Efficient farming:
Opportunities and obstacles of alternative drives

Foreword

CLAAS‘ goals as an agricultural machinery manufacturer and innovation leader include creating efficient and environmentally-friendly solutions - due to our responsibility towards future generations and because agriculture only works in harmony with nature. At the same time, we take the cost pressure on farmers very seriously. We are constantly weighing up which innovations are practicable, climate-friendly and financially feasible.

This is embedded in a political context. For example, the Climate Protection Act defines an abatement path for greenhouse gas emissions for each emission sector. According to this, only 56 million tons of CO_2 equivalents may be emitted in the agricultural sector by 2030. Compliance is checked on the basis of a previous year‘s estimate. This estimate for 2022 results in total agricultural greenhouse gas emissions of 61.5 million tons of CO_2 equivalents (55.5 million tons of agriculture in the narrower sense plus 6 million tons of fuel consumption) and is therefore below the 67.6 million tons permitted under the abatement path. Compared to 2021 emissions, this is a decrease which is attributable to lower figures in pig farming and lower sales of synthetic fertilizers.

The 1.5C threshold which was adopted in the 2015 Paris Climate Agreement to reduce greenhouse gas emissions and adapt to the effects of climate change is also binding in this context. According to this, the world should only warm by an average of 1.5C or 2C by 2100 compared to 1850.

As the Federal Environment Agency‘s (German EPA) 2023 projection report shows, the agricultural sector will as in previous years more than meet the targets set out in the Federal Climate Protection Act and thus partially compensate for the other sectors‘ shortfalls. As agricultural technology sector we are delighted to be able to support this development with innovative solutions, both now and in the future.

CLAAS sees this as making the operation of agricultural machinery more efficient and therefore more sustainable across the entire process chain. Alongside considerations for alternative drives, this includes increased process efficiency with the help of networked machines, optimizing operation through smart automation and increasing overall machine efficiency.

Dr.-Ing. Martin von Hoyningen-Huene
Member of CLAAS Group Executive Board
Executive Vice President
BU Tractors & Implements / SU Engineering

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Member of the board DLG e.V.

Greenhouse gas emissions are more difficult to avoid in agriculture than in other sectors. There is no such thing as a climate-neutral cow and even an oat drink is not emission-free. This is precisely why we need to use the entire range of production technology innovation tools to reduce the carbon footprint of our products. Simply downsizing domestic production is not a solution but will only lead to emissions being shifted to other regions of the world, meaning we will have to import more food from there. A sustainable increase in productivity is the key to climate-friendly agriculture including technologies for the most efficient use of resources, higher output with fewer animals and, obviously, replacing fossil fuels for powering agricultural machinery. The goal is clear and is shared by everyone - but the way to achieve it is to be found by those who are directly involved in the matter: the agricultural entrepreneurs and their partners in industry and trade.

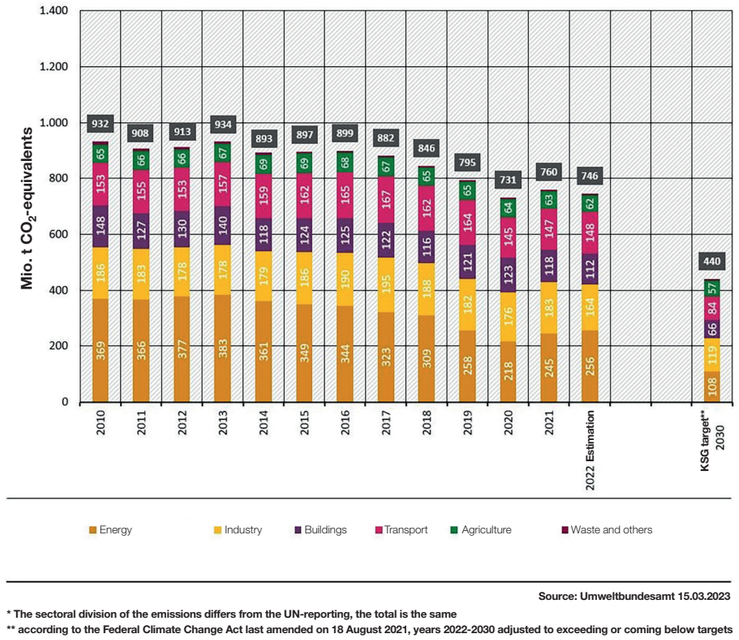
The impact of agriculture on climate change

Climate change is currently the biggest challenge facing European agriculture. The most effective levers for achieving climate neutrality could be more efficient food production which causes far fewer emissions and the use of alternative drives.

The figures are clear. In 2021, German agriculture was responsible for the emission of approximately 56 million tons of CO_2 equivalents This represents 7.4% of German greenhouse gas emissions. Major sources are methane emissions from livestock farming and nitrous oxide emissions from agricultural soils. The proportion of methane (CH4) from animal digestion was 46.4 %, while the proportion of nitrous oxide (N2O) from soils (including emissions from the application of energy crop fermentation residues) was 29.5 %. The remaining 24.1% of emissions from agriculture came from manure management, storage of energy crop fermentation residues, liming and urea application.

Development of greenhouse gases in Germany

Divisions of the sectors according to the Federal Climate Change Act *



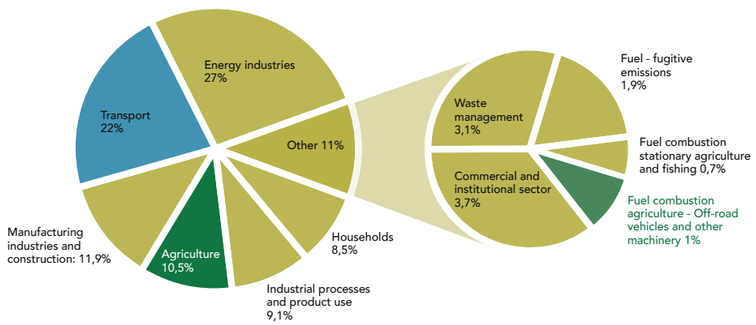
Source: Umweltbundesamt 15.03.2023

*** The sectoral division of the emissions differs from the UN-reporting, the total is the same**
**** according to the Federal Climate Change Act last amended on 18 August 2021, years 2022-2030 adjusted to exceeding or coming below targets**

Challenges of alternative drives in agriculture

One of the biggest challenges in terms of alternative drives is the seasonal use of powerful machines such as large tractors and harvesters. Above all, this requires high machine performance and machine utilization combined with high energy requirements and a practical range of coverage. In addition, many machines are used in various „off-grid“ scenarios where access to public petrol stations, gas and electricity grids or charging stations is limited which represents an additional challenge. Sufficient energy for an entire working day and the ability to refuel on the farm or in the field are essential for real-life applications.

At the same time, there is a need to effectively reduce CO_2 emissions. There are various approaches that could make agriculture CO_2-neutral in the near future. Some technologies for this already exist today, others are well on the way. The most important requirement for an environmentally-friendly future is technological openness. After all, an economic sector as complex as agriculture needs individual approaches to meet the different requirements of the diverse areas of application. Three alternative drive systems are currently being discussed: battery-electric drives, gas-powered solutions and environmentally-friendly liquid fuels. The advantages and disadvantages of the three approaches are explained below.



Source: CEMA (2023)

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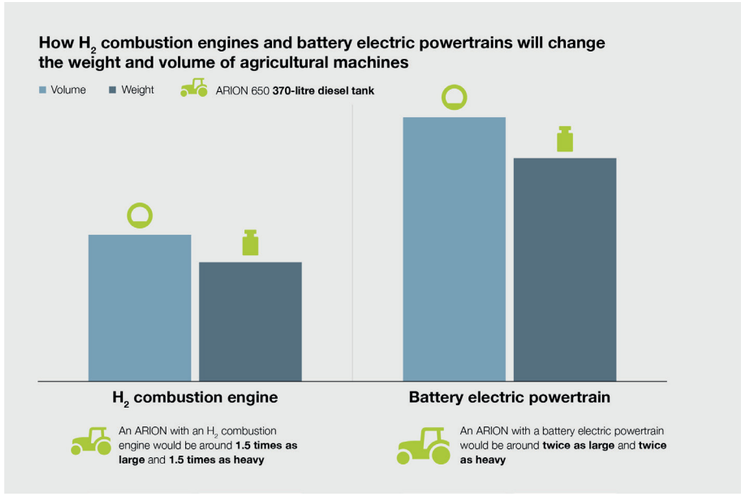
Comparison of alternative drives in agriculture

Battery-electric drives

Battery-electric drives have now established themselves in passenger transportation and have proven to be a viable alternative to the combustion engine. There are also areas in agriculture where a battery-electric drive makes sense, for example for small tractors. When it comes to applications in close proximity to the farm, light field work or municipal use, a battery-electric machine meets the practical requirements. However, the use of battery-electric drives is not yet conceivable for larger and powerful machines. These machines are often used for heavy-duty work and often for the entire working day which would require a very large and therefore heavy battery. A tractor in the mid-power segment with a battery-electric drive would be around twice as large and twice as heavy as a conventional tractor with an engine and liquid fuel. As a result, the machine would cause considerable soil damage during field work which would also lead to a trade-off as the soil pressure of the respective methods must be taken into account in order to maintain healthy soils during field work. A reduced battery capacity with acceptable additional weight would not allow a practical range of coverage.



Source: CLAAS (2023)

Prof. Dr. Peter Pickel
Manager External Relations, John Deere

The reduction of CO_2-eq emissions is one of the biggest challenges facing agriculture and agricultural technology. Although greenhouse gas emissions from the consumption of fossil fuels in agriculture in Germany account for less than 10% of total emissions from agriculture, agricultural machinery manufacturers are convinced that they need to work on new alternative drive technologies in order to reduce the consumption of fossil fuels. As farmers are increasingly generating green electricity themselves with PV systems and wind power plants it stands to reason that this should also be used to power mobile machinery. This is why some agricultural machinery manufacturers are currently developing battery-powered agricultural machinery. According to the current state of battery technology the power density of batteries above approx. 100 hp is not sufficient to enable long days of field work without recharging, otherwise the batteries on the agricultural machinery would have to be too large and too heavy. Much the same applies to hydrogen as an energy source combined with fuel cells as a power source.

Prof. Dr. Jürgen Krahl
Fuel Joint Research Group

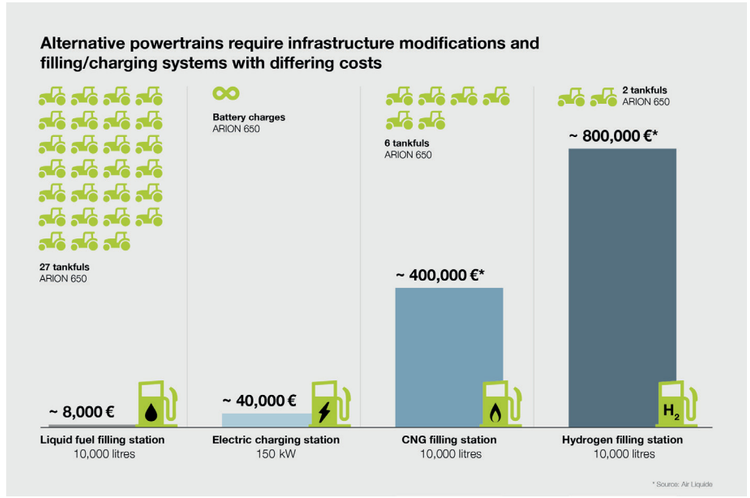
Although everyone is talking about green hydrogen, it is currently hardly available as an energy source. Using it in transportation is possible but requires a separate infrastructure and high pressure for storage. Before hydrogen is used in agriculture under these conditions, it is better off in industry.

Biodiesel has been available for decades and can be used in many tractor engines without any problems - in some cases up to 100 percent. It can be produced from cultivated biomass as well as from residual and waste materials. Together with HVO and diesel fuel, blended fuel can be formulated that meets the EN 590 diesel standard and can therefore be used in all agricultural machinery without further ado. One example is diesel R33 which saves more than 20 percent CO_2 in the existing fleet. Higher reductions are possible.

Today, sustainable fuels can already protect the environment. Ideological discussions neither help agriculture nor prevent global warming. Climate change will not wait. But it can be slowed down.

Gas-based drives

At present, the use of hydrogen with fuel cells in agriculture is simply not realistic. Agricultural machinery requires a lot of power in a short period of time - a fuel cell is not designed for this. In future, however, the use of hydrogen combustion engines would be possible. In contrast to electric drives, these have the advantage that the existing drive train of agricultural machinery could largely be retained, even if a different engine had to be installed. However, carrying hydrogen requires ten times the tank volume compared to the previous setup or frequent refueling. The additional construction space would completely change the current machine design. Further challenges lie in infrastructure and logistics: building your own hydrogen filling station is extremely expensive compared to a diesel filling station. Fuel logistics pose additional challenges due to the low energy density of gaseous fuels. Furthermore, unlike electricity from the socket hydrogen would have to be delivered to the farm or field very frequently which would lead to higher logistical costs.



Source: CLAAS (2023)

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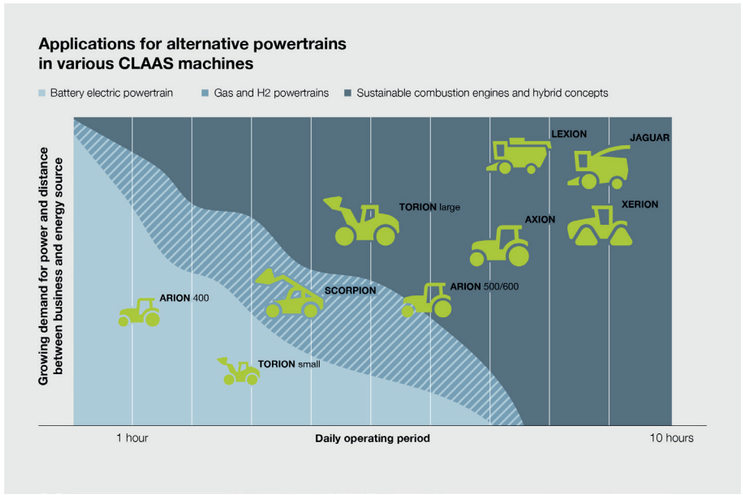
Liquid fuels

Drop-in fuels are the most promising drive technology. The term is derived from the advantage that no modifications to the vehicle are necessary for their use. For example, biological waste and oils are used for their production similar to the fuel HVO („Hydrotreated Vegetable Oil“). Another drop-in fuel is e-fuel which is made from water and CO_2 using electricity. Although the consumption of drop-in fuels just like conventional diesel releases CO_2, the same amount of CO_2 is removed from the environment during their production. They are therefore CO_2-neutral. In addition, the switch to HVO would be by far the quickest, cheapest and most effective in a direct comparison as the existing fleet would also benefit. An average farm would have to invest around 8,000 Euros in a refueling system if it did not already own one.

HVO is already available but is not yet widely used in real life as the sustainable diesel alternative is not yet allowed to be sold at filling stations in some countries - but this is expected to change soon. E-fuels will only be available in sufficient quantities from around 2030. Another environmentally-friendly liquid fuel is biodiesel which is already available and in use. However, its use would make modifications to the machines necessary. In addition, handling and storage are more complicated.

The CLAAS CO_2-Strategy

CLAAS examined the technical challenges, farm infrastructure and future energy availability on farms in a strategy project. This CO_2 strategy is based on the EU‘s goal of climate neutrality by 2050 which requires all sectors (agriculture, energy, industry, transport, households, trade/commerce and waste management) to make their contribution. As an innovation leader CLAAS takes this responsibility very seriously. For this reason, new technologies are investigated and evaluated in order to be able to offer energy-efficient, cost-effective and sustainable solutions. Furthermore, farmers are faced with ever-increasing fuel costs which is why CLAAS has been focusing on efficiency measures in the various machines for some time now and will intensify this further with additional projects as part of the CO_2 strategy.



Source: CLAAS (2023)

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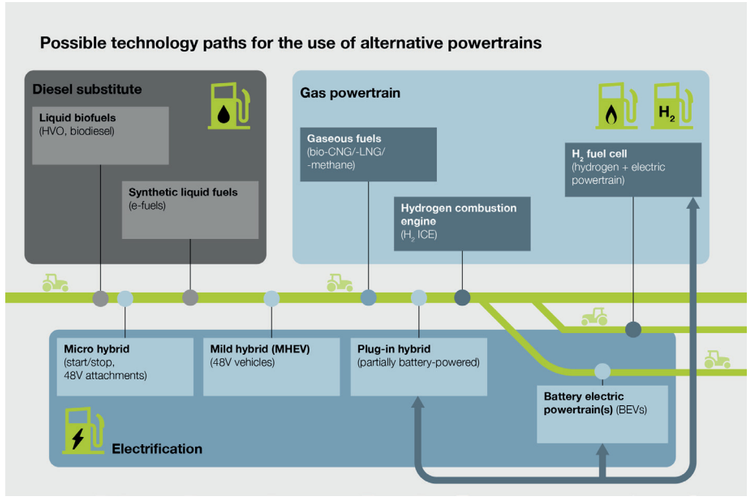
Conclusions and future prospects

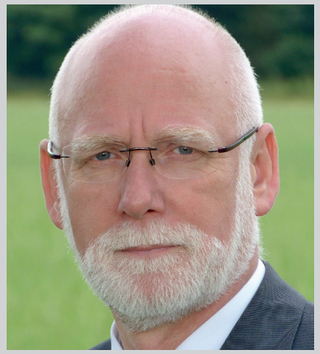
Whether large machines with high performance requirements such as combine harvesters, forage harvesters or tractors will be powered by electricity, hydrogen or HVO in ten years‘ time to carry out their work in the fields cannot be said with certainty at present. Much depends on how the technologies develop and what political parameters are created. However, it is important to fundamentally understand that the real problem is the combustion of fossil fuels, not the engine itself.



Source: CLAAS (2023)

Eberhard Hartelt
Environmental officer of the German Farmers‘ Association | President of the Farmers‘ and Winegrowers‘ Association Rheinland-Pfalz South

Alternative drives are extremely important for agricultural operations and also represent a great opportunity in spite of the technical challenges. Like few other sectors, the agricultural industry is in a position to master the phase-out of fossil fuels „ on its own“. Machines that are mainly used for light work around the farm can be supplied with electricity that farmers generate themselves using wind, sun or biogas. At the same time, they are able to grow the raw materials for sustainable liquid fuel which will be needed for heavy machinery for a long time to come on their own fields. This potential should not be wasted. It is key that future challenges are approached in a technologically open manner and without ideological blinkers. Furthermore, it is important that, apart from financial incentives for investing in new technology, retrofit solutions for existing machines are also offered. Only in this way is it possible to change fleets quickly without placing an unreasonable burden on farms.



Ludger Frerichs
Head of the Institute for Mobile Machines and Commercial Vehicles, Technical University of Braunschweig

In the foreseeable future, we will be able to electrify up to 50% of agricultural machinery. This will mainly be machines used in close proximity to the farm, up to about 100 or soon 150 kW. Although we are working on other solutions, we will still need combustion engines for agricultural machinery for some time to come. These are machines that work productively in the field for many hours a day at high performance. These are machines that work productively in the field for many hours a day at high performance. It goes without saying that we need to move away from fossil diesel. At least until economical „e-fuels“ are available for agricultural machinery we should rely on plant-based fuels.

Battery-electric solutions mean extra weight

The comparison of the three alternative drives shows that liquid fuels are still to be favored for the time being, especially in the medium to high power segment. The reason for this is simple: there is currently no sensible alternative, at least not for harvesters and large tractors from 150 hp. Battery-electric solutions involve a significant increase in weight. This additional weight increases the energy demand, causes soil compaction and thus also affects soil fertility and yield. A JAGUAR forage harvester with an electric drive would therefore be at least twice as large as a current model with liquid fuel. With a hydrogen combustion engine, the additional weight would be much lower but the dimensions would be similar when it comes to installation space. This means that tractors and harvesters would have to be designed completely different. However, the speed of technological development should be taken into account in future scenarios. In particular, battery capacity and charging speed have improved steadily in recent years.

Electrification up to 150 hp

Despite the mentioned restrictions, agricultural machinery will be electrified in the coming years. And this will be the case for machines up to 150 hp. This is because battery-electric drives are a suitable alternative for near-farm applications, light field work and municipal tasks. These machines do not require long ranges and are less needed for energy-intensive field work lasting over ten hours. These machines do not require long ranges and are less needed for energy-intensive field work lasting over ten hours. Therefore, they can be regularly connected to a charging station. Another important point is that over 60% of farms already have their own photovoltaic systems. Their own electrically powered machines will be very attractive consumers.

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Use of sustainable liquid fuels

Since fossil diesel is not a solution for the medium term, the use of sustainable liquid fuels such as HVO, biodiesel and e-fuels are an obvious option. Above all, biogenic fuels would make more sense in agriculture than in the passenger car sector where they are currently blended with diesel and gasoline. The existing fleet of tractors and harvesters could be operated almost CO_2-neutrally with sustainable, liquid fuels - especially with drop-in fuels such as HVO - while the existing infrastructure can continue to be used. Another advantage is the immediate availability of liquid biofuels. At the same time, alternative liquid fuels also create increased energy supply security for the socially important agricultural sector due to their good storability and their potential for local cultivation. In principle, e-fuels are also interesting. However, they will not be available in large quantities in the near future. In addition, the strong demand from the shipping and aviation sectors ensures solvent competitors. In principle, farmers are therefore dependent on sustainable liquid fuels as long as the favored technologies in road transport can only be partly used in agriculture, as outlined above.

Create tax incentives

The fact that liquid, sustainable fuels are currently almost never used in agriculture is due to the political requirement that sustainably powered vehicles should not emit any CO_2. This approach allows the carbon footprint of the individual sectors to be tracked more effectively. It does not matter that HVO, biodiesel and e-fuels are almost CO_2-neutral in terms of the circular economy (see above). In addition, they are currently still at a disadvantage in terms of subsidies and taxes compared to fossil diesel which means that there are currently no incentives for farmers at all. Fair taxation (at least comparable to the current price for agricultural diesel) would encourage its use in the existing fleet. This also means, however, that if subsidies for agricultural diesel are discontinued, incentives for the use of alternative drive systems must be created at a political level. (Until the end of 2021, biofuel used in agriculture and forestry was tax-relieved at 45 cents per liter. Since January 1, 2022 tax relief has no longer been granted).

The important demand remains that agricultural machinery manufacturers such as CLAAS need political support and a reliable framework for the development of alternative drive systems in order to be given a head start, particularly in the lower horsepower segments.

Dr. Edgar Remmele
Deputy Head of the Technology and Support Center (TFZ) Straubing

Renewable, climate-friendly liquid fuels will continue to supply the drive energy for harvesting work for many years to come, for example, as they are lightweight and have a small tank volume, making it possible to carry large amounts of energy on mobile machines. Plant-based oil fuel, biodiesel and paraffinic diesel fuel, such as HVO, are standardized fuels that have been tested in field trials and whose sustainability is guaranteed by regulations at European and national level. Incentives are required for a switch from diesel fuel to renewable liquid fuels. Under no circumstances, however, should renewable fuels be treated less favorably than conventional diesel fuel as is currently the case with the energy tax.

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