DB Cargo

Whitepaper

Fuel for the future

How DB Cargo is responding to the diesel phase-out with the biofuel HVO

Introduction

Dear Reader,

In the famous words of French author, Antoine de Saint-Exupéry: 'As for the future, your task is not to foresee it, but to enable it'. What drives us at DB Cargo is not waiting to see what happens but taking the reins ourselves and enabling a liveable future. Climate protection is thus always at the top of our agenda, and every day we ask ourselves what further improvements we can make.

After all, even today, rail is already the most environmentally friendly way to transport goods from A to B. Despite this, we never rest on our laurels and are always on the lookout for ways to become greener. On electrified lines, for example, we offer climate-neutral transport using 100% renewable power. And we now also have an exciting product in our arsenal for diesel transport; a biofuel called Hydrotreated Vegetable Oil, or HVO for short. This sustainable fuel is the subject of this white paper.

In this paper, we present our roadmap for helping Deutsche Bahn achieve its goal of becoming climate neutral by 2040 and explain how HVO is making an important contribution to this. We also take a look at the other positive effects of HVO and why we will continue to rely on this environmentally friendly fuel in the future. Finally, our experts Patrick Bertman and Jörg Schneider, who have been working intensively with HVO for some time, will provide some interesting background information on the subject.

I wish you an enjoyable and enlightening read.

Yours,

Thorsten Meffert
Vice President of Marketing
DB Cargo Group

DB Cargo on course for climate neutrality

With droughts, floods, melting glaciers and an increasing number of forest fires around the globe, the effects of climate change are becoming ever more visible and, in the absence of determined countermeasures, will be increasingly felt. The world's goal of limiting warming to 1.5°C is looking increasingly difficult.

We are therefore all called upon to take action now to prevent a further worsening of the situation. The transport sector, in particular, has a significant responsibility as it accounts for around 20% of the CO_2 emissions in Germany. The Federal Climate Protection Act calls upon the sector to lower its contribution to further warming by reducing annual emissions from 163.5 million tonnes of CO_2 equivalents in 2019 to 85 million tonnes in 2030.

When it comes to cutting emissions in the transport sector, road transport often comes to mind first. The debate surrounding electric cars and the charging infrastructure has been ongoing for many years now, for example. But there is also potential for the rail sector to reduce emissions. This responsibility also falls on the shoulders of DB Cargo AG and, of course, its customers.

And as these companies' ambitious plans show, the challenge has been accepted; nothing less than climate neutrality across all rail transport is the goal.

'The departure from diesel is a done deal at DB. We are doing everything we can to make rail even greener.'

Dr Richard Lutz, Chairman of the Management Board and CEO of Deutsche Bahn AG

Deutsche Bahn's ambitious plans go far beyond the requirements set out in law. While Germany is aiming for climate neutrality in 2045, DB plans to be carbon neutral by 2040. A long but rewarding path and, given that Deutsche Bahn has already reduced its CO_2 emissions by around 70% in the last 30 years, a realistic goal.

But how is it to be achieved? The guidelines are set by the ‚Strong Rail' strategy, which states that, by 2038, the proportion of renewable power in DB's traction current mix is rise to 100% in Germany. This means 100% renewable power on all electrified rail lines. In addition, the proportion of fossil diesel used by the Group for rail transport is to be steadily reduced, falling to zero by 2040.

This is where hydrotreated vegetable oil, or HVO for short, comes in, as this fuel is to be used to replace climate-polluting diesel.

HVO is already playing an important role in the Group's 'Diesel phase-out starter package' programme. With the volume of the green biofuel currently planned, DB Cargo is making a significant contribution to the success of this programme, which also includes reducing CO_2 emissions.

Definition:

CO_2e

CO_2e, or carbon dioxide equivalent, is a metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential. Greenhouse gases other than carbon dioxide include methane and nitrogen for instance. The gases all make different contributions to the greenhouse effect and are made comparable through the CO_2e calculation. For better readability, we use the term CO_2 throughout this white paper.

How HVO will make rail freight transport greener

Whether in road transport, aviation, shipping or rail, the replacement of fossil fuels by environmentally friendly alternatives is one of the major challenges facing the transport sector. Innovative products do already exist, however. These include electric and hydrogen-powered vehicles as well as alternative fuels. Unfortunately, not all of these technologies are yet ready for large-scale use, especially in heavy rail freight transport.

Rail is already one of the most environmentally friendly means of transport. Almost three-quarters of the transport volume in the rail sector is provided by electric power, and more than 60% of the rail network is electrified. The statistics for rail freight transport are even better. Around 95% of trips are already powered by electricity, and diesel is only needed for 5% of the transport volume. The environmentally friendly package that DB Cargo offers its customers is already being supported by additional initiatives, such as DB***eco plus*** and DB***eco neutral***.

With the alternative fuel HVO, otherwise known as DB***eco fuel***, another product has been added in the past two years. A big advantage of HVO technology is that it can already be used wherever fossil fuels are currently deployed. Not only can the low-emission biofuel be used to reduce diesel emissions associated with rail, but it can also play a major role elsewhere.

From a technological point of view, diesel engines cannot yet be dispensed with entirely, as alternative drive systems, such as production-ready fuel cells powerful enough to handle rail freight transport, do not yet exist. Until that time comes, a bridging technology is needed for existing vehicles.

»

‘Every goods train already cuts CO_2 by 80–100% compared with road transport. With its 3,600 trains a day, DB Cargo is thus saving 7 million tonnes of CO_2 every year.’

Patrick Bertman, Head of Product and Pricing Strategies

With DBeco fuel, DB Cargo is expanding its portfolio through the use of 100% HVO instead of fossil diesel fuel. DB Cargo is thus already reducing its CO_2 emissions and is well on the way to achieving the climate targets it has set itself for 2040.

But this can only succeed if the biofuel HVO is not only produced but actually used. DB Cargo is playing a pioneering role in this area too and has already approved its entire German diesel locomotive fleet of 800 vehicles for the environmentally friendly fuel, meaning that every DB Cargo locomotive is able to run on this biofuel. Throughout the DB Group, 1,000 locomotives can already be refuelled with HVO, with the remaining 2,000 diesel vehicles to follow in the next five years.

This has already had an impact on sales of the diesel alternative. With 17 million litres of the biofuel sold to date, Deutsche Bahn will reach the

Definition:

DB Cargo climate protection solutions

Transport by rail already represents an environmentally friendly package, which DB Cargo offers its customers as standard. Adding Eco Solutions to this enables the realisation of fully climate-neutral logistics chains today:

DB*eco plus*:
Use of 100% renewable power on electrified lines in Germany and other countries; 10% of revenues used to support renewable energy projects.

DB*eco fuel*:
Use of HVO to reduce CO_2 emissions on non-electrified lines by approximately 90%. Any remaining emissions from the upstream chain are also offset.

DB*eco neutral*:
Offsetting unavoidable emissions through climate protection certificates that meet the CDM Gold Standard, for example for pre- and onward carriage by HGV; perfectly complements DB***eco plus*** and DB***eco fuel***.

volume target it originally set itself for 2025 two years early. The reason for this is the continuing development of the refuelling station infrastructure for HVO as well as the positive results in all engine tests.

HVO as a bridging technology

In the future, Deutsche Bahn will no longer rely on fossil fuels for new vehicles, but on new drive concepts, such as hydrogen and the development of battery technologies that can also be used for rail freight transport. In the meantime, it is projected that HVO will help save at least 50,000 tonnes of CO_2 by 2025. Compared to fossil diesel, HVO causes around 90% less CO_2 emissions on balance, because only CO_2 that was previously removed from the atmosphere by growing vegetation is released during combustion in the engine. The remaining emissions occur in the product's upstream chain, i.e. during production and delivery.

The climate is already benefiting today

HVO is therefore already succeeding in noticeably reducing DB Cargo's CO_2 emissions and is thus making a significant contribution to the main goal of a climate-neutral, fully green rail service. In other respects, too, the carbon footprint of HVO is clearly superior to that of conventional diesel (see chart). Even local emissions such as soot are significantly reduced, and there is also a demonstrable reduction in noise and odour emissions. All this is achieved without any loss of locomotive power.

HVO versus fossil diesel

The use of HVO also reduces local greenhouse gas emissions. This example compares it with conventional diesel:

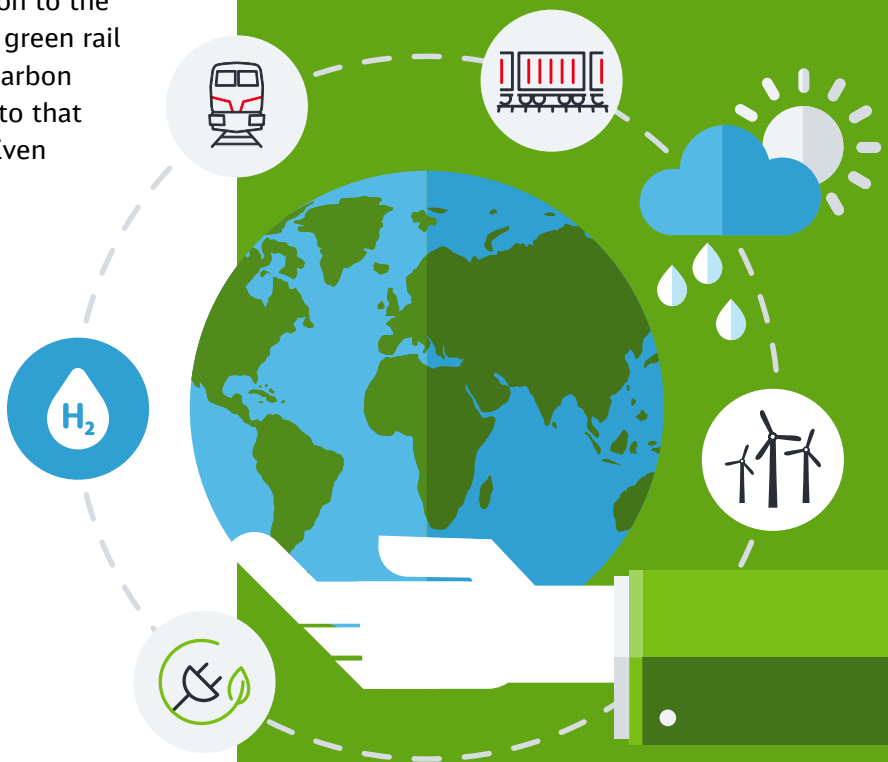
up to **55 %*** **less carbon**

up to **43 %*** **less nitric oxide**

up to **61 %*** **less hydrocarbon**

up to **80 %*** **less dust mass**

*depending on engine type and operating point



Turning waste into fuel

Upcycling has been a popular topic for a number of years now. It refers to the upgrading of used or unusable items into something new and more useful. Old pallets might be turned into sofas, for example, wine bottles into candlesticks or truck tarpaulins into sturdy outdoor bags.

The principle is similar for Hydrotreated Vegetable Oil: biological residues and waste materials are converted into high-quality fuel. This is upcycling at its best.

Fuel from waste, not food

In principle, many substances can be used as feedstock for HVO. But usable does not necessarily mean sensible or sustainable. When deciding on the feedstock, it is important to analyse both its environmental and social impact.

For example, when agricultural land is used to grow crops for fuel production, fuel competes with food, which is an unacceptable outcome.

»

Definition:

Diesel

Diesel fuel is a mixture of various petroleum-based hydrocarbons. HVO is a renewable fuel with a similar chemical composition to fossil diesel. In addition to vegetable oils, the production of this type of fuel uses waste, oils and fats from residual substances such as used cooking oil.

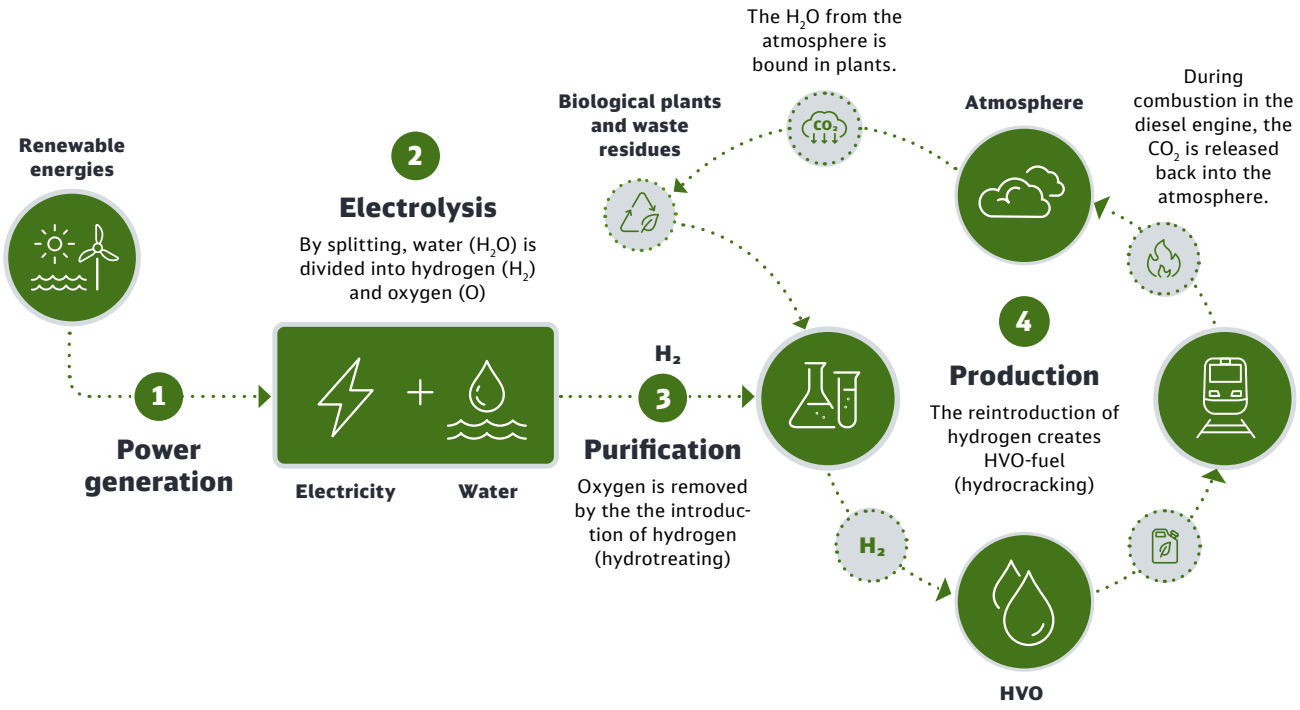
For this reason, DB Cargo only uses biofuel that is made from biological residues and waste materials. These include different types of waste grease, such as used cooking oil or grease from grease traps.

Throughout Europe, approximately two to four million tonnes of waste grease is available annually. Using grease avoids the food versus fuel dilemma and instead takes advantage of an environmentally and socially sound product. DB Cargo also refuses to use residual materials from palm oil and uses only HVO producers with a certified palm oil-free status.

How is waste turned into highly efficient fuel?

In addition to the plant waste residue, you need electricity and hydrogen. First, electrolysis is used to split water into oxygen and hydrogen. In the subsequent hydrotreating process, vegetable oils are then chemically modified by removing sulphur, oxygen and nitrogen and adding hydrogen. In the next step (hydrocracking), the resulting hydrocarbons are split into smaller chains again with the addition of hydrogen (cracking), producing the HVO fuel.

How the biofuel HVO is produced for our diesel locomotives



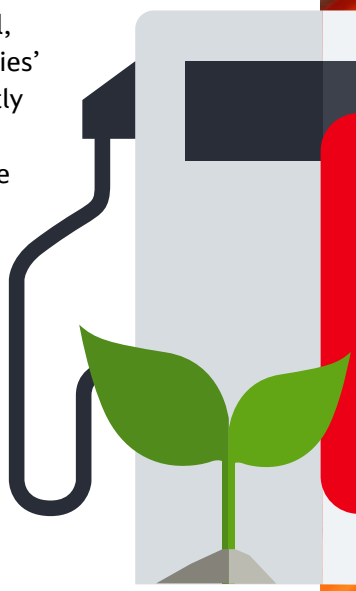
Refuelling and more – how HVO works in practice

The positive effects of the environmentally friendly biofuel HVO on climate change are only one side of the coin. Because, no matter how sustainable the product, if the consumer is not convinced, the product will not be used.

Current usage figures for HVO show that market acceptance of the sustainable fuel is, in fact, already extremely high and that users can see its advantages. But what benefits does it offer over fossil diesel?

HVO is not only environmentally friendly

As described above, HVO is an alternative for companies interested in environmentally friendly transportation, but who are dependent on internal combustion engines. Greenhouse gas emissions are around 90% lower than with conventional diesel, which helps to make companies' own supply chains significantly greener. Moreover, switching from fossil fuels to alternative fuels is also beneficial for DB's own vehicle fleet:



'We have squared the circle - we can run freight trains for our customers in a completely CO_2-neutral manner with alter native fuels and the existing fleet of locomotives.'

Dr. Sigrid Nikutta, DB Director of Freight Transport and Chairman of the Board of DB Cargo

Positive impact without retrofitting:

without retrofitting:
Diesel locomotives can be converted over to HVO without technical modifications. This applies to the entire DB Cargo diesel fleet in Germany, meaning that a transition to HVO does not entail any additional investment.

Mixed fuel:
HVO can be mixed with fossil diesel in any ratio, and locomotives can also run entirely on HVO.

Durability:
The biofuel is significantly less sensitive to cold than fossil diesel. This prevents clogging and eliminates the need to switch between summer and winter diesel. The biofuel can also be stored for longer.

Engine friendly:
The fact that HVO does not contain aromatics results in less coking of important engine components and thus greater durability. The biofuel is also less prone to the development of bio-cultures, commonly referred to as ‘diesel bug’.

Efficiency:
Compared with conventional diesel, no performance differences have been observed to date; the diesel locomotives deliver the usual performance.

«

These properties were verified in long series of tests, culminating in 2020 with the Federal/State Working Group on Pollution Control’s approval for use of the fuel by the rail sector. DB Cargo itself tested the suitability of HVO in extensive test bench and service trials, allowing it to recently achieve a significant reduction in CO_2 emissions even on non-electrified lines.

HVO milestone for 2025 already reached

As mentioned, Deutsche Bahn is already using significantly more HVO than originally expected. In fact, in 2023, the company will use 17 million litres, twice the amount originally planned for the year. This means that the Group will already reach its 2025 volume target in 2023; an important milestone on the road to phasing out fossil diesel. Good availability will be assured by the expansion of refuelling infrastructure and increased production.

This is being driven by the ongoing conversion of diesel refuelling stations over to HVO. In 2022, five refuelling stations offering HVO were already in operation and eight more will be added in the course of 2023. That makes 13 refuelling stations to supply a growing number of approved HVO locomotives. This represents a bottleneck in the transition to the new fuel and explains one reason for the current limited availability on the railways. Planning for the repurposing, expansion or new construction of HVO refuelling stations is already well under way in order to remove this obstacle.

The second area currently limiting availability is also only temporary: production. In recent years, production of HVO in the European Union has increased significantly from 0.5 billion litres in 2011 to 4 billion litres in 2021, and this upward trend is accelerating. Production volumes of 30 billion litres are expected as early as 2025.

»

Favourable cost outlook

Supply shortages combined with high demand naturally affect the price for the end user. Currently, HVO is still somewhat more expensive than fossil diesel. However, prices are expected to level out, partly as production volumes increase. Carbon pricing, taxation and the opportunity for HVO producers to create and trade greenhouse gas emissions allowances will also bring about further price convergence. Given the operational advantages outlined, the remaining price difference is almost negligible.

It is worth noting that it is not only in rail transport that HVO, as an alternative to fossil diesel, represents a sustainable solution on the path to eventually phasing out diesel altogether. Biofuel is also an alternative for road vehicles. Unfortunately, Germany does not yet allow the dispensing of 100% HVO at public refuelling stations, but the trend is moving in that direction. Currently, only admixtures of up to 26% HVO in fossil diesel are permitted. The situation is different in Sweden and the Netherlands, where filling stations that offer pure HVO for motor vehicles already exist. Car manufacturers do, however, have to approve the use of HVO in their engines; something that Volkswagen has started doing for its new cars.

800

locomotives approved for HVO by DB Cargo

As of April 2023

HVO refuelling stations in operation

1. Aulendorf
2. Frankfurt Abf
3. Kassel
4. Westerland
5. Würzburg
6. Bremen Speckenbüttel
7. Seelze
8. Gremberg
9. Katzhütte
10. Mannheim
11. München Nord
12. Nürnberg Rbf

HVO refuelling stations in planning

13. Neuruppin

‘People opting for HVO are making an active contribution to climate protection’

Patrick Bertman and Jörg Schneider have been working at DB Cargo for years on the development and marketing of environmentally friendly fuels and climate protection in general. In this interview, both experts provide an insight into the current state of development and look ahead to the future.

Mr Schneider, Mr Bertman, before we go into HVO in detail, let me ask a general question: How satisfied are you with the progress made by Deutsche Bahn on its journey to climate neutrality to date?

Patrick Bertman: I think Deutsche Bahn is on the right track. We have initiated many measures and some have already been completed successfully. For example, the share of renewable power in DB’s traction power is growing steadily and is already at 65%. The transition to alternative fuels is also progressing well. This is important because we have the ambitious goal of being climate neutral ten years earlier than the target date set by the European Union‘s European Green Deal. Deutsche Bahn has already done a good job of reducing CO_2 emissions by almost 70% over the past 30 years. We are currently making excellent headway with the diesel phase-out in particular. In 2023, Deutsche Bahn will already be using 17 million litres of HVO biofuel in its diesel locomotives, which is double the amount originally projected. And also two years earlier than targeted.

»

While we are on the subject of diesel phase-out: HVO is only one of many alternatives discussed at DB Cargo. Why was this biofuel chosen?

Jörg Schneider: HVO simply combines some very important factors. It is extremely sustainable and produced from biological waste and residual materials, meaning that the use of HVO does not come into conflict with food production. An additional important factor, however, is that HVO can be used in the existing diesel fleet without technical modifications. It was the best solution from an environmental, economic and social perspective, especially since there are no production-ready alternatives currently available for rail freight transport.

PB: Another reason is availability on the market. If there wasn't such a large amount available, we simply would not have been able to achieve the volumes that we have for 2023. There will be no availability problems with HVO, not even in the future. Market analyses show that global HVO production will increase to 30 billion litres by 2025. However, if you compare this with the 17 million litres we will be using in 2023 and the 500 million litres that will be required by the German rail sector as a whole, expansion of the refuelling infrastructure is clearly the next item on our agenda. That's what we're currently working on.

The refuelling infrastructure is an important aspect, especially with regard to transport within factories and other industrial sites, for which HVO could be beneficial. When we look at this type of transport, how are these locomotives, which only operate within a very limited area, going to access HVO?

PB: We are trying to set up as dense a network of refuelling stations as possible so as to offer a refuelling facility for all customers. However, this depends on many factors and is associated with different costs. The same is true for stations where locomotives previously refuelled with

Alternative drive systems and fuels

HVO is considered the most practical bridging technology between now and the end of the diesel phase-out. Alternatives are not yet ready for full-scale production. The advantages and disadvantages of some of these are detailed below.

Air-to-fuel:

- ⊕ Infrastructure can be converted to the new fuels obtained through carbon capture
- ⊕ CO_2 savings of up to 100%
- ⊖ Market availability
- ⊖ Favourable costs compared with fossil diesel
- ⊖ Energy efficiency

Battery-powered locomotive:

- ⊕ CO_2 savings of up to 100%
- ⊕ Zero local emissions
- ⊕ Low-noise operation
- ⊖ Unsuitable for longer operation

Battery-powered locomotive as future retrofit for bi-mode locomotives (last mile):

- ⊕ CO_2 savings of up to 100%
- ⊕ Zero local emissions
- ⊕ Use of electrified drive train
- ⊕ Brake recuperation possible
- ⊖ Battery power for a short time only

H2 engine:

- ⊕ CO_2 savings of up to 100%
- ⊕ Low-noise operation
- ⊕ High power density possible for heavy cargo
- ⊖ No testing in rail freight transport to date
- ⊖ No brake recuperation possible
- ⊖ Weight and space requirement of H2 engine
- ⊖ No hydrogen infrastructure yet

H2 fuel cell:

- ⊕ CO_2 savings of up to 100%
- ⊕ Low-noise operation
- ⊖ No fuel cells yet with the required power
- ⊖ Weight and space requirement of the system
- ⊖ Complex and expensive system
- ⊖ No hydrogen infrastructure yet

H2 fuel cell as future retrofit for bi-mode locomotives (last mile):

- ⊕ CO_2 savings of up to 100%
- ⊕ Low-noise operation
- ⊕ Usable built-in electrified drive train
- ⊕ Brake recuperation possible
- ⊖ Expensive system
- ⊖ Weight and space requirement of the system
- ⊖ No hydrogen infrastructure yet

fossil diesel. Questions we need to consider include: Is additional on-site refuelling infrastructure required, or can the refuelling station be converted over to HVO? Is the refuelling station even able to offer HVO? How many litres will be delivered at the station per year? And a very important aspect: Will the refuelling station still be used by other rail companies that will continue to require fossil diesel? A detailed examination is always required to plan the infrastructure and quantify additional costs.

Could you explain what specific advantages HVO offers the customer?

PB: Those opting for HVO are making an active contribution to climate protection and credibly demonstrating their competitive position as clear pioneers. Customers can also demonstrate the CO_2 savings they are achieving from climate-neutral rail transport in their carbon footprint or CSR report. In return, they receive a certificate attesting to the savings they have made, which can be displayed on their website or social media channels, for instance, and shown to their customers as evidence of their environmentally friendly transport credentials.

What developments do you expect in the coming years in relation to biofuel production anduse and the refuelling infrastructure in Germany?

JS: HVO production will increase significantly over the next few years; from around four billion litres in 2021 to 30 billion litres in 2025. Demand will also continue to grow, which will, in turn, drive a gradual expansion of the refuelling infrastructure in Germany. The current focus is on converting large refuelling stations. For instance, from

1 April 2023, DB Cargo AG will have access to nine HVO refuelling stations, through which it will be able to cover 1/5 of its diesel requirements in Germany with HVO.

How do you expect costs to develop? Is HVO likely to become a more financially appealing prospect compared with conventional diesel in the future?

PB: Yes, but this will also be dependent on favourable taxation. If politicians want a more environmentally friendly transport sector, green alternative fuels must not be taxed the same as environmentally damaging, fossil-based diesel fuel. Increased production is also projected to create economies of scale in HVO costs. In addition, the emergence of new suppliers and production facilities will reduce the currently still very high transport costs. We have already observed this trend in the first quarter of 2023 and expect further cost reductions in the future.

Do you also see potential for greater HVO use for motor vehicles, or will it be used predominantly by the rail industry?

JS: HVO is better suited to sectors where there are currently no production-ready alternatives to replace the diesel engine. Besides rail, these include inland waterway transport and the aviation sector. For road transport, there are already production-ready technical alternatives to the diesel engine, such as fuel cells or battery technology. It is therefore more likely that HVO will only play a niche role in that sector.

Let's take another look into the future: What is the current state of development for further alternatives or successors?

JS: A great deal of research is being done in this area and interesting approaches are being pursued, such as ammonia and air-to-fuel technology, but these are still at the pilot stage. Deutsche Bahn trials the latest rail transport technologies on its two Advanced Train Lab test trains. This enables us to proactively pursue research into alternative drive systems.

HVO is seen as a bridging technology. Do you already have an idea of the ultimate technology that HVO is the bridge to, or are you unable to venture a forecast in this regard?

PB: Besides reducing our diesel fleet, DB Cargo is ensuring the efficient and optimal use of HVO. We are, however, open to new technologies. The object is to find the best possible solution for our requirements, so we are keeping our options open. It remains to be seen whether fuel cells or battery technology will win out in the end.

JS: Let us also not forget innovations such as the bi-mode locomotive, which, in the future, will run on electrified lines with zero emissions. Around 150 of these locomotives have already been ordered and are expected to make our fleet even more environmentally friendly from 2024.

Definition:

Bi-mode locomotives

Bi-mode locomotives have a diesel engine, but run electrically on routes with overhead lines. That means the locomotives can also be used in private sidings, which are not typically electrified.

Conclusion

Electric cars and hydrogen buses are the most visible elements of the decarbonisation of transport on the roads. But a lot is also happening on the already environmentally friendly railways, as the example of the biofuel HVO shows.

This 'green diesel' gives the fuel-dependent locomotives a significantly improved carbon footprint, without sacrificing performance, and is also gentle on the engine. Moreover, the use of residual and waste materials does not compete with food production, which is one of the criticisms levelled against plant-based biodiesel, for example. HVO is thus the perfect bridging technology on the journey to the eventual diesel phase-out at Deutsche Bahn.

There is still a long way to go, however, as there is not yet a production-ready technology to make fossil fuels or their substitutes obsolete in rail freight transport. Therefore, a product such as HVO, which eliminates the need to retrofit the existing locomotives and ensures that the current vehicle fleet can continue to be used, is an important step on the road to climate neutrality.

The takeaways

01

In principle, every diesel locomotive can refuel with HVO and thus contribute to climate protection. No engine modifications are required for this, so the transition is simple once the engine is approved.

02

DB Netz AG is steadily expanding its network of refuelling stations for HVO and successively ramping up the supply, which will also gradually be reflected in the priceof this biofuel.

03

If you are interested in learning more about HVO or are considering switching your diesel traffic over to this sustainable fuel, please do not hesitate to contact us. We look forward to hearing from you.

DB Cargo

Publisher: DB Cargo – Marketing
Responsible for the content:
Thorsten Meffert (V. i. S. d. P.), Vice President Marketing
Uta Kadow, Head of Marketing Communication
Project Management:
Silke Steiner | +49 69 265 34455 | silke.steiner@deutschebahn.com
Concept/Design/Editorial: 480Hz GmbH

dbcargo.com **dbcargo.com/newsletter**

Follow us on social media: