

Status of zero-emission buses 2021



CROW-KpVV

CROW-KpVV develops, disseminates and safeguards collective knowledge for local and regional authorities in the field of mobility. This knowledge provides fundamental support for policy development and implementation.

About CROW

CROW devises smart and practical solutions for issues related to infrastructure, public space, traffic and transport in the Netherlands. We do this together with external professionals who share knowledge with each other and make it applicable in practice.

CROW is an independent, non-profit knowledge organization that invests in knowledge for today and tomorrow. We strive for the best solutions for issues from policy to management in infrastructure, public space, traffic and transport and work and safety. Furthermore, we are experts in the field of tendering and contracting.

CROW

PO box 37, 6710 BA Ede
Telephone +31 (0)318 69 53 00
Email klantenservice@crow.nl
Website www.crow.nl

November 2021

CROW and those parties involved in the production of this publication have exercised due circumspection in amassing the data it contains in line with the latest scholarly and technological insights. Nevertheless, the possibility of inaccuracies cannot be ruled out completely. Users accept that risk.

CROW excludes all liability for losses that may arise from the use of this information, partly for the benefit of those parties involved in the production of this publication.

The content of this publication is protected by copyright law. The copyright is held by CROW.

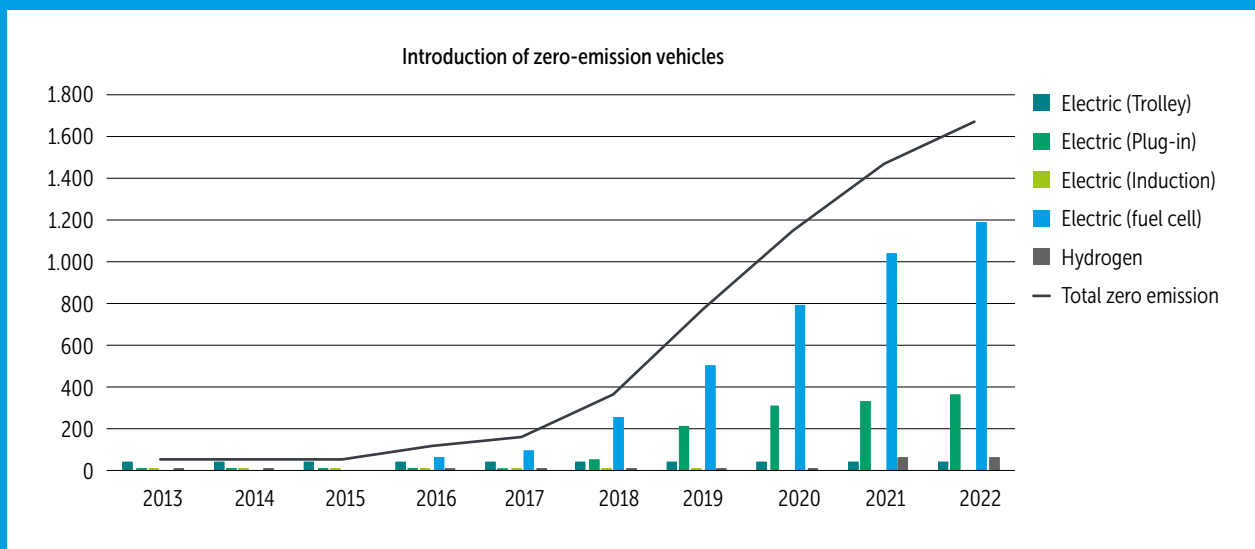
Introduction

In 2015, it was still normal to hear diesel buses rattling through Dutch towns and cities. But 'cleaner' examples were on their way: CNG buses, or buses that use natural gas, were the first to achieve a reduction in CO₂ emissions. In addition, various regions introduced hybrid vehicles that were more environmentally friendly than the old diesel buses.

Although the first electric buses appeared back in 2013, they had a very limited range. Manufacturers, transport companies and public transport authorities then started experimenting with fully electric vehicles in order to further decrease harmful emissions.

When the Administrative Agreement on Zero Emission Buses (BAZEB) was established in 2016, the final destination suddenly appeared on the horizon: all buses used for urban and regional transport had to be emission-free by 2030. This agreement clearly defined the timeframe, and once again emphasised the importance of sustainable public transport.

In this brochure, CROW-KpVV shows how much progress has been made on this journey, while also explaining some of the stops on the way to the final destination.



Developments in zero-emission vehicles

The first public transport companies started using zero-emission vehicles in 2013. The province of Fryslân took in 2013 the initiative to purchase eight BYD battery buses for sustainable transport on Schiermonnikoog. Meanwhile, Qbuzz (under brandname U-OV) introduced three induction-based midi-buses made by Octare for Utrecht's city line 2, between the main train station (Centraal Station) and the city centre. The buses on Schiermonnikoog were charged via the mains, while the buses in Utrecht were charged via induction. In practice, the latter turned out to be more difficult than expected; the buses experienced many malfunctions and were decommissioned in 2019 and replaced by new Heuliez battery buses. But BYD's buses are still going strong on Schiermonnikoog, eight years later.

New zero-emission buses were only introduced in 2016, when Eindhoven received 43 articulated VDL buses for its local bus routes. Hermes rapidly charges them in the depot, which is close to the station, via the pantograph on the roof. In certain parts of Brabant and Limburg, such as the towns of 's-Hertogenbosch and Venlo, smaller VDL buses (10 and 12 metres) were introduced. They are charged en route, on the streets, using a pantograph.

In 2018, major advances in public transport were made with the introduction of electric buses in various regions. In Amstelland-Meerlanden, 100 articulated VDL buses were deployed for transport around Schiphol Airport, while in Noord-Holland Noord, over 20 BYD midi-buses were put into service in and around Alkmaar. The Hague was the first major city to introduce electric buses. HTM deployed eight VDL buses on a single route, which are charged via a pantograph at the end terminal. Difficulties were initially encountered in the charging process due to the proximity of salty seawater. However, the charging stations started to work effectively after a few modifications.

The latest major introduction of electric buses took place in December 2020 in the IJssel-Vecht concession, where over 250 BYD buses came into service. Surprisingly, a decision was made to charge all the buses using a pantograph attached to the charging station, except in Zwolle where the pantograph is located on the bus roof.

Various new introductions of zero-emission vehicles are taking place in 2021 and 2022. Extra buses are expected to be introduced for the Amstelland-Meerlanden concession. The public transport operators in Amsterdam and Rotterdam will also receive new deliveries of zero-emission buses. Transdev will be replacing buses in the Gooi and Vechtstreek region with electric buses during the course of 2022. There has been more uncertainty about the introduction of new zero-emission vehicles because of COVID-19. Due to a decrease in passenger numbers, and thus revenues, it has become more difficult to finance the new buses. In response to this, the government has taken steps to make them more affordable. At the start of 2022, the Ministry of Infrastructure and Water Management will launch a subsidy scheme to stimulate the introduction of (extra) zero-emission buses.

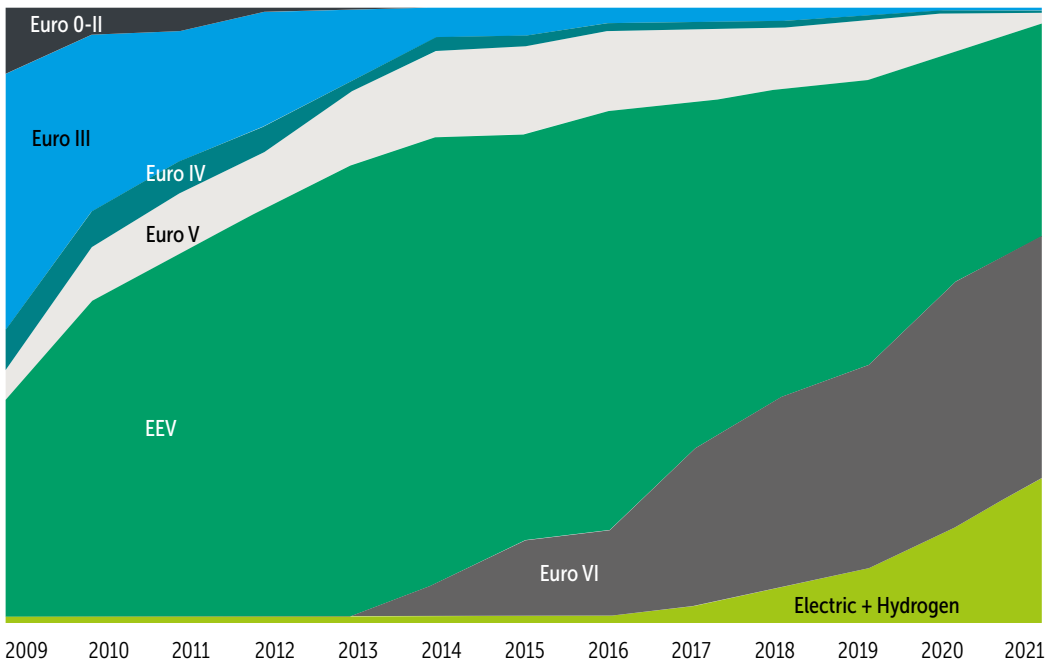
Hydrogen

After a 2016 pilot involving a hydrogen-based bus made by Solbus, hydrogen buses were introduced in various regions in 2017. Groningen, Rotterdam and Eindhoven each purchased two hydrogen buses. The VDL/Phileas hydrogen buses in Eindhoven came from Amsterdam's public transport operator GVB, which had been using them for the previous two years. After two years in Eindhoven, the buses were cast aside for good. A second bus pilot followed in 2019, this time involving Ursus in Gelderland. Both buses were decommissioned at the end of 2020.

In the summer of 2020, Connexxion decided to introduce new VDL hydrogen buses in the Hoekse Waard. The hydrogen used by these four 12-metre VDL buses was located in a range extender (trailer) behind the bus. The advantage of this set-up was that the trailer could be easily swapped in case of malfunctions. The downside, as far as Connexxion was concerned, was that drivers needed a D+E driving licence to drive the bus and trailer combination. A standard D driving licence was sufficient for hydrogen buses without a range extender.

New hydrogen buses manufactured by Van Hool were deployed in Groningen-Drenthe in 2021. Considering the two existing buses, this took the total to twenty. In addition, the Groningen-Drenthe region has already had around 150 electric buses since the end of 2019. The hydrogen buses are mainly serving regular regional routes. Depending on the specific type, electric buses are being used for city routes (including Q-link) or regional routes.

Development bus fleet 2009-2021



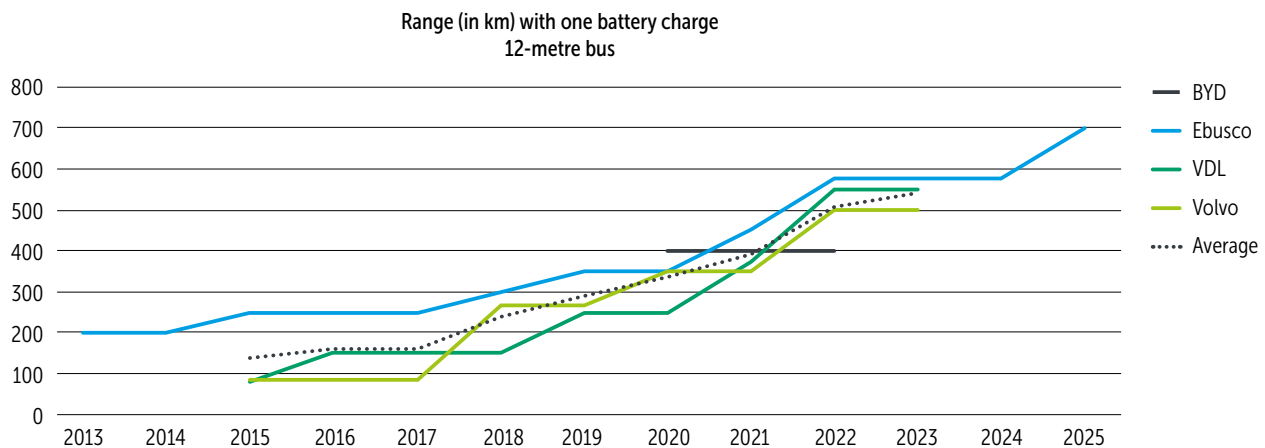
Range of zero-emission buses

In electric buses, the power needed to drive the motor is obtained from a battery pack. The potential distance that can be covered with a single charge is determined by the pack's capacity. A bus's actual range is also determined by factors such as its weight and aerodynamics, as well as the road and weather conditions. The capacity of the battery packs has more than doubled over the past decade. In another 5 years, the capacity is expected to have increased by approximately 70%, due to the introduction of a new type of battery, the solid state battery. This would mean a potential range of 700 kilometres on one battery charge. Therefore, buses would be able to travel longer distances.

The current generation of hydrogen buses have a range of 350 to 400 kilometres. Belgium-based bus constructor Van Hool has been building hydrogen buses for the American and European markets since 2005. Yet the number of hydrogen buses across Europe remains limited. To date, Van Hool has supplied approximately 200 hydrogen buses in Europe. As a result, hydrogen buses are only a very limited part of Europe's total bus fleet.

Battery-based (electric) buses and hydrogen buses both have advantages and disadvantages. As far as battery-based electric buses are concerned, charging facilities must be installed in the depot (and possibly en route) and then connected to the electricity grid. And this requires coordination with municipalities and grid operators. For hydrogen buses, there are only limited filling facilities, and they must often be installed specifically for buses. In addition, hydrogen needs to be produced and transported to the filling stations. On the other hand, hydrogen does not directly burden the (already overloaded) energy grid, and can be used to store surplus (green) energy.

At this moment in time, the price of hydrogen per kilometre is considerably higher than diesel or electricity, so subsidies are needed to make the price competitive. A tank can be filled with hydrogen at approximately the same speed as with diesel, which offers an advantage during operation.



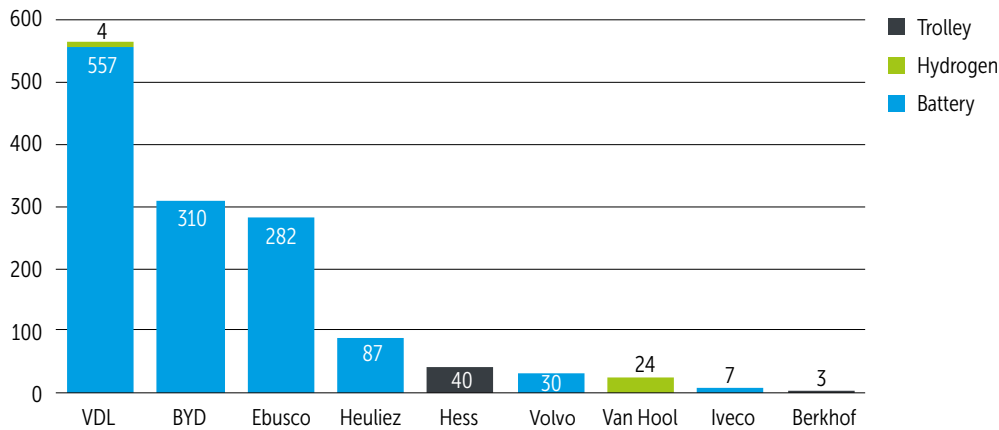
Statistics are based on data supplied by the manufacturer. The actual range is determined by, among other factors, the outdoor temperature, the length of the journey and the driver's driving style. The exact specifications of the bus can also lead to major differences (e.g. heat pump, block heater based on diesel/HVO).

Status of zero-emission buses in August 2021

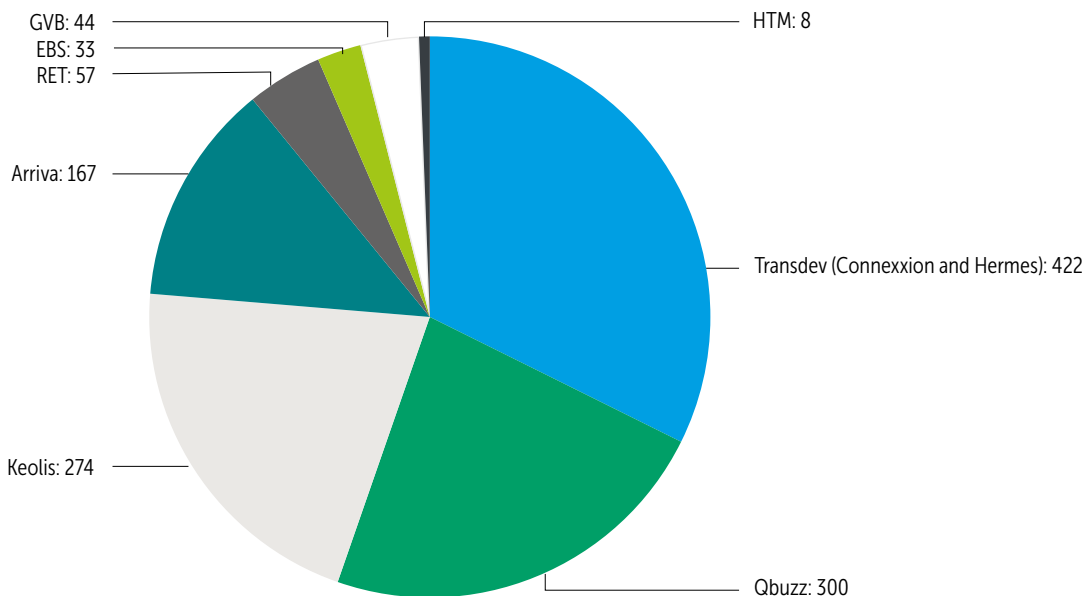
VDL is currently the market leader in zero-emission buses in the Netherlands. The company supplies almost half of all zero-emission buses – both electric and hydrogen – in versions ranging from minibus to articulated bus. BYD is a distant second with over 300 buses in the Netherlands, following their introduction in the IJssel-Vecht concession. Over the past year, bus constructor Ebusco has supplied over 150 buses in the Netherlands, which means it follows closely in third place. The handful of zero-emission buses by Optare, Solbus and Ursus have all been taken off the road in the meantime. Van Hool's buses only run on hydrogen.

Transport company Transdev, which includes operators like Connexion and Hermes, currently has the most zero-emission buses in the Netherlands. In Noord-Holland, Transdev primarily uses electric buses for the Amsteland-Meerlanden, Haarlem-IJmond and Noord-Holland Noord concessions. It also does the same for the Zuidoost-Brabant concession in the Eindhoven region. Transport companies Qbuzz and Keolis are still a long way behind. Qbuzz primarily uses zero-emission buses for the Groningen-Drenthe concession, while Keolis uses them for the IJssel-Vecht concession (provinces of Gelderland and Overijssel).

Suppliers zero-emission busses

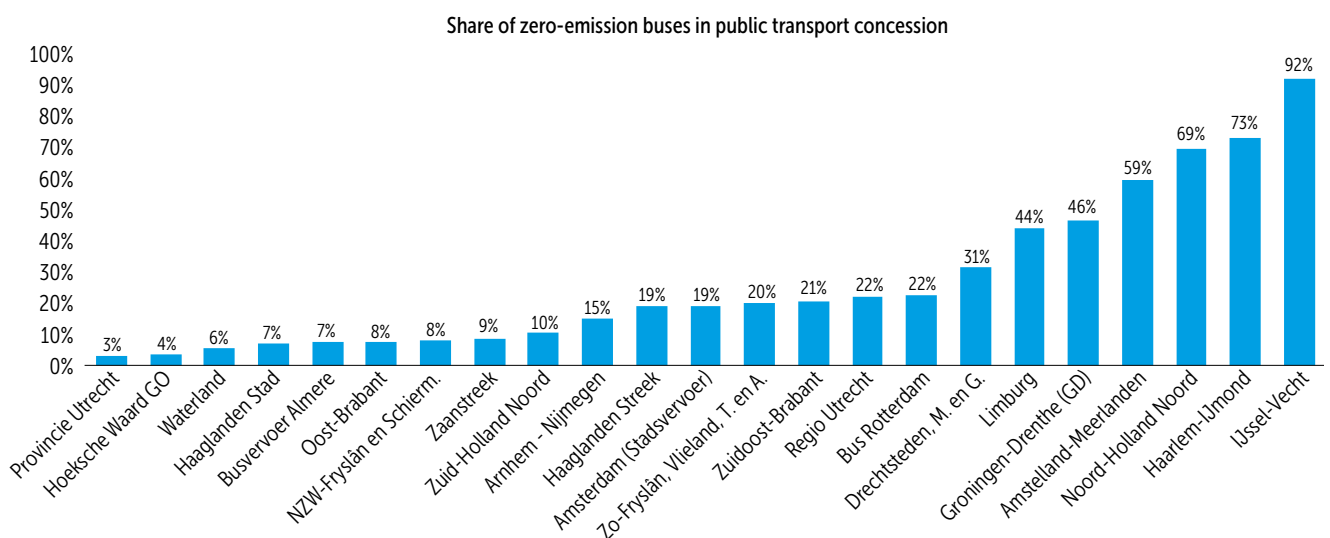


Zero-emission BUSES per transport company



Currently, the Amsterdam transport region has the most zero-emission buses within its boundaries. Of the 830 buses in this region, 228 are zero-emission buses (which represents 17% of the national total). There are 30 zero-emission buses in the province of Friesland (mainly on the Wadden islands) and 8 buses in the province of Flevoland (city buses in Almere). Zero-emission buses are not being used by public transport companies in the province of Zeeland.

At the moment, IJssel-Vecht is the concession with the highest proportion of zero-emission buses. With the introduction of a new fleet of electric BYD buses at the end of 2020, this new concession rose directly to the number one spot. Most concessions with a low proportion of zero-emission buses will be put out to tender in the coming years. It is very likely that, as in IJssel-Vecht, more zero-emission buses will be deployed by the new concession operators.



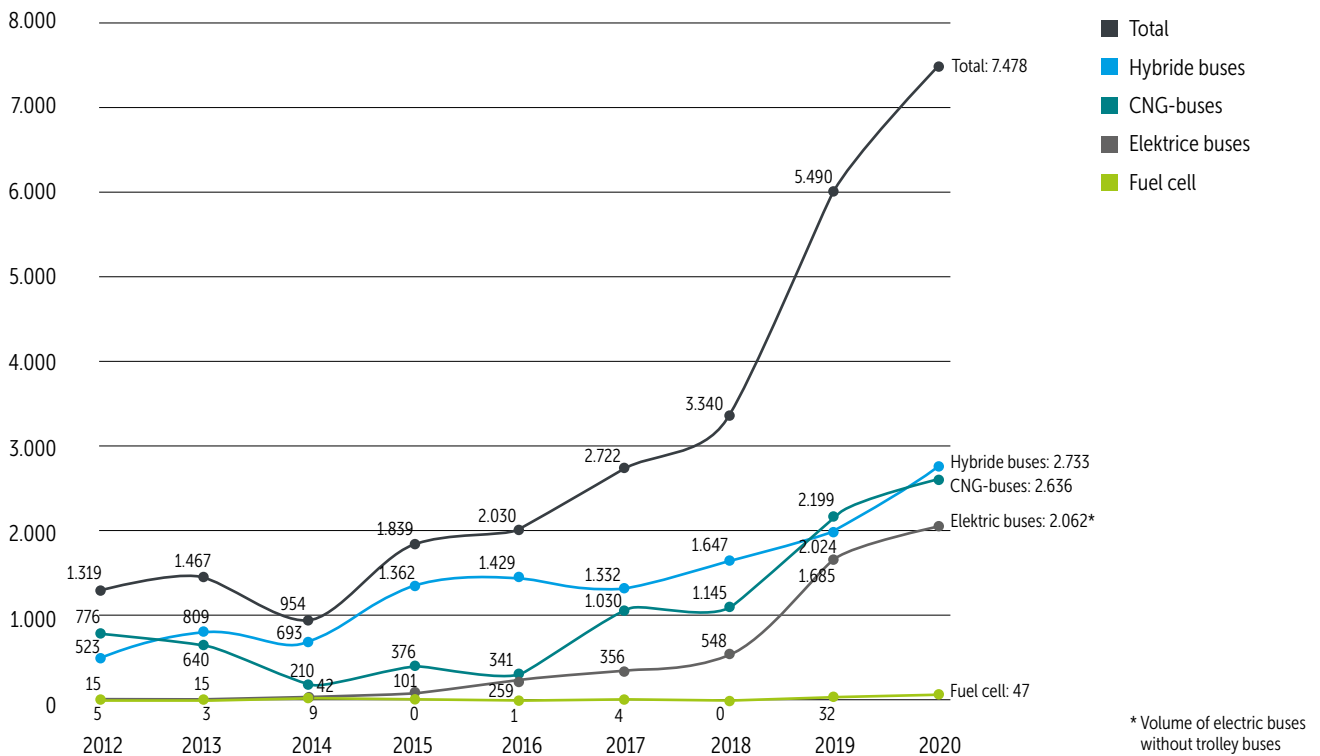
Concessions without zero-emission buses have not been included in this graph.

Zero-emission buses in Europe

France, the United Kingdom, Poland, the Scandinavian countries, Germany and the Netherlands currently operate over 50% of electric buses in Europe. Proportionately speaking, the Netherlands has the most zero-emission buses within its fleet. In 2018, France passed legislation that made it mandatory to only purchase low-emission vehicles. As of 2020, low-emission vehicles must account for at least 50% of newly acquired vehicles; this will rise to 100% as of 2025. The 2016 Administrative Agreement on Zero-Emission Buses in the Netherlands determined that all new public transport buses must be zero-emission as of 2025, and that the whole bus fleet must be emission-free as of 2030.

In 2020, 2062 new electric buses were registered in Europe, 382 of which were in the Netherlands. This represents a sizeable increase on 2019, when 1685 e-buses were registered in Europe, including 412 in the Netherlands. Alternatives for traditional buses are becoming increasingly popular in Europe: hybrid buses and CNG buses both have a larger share than electric buses. Hydrogen buses, or fuel cell buses, represent a very limited share of the total fleet. This can be attributed to higher costs for the initial purchase, installation of filling stations, and fuel.

Development of Alternative Drivelines, Western-Europe + Poland GVW >8t



Source: <https://www.sustainable-bus.com>

Case study

Rotterdam

Parkshuttle – electric transport without driver

1999, the Parkshuttle was launched on the route between Rotterdam Metro Kralingse Zoom and Capelle aan den IJssel. The Parkshuttle is known as a “horizontal lift” service, where shuttles drive from one stop to the next. Passengers can call the shuttles to a stop and programme the destination once inside the shuttle. A supervisor keeps an eye on the shuttles remotely, and can intervene in case of problems.

After a head-on collision in 2005 (due to an error by the supervisor), the service was suspended for several long periods, partly due to issues with the software. Since 2008, the second generation of shuttles has been running back and forth reasonably smoothly on the now extended route. Between 1500 and 2000 passengers use the Parkshuttle every day.

On 3 June 2019, the Parkshuttle was shut down for five months in order to introduce new shuttles and to extend the route to the Waterbushalte. The aim was for shuttles to share the road with regular traffic on a certain part of the route. However, the five-month period was not long enough to perform the required testing and to modify the route. The relaunch was postponed again in 2020, partly due to the COVID-19 pandemic.

When it comes to zero emissions, the Parkshuttle is a unique case: although the shuttles are classed as regular public transport, they function completely differently than regular buses.





Case study

Eindhoven

The first concession with large-scale use of zero-emission buses

On Sunday 11 December 2016, 43 new electric buses manufactured by VDL left the Hermes depot in Eindhoven. Zuidoost-Brabant became the first concession where electric buses were used on a large scale. These 18-metre long buses were deployed on several inner-city routes and on the routes to Eindhoven Airport and the High Tech Campus. The buses were very innovative at the time and news about their use spread far and wide. This also resulted in a lot of international interest. Not only because of the large numbers, but also because they were the first articulated electric buses in Europe.

However, this series of buses cannot yet be driven for a whole shift. The Hermes buses can only do the route a few times, before returning to the depot near Eindhoven station to be (rapidly) charged. The depot therefore has a complete power plant, with enough charging stations for all buses, which allows both rapid charging during the day and slow charging at night. Drivers' timetables have been modified to take the new electric buses into account. The timetables stipulate when drivers have to charge their buses, and that another bus normally has to be used for their next journey. This means that only a limited number of extra buses have been needed. Drivers are given a one-day training course, where they learn how to drive the new buses. The aim is to consume the electricity as efficiently as possible.





Case study

IJssel-Vecht

First completely zero-emission concession

The IJssel-Vecht concession was initially formed by combining the Veluwe concession (province of Gelderland) and the Midden-Overijssel concession (province of Overijssel). The expiring concessions of IJsselmond and Lelystad were added at a later date. IJssel-Vecht was the first concession in the provinces of Gelderland, Overijssel and Flevoland to bear the new 'RRReis' name.

The tender by transport company Keolis included an almost fully electric fleet (excluding neighbourhood buses and the temporary part of the concession) and more timetable hours. At the start of the concession in December 2020, there were 246 BYD electric buses, which could be charged at five bus stations while en route.

But problems with the new buses were encountered from the very outset: buses would randomly break down and drivers complained about (cold) draughts in the driver's cabin. Because there was a delay in the concession being awarded, only a very short period was available to test the buses. Keolis worked with BYD to set up a 'repair garage', to which all the buses were taken. This helped resolve most of the problems. The last buses were introduced in July 2021: 13 small electric buses for several quieter routes in the concession.





Case study

Groningen-Drenthe Pilot for buses

164 zero-emission buses hit the road at the start of the new Groningen-Drenthe concession in December 2019. Interestingly, the 152 new zero-emission buses had been ordered from three different suppliers: VDL (32 12-metre buses and 11 18-metre buses), Heuliez (49 18-metre buses) and Ebusco (60 12-metre buses). By ordering from different suppliers, it was possible to spread the risk of late delivery, and allowed transport company Qbuzz to quietly work towards the start of the new concession. The client, OV-bureau Groningen Drenthe, helped to install 23 en-route charging stations (for what is known as 'opportunity charging') and four charging depots. Because different types of buses have been purchased, some are charged via plug-in (Ebuscos) while the others use a pantograph (VDL and Heuliez).

The OV-bureau and transport operator Qbuzz worked together closely to determine which buses were suitable for specific routes. Buses with smaller battery packs are used for inner-city routes, which makes it possible to quickly re-charge at the end terminal, while buses with larger battery packs serve regional routes. As it stands, there are no zero-emission Qliners, which are buses used over longer distances. But a project is currently underway to convert Qliner buses from diesel to hydrogen.





Sources

- [Feasible for all public transport buses to be zero-emission in 2030, CROW, June 2020](#)
- [Electric bus, Wikipedia](#)
- [Public costs and benefits of public transport buses, CE Delft, September 2018](#)
- [Only 425-kilometre range for hydrogen buses in Zuid-Holland, WattisDuurzaam.nl, April 2020](#)
- [Electric bus manufacturer Proterra raises \\$140 million, WattisDuurzaam.nl, January 2017](#)
- [Fact sheet on Zero Emission Mobility, Amsterdam transport region, December 2018](#)
- [Solid state battery, Wikipedia](#)


Colophon

Status of zero-emission buses 2021

Edition of

CROW-KpVV, Ede

This publication has been partly financed by the KpVV programme. The KpVV programme develops, disseminates and safeguards collective knowledge for local and regional authorities in the field of mobility. This knowledge provides fundamental support for policy development and implementation. Financing for the KpVV programme comes from the provinces and transport regions.

 **Interprovinciaal Overleg**
van en voor provincies


METROPOOLREGIO
ROTTERDAM DEN HAAG

 **Vervoerregio**
Amsterdam

Article number

K-D115_EN

Text and photography

Martijn Rotteveel

Editor-in-chief

Constant Stroecken

Design

Inpladi bv, Cuijk

Production

CROW

Contact

CROW Customer service: klantenservice@crow.nl
or (0318) 69 53 15

Download

This publication can be downloaded for free from
www.crow.nl

