained at a low but relatively uniform level over the last 10 years. Transport Analysis considers that light trucks that run on petrol will stay at the same level as in previous years.

*New assessment for 2023:* We believe that petrol-powered light trucks will stay at last year's level, i.e. accounting for 3.9% of newly registered light trucks.

**Diesel:** The share accounted for by diesel-electric light trucks fell from 93% in 2018 to 78% in 2022. Our assessment is that this figure will continue to decrease. The increase in market shares for electric light trucks, plug-in hybrids and ethanol-powered light trucks is expected to occur at the expense of the diesel-electric light trucks.

## Follow-up of last year's forecast

In last year's forecast we overestimated the number of and share accounted for by newly registered diesel-electric light trucks. The number and share figures for natural gas-powered light trucks were also overestimated. At the same time, we underestimated the number and

[31] Mobility Sweden, "Fordonsåret 2022 and prognosen 2023". [Vehicle year 2022 and 2023 forecast]

share figures for electric and ethanol-powered light trucks, plug-in hybrids, and electric hybrids. In the case of petrol, we overestimated the number of light trucks, but underestimated their share. This occurred because, overall, we expected more new registrations of light trucks than was in fact the case.

### Table 3.2. Forecast and results for newly registered light trucks, broken down by fuel type, 2022.

| | *Petrol* | *Diesel* | *Electric* | *Electric hybrids* | *Plug-in hybrids* | *Ethanol* | *Natural gas* |
|---|---|---|---|---|---|---|---|
| Forecast, number of | 1,531 | 34,877 | 4,720 | 0 | 128 | 851 | 425 |
| Results, number of | 1,432 | 28,805 | 5,024 | 5 | 262 | 1,162 | 196 |
| Absolute difference | 99 | 6,072 | -304 | -5 | -134 | -311 | 229 |
| Relative difference | 7% | 21% | -6% | -100% | -51% | -27% | 117% |
| Forecast, share | 3.6% | 82% | 11% | 0.0% | 0.3% | 2.0% | 1.0% |
| Results, share | 3.9% | 78% | 14% | 0.0% | 0.7% | 3.1% | 0.5% |
| Absolute difference | -0.3% | 3.9% | -2.5% | 0.0% | -0.4% | -1.1% | 0.5% |

## Deregistered light trucks by fuel type

- The share of petrol-powered light trucks being deregistered will gradually decrease by one percentage point per year from the 2023 level of 14% to 11% by 2026.
- The share of natural gas-powered light trucks deregistered is 1.7%, i.e. the same as in 2022, over the entire projected period.
- The share of ethanol-powered light trucks deregistered is 0.3%, i.e. the same as in 2022, over the entire projected period.
- The share of electric light trucks being deregistered will increase from 0.4% to 0.5% by the end of the projected period.
- The share of deregistered diesel vehicles is calculated as a residual, with the result that the figure will increase from 82% in 2022 to 87% in 2026.
- We expect the shares for other fuels (electric hybrids and others) to remain the same as in 2022, i.e. 0%.

Our calculation of the breakdown by fuel type among deregistered vehicles is based on historical trends. Roughly the same numbers of petrol- and diesel-powered vehicles were deregistered in 2010, after which the share of petrol vehicles has decreased, while the share of diesel vehicles has grown. Over the last two years the share accounted for by deregistered petrol-powered light trucks has been around 15%. In this year’s forecast we anticipate that the share accounted for by deregistered petrol-powered light trucks will decrease by 1% per year (in earlier forecasts we assumed that this share would decrease by 1.5% per year). The share of deregistered diesel-electric vehicles has increased each year since 2013, with the exception of 2022. We believe that that this figure will continue to increase, and calculate it as a residual item.

A follow-up of last year's forecast reveals that we overestimated the numbers of deregistered diesel-electric, natural gas- and ethanol-powered light trucks, while underestimating the numbers of petrol-powered and electric light trucks that were deregistered; see Table 3.3.

**Table 3.3. Forecast and results for deregistered light trucks broken down by fuel type, 2022.**

| | *Petrol* | *Diesel* | *Electric* | *Electric hybrids* | *Plug-in hybrids* | *Ethanol* | *Natural gas* | *Other* |
|---|---|---|---|---|---|---|---|---|
| Forecast, number of | 4,004 | 24,213 | 87 | 0 | 0 | 145 | 581 | 0 |
| Results, number of | 4,087 | 22,365 | 115 | 0 | 0 | 72 | 470 | 7 |
| Absolute difference | -83 | 1,848 | -28 | 0 | 0 | 73 | 111 | -7 |
| Percentage difference | -2% | 8% | -24% | 0% | 0% | 102% | 24% | -100% |
| Forecast, share | 14% | 83% | 0.3% | 0.0% | 0.0% | 0.5% | 2.0% | 0.0% |
| Results, share | 15% | 82% | 0.4% | 0.0% | 0.0% | 0.3% | 1.7% | 0.0% |
| Absolute difference | -1.3% | 0.9% | -0.1% | 0.0% | 0.0% | 0.2% | 0.3% | 0.0% |

## Light trucks off the road by fuel type

- The share of all light trucks off the road accounted for by petrol-powered light trucks is expected to decrease by one percentage point per year, i.e. from 29% in 2023 to 26% in 2026.
- The shares for natural gas-powered (0.4%), ethanol-powered (0.4%) and electric (0.2%) light trucks off the road are the same as in 2022 over the entire projected period.
- The share for electric hybrids, plug-in hybrids and other light trucks off the road is 0%, i.e. the same as in 2022, over the entire projected period.
- The share for diesel vehicles off the road is calculated as a residual item.

Our calculation of the breakdown by fuel type among vehicles off the road is based on historical trends. The share of vehicles off the road accounted for by petrol-powered light trucks has decreased annually by between 2.2 and 0.4 percentage points over the last 10 years, while the share for diesel-electric light trucks has at the same time increased by roughly the same amount. Our assessment is that the share for petrol-powered vehicles off the road will decrease by one percentage point per year over the entire projected period.

The shares accounted for by natural gas-powered, ethanol-powered, and electric light trucks off the road have remained at roughly the same levels in recent years. We consequently anticipate that they will stay the same over the entire projected period. The same applies to the shares for electric hybrids, plug-in hybrids and other light trucks off the road.

### Light trucks on the road by fuel type and follow-up of last year's forecast

Light trucks on the road for a given fuel type are calculated as the number of light trucks on the road running on a given fuel the year before, plus the number of light trucks off the road running on that fuel that were on the road the year before, plus the number of newly registered light trucks running on that fuel the same year, and minus those light trucks running on that fuel that were deregistered or off the road during the year, using formula (4) in Section 6.2. The previous year's forecast for the breakdown by fuel type among the light trucks on the road was highly consistent with the actual results. The biggest absolute difference is seen for the diesel vehicles, where the forecast was roughly 12,000 vehicles too high. The biggest relative difference pertained to plug-in hybrids, with last year's forecast underestimating their number by 32%; see Table 3.4.

**Table 3.4. Forecast and results for light trucks on the road broken down by fuel type, 2022.**

| | *Petrol* | *Diesel* | *Electric* | *Electric hybrids* | *Plug-in hybrids* | *Ethanol* | *Natural gas* |
|---|---|---|---|---|---|---|---|
| Forecast, number of | 45,119 | 551,181 | 13,035 | 58 | 288 | 4,029 | 8,761 |
| Results, number of | 43,117 | 539,156 | 13,217 | 62 | 421 | 4,255 | 8,604 |
| Absolute difference | 2,002 | 12,025 | -182 | -4 | -133 | -226 | 157 |
| Relative difference | 5% | 2% | -1% | -6% | -32% | -5% | 2% |
| Forecast, share | 7.2% | 88.5% | 2.1% | 0.0% | 0.0% | 0.6% | 1.4% |
| Results, share | 7.1% | 88.6% | 2.2% | 0.0% | 0.1% | 0.7% | 1.4% |
| Absolute difference | 0.2% | 0.0% | -0.1% | 0.0% | 0.0% | -0.1% | 0.0% |

**Note: The category "Other" is not reported.**

## 3.3 Emissions classes for light trucks

Our forecasts pertain to how great a share of the number of light trucks on the road are classed in emissions class Euro 6,[32] electric, electric hybrid, or plug-in hybrid, and how great a share belong to earlier emissions class Euro 5 or lack information regarding their emissions class.

[32] A light truck is to be classed as Euro 6 if it meets the applicable emissions requirements and other requirements as per Table 2 in Appendix I to Regulation (EC) no. 715/2007 or Appendix 1 to Regulation (EC) no. 595/2009. In practice there are a number of subcategories of Euro 6, but Transport Analysis has chosen to make its forecast at the overall level.

## Newly registered light trucks by emissions class

All newly registered vehicles are assumed to belong to emissions class Euro 6, electric, electric hybrid, or plug-in hybrid.

The breakdown by emissions class is based on the assumptions regarding the breakdown by fuel type in the new registrations (Section 3.2). We assume that all vehicles that run on liquid fuels or natural gas fall into emissions class Euro 6.

## Deregistered light trucks by emissions class

The shares of electric, electric hybrid, and plug-in hybrids that are deregistered are the same as in the forecast for the breakdown by fuel type.

The share of deregistered vehicles for which no emissions class information is available is decreased by the mean value for the reductions over the last five years (3.4 percentage points) over the entire projected period.

We assume that the remaining deregistered light trucks will break down into emissions classes Euro 5 (60%) and Euro 6 (40%) in 2023. For the years to follow, we are increasing the breakdown figures by 5.2 percentage points per year, which, for 2026, gives us 44% for Euro 5 and 56% for Euro 6.

It is assumed that there will be no deregistrations of vehicles in other emissions classes.

Our assumptions regarding deregistrations are based on historical trends.

With the exception of those vehicles for which emissions class information is lacking and those that are electric, nearly all the remaining vehicles that are deregistered fall into emissions classes Euro 5 and Euro 6. The breakdown between Euro 5 and Euro 6 has changed over time, with the share for Euro 5 decreasing while Euro 6 increases. The rate of change (5%) assumed in the forecast corresponds to the average change over the last five years.

## Light trucks off the road by emissions class

The share of electric, electric hybrids and plug-in hybrids that are off the road is the same as in the forecast for the breakdown by fuel type.

The share of vehicles that are off the road and for which no emissions class is available is decreased by the mean value of the decreases over the last five years (1.0 percentage points) over the entire projected period.

We assume that the remaining light trucks will break down into emissions class Euro 5 (47%) and Euro 6 (53%) in 2023, after which we will adjust the breakdown by 3.4 percentage points per year, so that 32% will fall into Euro 5 and 68% into Euro 6 in 2026.

Vehicles belonging to other emissions classes are presumed to be off the road.

Our assumptions regarding deregistrations are based on the historical trends.

With the exception of those vehicles for which emissions class information is lacking and those that are electric, nearly all the remaining vehicles that are off the road fall into emissions classes Euro 5 and Euro 6. The breakdown between Euro 5 and Euro 6 has changed over time, with the share for Euro 5 decreasing while Euro 6 increases. The rate of change (3.4%) assumed in the forecast corresponds to the average change over the last five years.

### Light trucks on the road by emissions class and follow-up of last year's forecast

Light trucks on the road for a given emissions class are calculated as the number of light trucks on the road belonging to that emissions class the year before, plus the number of light trucks off the road in that emissions class on the road the year before, plus the number of newly registered light trucks in that emissions class that same year, and minus the light trucks in that emissions class that were deregistered or off the road during the year, using formula (4) in Section 6.2.

The previous year's forecast for emissions classes among the light trucks on the road was highly consistent with the actual results. The greatest absolute difference is seen for Euro 6, where the forecast was roughly 8,400 vehicles too high; see Table 3.5.

**Table 3.5. Forecast and results for light trucks on the road broken down by emission class, 2022.**

| | *EEV* | *EL* | *Electric hybrid* | *Plug-in-hybrid* | *EURO 4* | *EURO 5* | *EURO 6* | *EURO III* | *EURO IV* | *Missing* |
|---|---|---|---|---|---|---|---|---|---|---|
| Forecast, number of | 1,212 | 12,845 | 173 | 288 | 772 | 134,719 | 276,985 | 12 | 56 | 195,446 |
| Results, number of | 917 | 13,193 | 199 | 421 | 573 | 133,229 | 268,614 | 8 | 32 | 191,685 |
| Absolute difference | 295 | -348 | -26 | -133 | 199 | 1,490 | 8,371 | 4 | 24 | 3,761 |
| Relative difference | 32.2% | -2.6% | -13% | -31.7% | 34.7% | 11% | 3.1% | 50.0% | 75.0% | 2.0% |
| Forecast, share | 0.2% | 2.1% | 0.0% | 0.0% | 0.1% | 21.6% | 44.5% | 0.0% | 0.0% | 31.4% |
| Results, share | 0.2% | 2.0% | 0.0% | 0.1% | 0.1% | 21.9% | 44.1% | 0.0% | 0.0% | 31.5% |
| Absolute difference | 0.0% | -0.0% | 0.0% | 0.0% | 0.0% | -0.2% | 0.4% | 0.0% | 0.0% | -0.1% |

## 3.4 Carbon dioxide emissions for light trucks

Transport Analysis has projected the average carbon dioxide emissions as measured in grams per kilometer for newly registered light trucks. The forecast pertains to emissions measured using the WLTP-cycle. The projections are based on emissions data per vehicle as entered in the Swedish Road Traffic Register.

### Newly registered light trucks by carbon dioxide emissions

The average emissions from diesel-electric light trucks are presumed to decrease by 2.8% per year over the entire projected period.

The average emissions for the remaining fuel categories are assumed to be the same as in 2022 over the entire projected period.

The average carbon dioxide emissions from diesel-electric light trucks decreased from 200 grams per kilometer in 2020 to 189 grams per kilometer in 2022. We believe that this trend will continue so that carmakers can meet the EU emissions requirements. There are those who believe that the emissions reductions required for light trucks by 2025 could be achieved without the share of electric light trucks needing to grow.[33] The average yearly decrease between 2020 and 2022[34] was 2.8%. We have assumed this rate of decrease for all projected years.

We assume that there will be no change in average carbon dioxide emissions for other fuel types. This means in principle that we are assuming that consumers will choose vehicles of the same size and engine performance as before for each fuel type, and that no technical advancements that reduce their emissions will occur (except for the diesel-electric vehicles). Average emissions for the vehicle fleet are evolving due in part to more energy-efficient diesel-electric light trucks, and we also believe that there will be a redistribution of fuel types within the new registrations. Average emissions for the entire vehicle fleet are calculated by multiplying the emission levels per fuel type by the shares accounted for by each fuel type in the new registrations for each fuel type, and then calculating the sum of the products.

Using this method, the average emissions for 2023 amount to 54 grams per kilometer. The emissions will total 130 grams per kilometer in 2025, a decrease of 29%. This is a bigger reduction than the 15% required by the EU regulations. We still consider this decrease to be realistic, as it may vary from country to country, and Sweden is viewed as a country in which the decrease should exceed the average for the EU.

### Follow-up of the forecast for 2022

In our forecast for 2022, the average carbon dioxide emissions for the newly registered light trucks was 178 grams per kilometer. The actual result was lower, i.e. 162 grams per kilometer.

## 3.5 Light trucks on the road by ownership category

The share of light trucks in commercial use is the same as the mean value for the years 2020–2022 for the entire projected period.

The share of light trucks that are privately owned is the same as the mean value for the years 2020–2022 for the entire projected period.

The remaining light trucks are on the road as company vehicles.

The breakdown between light trucks in commercial use, those used as company vehicles, and those that are privately owned has remained stable over time. Transport Analysis believes that this breakdown will continue to be stable over time.

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[33] Sonsoles Díaz, *The often forgotten larger, heavier cousins of passenger cars: Europe's CO2 regulation for vans*, 17/6 2021, https://theicct.org/the-often-forgotten-larger-heavier-cousins-of-passenger-cars-europes-co2-regulation-for-vans/.
[34] For these we have data from the WLTP cycle.

# 4 Short-term forecast, heavy trucks

This chapter describes how the forecast for heavy trucks is produced. A truck is a vehicle that is configured primarily for transporting goods. Any truck with a total weight in excess of 3.5 tonnes is classed as a heavy truck.[35] This chapter also includes a follow-up of last year's forecast and results.

## 4.1 Number of heavy trucks

### Newly registered heavy trucks

The number of newly registered heavy trucks has been projected using the ARIMA model, which is presented in Section 6.5 and based on the National Institute of Economic Research's forecast of the evolution of the total demand and offering (TDO), which equals GNP + imports of goods and services. However, we have adjusted the results obtained from the model downward somewhat, as we have noted that, historically, it tends to overestimate the actual results.

It has proven difficult to find an accurate statistical model for predicting new registrations of heavy trucks. Unfortunately, the aforementioned model does not fully satisfy the requirements for an ARIMA model (see Section 6.5). When we tested the model retrospectively over a time span of four years, we found that it overestimated the number of newly registered vehicles. However, the model does offer some indication of what sort of trend we can expect, and we have consequently chosen to base our forecast on the model results, albeit with certain adjustments.

The Swedish Association for Motor Retail Trades and Repairs (MRF) issues forecasts of sales of trucks weighing over 16 tonnes. Their forecast from March 2023 estimates that 5,500 such vehicles will be sold in 2023. If we extrapolate MRF's forecast up to include all trucks over 3.5 tonnes based on the historic relationship between the MRF data and Transport Analysis' data, the resulting figure is roughly 7,000 trucks.

There were 2,567 heavy trucks newly registered in the first four months of 2023, a figure that is somewhat higher than the number of new registrations in the first quarter, historically speaking. Truck sales in the first quarter have historically accounted for roughly 33% of the sales for the year. Extrapolating the figures for the first quarter of 2023 to the entire year, we derive a total of roughly 7,900 trucks. Our model yields 7,600 newly registered heavy trucks in 2023, which we find to be somewhat high in relation to both the MRF forecast and the prevailing economic situation.

### Deregistered heavy trucks

The number of deregistered trucks equals 4.3% of the vehicle stock for the previous year.

[35] Swedish Transport Agency (2022b).

The total number of deregistrations per year varies, although the share of the total vehicle stock accounted for by such vehicles that are deregistered the following year has remained relatively constant at around 4% since 2010. In recent years (2019–2022) this share has corresponded to 4.3% of the last year's vehicle stock. We believe that the total share of deregistrations in relation to the total vehicle stock the year before will remain at the same level as before over the entire projected period.

### Heavy trucks off the road

The share of heavy trucks off the road will be 38% of the vehicle stock over the entire projected period.

In historical terms, the share of heavy trucks off the road in relation to the entire vehicle stock has remained relatively constant over time. Since 2013 the figure has been 38–39%. We believe that this share will remain at 38% for the entire projected period.

### Heavy trucks on the road

Heavy trucks on the road are calculated based on the most recent known vehicle stock, i.e. heavy trucks on the road plus heavy trucks off the road. To this is added the next year's projected number of newly registered heavy trucks, while the number of projected deregistered heavy trucks is then subtracted, after which the forecast number of heavy trucks off the road is subtracted.[36]

### Follow-up of the 2022 forecasts

The number of deregistrations in 2022 was roughly as projected. The number of newly registered trucks was underestimated by 550, while the number of vehicles off the road was underestimated by 650. Taken together, this means that the number of trucks on the road was overestimated by roughly 200.

**Table 4.1. Forecast and results for heavy trucks on the road, number off the road, newly registered or deregistered in 2022.**

| | *On the road* | *Off the road* | *New registrations* | *Deregistrations* |
|---|---|---|---|---|
| Forecast | 86,250 | 53,449 | 6,768 | 5,973 |
| Results | 86,060 | 54,099 | 7,318 | 5,956 |
| Absolute difference | 190 | -650 | -550 | 17 |
| Relative difference | 0.2% | -1.2% | -7.5% | 0.3% |

## 4.2 Fuel breakdown for heavy trucks

### Newly registered heavy trucks by fuel type

The breakdown by fuel type and the introduction of EVs are being impacted by a number of policy instruments introduced to achieve climate objectives, one of which consists of new rules

[36] Formula 3, Section 6.2.

for carbon dioxide emissions from new vehicles. In 2019 the EU adopted a regulation setting forth standards for carbon dioxide emissions from new heavy vehicles. The regulation is intended to reduce emissions from new heavy vehicles by 15% by 2025 and 30% by 2030 compared to a reference period running from July 1, 2019 through June 30, 2020.[37] The European Commission's most recent proposal calls for intensifications of these requirements, i.e. emission reductions of 45% as of 2030, 65% as of 2035, and 90% as of 2040.[38] However, according to the Commission, these proposals require support in the form of targeted investments in emissions-free vehicles as well as charging and refueling infrastructure.

A preliminary agreement was announced on March 28, 2023, between the EU Parliament and the European Council concerning the regulation governing alternative fuel infrastructure (AFIR). The agreement specified compulsory national minimum goals for the building out of infrastructure for alternative fuels, charging stations at least every 60 kilometers for cars and at least every 120 kilometers for trucks throughout the Trans-European Transport Network's core system.[39] Refueling stations for hydrogen must be present at least every 200 kilometers throughout the Trans-European Transport Network's core system.

In 2020, Fossil Free Sweden and Bil Sweden (currently Mobility Sweden) issued a road map for fossil-free competitiveness with respect to heavy vehicles. It is estimated therein that the efficiency of combustion engines could be increased 10–15% by 2030 and that, in such case, EVs would have to account for 15–20% of new car sales in order to achieve the current EU requirements. According to the road map, it is estimated that EVs will need to account for 5% of new sales of heavy vehicles at the European level by 2025, and for 20% by 2030 to achieve the objectives currently in place. The Fossil Free Sweden and Bil Sweden road map contains a low scenario and a high scenario for sales of heavy EVs. The share of newly registered electric heavy vehicles is 30% by 2030 in the low scenario, and 50% in the high scenario. Vehicle manufacturers have made similar forecasts.[40] Scania estimates that 10% of European sales will be EVs by 2025, and that figure will be 50% by 2030.[41] Volvo also predicts that 50% of global sales of new trucks will be electric by 2030.[42]

It is possible to seek subsidies for purchases of eco-friendly heavy vehicles. One such subsidy comes in the form of a climate premium for eco-friendly trucks and is dispensed by the Swedish Energy Agency. The premium can be disbursed for heavy trucks exceeding 3.5 tonnes that are run exclusively on bioethanol, natural gas, or electricity from fuel cells, batteries or external sources. The maximum subsidy covers 20% of the purchase cost, but no more than 40% of the price difference between the eco-friendly vehicle and the nearest comparable one.[43] The subsidy is expected to remain in effect through 2024.

[37] The European Parliament & Council's Regulation (EU) 2019/ of June 20, 2019 on the establishment of standards for carbon dioxide emissions from new heavy vehicles and on the amendment of the European Parliament and Council's regulations (EC) nos. 595/2009 and (EU) 2018/956, and the Council's Directive and 96/53/EC
[38] Ibid.
[39] *Infrastruktur för alternativa bränslen: preliminär överenskommelse om fler laddnings- and tankstationer i Europa*, www.consilium.europa.eu/sv/press/press-releases/2023/03/28/alternative-fuel-infrastructure-provisional-agreement-for-more-recharging-and-refuelling-stations-across-europe/.
[40] Fossil Free Sweden & Bil Sweden, *Färdplan för fossilfrikonkurrenskraft – Fordonsindustrin – Tunga fordon* (2020), [Road map for fossil-free competitiveness-The automotive industry-Heavy vehicles] https://fossilfrittsverige.se/wp-content/uploads/2020/09/Fardplan_Tunga-fordon.pdf.
[41] Scania Sverige, *Scanias vision*, https://www.scania.com/se/sv/home/products/attributes/electrification/scanias-vision.html
[42] *Volvo leder den växande marknaden för elektriska lastbilar*, www.volvotrucks.se/sv-se/news/press-releases/2023/feb/volvo-leads-the-booming-market-for-electric-trucks.html .
[43] Swedish Ministry of the Environment, *Regulation (2020:750) on state subsidies for certain eco-friendly vehicles Swedish Code of Statutes 2020:2020:750 through SFS 2021:1274-Swedish Parliament*,

It is also possible to seek subsidies for heavy natural gas vehicles via Klimatklivet.[44] Since its inception, the Swedish Environmental Protection Agency has granted subsidies for 922 heavy vehicles. Just over 300 applications regarding natural gas vehicles were submitted in 2021–2022.[45] Klimatklivet will be able to offer subsidies through 2026.

Our assessment is that the number of trucks subsidized via the climate premium and Klimatklivet are to be viewed rather as a lower limit for the number of newly registered natural gas-powered and electric trucks, as other types of subsidies and policy instruments also exist. We believe that the number of electric trucks will continue to grow, due both to EU requirements regarding emissions from new vehicles and to vehicle manufacturers' plans. Although no funding has been appropriated for the climate premium beyond 2024, our assessment is based on the belief that the combined policy instrument mix will continue to promote a higher share of eco-friendly trucks in 2025 as well.

## Assessment for each fuel type

**Electricity**: There were 231 heavy electric trucks on the road at the end of 2022, 174 of which had been registered during the year. This trend is progressing very quickly. Sixty-four electric trucks were newly registered in the first quarter of 2023. Projected over the entire year (based on the first quarter accounting for 23% of sales for the year), this gives us 272 trucks in 2023. Our assessment is that the number of newly registered electric trucks will continue to grow at a more rapid than linear rate, i.e. with the rate of increase growing each year.

*New assessment for 2023:* The share of electric trucks among the newly registered heavy trucks will increase non-linearly from 4.1% of newly registered heavy trucks in 2023 to 12.5% in 2026.

**Natural gas:** The share of newly registered heavy trucks accounted for by natural gas trucks was between 0.5% and 2% from 2002 to 2018, after which this figure slowly rose to 7% in 2022. Nevertheless, the future of natural gas is highly uncertain. In 2020 the European Commission decided to approve Sweden's introduction of a 10-year tax exemption for biogas.[46] This decision was appealed, and the EU Court of Justice reversed the decision at first instance. The Swedish Government is working with the Commission to obtain new approval.[47] Despite this uncertainty, we believe that natural gas will continue to play a role in our journey toward fossil freedom.

*New assessment for 2023:* Our assessment is that the share of natural gas trucks will grow in a manner consistent with the trend from 2018 to 2022. This gives us a figure of 7.7% of newly registered heavy trucks in 2023 (554 trucks), and 11.3% for 2026.

**Petrol:** The share of petrol-powered trucks has been between 0.5% and 0.3% over the last 10 years. The figure for 2022 was 0.3%

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https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-2020750-om-statligt-stod-till-vissa_sfs-2020-750 [downloaded 2022-04-22].

[44]Swedish Environmental Protection Agency *Klimatklivet*, https://www.naturvardsverket.se/amnesomraden/klimatomstallningen/klimatklivet/ [hämtad 2023-04-28].

[45] Transport analysis Utr 2023/32 #5, Email from the Swedish Environmental Protection Agency.

[46]Swedish Government Offices (2020) *Skattebefrielse möjlig för biogas and biogasol*, [Tax exemption possible for biogas and biogasol] https://www.regeringen.se/pressmeddelanden/2020/06/skattebefrielse-mojlig-for-biogas-och-biogasol/ [downloaded 2022-04-22].

[47] Swedish Government Offices (2023), *Regeringen kontaktar EU-kommissionen för att rädda skattebefrielsen för biogas*, [The government contacts the European Commission to save the tax exemption for biogas] https://www.regeringen.se/pressmeddelanden/2023/03/regeringen-kontaktar-eu-kommissionen-for-att-radda-skattebefrielsen-for-biogas/ [downloaded 2023-04-25].

*New assessment for 2023:* The share of petrol-powered heavy trucks will be 0.3% for the entire projected period.

**Diesel:** Diesel has been and will continue to be the dominant fuel type for heavy trucks.

*New assessment for 2023:* The rest of the newly registered heavy trucks will be diesel-electric. For 2023 we believe that diesel-powered heavy trucks will account for 73% of the newly registered heavy trucks, a figure that will decrease to 55% by 2026.

**Hydrogen:** Considerable R & D activity is underway with respect to heavy trucks that can run on hydrogen. It is possible that there may be hydrogen-powered heavy trucks on the road over the next four years. However, Transport Analysis considers that such vehicles will be so few in number that it remains impossible to predict the actual figure.

**Follow-up of last year's forecast**

A follow-up of last year's forecast for newly registered heavy trucks broken down by fuel type shows extremely small differences between the forecast and the actual results for all fuel types except diesel. Overall, last year's forecast underestimated the number of newly registered trucks, a consequence of the fact that the number of newly registered trucks was underestimated for diesel. (Table 4.2).

### Table 4.2. Forecast and results for new registrations of heavy trucks, broken down by fuel type, 2022.

| | *Petrol* | *Diesel (+ Biodiesel)* | *Electricity* | *Natural gas* | *Other* | *Total* |
|---|---|---|---|---|---|---|
| Forecast | 19 | 6,093 | 206 | 421 | 29 | 6,768 |
| Results | 20 | 6,611 | 174 | 500 | 13 | 7,318 |
| Absolute difference | -1 | -518 | 32 | -79 | 16 | -550 |
| Relative difference | -4% | -8% | 18% | -16% | 123% | -8% |
| Breakdown forecast | 0.3% | 90% | 3.0 % | 6% | 0.4% | 100% |
| Breakdown results | 0.3% | 90% | 2.4% | 7% | 0.2% | 100% |

## Deregistered heavy trucks by fuel type

The share of deregistered trucks broken down by fuel type is the same is in 2022 with regard to petrol, electric hybrids, ethanol, and other fuels for the entire projected period.

The share of deregistered electric trucks will increase yearly, i.e. from 0.1% in 2023 to 0.25% in 2026.

The share of natural gas vehicles is the same as the average for the next five years over the entire projected period.

The remaining deregistrations pertain to diesel vehicles, whose share will decrease somewhat during the projected period.

Diesel-electric trucks account for 96% of the heavy trucks on the road. Despite the introduction of new drivetrains, they will continue to make up the absolute majority of trucks on the road over the entire projected period. Our assessment is that they will also account for the largest share (97%) of the heavy trucks deregistered during the projected period. We believe that deregistrations of electric and natural gas trucks will increase somewhat as the stock of such vehicles grows.

## Heavy trucks off the road by fuel type

The share of trucks off the road that run on petrol, electric hybrids, and vehicles running on ethanol and other fuels will be the same as in 2022 for the entire projected period.

The share of electric trucks off the road will grow by 0.05 percentage points over the projected period.

The share of natural gas trucks off the road will follow the trend of the last 10 years.

The remaining share of trucks off the road will be diesel-powered.

Our assessment is that the number of electric trucks will grow during the projected period, and that it is reasonable to assume that the share of electric trucks off the road will also increase somewhat. Natural-gas-powered trucks will also continue to increase within the fleet, and we believe that their share of the trucks off the road will grow. We assume that they will follow the trend for the last 10 years, which entails an increase from 0.4% in 2022 to 0.47% in 2025.

## Heavy trucks on the road by fuel type

Heavy trucks on the road by fuel type are calculated using the same method as for the number of heavy trucks on the road but broken down by fuel type.[48]

## Follow-up of 2022 forecasts

The projected fuel breakdowns among the heavy trucks on the road were relatively consistent with the actual results. The largest absolute difference is seen for diesel vehicles, where the number of trucks on the road was overestimated, although the relative difference is only 0.3%. The largest relative difference is seen for electric trucks on the road (Table 4.3).

**Table 4.3. Forecast and results for number of heavy trucks on the road, broken down by fuel type, 2022.**

| | *Petrol* | *Diesel (+ Biodiesel)* | *Electric* | *Natural gas* | *Other* | *Total* |
|---|---|---|---|---|---|---|
| Forecast | 916 | 83,180 | 276 | 1,732 | 147 | 86,250 |
| Results | 900 | 82,932 | 231 | 1,863 | 134 | 86,060 |
| Absolute difference | 16 | 248 | 45 | -131 | 13 | 190 |
| Relative difference | 1.8% | 0.3% | 19% | -7% | 9% | -0.2% |
| Breakdown forecast | 1.1% | 96% | 0.3% | 2.0% | 0.2% | 100% |
| Breakdown results | 1.0% | 96% | 0.3% | 2.2% | 0.2% | 100% |

48 Formula 4, S 6.2.

## 4.3 Emissions classes for heavy trucks

Our forecast pertains to how great a share of the heavy trucks on the road are classed in emissions classes Euro VI, Euro V and Electric, and how great a share belongs to other emissions classes or lack information regarding their emissions class.

### Newly registered heavy trucks by emissions class

All newly registered heavy trucks are assumed to belong to emissions class Euro VI, with the exception of the electric trucks, which are calculated using the same numbers and in the same way as described in Section 4.2.

Since 2018, 94% of the newly registered heavy trucks have belonged to Euro VI. At the same time, the share of Euro V trucks has decreased from 1.8 till 1.1%. A handful of Euro II, Euro III and Euro IV trucks have also been newly registered, but collectively they account for less than 0.5% of the new registrations. Even though a few trucks that do not belong to Euro VI are still being newly registered, we have chosen to maintain our assumption from last year's forecast that all newly registered trucks, except for the electric ones, belong to Euro VI. The main reason for doing so is to keep the model simple, and because interest in the forecast has to do mainly with the breakdown between Euro V and Euro VI trucks on the road. The few newly registered trucks that do not belong to Euro VI have little importance in terms of the breakdown for vehicles on the road.

### Deregistered heavy trucks by emissions class

The share of deregistered heavy trucks about which we lack information as to their emissions classes will follow the trend seen from 2015 to 2022.

The share of deregistered heavy trucks belonging to the EEV[49] emissions class will be 1.7% for the entire projected period, i.e. the same as last year.

The share of deregistered electric trucks is calculated using the same numbers and in the same way as described in 4.2.

The remaining share of deregistered heavy trucks are assumed to be Euro V or Euro VI. The breakdown between these classes will follow the trend for the breakdown for the years from 2015 to 2022.

We assume that other emissions classes will account for 0% of deregistrations.

In 2021 we lacked emissions class information for 69% of the heavy trucks deregistered. The corresponding figure for 2015 was 97%. It is our assessment that the share of deregistered heavy trucks for which we lack emissions class information will continue to decline in a manner consistent with the trend seen from 2015 to 2022.

The shares of deregistrations associated with emissions classes Euro V and Euro VI were respectively 11% and 18% in 2022. The deregistrations associated with emissions class EEV amounted to 1.7% that same year. The other emissions classes accounted for very small shares, the largest of them being Euro IV, with a share of 0.3%. These emissions classes are assumed to equal 0% for the entire projected period so as to simplify the forecasting process.

[49] EEV stands for Enhanced Environmentally friendly Vehicle.

Even though the share for electric trucks was only 0.05%, we have chosen to forecast for them, as their share will be growing in the future.

The breakdown for deregistered Euro V and Euro VI trucks was 67% Euro V and 33% Euro VI in 2015. The share for Euro VI has grown since then, and they accounted for 64% of the deregistrations in 2022. It is our assessment that this breakdown will continue to follow the earlier trend. This means that the share for Euro VI will increase to 82% by 2026. Relative to all deregistrations, this means that the share for Euro V will be roughly 9% in 2026, while the share for Euro VI will be 40%.

## Heavy trucks off the road by emissions class

The share of heavy trucks off the road for which we lack emissions class information will follow the trend seen between 2015 and 2022.

The share of heavy trucks off the road belonging to the EEV emissions class will follow the trend seen between 2015 and 2022.

The share of heavy trucks off the road belonging to emissions classes Euro III and Euro IV is the same as in 2022 over the entire projected period.

The share of heavy electric trucks off the road is calculated using the same numbers and in the same way as described in Section 4.2.

The remaining share of heavy trucks off the road belongs to emissions classes Euro V and VI.

The share of heavy trucks off the road belonging to other emissions classes is assumed to be zero.

In 2022 we lacked emissions class information for 90% of the heavy trucks off the road. The corresponding figure for 2015 was 98%. Our assessment is that the share of heavy trucks off the road for which we lack emissions class information will continue to decrease, following the trend seen from 2015 to 2022. This means that the figure will be 85% in 2026.

The share of heavy trucks off the road belonging to the EEV emissions class grew from 0.2% to 0.6% from 2015 to 2021. Our assessment is that this trend will continue, giving us a share of 0.8% in 2026.

The share of heavy trucks off the road belonging to emissions classes Euro III and Euro IV has increased somewhat over time, although it has remained relatively stable in recent years. We consequently believe that the respective figures will stay at 0.15% and 0.17%.

The shares of heavy trucks off the road belonging to emissions classes Euro V and Euro VI were, respectively, 3% and 6% in 2022. The breakdown between Euro V and Euro VI changed from 60% Euro V and 40% Euro VI in 2015 to 35% Euro V and 65% Euro VI in 2022. We are assuming a breakdown of 35% Euro V and 65% Euro VI for the entire projected period.

Other fuels accounted for a very small share of the heavy trucks off the road, with the figure assumed to be zero in the forecast.

## Heavy trucks on the road by emissions class

Vehicles on the road for each emissions class are calculated using the same method as for fuel types, but for the emissions class rather than the fuel type.

### Follow-up of 2022 forecasts

The forecast for 2022 indicated that the share for the most recent emissions class (Euro VI) would be 59% for heavy trucks on the road, which agreed well with the actual result. The share for Euro V trucks was marginally underestimated. (Table 4.4).

**Table 4.4. Forecast and results for the share of heavy trucks on the road by emissions class, 2021.**

| | *Euro V* | *Euro VI* | *Other classes or info lacking* |
|---|---|---|---|
| Forecast | 6% | 59% | 34% |
| Results | 7% | 59% | 34% |
| Absolute difference | -0.3% | 0.0% | 0.2% |

## 4.4 Heavy trucks on the road by ownership category

The forecast is made directly for vehicles on the road.

The share of heavy trucks owned by physical persons will be 4.2% over the entire projected period.

The share of heavy trucks that are owned by a legal entity and in commercial use will follow the trend seen between 2018 and 2022.

The remaining share of heavy trucks are owned by a legal entity and used as company vehicles.

The breakdown for the number of heavy trucks on the road between the ownership categories “physical persons” and “legal entities” has been stable over the last 10 years. The share of heavy trucks owned by physical persons has been between 4.7% and 4.5%, although it did fall to 4.2% in 2022. It is our assessment that this share will remain at roughly the same level over the entire projected period.

Among the heavy trucks owned by a legal entity we can see a weak shift towards more being used commercially and fewer as company vehicles. We have consequently chosen to let the forecast for heavy vehicles in commercial use owned by a legal entity be dependent upon the trend seen over the last five years. This means that the share of such heavy trucks in commercial use will increase from 63% in 2022 to 66% in 2026, while the share of heavy trucks used as company vehicles will decrease from 33% to 30% over that same period of time.

### Follow-up of 2022 forecasts

A follow-up of last year’s forecast shows that the breakdown was relatively accurate. The forecast for ownership by a physical person exhibited the greatest deviation, and was overestimated by just over 8%.

**Table 4.5. Forecast and results for number of heavy trucks on the road, broken down by ownership, 2022.**

| | *Legal entity, commercial use* | *Legal entity, company vehicle* | *Physical person* |
|---|---|---|---|
| Forecast | 53,720 | 28,669 | 3,861 |
| Results | 53,944 | 28,544 | 3,572 |
| Absolute difference | -224 | 125 | 289 |
| Relative difference | -0.4% | 0.4% | 8.1% |

## 4.5 Number of axles and average total weight for heavy trucks on the road

### Heavy trucks on the road trucks by number of axles

The forecast is made directly for vehicles on the road.

The shares of heavy trucks with two axles or four or more axles follow the respective trends from 2020 to 2022.

The share of heavy trucks for which information as to the number of axles is lacking is the same as in 2022 (0.01%) over the entire projected period.

The remaining share of heavy trucks have three axles.

The share of trucks with four or more axles grew from 8% to 16% over the last 10 years. We consequently find it appropriate to apply this trend in projecting the share of trucks with four or more axles over the coming years.

The share of trucks with two axles fell from 42% to 33% over that same period. Here again we believe that following this trend offers a good forecasting method.

### Follow-up of 2022 forecasts

Last year’s forecast was also based on the aforementioned trend, and it underestimated the number of trucks with two axles somewhat, while at the same time somewhat overestimating the number of heavy trucks with four or more axles. This could indicate that the trend toward fewer trucks with two axles and more with four or more is weakening, with the result that it has been shortened from 10 to 3 years in this year’s forecast.

**Table 4.6. Heavy trucks on the road broken down by number of axles, forecast and results for 2022.**

| | *2 axles* | *3 axles* | *4 or more axles* | *Info lacking* | *Total* |
|---|---|---|---|---|---|
| Forecast | 28,164 | 43,659 | 14,420 | 7 | 86,250 |
| Results | 28,740 | 43,910 | 13,404 | 6 | 86,060 |
| Absolute difference | -576 | -251 | 1,016 | 1 | 190 |
| Relative difference | -2.0% | -0.6% | 7.6% | 11% | 0.2% |
| Breakdown, forecast | 33% | 51% | 17% | 0% | 100% |
| Breakdown, results | 33% | 51% | 16% | 0% | 100% |

## Average total weight of heavy trucks on the road by number of axles

The forecast is made directly for vehicles on the road, based on the forecast for heavy trucks broken down by number of axles.

The average weights for heavy trucks with two, three, or four or more axles and the average weight for heavy trucks for which we lack information as to the number of axles follow the respective trends from 2013 to 2022.

The average total weights for all trucks are calculated by weighting together the forecast for the average total weight broken down by number of axles with the forecast for the breakdown of heavy trucks by number of axles.

The forecasting method is the same as last year, which was accurate with regard to the average weight by number of axles. The difference was greatest for the total. This was due to the difference in the projected number of trucks by number of axles and the actual results (Table 4.7).

**Table 4.7. Average total weights [kg] for heavy trucks on the road broken down by number of axles, forecast and results for 2021.**

| | *2 axles* | *3 axles* | *4 or more axles* | *Info lacking* | *Total* |
|---|---|---|---|---|---|
| Forecast | 13,710 | 27,476 | 35,574 | 6,516 | 24,334 |
| Results | 13,727 | 27,517 | 35,632 | 6,540 | 24,174 |
| Absolute difference | -17 | -41 | -58 | -24 | 160 |
| Relative difference | -0.1% | -0.1% | -0.2% | -0.4% | 0.7% |

# 5 Short-term forecast, buses

This chapter describes how the forecast for buses is prepared. A bus has more than eight seats in addition to the driver and is designed primarily for passenger transport.[50] Making forecasts for buses differs significantly from making forecasts for passenger cars and trucks. The number of such vehicles is lower, the variations between years are great, and their evolution is driven in large measure by the requirements set by the public transport authorities in conjunction with procurement processes, making the short-term forecasts for buses more uncertain.

## 5.1 Number of buses

### Newly registered buses

There are 1,400 buses newly registered each year. This figure is uncertain, particularly for individual years, and must be viewed as an average for the years covered by the forecast.

In our analysis of new registrations we found no correlations with other factors in the way that we were able to find them for passenger cars and light trucks. Roughly 70% of all buses are used in public transport,[51] giving us reason to believe that the new registrations are driven largely by procurement processes. Predicting increases and decreases in the intensity of procurement processes has proven difficult. In 2019 we consequently decided to assume that the number of new registrations would be 1,400 vehicles per year, which corresponds to a "normal year" in recent years. The methodology memorandum for the 2019 forecasts provides a more detailed account of the general considerations we have made in preparing the forecasts for buses.[52]

The number of newly registered buses has varied more in recent years than previously. If we study the period from 2008 to 2021, we see a peak of just over 1,800 buses and a low of just over 800 over the last two years. The average for the number of newly registered buses over the last five years is 1,353. In this year's forecast we have chosen to apply the same assumption as in previous forecasts, i.e. 1,400 newly registered buses per year over the entire projected period.

### Deregistered buses

Some 6.8% of the number of "buses in the vehicle stock for the previous year will be deregistered, which corresponds to the mean value for the period from 2018 to 2022.

From 2009 to 2022 the number of deregistrations varied between 4.6% and 7.7% of the number of buses in the vehicle stock the year before. The exception to this occurred in 2013,

[50] Swedish Transport Agency, (2022a) "Buss" [Bus].
[51] An earlier comparison between the FRIDA database, to which the public transport authorities report data regarding their vehicle fleets, with data from the Swedish Road Traffic Register shows that roughly 70% of the buses on the road are operating in services subject to procurement processes. SL (Stockholms Lokaltrafik) is not currently included in FRIDA. Swedish Public Transport, "FRIDA environmental and vehicle database".
[52] Transport Analysis, (2019) "Korttidsprognoser för den svenska vägfordonsflottan – methoder and antaganden [Short-term forecasts for the Swedish vehicle fleet-methods and assumptions] PM 2019:3".

when the Swedish Transport Agency conducted an administrative clean-up that resulted in a greater number of deregistrations (9.5%). The average for the period is 6.2%.[53] If we consider only the last five years, the share of deregistrations has increased each year, from 5.5% in 2017 to 7.7% in 2021, only to decrease to 6.4% in 2022.

Last year we changed our assessment from the share of deregistered buses equaling the average for the preceding 10 years to equaling the average for the preceding five years. The forecast for 2022 was accurate, so we have chosen to continue assuming that the share of deregistrations for the entire projected period will be the same as the average for the last five years.

## Buses off the road

Some 28.4% of the buses in the vehicle stock will be removed from traffic over the entire projected period.

In the last 15 years the share of buses off the road in relation to the entire stock has been relatively constant. The figure varied from 25% to 34% from 2008 to 2022, with an average of 29%. The highest share, 34%, was seen in the first year of the Covid pandemic, 2020. This high figure is probably due, for instance, to tour operators canceling their tourist buses because of the lower travel demand. In last year's forecast the share of vehicles off the road was the same as the average for the last 10 years, i.e. 29.3%. The share of those off the road in 2022 was 27.4%. Our assessment in the present forecast is that the share of buses off the road will again be 28.4%, i.e. the average for the last 10 years, excluding 2020.

## Buses on the road

Buses on the road is based on the stock of buses, i.e. buses on the road and buses off the road in the most recent known year. To this is then added the projected number of newly registered buses for the next year, minus the deregistered buses. The buses off the road are then subtracted to derive the number of buses on the road.[54]

## Follow-up of 2022 forecasts

The forecast number of buses on the road depends upon assessments of the numbers of newly registered buses, deregistered buses, and buses off the road. A comparison between the forecast and actual results for 2022 shows that our forecast underestimated the number of vehicles on the road by 335, or 2.4% (Table 5.1) and overestimated the number of those off the road, with our forecast being 375 buses (7%) too high. The numbers of new registrations and deregistrations were overestimated marginally.

[53] We have ignored data from 2013, when the Swedish Transport Agency conducted an administrative clean-up which resulted in a higher number of deregistrations.
[54] See formula 3 in Section 6.1.

**Table 5.1. Comparison of forecast and results for buses, 2022.**

| | *On the road* | *Off the road* | *New registrations* | *Deregistrations* |
|---|---|---|---|---|
| Forecast | 13,904 | 5,751 | 1,400 | 1,288 |
| Result | 14,239 | 5,379 | 1,370 | 1,254 |
| Absolute difference | -335 | 375 | 30 | 34 |
| Relative difference | -2.4% | 7.0% | 2.2% | -2.7% |

# 5.2 Fuel breakdown

## Newly registered buses by fuel type

Compared to other types of vehicles, buses account for a larger share of those that run on alternative fuels. In 2022, 26% of the buses on the road had an electric, electric hybrid, natural gas, or ethanol drivetrain. There is consensus within the public transport sector to commit to renewable fuels rather than fossil fuels wherever possible.[55] The shares of new registrations accounted for by buses running on each fuel type fluctuate notably. This probably depends on which regional public transport authorities procured buses in the year in question, and on the requirements they set, making it difficult to predict the fuel-type breakdown. Our forecasts should be viewed more as an indicator of the evolutionary trend.

We have studied the fuel-type breakdowns for various classes of buses to aid in our forecasting process. According to European Parliament and Council Directive 2001/85/EC, buses are classed as follows:

There are three vehicle classes for vehicles configured to carry more than 22 passengers in addition to the driver:

- **Class I:** vehicles designed with space for standing passengers to enable frequent passenger movements
- **Class II:** vehicles designed primarily to carry seated passengers and to allow standing passengers to ride in the aisle and/or in a space that is not larger than the space taken up by two double seats
- **Class III:** vehicles designed exclusively to carry seated passengers.

There are two classes for vehicles configured to carry a maximum of 22 passengers in addition to the driver:

- **Class A:** vehicles designed to carry standing passengers. A vehicle in this class is equipped with seats, and must have space for standing passengers
- **Class B:** vehicles that are not designed to carry standing passengers. A vehicle in this class lacks space for standing passengers.

[55] Partnersamverkan för en bättre kollektivtrafik, *Branschgemensamt miljöprogram* [The partnership for better public transport, Industry-wide environmental program] (2018), www.svenskkollektivtrafik.se/globalassets/partnersamverkan/dokument/miljo-och-sakerhet/miljoprogrammet/branschgemensamt_miljoprogram_20180705.pdf

Bus classes I and II presumably contain local and regional buses that are mainly procurements. Bus class III presumably consists of coaches. The breakdown by these bus classes reveals differences in terms of the shares accounted for by alternative fuels (Table 5.2).

**Table 5.2. Number of buses on the road by bus class and fuel type, 2022.**

| | *Unknown* | *A* | *B* | *I* | *II* | *III* |
|---|---|---|---|---|---|---|
| Petrol | 31 | 0 | 2 | 0 | 1 | 0 |
| Diesel | 638 | 112 | 1,633 | 1,667 | 4,534 | 1,853 |
| Electricity | 46 | 12 | 2 | 776 | 78 | 1 |
| Electric hybrid/Plug-in hybrid | 5 | 0 | 0 | 117 | 25 | 0 |
| Ethanol | 4 | 0 | 0 | 56 | 5 | 0 |
| Natural gas | 193 | 7 | 10 | 1,558 | 871 | 2 |
| Total | 917 | 131 | 1,647 | 4,174 | 5,514 | 1,856 |
| Shares of buses per bus class | 6% | 1% | 12% | 29% | 39% | 13% |

## Assessment for each fuel type

**Electricity:** There are a number of policy instruments that are promoting a higher share of electric buses, including the EU's regulations on emissions from heavy vehicles and proposals that all new city buses must be emissions-free by 2030,[56] as well as goals set by manufacturers and purchasers. For example, Västtrafik has set a goal that all city bus services must be electric by 2030.[57] Another such policy instrument is the electric bus premiums, which can be applied for by those purchasing an electric bus.[58]

Sweden enjoys a relatively high level of electrification already. Electric buses are now available in all bus classes, although the number of electric buses is low across all bus classes except Class 1. Bus class I accounted for 29% of the buses on the road and 17% of the new registrations in 2022. Fully 85% of the buses newly registered in 2022 belonged to bus class I. In 2020 and 2021 the corresponding figures for electric buses in Class I were 34% and 79%, respectively. Our assessment is that the high share of electric buses among new registrations for bus class I will continue over the projected period.

In the case of bus class II, electric buses accounted for 39% of those on the road and 60% of the new registrations. In 2020 there was only one electric class II bus on the road, with 17 in 2021 and fully 78 in 2022, which corresponded to 7% of the new registrations. We interpret

[56] European Commission, *Nollemissionssmål för nya buses and lastbilar 2030*, [Zero emissions goal for new buses and trucks 2030] https://ec.europa.eu/commission/presscorner/detail/sv/IP_23_762
[57] Västtrafik (2023)*Nu elektrifierar vi Västsverige*, [We are now electrifying Western Sweden] https://www.vasttrafik.se/om-vasttrafik/hallbara-resor/elektrifiering/
[58] Riksdag Administration, *Förordning (2016:836) om elbusspremie Svensk författningssamling2016:2016:836 t.o.m SFS 2021:1273-Riksdagen*, [Regulation (2016:836) on electric bus premium Swedish Code of Statutes *2016:2016:836 through SFS 2021:1273-Riksdagen*] Sweden https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-2016836-om-elbusspremie_sfs-2016-836 [downloaded 2022-04-12]. Transport Analysis has previously compared the number newly registered electric buses for which premiums were paid, and found that the new registrations exceeded the disbursements.

the trend in 2022 to mean that there are now electric buses capable of providing regional service.

There is only one registered electric bus in Class III at present. Our assessment is that there will be few such buses even in 2025.

Class A buses accounted for only 1% of the bus fleet, with 12 electric buses on the road.

Class B buses accounted for 12% of the bus fleet and 10% of the new registrations in 2022. There were only two electric Class B buses in 2022.

The foregoing, i.e. our belief that electrification is occurring mainly in bus class I and gradually in bus class II, leads us to our overall estimate that the share of electric buses will be 22% in 2023, 26% in 2024, 31% in 2025, and 36% in 2026. This is a considerable decrease compared to the projections Transport Analysis made in 2021. In last year's forecast we used a linear projection in which the share of electric buses for 2023 was overestimated, as the result was 19% compared to the projected 28%. This year's forecast is a projection aided by a power function, i.e. it is not assumed that the rate of electrification will be the same each year, but rather that it will increase over the years.

*New assessment for 2023:* The share of newly registered electric buses will be 22% in 2023, 26% in 2024, 31% in 2025, and 36% in 2026.

- The share of newly registered natural gas buses will be 10% over the entire projected period.
- No (or a negligible number of) petrol buses will be newly registered during the projected period.
- No (or a negligible number of) ethanol buses will be newly registered during the projected period.
- The share of newly registered electric hybrid buses will be 0.9% over the projected period.
- The remaining newly registered buses will be diesel buses.

**Natural gas:** The number of newly registered natural gas buses varies dramatically from year to year, and is likely dependent on the prevailing conditions and assumptions in different regions, and on the existing refueling infrastructure for natural gas. A number of municipalities run on biogas produced in their own waste treatment plants, where slaughterhouse waste and compost are converted into biogas. Given earlier heavy investments by municipalities in biogas, it may be assumed that the existing natural gas buses will be replaced by new ones to some degree when the time comes, despite the uncertain situation surrounding tax exemptions for biogas in Sweden.

Natural gas-powered buses are available in all bus classes. Natural gas buses in Class I (37%) and Class II (16%) account for the bulk of the vehicles on the road.

Ninety-four natural gas buses were newly registered in 2022, which corresponds to 7% of the new registrations. This is considerably lower than in the previous three years.

*New assessment for 2023:* Last year's forecast assumed that the share of natural gas vehicles would be around 17% over the entire projected period. Our assessment in this year's forecast is that the figure will be 10% for the entire projected period.

**Plug-in hybrids and electric hybrids:** We are unable to distinguish in the register between plug-in hybrids and electric hybrids that cannot be recharged. As a result, we are forced to project electric hybrids and plug-in hybrids together. The share of electric hybrid buses newly registered in the last five years averages 1% per year. No electric hybrid buses were newly registered in 2022. Our assessment is that the share of electric hybrid buses will be barely 1%, which is consistent with last year's assessment.

**Ethanol:** No ethanol buses have been newly registered since 2014. As in last year's forecast, our assessment is that no new ethanol buses will be registered (or that their number will be negligible).

**Petrol:** The share of newly registered petrol-powered buses has been 0.1% over the last five years, or roughly 1–2 buses per year.

*New assessment for 2023:* Our assessment is that the share of petrol-powered buses will remain at a negligible level, and we have assumed zero petrol-powered buses for the entire projected period.

**Diesel:** Diesel has been the dominant fuel for buses, although their share decreased from a peak of 94% in 2016 to 56% in 2021, only to then increase to 74% in 2022.

*New assessment for 2023:* Our assessment regarding other fuel types leads us to believe that the share of diesel vehicles among the newly registered buses will decrease from 67% in 2023 to 63% in 2026.

## Follow-up of 2022 forecasts

A follow-up of last year's forecast shows that the number of newly registered buses came in very close to the projected number, although the shares of electric, electric hybrid, and natural gas buses were lower than in the forecast, with the result that the share of diesel buses was higher (Table 5.3).

### Table 5.3. Forecast and results for number of newly registered buses, broken down by fuel type, 2022.

| | *Petrol* | *Diesel (+ Biodiesel)* | *Electric* | *Electric hybrid* | *Ethanol* | *Natural gas* | *Other* | *Total* |
|---|---|---|---|---|---|---|---|---|
| Forecast | 0 | 748 | 399 | 14 | 0 | 239 | 0 | 1,400 |
| Result | 2 | 1,009 | 265 | 0 | 0 | 94 | 0 | 1,370 |
| Absolute difference | -2 | -261 | 134 | 14 | 0 | 145 | 0 | 30 |
| Relative difference | - | -26% | 51% | - | - | 154% | - | 2.2% |
| Breakdown, forecast | 0% | 53% | 29% | 1% | 0% | 17% | 0% | 100% |
| Breakdown, results | 0% | 74% | 19% | 0% | 0% | 7% | 0% | 100% |

## Deregistered buses by fuel type

- The share of deregistered petrol buses is 0.2% over the entire projected period, with 0.4% electric hybrids and 1.8% ethanol buses.

- The share of deregistered electric buses is expected to increase as the vehicle stock grows, i.e. from 2% in 2023 to 5% in 2026.
- The share accounted for by natural gas buses will increase from 15% in 2023 to 19% in 2026.
- The remaining share of deregistrations will consist of diesel buses.

There have been few deregistered buses running on fuels other than diesel heretofore, making it difficult to make projections based on history. It is reasonable to assume that deregistrations will trend in a manner similar to the way they have done previously. We consequently consider that the share for electric buses will increase somewhat (by one percentage point per year), as will the figure for natural gas buses (calculated based on the rising trend from previous years), while the share of deregistrations accounted for by diesel buses is expected to decrease somewhat.

The shares of deregistrations accounted for by electric hybrids and ethanol buses correspond to the average for the previous five years. The share of deregistrations accounted for by petrol buses is expected to be the same as in 2022.

These assessments are consistent with last year’s forecast.

## Buses off the road by fuel type

- The shares of electric hybrid buses and buses off the road that run on other fuel types are expected to be the same as the average figures for 2021 and 2022 over the entire projected period, i.e. 0.6% and 0.1%, respectively.
- The shares of electric, natural gas and petrol buses off the road are expected to follow the trends of the last five years.
- With regard to the share for ethanol buses, which are decreasing in number and for which no vehicles are being newly registered, i.e. they will disappear entirely, we are calculating the share accounted for by the remaining vehicle stock rather than a share of the total number of deregistered buses. We assume that 40% of the stock of ethanol buses will not be on the road in 2023, and that the share of those off the road will increase to 49% by 2026.
- The remaining share of the buses off the road are diesel buses.

Up until 2020, diesel buses account for over 90% of the buses off the road. This figure had fallen to 87% by 2022. Other fuel types have thus accounted for lower shares, and the changes moving forward are expected to be relatively minor.

The shares of natural gas and electric buses off the road are expected to grow, while the share of petrol buses is expected to decrease.

## Buses on the road by fuel type

Buses on the road for each fuel type are calculated based on the vehicle stock, i.e. the buses on the road and off the road for the last known year. The next year’s newly registered buses are then added, and the deregistered buses are subtracted. We then also subtract the buses off the road to derive the number buses on the road.[59]

[59] See formula 4, Section 6.1.

The results for 2022 show that last year's forecast generally overestimated the number of buses on the road for all fuel types except diesel, which was largely due to the fact that the projections for newly registered electric and natural gas buses were overestimated, with the result that the forecast numbers of electric and natural gas buses were overestimated as well.

### Follow-up of 2022 forecasts

The overestimation of the number of petrol buses on the road is likely attributable to the share of petrol buses among the deregistrations having been overestimated somewhat in last year's forecast. The fact that there were fewer ethanol buses on the road than predicted in last year's forecast is likely due to the overestimation of the share of ethanol buses among those off the road.

**Table 5.4. Forecast and results for number of buses on the road, broken down by fuel type, 2022.**

| | *Petrol* | *Diesel (+ Biodiesel)* | *Electric* | *Electric hybrid* | *Ethanol* | *Natural gas* | *Other* | *Total* |
|---|---|---|---|---|---|---|---|---|
| Forecast | 54 | 9,667 | 1,062 | 176 | 75 | 2,869 | 2 | 13,904 |
| Result | 34 | 10,437 | 915 | 147 | 65 | 2,641 | 0 | 14,239 |
| Absolute difference | 20 | -770 | 147 | 29 | -10 | 228 | 2 | -355 |
| Relative difference | 58% | -7% | 16% | 20% | 15% | 9% | - | -2% |
| Breakdown, forecast | 0.4% | 70% | 8% | 1% | 0.5% | 21% | 0.02% | 100% |
| Breakdown, results | 0.2% | 73% | 6% | 1% | 0.5% | 19% | 0% | 100% |

## 5.3 Emissions classes for buses

### Newly registered buses by emissions class

All new registrations belong to emissions class VI or electric/electric hybrids.

We are making the same assessment as in previous years. Over the last four years, 97–99% of newly registered buses were classed as Euro VI or electric/electric hybrid. The small remaining share likely consist of older imported buses.

### Deregistered buses by emissions class

The share of deregistered buses in emissions class Euro VI and electric/electric hybrids will follow the trend for the years 2015 to 2022.

The deregistrations mean that buses in older emissions classes are gradually being phased out. The share of deregistered Euro VI and electric/electric hybrid buses in 2015 was 0.3%, while the corresponding figure in 2022 was 12%. This figure has increased gradually over time with the exception of 2020, when it was 5%, as compared to 7% the year before. 2020 is a special year because of the Covid pandemic. In 2020 older buses belonging to emissions class Euro V or lower became prohibited in environmental zone 1, which is present in a number of larger Swedish cities.[60]

### Buses off the road by emissions class

The share of buses off the road in emissions class Euro VI and electric/electric hybrids will follow the trend for the years 2013 to 2022, excluding 2020 and 2021.

The share of Euro VI and electric/electric hybrid buses off the road in 2013 was 0.3%. This figure increased to 10% in 2018 and then decreased somewhat to 9% in 2019. This share increased markedly to 26% and 25% in 2020 and 2022, respectively, only to decrease somewhat to 21% in 2022. This may have been attributable to more newer buses not being on the road during the Covid pandemic, i.e. years that we have viewed as extraordinary and excluded from the trend projection.

### Buses on the road by emissions class

Buses on the road for each emissions class are calculated in the same way as for fuel, but by emissions class instead.

### Follow-up of 2022 forecasts

In last year's forecast we predicted that the share of buses on the road in emissions classes Euro VI and electric/electric hybrid would be 71%, which was in fact the case. Our forecasting model points to 100% by 2026, although buses in other emissions classes will likely still be present, albeit in negligible numbers.

## 5.4 Axles and average total weight for buses on the road

### Buses on the road with two axles or three or more axles

The share of buses with three or more axles will follow the trend for the last 10 years (2013–2022).

Buses are classed based on their number of axles in increments of two, three, and four or more axles. The share of buses with four or more axles is very small, and they have consequently been consolidated with the three-axle buses in the statistics. The projections for the percentage breakdown for the groups "buses with two axles" and "buses with three or more axles" on the road are prepared by taking the projected number of buses on the road multiplied by the projected shares of buses with two axles and three or more axles, respectively.

In 2013 and 2014, 50% of the buses on the road has two axles, and 50% had three or more. Prior to then, buses with two axles were somewhat more numerous than those with three or more. Since 2015 the share of buses with three or more axles has exceeded the share of

[60] Swedish Transport Agency, *Miljözoner* [Environmental Zones], 2021, https://www.transportstyrelsen.se/sv/vagtrafik/Miljo/Miljozoner/ [downloaded 2022-05-12].

buses with two. This difference has also grown. In 2022, 55% of the buses on the road had three or more axles.

## Average total weight for buses with two axles versus three or more axles

The weight of buses with two axles will follow the trend for the last six years (2017–2022).

The weight of buses with three or more axles will follow the trend for the last six years (2017–2022).

The average weight for all buses on the road is calculated based on the projected weights for buses with two axles and buses with three or more axles, as weighted by the share of buses with two versus three or more axles in the forecast (see previous sections).

Slow but stable trends toward heavier buses are discernible. As a result, these trends are forecast using linear projections.

## Follow-up of 2022 forecasts

A follow-up of our forecast for buses on the road broken down by number of axles shows that the forecast underestimated the numbers somewhat, although this was because we predicted a lower total number of buses on the road than was actually the case; see Table 5.5.

**Table 5.5. Buses on the road broken down by number of axles; forecast and results for 2022.**

| | *2 axles* | *3 or more axles* | *Total* |
|---|---|---|---|
| Forecast | 6,305 | 7,559 | 13,904 |
| Result | 6,467 | 7,771 | 14,238 |
| Absolute difference | -162 | -172 | -334 |
| Relative difference | -2.5% | -2.2% | -2.3% |
| Breakdown, forecast | 45% | 55% | 100% |
| Breakdown, results | 45% | 55% | 100% |

With regard to weight, we can see that the forecast was essentially the same as the result.

**Table 5.6. Average total weight [kg] for buses on the road broken down by number of axles; forecast and results for 2021.**

| | *2 axles* | *3 or more axles* | *Total* |
|---|---|---|---|
| Forecast | 13,971 | 25,493 | 20,243 |
| Result | 13,823 | 25,541 | 20,218 |
| Absolute difference | 94 | -48 | 25 |
| Relative difference | 0.7% | -0.2% | 0.1% |

# 6 Appendices

## 6.1 Method for calculating vehicle stock and vehicles on the road

The number of vehicles in the stock (vehicles on the road and vehicles off the road at year-end) for a forecast year *t* is given by

$$B_t = B_{t-1} + N_t - Avreg_t, \qquad (1)$$

where *B* is the number of vehicles in the stock, *N* the number of new registrations and *Avreg* the number of deregistrations.

The number of vehicles on the road is thus

$$T_t = B_t - Avst_t, \qquad (2)$$

where *T* is the number of vehicles on the road and *Avst* is the number of vehicles off the road. By combining (1) and (2), the vehicles on the road can be determined using

$$T_t = T_{t-1} + Avst_{t-1} + N_t - Avreg_t - Avst_t. \qquad (3)$$

When making our forecasts we have access to data regarding the vehicle stock, vehicles on the road, new registrations, vehicles off the road, and deregistrations for the year before. (See further under Section 1.3). These data serve as the basis for projecting vehicles on the road for the present year. The projections for vehicles on the road in the ensuing three years are based on the forecast for the year before the year to which the forecast pertains.

The number of vehicles in *T* in year *t* broken down by fuel type *j* is calculated based on the results from the foregoing calculations using

$$T_{t,j} = T_{t-1,j} + Avst_{t-1,j} + N_{t,j} - Avreg_{t,j} - Avst_{t,j} \qquad (4)$$

## 6.2 Forecast of vehicle characteristics associated with the vehicles

The projected vehicle characteristics differ from one vehicle category to another. The following characteristics are calculated for passenger cars and light trucks:

- Fuel type, e.g. diesel, petrol, ethanol, electricity, natural gas and plug-in hybrid
- Emissions class, e.g. Euro 5, Euro 6 and electric

- Average carbon dioxide emissions
- Ownership, e.g. legal entity or physical person

Carbon dioxide emissions are not reported for heavy trucks or buses. However, the number of axles and average total weight are reported.

**Forecast of fuel type and emissions class**

In the case of fuel type and emissions class, the breakdowns by fuel type and emissions class are projected for new registrations, deregistrations, and vehicles no longer on the road. The forecast breakdowns consist of general assessments based on data from previous years and on our monitoring of external factors. The ways in which the breakdowns are projected for each vehicle category are described in Sections 2.2–2.3, 3.2–3.3, 4.2–4.3, and 5.2–5.3. Vehicles on the road for emissions class $j$ are then projected using

$$T_{t,j} = T_{t-1,j} + Avst_{t-1,j} + N_{t,j} - Avreg_{t,j} - Avst_{t,j}. \quad (4)$$

The forecast for carbon dioxide emissions is done only for newly registered vehicles. See Sections 2.4 and 3.4 for a more detail description of the method used.

**Simplified forecasts of number of axles, total weight, and ownership**

A simplified model is used for the number of axles, average total weight and ownership. The breakdowns for new registrations, deregistrations and vehicles no longer on the road are not projected, but rather the forecast is made directly for vehicles on the road. The ways in which these breakdowns are projected are described for each vehicle category and characteristics in Sections 2.5, 3.5, 4.4–4.5 and 5.4.

# 6.3 Passenger cars

## Methods for projecting the number of newly registered passenger cars

The forecast for the number of newly registered passenger cars is, as in previous years, based on a time series regression in the form of an ARIMA (Auto-Regressive Integrated Moving Average) model. In simple terms, this is a regression analysis over time, which can be used to project the future evolution.

An ARIMA model is based on earlier values for the dependent variable, in this case newly registered passenger cars. The model consists of three parts: 1) AR (Auto-Regressive), which is dependent on the time series' earlier values; 2) I (Integrated), which becomes necessary for time series with systematic variations, i.e. time series that are not stationary; and 3) MA (Moving Average), which is the perturbation term (or the random term) for the linear function of earlier perturbation terms. If the model consists of two AR lags, one differentiation and no MA lag, the model is written out as ARIMA(2,1,0). There are also SARIMA models if the time series is season-dependent, as well as ARIMAX models, which mean that we also add one or more independent variables. An ARIMAX model is described as:

$$y_i = \beta x_i + \sum_{j=1}^{p} \phi_j y_{i-j} + \varepsilon_i + \sum_{j=1}^{q} \theta_j \varepsilon_{i-j}$$

where *Y* is the number of newly registered cars, *i* is a time point (year in our case), *X* is an independent variable, β is the coefficient of the independent variable, Φ is the AR parameter, θ is the MA parameter, and ε is an error term.

The following criteria need to be met in order to choose an ARIMA model, and these are the requirements we set when choosing the model:

- The time series for newly registered cars must be stationary. If it is not, we need to use an ARIMA model that has at least one differentiation, such as ARIMA(1,**1**,0).
- There must be systematic variation in the time series for newly registered cars. The absence of systematic variation will entail that the best prediction for the future will be the mean value of earlier observations.
- The number of AR lags must be based on the partial autocorrelation in the time series, for instance by visually discerning the number of bars that extend beyond the marked area in a PACF diagram (see Figure 6.1).
- The number of MA lags must be determined based on the autocorrelation.
- The residuals (estimates of the error term) in the model must be mutually independent.
- The residuals (estimates of the error term) in the model must be normally distributed.
- The parameter estimates must be statistically significant for each parameter. These estimates are made using either the Maximum Likelihood method or the Conditional Least Squares method. We used the Conditional Least Squares method for the model ultimately chosen.

Another starting point is that the model chosen must be as simple as possible while at the same time meeting our requirements. We have simulated forecasts for earlier time points in order to choose the right model. All requirements must be satisfied for a forecast interval of four years back in time, for at least three previous forecasts. We consequently tested all requirements for the years 2014–2017 (and then proceeded based on statistics regarding new registrations through 2013), 2018–2021 (the most recent year with statistics regarding new registrations 2017), and 2023–2026. The requirements must be met for the earlier simulated forecasts, and we can also select the model based on how it works in comparison with accurate values from earlier years.

In the event of equivalent models, so-called AIC (Akaike Information Criterion)[61] and SBC (Schwarz Bayesian Criterion) values can be included in the assessment, in which case the model with lower values has an advantage.[62]

Earlier studies have shown a clear positive correlation between income and vehicle possession, i.e. higher income means greater access to a car.[63] It has also been shown that demand for transportation is affected by one's disposable income[64] and follows the economic

[61] Profillidis,and Botzoris,(2018) *Modeling of Transport Demand*
[62] Menegaki, A, (2020) *A Guide to Econometric Methods for the Energy-Growth Nexus.*
[63] Ulfarsson et al. 2015
[64] Rothengatter (2011)

cycle to a considerable extent. During a recession we consume and travel less, and lower employment means fewer commuter trips.[65]

To be able to project the size and number of newly registered vehicles in the future vehicle fleet we thus need a model which, in addition to previous values for newly registered cars, is also based on the future development of the economy. Sweden's GNP is perhaps the metric used most to describe the development of the economy. Other available metrics that could be useful include the National Institute of Economic Research's economic barometer [66] and the repo rate. More precise metrics that could be used include disposable household income and household confidence in the economy. The risk in using overly precise metrics is that we could overfit the model. This would mean that we would have a model that is good at explaining the historical evolution, but only under the historical circumstances, which could change in the future. Because the purpose of the model is to make forecasts continually, we also need reliable and recurrent forecasts for our input data that we can use as the basis for projecting new car registrations. There are numerous variables that could be of interest as independent variables in our model, but which are disqualified as options because they do not have values that stretch back or forward in time far enough. The selection of available variables for projecting the number of newly registered passenger cars is thus relatively limited. We have chosen to base our model on the total change in GNP in order to capture the general development of the economy, and on the employment rate for the working population, which serves as a proxy for household purchasing power. The National Institute of Economic Research issues predictions for both these variables on an ongoing basis, making them advantageous to use.[67]

All in all, this means that we use two independent variables as input data in our ARIMAX model:

- Total GNP in fixed prices in terms of the percentage change compared to previous years. Input data from the National Institute of Economic Research for the years 1978–2026.
- Unemployment in percent, expressed as a share of the working-age population that is jobless. Input data from the National Institute of Economic Research for the years 1978–2026.

The two best models that met all our requirements were an **AR**IMA**X**(1,0,0) model, in which we take into account a lag for the dependent variable, i.e. newly registered cars from the previous year. For this model we use the Conditional Least Squares (CLS) method for the parameter estimates. We thus use neither differentiation (I) nor lag in the random term (MA). In other words, both I and MA were derived from the model, so that we have an ARX(1) model with two independent variables. The output from the SAS statistical program for the years 2023–2026 is provided below. Bear in mind that the three earlier forecast intervals of four years must also meet all the requirements. The forecasts for 2014–2017 and 2018–2021 thus meet all the requirements.

[65] Ekspertgruppen for fremtidens mobilitet [Expert group for future mobility] 2018
[66] https://www.konj.se/publikationer/konjunkturbarometern.html
[67] https://www.konj.se/publikationer/konjunkturlaget.html

## Autocorrelation Check for White Noise

| To Lag | Chi-Square | DF | Pr > ChiSq | Autocorrelations | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 6 | 64.33 | 6 | <.0001 | 0.847 | 0.632 | 0.422 | 0.206 | 0.034 | -0.081 |

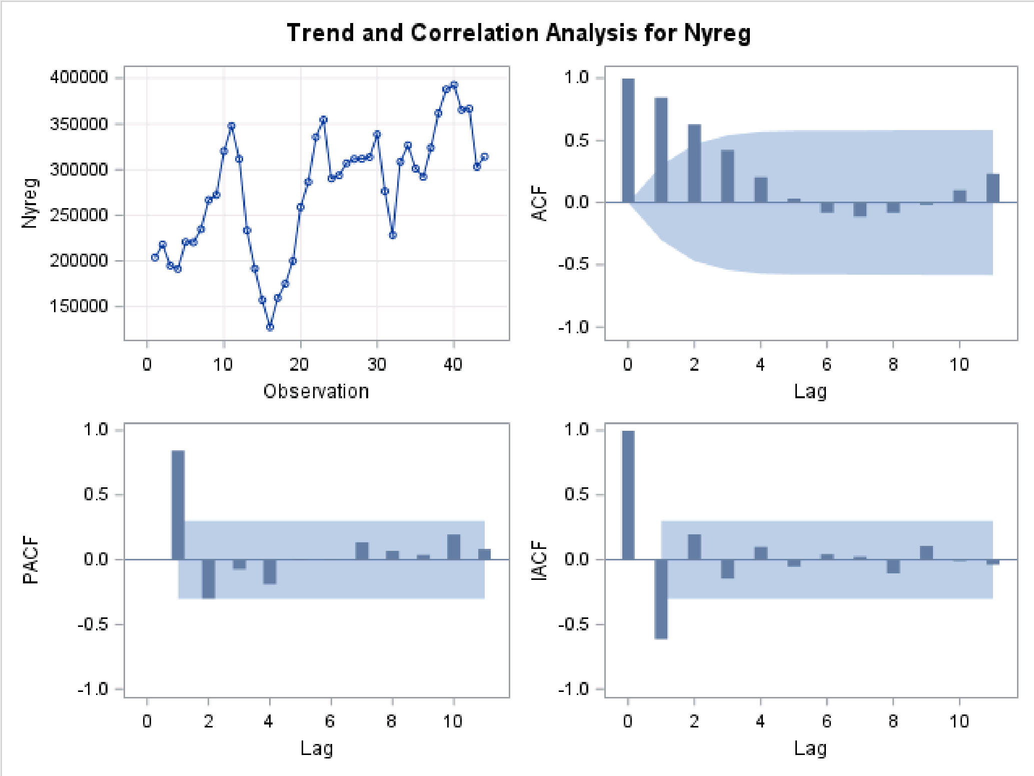



**Figure 6.1. Partial autocorrelation function.**

Up in the left-hand corner of the diagram we see a tendency toward non-stationarity, as we can discern a weak increasing trend. This is a borderline case. We consequently tried differentiating (I) – e.g. with an ARIMA(1,2,0) model. However, in comparing the models, we concluded that the (I) step does not give us a better model. We see in the PACF diagram that one lag clearly stands out, but we also tested models with two AR lags, and ARX(1) still proved to be most suitable overall.

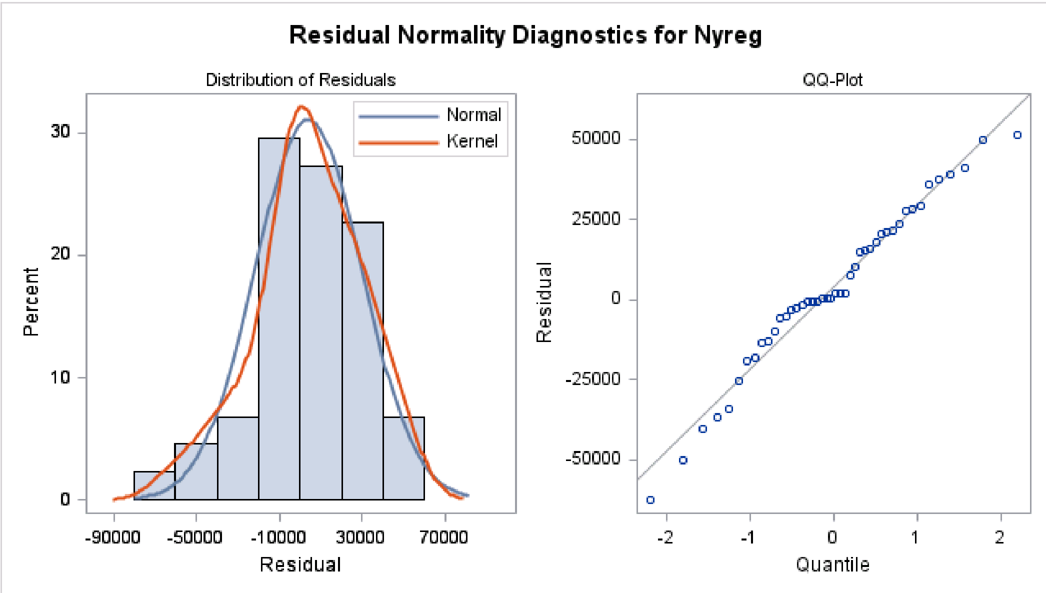
### Conditional Least Squares Estimation

| Parameter | Estimate | Standard Error | t Value | Approx Pr > \|t\| | Lag | Variable | Shift |
|---|---|---|---|---|---|---|---|
| MU | 227829.0 | 29920.7 | 7.61 | <.0001 | 0 | Nyreg | 0 |
| AR1,1 | 0.99528 | 0.03271 | 30.43 | <.0001 | 1 | Nyreg | 0 |
| NUM1 | 6719.4 | 1436.2 | 4.68 | <.0001 | 0 | bnptot_forandr_mars22 | 0 |
| NUM2 | -10920.0 | 4012.2 | -2.72 | 0.0096 | 0 | arblos_mars22 | 0 |

| | |
|---|---|
| Constant Estimate | 1076.063 |
| Variance Estimate | 7.252E8 |
| Std Error Estimate | 26929.47 |
| AIC | 1026.359 |
| SBC | 1033.496 |
| Number of Residuals | 44 |

**Autocorrelation Check of Residuals**

| To Lag | Chi-Square | DF | Pr > ChiSq | Autocorrelations | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 6 | 4.75 | 5 | 0.4478 | 0.210 | -0.076 | -0.010 | -0.102 | -0.150 | -0.115 |
| 12 | 13.91 | 11 | 0.2378 | -0.167 | -0.079 | -0.051 | 0.006 | 0.205 | 0.269 |
| 18 | 17.10 | 17 | 0.4477 | -0.096 | 0.021 | 0.060 | -0.024 | 0.116 | 0.127 |
| 24 | 21.02 | 23 | 0.5801 | 0.072 | 0.068 | -0.158 | -0.035 | 0.034 | -0.083 |




Note that the residuals deviate from the normal distribution in the left-hand diagram above and, in combination with the QQ plot to the right, we still believe that this model works. Out of five other models that also meet all the requirements, all had a better normal distribution for the residuals. After assessing how the other values had turned out previously and in the next ensuing year, we consequently chose this model.

**Input Number 1**

| | |
|---|---|
| Input Variable | bnptot_forandr_mars22 |
| Overall Regression Factor | 6719.441 |

**Input Number 2**

| | |
|---|---|
| Input Variable | arblos_mars22 |
| Overall Regression Factor | -10920 |

**Forecasts for variable Nyreg**

| Obs | Forecast | Std Error | 95% Confidence Limits | |
|---|---|---|---|---|
| 45 | 271,563 | 26,700 | 219,231 | 323,895 |
| 46 | 280,569 | 37,626 | 206,822 | 354,316 |
| 47 | 295,425 | 45,920 | 205,423 | 385,428 |
| 48 | 298,521 | 52,837 | 194,961 | 402,082 |

The confidence interval, which is very high, provides an indication of how difficult it is to make forecasts regarding new car registrations. However, we publish only point estimates.

## 6.4 Model for estimating number of newly registered light trucks

The number of newly registered light trucks is calculated based on the percentage change in GNP and the number of newly registered light trucks the year before, using the formula $Y_t = a + b*Y_{t-1} + c*x_t + e$. $Y_t$ is the number of newly registered light trucks and $x$ is the percentage change in GNP in fixed prices; a, b and c are parameters estimated based on data from 1996 to 2022, and e is residuals. An estimate using OLS in Excel gives us $a$ = -1523, $b$ = 0.917 and $c$ = 2309.

The $Y_t = a + b*Y_{t-1} + c*x_t + e$ model is relatively simple, with the number of newly registered light trucks for a given year being assumed to depend on that same year's growth in GNP and the number of new registrations during the previous year. The model [has] a high explanatory value for the newly registered vehicles ($R^2 = 0.90$). We find that the model is generally a good tool in helping us to project the number of newly registered light trucks. The forecast for GNP growth in 2023–2026 is based on the National Institute of Economic Research's forecast from March 2023.

## 6.5 Newly registered heavy trucks

The forecast for the number of newly registered heavy trucks is based on a time series regression in the form of an ARIMA model.[68]

To project the size of the future vehicle fleet and the number of newly registered vehicles we need a model which – in addition to historical values for newly registered heavy trucks – is also based on the future development of the economy. Many metrics are used to describe Sweden's economic development. We have tested 20 such metrics, and the results analyses of the ARIMA runs indicate that TEU is best suited for use in this case. We use the same methodology as for passenger cars in selecting the best ARIMA model. The ARIMA runs for passenger cars showed that GNP and Unemployment were the best input data for independent variables. In the case of heavy trucks, only one independent variable was found to be best suited in the model, i.e. TEU. TEU = GNP + Imports of goods and services. It is a relatively broad metric. The risk in using overly narrow metrics is that we might overfit the model. This would mean that we would have a model that is good at explaining the historical trends, but only under the historic circumstances, which are subject to change in the future. Because the purpose of the model is to make forecasts continually, we also need reliable and recurrent projections for our input data, which we can in turn use as the basis for our projections of new registrations of heavy trucks. There are numerous variables that could be of interest as independent variables in our model, but which are disqualified as options as they do not have values that stretch back or forward in time far enough. The selection of available variables for projecting the number of newly registered heavy trucks is thus relatively limited. We have chosen to base the model on TEU per year in order to capture the general development of the economy.

All in all, this means that we are using an independent variable as input data in our ARIMAX model:

- TEU in fixed prices. Input data from the National Institute of Economic Research for the years 1995–2026.

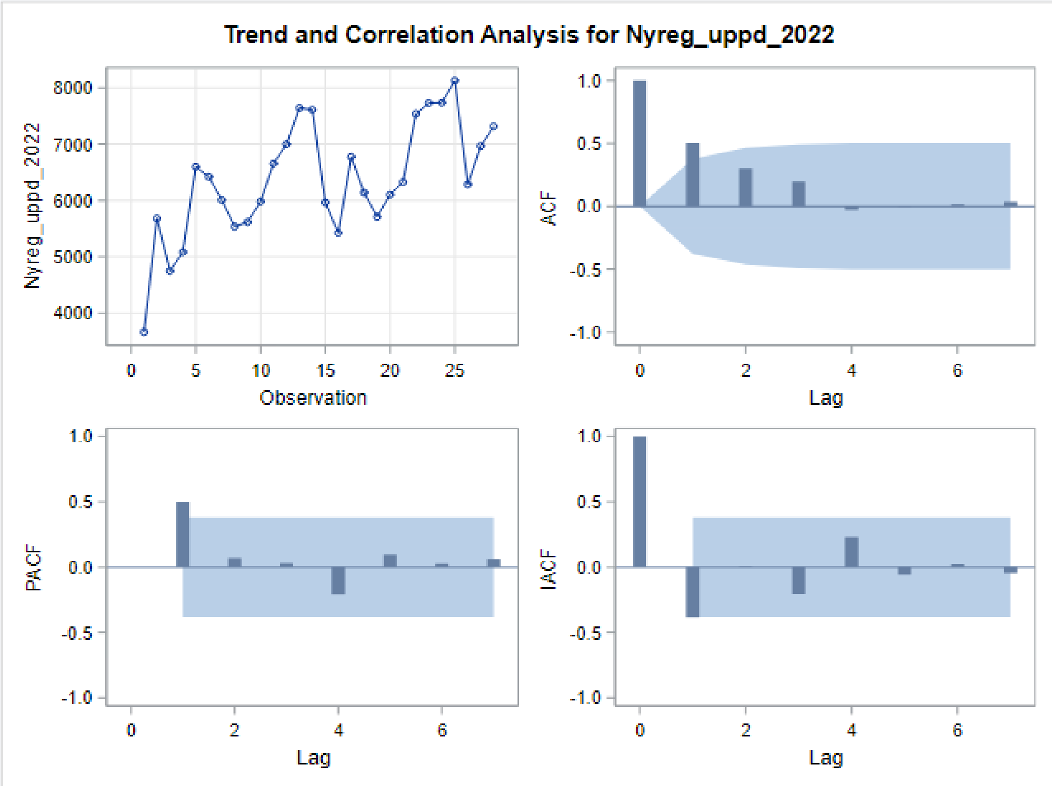
The best model (after having tested all the possible combinations) that came closest to meeting all the requirements was an **AR**IMA**X**(1,0,0) model, in which we take into account a lag for the dependent variable, i.e. newly registered heavy trucks. We thus use neither differentiation (I) nor lag in the random term (MA). In other words, both I and MA disappeared in the model, so that we have an ARX(1) model with one independent variable.

Output from the SAS statistical program is presented below, solely for the years 2023–2026.

| Autocorrelation Check for White Noise | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| To Lag | Chi-Square | DF | Pr > ChiSq | Autocorrelations | | | | | |
| 6 | 12.19 | 6 | 0.0579 | 0.503 | 0.303 | 0.198 | -0.029 | 0.003 | 0.015 |

We see in the clipping from SAS above that this is a borderline case for white noise, otherwise we would have preferred the p value <0.0001.

[68] More regarding ARIMA models in Section 6.3, Passenger cars.




In the upper left-hand corner of the diagram we can see a tendency toward non-stationarity, as we can see a weakly upwardly inclined curve. This is a borderline case. We have consequently tried differentiating (I) – for example we tested an ARIMAX(1,1,0) model – and compared the different models, but determined that this model works, and that it works best. We see that one lag clearly stands out in the bottom left corner of the PACF diagram.

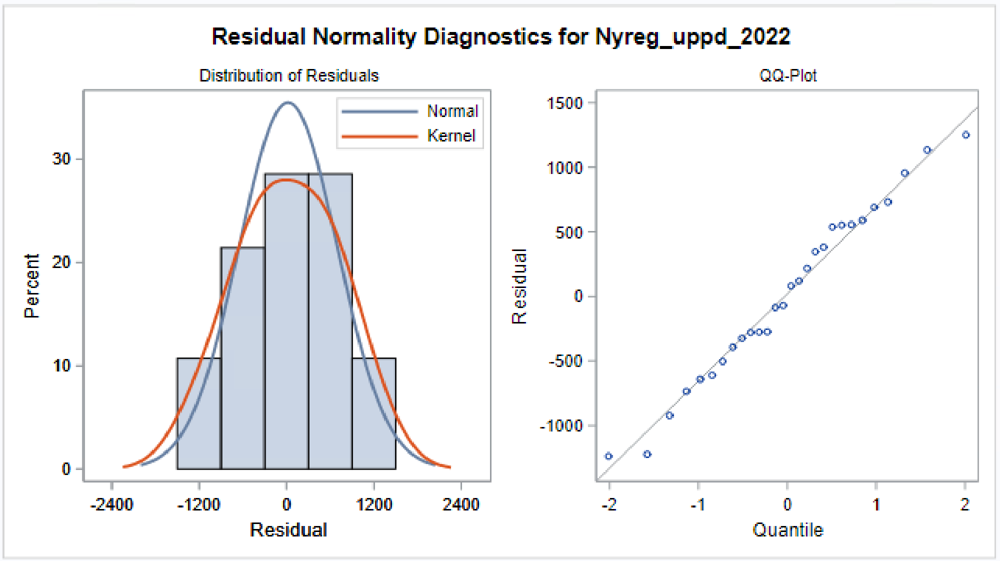
| Maximum Likelihood Estimation | | | | | | | |
|---|---|---|---|---|---|---|---|
| Parameter | Estimate | Standard Error | t Value | Approx Pr > \|t\| | Lag | Variable | Shift |
| MU | 2596.7 | 926.26348 | 2.80 | 0.0051 | 0 | Nyreg_uppd_2022 | 0 |
| AR1,1 | 0.36330 | 0.18750 | 1.94 | 0.0527 | 1 | Nyreg_uppd_2022 | 0 |
| NUM1 | 0.0006461 | 0.0001559 | 4.14 | <.0001 | 0 | TEU | 0 |

We have also seen that the p values had been even lower in the table above; this is a borderline case for the parameter AR1,1 working in the model.

| | |
|---|---|
| Constant Estimate | 1653.33 |
| Variance Estimate | 492219.1 |
| Std Error Estimate | 701.5833 |
| AIC | 449.4159 |
| SBC | 453.4125 |
| Number of Residuals | 28 |

| Autocorrelation Check of Residuals | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| To Lag | Chi-Square | DF | Pr > ChiSq | Autocorrelations | | | | | |
| 6 | 3.02 | 5 | 0.6970 | -0.008 | -0.032 | 0.038 | -0.272 | -0.065 | -0.072 |
| 12 | 4.89 | 11 | 0.9365 | 0.036 | 0.140 | 0.003 | -0.022 | 0.103 | 0.092 |
| 18 | 13.33 | 17 | 0.7137 | -0.217 | -0.219 | 0.036 | -0.124 | 0.064 | 0.132 |
| 24 | 25.11 | 23 | 0.3445 | -0.003 | 0.105 | -0.187 | -0.073 | 0.068 | -0.153 |

In the table above we see that the residuals are mutually independent.




In the diagram above we see that the residuals are relatively normally distributed.

| Model for variable Nyreg_uppd_2022 | |
|---|---|
| Estimated Intercept | 2596.714 |

| Autoregressive Factors | |
|---|---|
| Factor 1: | 1 - 0.3633 B**(1) |

| Input Number 1 | |
|---|---|
| Input Variable | TEU |
| Overall Regression Factor | 0.000646 |

| Forecasts for variable Nyreg_uppd_2022 | | | | |
|---|---|---|---|---|
| Obs | Forecast | Std Error | 95% Confidence Limits | |
| 29 | 7592.7185 | 701.5833 | 6217.6406 | 8967.7964 |
| 30 | 7787.5911 | 746.4484 | 6324.5790 | 9250.6031 |
| 31 | 7998.9869 | 752.1701 | 6524.7606 | 9473.2132 |
| 32 | 8191.6191 | 752.9221 | 6715.9190 | 9667.3192 |

The confidence interval, which is very high in the table above, offers an inkling of how difficult it is to make forecasts for newly registered heavy trucks. However, we will present only point estimates in our publication.

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