

WILL ALL AUTONOMOUS YARD VEHICLES BE ELECTRIC? YES - YARD EMISSION MONITORING FOR SUSTAINABILITY

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› COLOPHON

› This document is one of the project results of *Yard Emission monitoring for Sustainability – YES* (project number: 060.48581)

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› Date June 24, 2022

› Report number TNO 2022 P11204

This research project is part of the research programme Sustainable Living Labs, which is co-financed by the Dutch Research Council (NWO), the Ministry of Infrastructure and Water Management, Taskforce for Applied Research (SIA) and the Top Sector Logistics. TKI Dinalog monitors the progress and the relation to the content of the innovation agenda of the Top Sector Logistics

› Number of pages 23

› Affiliated project [Living Lab CATALYST](#)

› Project partners

Co-funded by:



TKI DINALOG
Dutch Institute for Advanced Logistics



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› YARD AUTOMATION: A STEP TOWARDS SUSTAINABLE YARD OPERATIONS?

RESEARCH IN A NUTSHELL

- › **CONTEXT** Digitization and automation are progressing fast in transport and logistics. Technological advancements are enabling higher levels of automation of vehicles [1]. Especially off-road, confined areas such as yards at ports and terminals offer a less complex Operational Design Domain (especially regarding interaction with other occupants) for deploying automated trucking applications in the short term [2][3].
- › **RESEARCH QUESTION AND AIM** In expert discussions it is often assumed or stated that automated yard vehicles will have an electric powertrain and thus that yard automation contributes to a sustainable yard. However, a clear line of reasoning explaining why the development of autonomous vehicles will go hand-in-hand with the development of electrification is lacking. Therefore the aim of this report is to establish an outlook on how powertrains of future automated yard vehicles are expected to develop by answering the question: **Can it be explained whether and why automated yard transport and electric driving go hand in hand?**
- › **RESEARCH METHOD AND PERSPECTIVES** The research question is answered through literature review and review of manufacturer publications and pilot projects. We consider this question from a technical, operational and legal perspective. Literature review yielded limited results, so the majority of our findings is based on publications by OEMs. Additionally, these are triangulated with expert interviews (DAF, VDL, TNO).
- › **MAIN FINDINGS** From a technical perspective, autonomous yard vehicles can have diesel, battery-electric, or hydrogen fuel cell power trains. Based on legal developments regarding zero-emission vehicles for achieving climate agreement goals, it can be expected that over time yard vehicles will be zero-emission.

› TECHNICAL - POWERTRAINS FOR AUTONOMOUS (YARD) TRUCKS

CAN ALL POWER TRAIN TYPES BE AUTOMATED?

- › If a (yard) truck has a 'drive-by-wire' control system, it can be controlled by an autonomous driving system.
- › Autonomous Vehicle (AV) computer systems need energy, but their power draw does not greatly reduce the range of battery-electric vehicles (BEVs) [4]. Therefore, AVs can be BEVs.
- › General Motors has argued that latency and power requirements mean AVs *should* be EVs [5]; However, interviews with VDL, DAF and TNO confirm autonomous vehicles can have different types of engines including Internal Combustion Engines (ICEs). This is confirmed by examples from several OEMs:
 - › Trials including [long-haul trucks](#) with automated driving functions;
 - › [Available Autonomous yard vehicles](#) and [Terberg](#) as an example of an OEM that gives its customers the choice for powertrain.
- › In an interview, VDL [6] stated all-electric systems are easier to automate because BE powertrains are mechanically less complex than diesel ones. A cost comparison between autonomous diesel and autonomous BE vehicles was not possible, since VDL develops autonomous vehicles from scratch and as integrated systems.
- › DAF [7] stated in an interview that autonomous driving systems for diesel and BE trucks would cost roughly the same. Currently, autonomous diesel trucks would be cheaper to buy because a BE truck is roughly 3 times as expensive as a diesel truck.
- › All manufacturers included in this study agree that (yard) trucks must become zero-emission vehicles soon, as shown in [this outlook overview](#). Some OEMs are already ramping down their ICE production and development [8], others are planning to do so [9].

› TECHNICAL – RECENT AUTONOMOUS ROAD TRUCK TRIALS

RECENT TRIALS ON CORRIDORS USED DIESEL OR BATTERY-ELECTRIC TRUCKS

- › Recent trials with autonomous trucks used battery-electric or diesel-powered trucks. This shows that autonomous road trucks do not have to be electric trucks.



Traton (2021) [10]
Battery-Electric



PACCAR (2021) [11]
Diesel engine
Partner: Aurora



Volvo (2021) [12]
Diesel engine
Partner: Aurora

› TECHNICAL – RECENT AUTONOMOUS YARD VEHICLES

DIFFERENT OPTIONS BY DIFFERENT MANUFACTURERS

- › Autonomous yard vehicles using different types of engines are currently for sale worldwide. This shows that autonomous vehicles do not have to be electric vehicles.



VDL diesel autonomous yard tractor [13]



Qomolo battery-electric autonomous yard truck [14]



Gaussin hydrogen autonomous yard truck [15]

› MANY OEMS DEVELOP BOTH ELECTRIC AND HYDROGEN YARD VEHICLES

EXAMPLE: TERBERG YARD TRACTORS

- › Manufacturers sell similar vehicles with different automation and power train options. Terberg is presented here as an example of an OEM that gives its customers the choice for the powertrain of autonomous yard vehicles.



Battery-electric [16]



Hydrogen fuel cell [17]



Autonomous diesel trial model
[18]

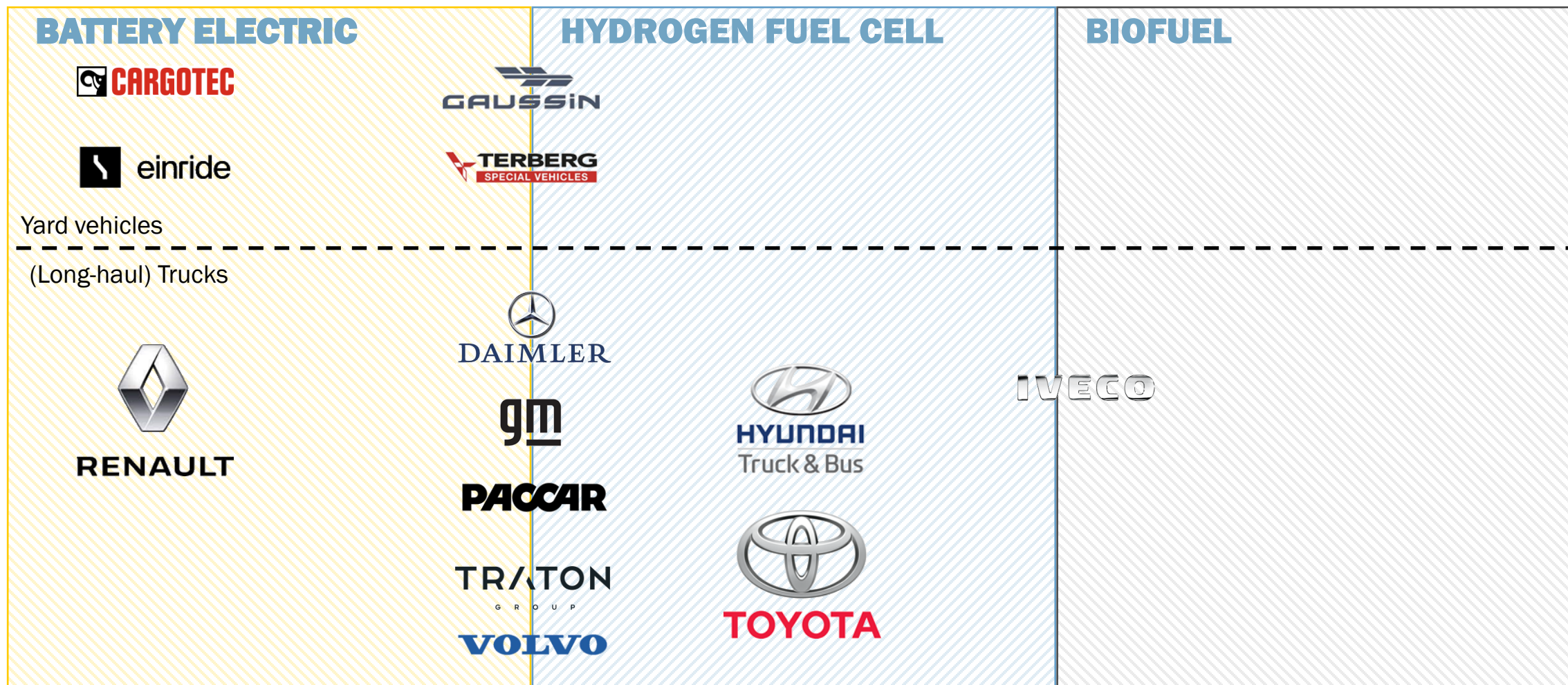
TECHNICAL - POWERTRAINS FOR YARD VEHICLES

OUTLOOK BY OEMS

	OEM	Powertrain outlook
Yard vehicles	Cargotec	Cargotec will produce only battery-electric zero-emission yard vehicles in the coming years [19].
	Einride	Einride believes the best way to power a truck is Battery Electric [20][21].
	Gaussin	Offers yard tractor models that can be powered by batteries or hydrogen fuel cells [22].
	Terberg	Offers yard tractor models that can be powered by batteries, hydrogen fuel cells or diesel [16][17][18] .
	Volvo	Offers the Volvo Vera as autonomous and electric yard tractor.
(Long-haul) Trucks	Hyundai	Believes hydrogen fuel cell vehicles show the most potential [23], but will deliver its truck models with batteries and fuel cell options in the coming years [24].
	IVECO	Has chosen bio-LNG for their line of (net) zero-emission vehicles and is developing an autonomous bio-LNG truck [25]. However, IVECO's VP for product development, Pablo Cebrián, said in 2020 he thinks "hydrogen is the best future alternative for long-distance transport" [26].
	PACCAR (a.o. DAF)	Is developing BE and Hydrogen Fuel Cell (HFC) trucks, but has shown autonomous and connected trucks powered by diesel engines at CES 2022 [11].
	Traton	Traton (MAN, SCANIA, Navistar) believes "the future of trucks is electric"[27]. Navistar (owned by Traton) is also building HFC trucks [28]. Navistar's CEO has said he thinks "Hydrogen fuel cells offer great promise for heavy-duty trucks in applications requiring a higher density of energy, fast refueling and additional range". No news on this has come out since Traton acquired Navistar in July 2021.
	Renault	Believes battery-electric (BE) is the best way to power a truck [29].
	Toyota	Invests in development of and trial with trucks using hydrogen fuel cells [30]. However Toyota believes the choice of drive train type is up to consumers and markets [31].
	Volvo	Believes ICE's will still be used [32], powered by bio-diesel or other e-fuels, but also develops HFC [33] and BEV [34] models.

› TECHNICAL – VISUALIZATION OUTLOOK (YARD) TRUCKS

POWERTRAIN DEVELOPMENT (MARCH 2022)



› OPERATIONAL PERSPECTIVE

CORRIDORS

CORRIDORS

- › Research in Germany [35] reveals that for freight companies, maximum driving range, refuelling time and lifetime operating costs are the three most important factors when purchasing a heavy-duty road truck. (Tank-to-wheel emissions are at the very bottom of their priorities list).
- › DHL has ordered 100 level 4 autonomous trucks from TuSimple. *“The plan is for the trucks to be battery-electric when battery life improves. Current testing is done with diesel trucks because of the 200-mile range currently available.”* [36].
- › A study comparing estimated purchase cost found BE trucks in Europe are likely to be significantly lower than those for HFC road trucks until at least 2030 [37].
- › A study comparing total cost of ownership (TCO) for battery-electric and hydrogen fuel cell trucks in China found the TCO would also likely be lower for BE trucks until at least 2030, due to lower vehicle purchase cost and lower fuel cost [38].

› OPERATIONAL PERSPECTIVE

YARDS

YARDS

- › ‘Range anxiety’ (the fear that a battery electric vehicle has insufficient energy to cover the distance needed), is less of an issue for yard vehicles. They are mostly operated in confined areas and drive short distances.
- › Recharging of batteries takes longer than refilling a diesel or hydrogen tank, so the uptime % of diesel or hydrogen fuel cell yard tractors will be higher than that of a similar battery-electric model. This is important for yard vehicles that are in (near)continuous use.
- › If and when rollout of ultra-fast ‘megawatt charging’ happens, the difference in uptime % will disappear.
- › During an interview with TNO, an owner of yard vehicles stated their individual use case and TCO calculations would determine which type of power train they choose for their vehicles [39].

› OPERATIONAL PERSPECTIVE

GENERAL OBSERVATIONS

GENERAL

- › For corridors and yard vehicles, the (lack of) availability of green hydrogen and electricity on site or the corridor will influence fleet owners' power train choice. According to the Dutch transport business association, the lack of electricity network capacity is already slowing down the electrification of road transport vehicles [40]. Similar supply concerns apply to yard trucks.
- › For most applications of road trucks, battery-electric models are expected to have a lower total cost of ownership [41].
- › Recharging batteries currently takes hours, where refilling fuel tanks takes minutes. This means battery-electric vehicles need to plan for significant downtime due to recharging.
- › For battery-electric vehicles, autonomous operation allows for more flexible planning of recharging and operations without taking driver shifts, driver wages, or mandatory breaks and rest time into account.

› **LEGAL PERSPECTIVE**

AUTONOMOUS VEHICLES

Rules and regulations can be an obstacle to realizing tests or use of autonomous vehicles.

THE NETHERLANDS

- › In the Netherlands, experiments with autonomous driving are explicitly allowed by a law called the ‘experimenteerwet zelfrijdende auto’s’ [42].
- › The emphasis placed on road safety and the unpredictable lead times and requirements makes getting approval for experiments under this law difficult [43].

INTERNATIONAL

- › Internationally, legislation is being introduced allowing (experiments with) autonomous vehicles on public roads [43].
- › For example, Germany adopted a law in July 2021 allowing level 4 autonomous vehicles on public roads [44].

› **LEGAL PERSPECTIVE**

ZERO-EMISSION VEHICLES

Legislation encourages companies to adopt zero-emission vehicles.

- › The EU is developing a range of policies and rules to reduce carbon emissions from the transportation sector [45].
- › The EU has adopted emissions standards for heavy duty vehicles, active from 2019 [46].
- › By May 2023, haulers operating zero-emissions trucks in the EU must receive discounts of at least 50% on distance-based road tolls [47].
- › In The Netherlands, companies purchasing a zero-emission truck can apply for a government subsidy [48].
- › During an interview, a fleet owner of yard trucks stated they believe legislation will in time force them to adopt low- or zero-emission vehicles. [39]

› SUMMARY

TECHNICAL

- › Technically, autonomous yard and road trucks can have different types of power trains; diesel, battery-electric, or hydrogen fuel cell models are available for purchase or being tested.
- › Development of autonomous vehicles often happens separately from development of zero-emission vehicles.
- › The type of powertrain does not greatly influence the cost of autonomous systems for trucks.
- › Most manufacturers sell vehicles with different types of power trains, leaving the choice up to their customers.

OPERATIONAL

- › Most vehicle owners will choose a power train type with the lowest vehicle total cost of ownership (TCO). For most use cases, battery-electric vehicles will have a lower TCO than hydrogen fuel cell vehicles (until at least 2030).
- › (Lack of) availability of green electricity and/or green hydrogen will be also influence the power train type preference of fleet owners.
- › Battery-electric vehicles need significant recharging time. Recharging and operations are easier to plan if no driver is involved.

LEGAL

- › In The Netherlands and the EU, laws and subsidies encourage the adoption of zero-emission vehicles.
- › Autonomous vehicle tests on public roads are allowed in The Netherlands, but in practice some hurdles are encountered when applying for a permit.

› AUTONOMOUS & ELECTRIC YARD VEHICLES – A GOOD COMBINATION

CONCLUSION

To answer our research question ‘**Will automated yard transport and electric driving go hand in hand?**’ we conclude the following:

- › There are no technical reasons why autonomous yard vehicles must (or must not) be electric (in terms of feasibility or costs). They can, but do not have to, go hand in hand.
- › Because of legal requirements and subsidies, it is likely that most vehicles operating on yards will become zero-emission vehicles. For most use cases, we expect battery-electric vehicles will be preferred due to their lower total cost of ownership.
- › Operationally, battery-electric vehicles can benefit from automation because this gives them more flexibility to plan recharging and operations without taking driver shifts, driver wages, or mandatory breaks and rest time into account.
- › If automated (yard) trucks will be electric as well, the road transport concepts will reduce both emissions and improve efficiency substantially. The cost reduction resulting from an automated truck might even compensate for the additional purchasing costs of an electric truck.
- › Therefore, we expect most (but not all) autonomous yard vehicles will also be electric vehicles.

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