ZERO EMISSION, FLEXIBLE VEHICLE PLATFORMS WITH MODULAR POWERTRAINS SERVING THE LONG-HAUL FREIGHT ECOSYSTEM (ZEFES)

Omar Hegazy,
Vrije Universiteit
Brussel (VUB),
ETEC Dept., &
MOBI-EPOWERS
research group,
Pleinlaan 2, 1050
Brussel, Belgium

Ben Kraaijenhagen,
Vrije Universiteit
Brussel (VUB),
ETEC Dept., &
MOBI-EPOWERS
research group,
Pleinlaan 2, 1050
Brussel, Belgium

Abstract

Long-haul BEVs and FCEVs need to become more affordable and reliable, more energy efficient, with a longer range per single charge, and a reduced charging time to meet the user's needs. Next to those, there is a real need to take zero emission long-haul freight transport in Europe to the next level by executing real-world demonstrations of BEVs and FCEVs spread all over Europe. This requires technology delivering on promised benefits, flexible and abundant charging points in need of novel charging concepts. In addition, as multiple needs in the logistics chain exist, novel tools for fleet managers providing them with better information on ZEV in logistic operation, providing information on better logistics planning, the charging and refuelling along the route, access to roads and traffic information. Therefore, the ZEFES (EU granted project under GA 101095856) will contribute to improving the Long-haul heavy-duty vehicles through the following key outcomes:

- Executing of real-world demonstrations of long-haul BEVs and FCEVs across Europe. Pathway for long-haul BEVs and FCEVs to become more affordable and reliable, more energy efficient, with a longer range per single charge and reduced charging times.
- Technologies delivering promised benefits to operate in complex transport supply chains. Mapping of flexible and abundant charging/Hydrogen Refuelling Stations (HRS) points and advanced charging concepts, such as Mega Charging systems (MCS).
- New tools for fleet management to support long-haul BEVs and FCEVs vehicles in the logistics supply chains.

Keywords: Greening Road freight transport, carbon reduction, electrification, alternative fuels, zero emission logistics

Abbreviations

BEV	Battery Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
ZEV	Zero Emission tailpipe Vehicle
CCs	Combined Charging System
HD	Heavy Duty
ZE HDV	Zero Emission Heavy Duty vehicle
HDV	Heavy Duty Vehicle
HDV BE	Heavy Duty Vehicle Battery Electric
HDV FCE	Heavy Duty Vehicle Fuel Cell Electric
HD ZEV	Heavy Duty Zero Emission tailpipe Vehicle
MCS	Megawatt Charging System
HRS	Hydrogen Refuelling Solutions
HDV	Heavy Duty Vehicle
ICE	Internal Combustion Engine
EU	Europe, European
OEM	Original Equipment Manufacturer
KPI	Key Performance Indicator
TCO	Total Cost of Ownership
WBG	Wide Band Gap
SiC	hard chemical compound containing silicon and carbon
DT	Digital Twin
AEVETO	Advanced Electric Vehicles (trucks & coaches) for Efficient and Economic Transport Operations

1. Introduction

Within the European Green Deal [1], Europe commits itself to be the first CO_2 neutral continent, by 2050. To achieve this, a first milestone is defined as an overall CO_2 reduction target of 55% by 2030 [2]. For the road transport sector, the target is set at 45% less CO_2 emissions by 2030, following Regulation (EU) 2019/1242. The regulation requires that manufacturers of heavy-duty vehicles (HDV) deliver more efficient vehicles: a reduction of CO_2 emissions for the newly produced fleet of 15% in 2025 and 45% in 2030. The use of zero tailpipe emissions vehicles (ZEV) for long distance heavy transport is an important part towards achieving the above targets. Until now, these vehicles have a limited range: this makes it difficult to use them effectively as replacements for vehicles with an internal combustion engine (ICE). Furthermore, a challenge exists regarding charging of the vehicles. A large-scale switch to electric vehicles for long distance heavy transport requires many charging points. Particularly, if the best use of driver’s breaks is to be made. The EU rules on driving times and rest periods prescribe a break of 45 minutes, which is a perfect moment to recharge the vehicle [3]. After such a break, the vehicles should be able to drive 400 km or more (until the next break). Energy prices are having a big impact on the rate of the introduction of ZEVs as well. Fuel cells will be a useful part in the fleet electrification process, especially for certain types of heavy transport, when there is a lack of ZEV-charging points, when there is a low price of hydrogen and when additional requirements are imposed upon the refuelling rate.

Given the near-term breakthrough of battery electric and fuel cell trucks, three important challenges remain. **Firstly**, the efficiency of the vehicles is a key factor for the rate of the introduction. Lower energy consumption means smaller battery packs are needed, which means lower investment (and less need for raw materials). Vehicles with smaller batteries are also lighter, which again means that less energy is used when on the road. Modularity will make sure the right vehicle configuration for each mission can be used. Together these will make charging briefer, limiting the need for charging capacity. Therefore, increasing the efficiency and modularity has a reinforcing effect. **Secondly**, preparing the technology for mass production, scaling-up the production will be needed, to reduce prices via volume effects and technical improvements. The modularity of vehicle components and architectures will be of big help here. **Thirdly**, when switching to ZEV, the question that arises as to how these vehicles can be used in the operator's fleets, given the range, charging possibilities and transport demand. Digitalization comes in here and will support the smooth integration of ZEVs and help increase the operational efficiency. In the ZEFES project, https://zefes.eu/, OEMs, suppliers, and research partners will work together towards the overall goal of ZEVs for long distance heavy transport, by focusing on efficiency improvements, mass production capabilities and demonstrating the use of the technology in daily operations. This will bring ZEV adoption in the freight transport ecosystem a big step further.

2. ZEFES Project structure

2.1. Ambition and Objectives

ZEFES project will make sure innovations will be implemented (Market readiness) by 2028/2029, or at the latest two to three years after that, around the 2030 deadline. This means it will accelerate the delivery of flexible platforms of 4 OEMs plus 2 trailer OEMs for multiple long haulage missions, geared towards achieving ambitious Key Performance Indicators (KPIs) on the vehicle front regarding efficiency, range and Total Cost of Ownership (TCO), as well as in the logistics sector. ZEFES project will proof that the technology can deliver on the promised benefits soon, at relatively high rates and medium traffic complexity, for freight transport.

Figure 1 – Logistics missions, challenges and KPIs

The results will improve the living environment of all citizens, contribute to the competitiveness of Europe thanks to technological advances and increase prosperity thanks to lower transport costs.
The ambition of the ZEFES project is a direct response to the call CL5-2022-D5-01-08, "Modular multi-powertrain zero-emission systems for HDV (BE and FCE) for efficient and economic operation (2ZERO)" [4].

2.2. Key project Objectives

Objective 1: improve modular Heavy Duty (HD) Battery Electric Vehicles (BEVs) and Fuel Cell Electric Vehicles (FCEVs).

To accelerate the transition to ZEVs, it is important that these vehicles offer the same or better properties than the conventional vehicles that have an ICE.

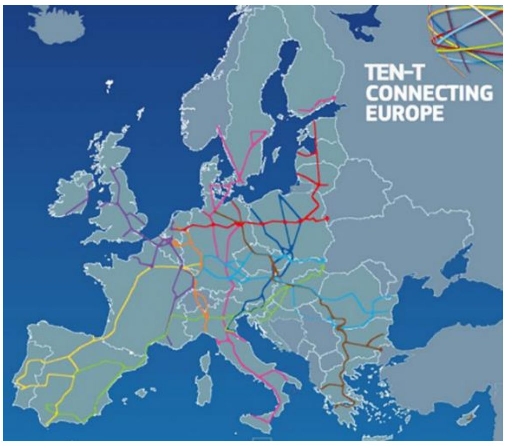
Figure 2 – Modular Heavy Duty (HD) Battery Electric Vehicles (BEVs) and Fuel Cell Electric Vehicles (FCEVs).

ZEFES has, therefore, the goal to deliver more efficient, multi-modular powertrains, with renewed components, including distributed battery packs and e-axles in the vehicles, the prime movers (tractor units or rigid trucks) and (semi-)trailers.

Figure 3 – Modular battery packs and e-axles in trailers

Objective 2: demonstrate an interoperable Megawatt Charging System (MCS) and the location deployment strategy for hydrogen refuelling solutions (HRS) to accommodate and make ZE HD transport possible along several corridors.

ZEFES will map several European corridors suitable for the successful rollout of ZEVs across Europe.



Users of commercial transport vehicles require well-distributed locations, regarding charging stations for BEVs and hydrogen refuelling solutions for FCEVs.

Connected fleets of vehicles help to improve the effectiveness of these vehicles and their charging/refuelling. Battery-packs in the trailers can be charged independently since this contributes to the flexible use of the prime movers and trailers.

Figure 4 – TEN-T corridors in Europe [5]

For FCEVs, the hydrogen works as a range extending energy carrier. Charging will be made briefer by developing an interoperable interface for the Megawatt Charging System (MCS) using recent wide bandgap (WBG) (i.e., silicon carbide (SiC)) power modules.

Objective 3: provide digital and fleet management tools specifically for HD ZEVs, fleet integration with remote operational optimisation of vehicle performance.
ZEFES will design an open platform to represent European logistics missions, enabling an assessment of the impact on environment and society of using HD ZEV.

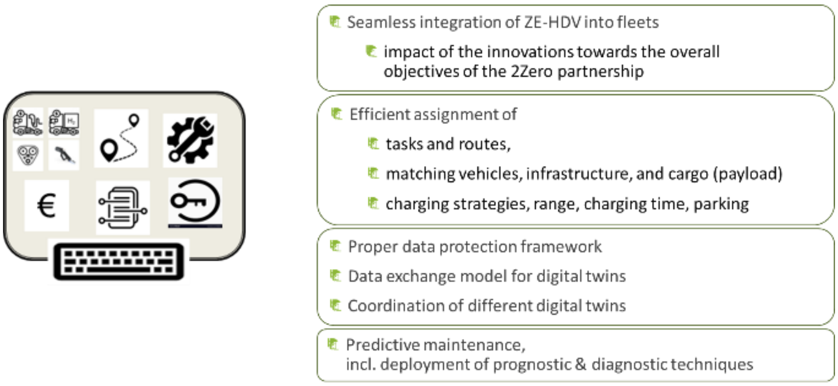
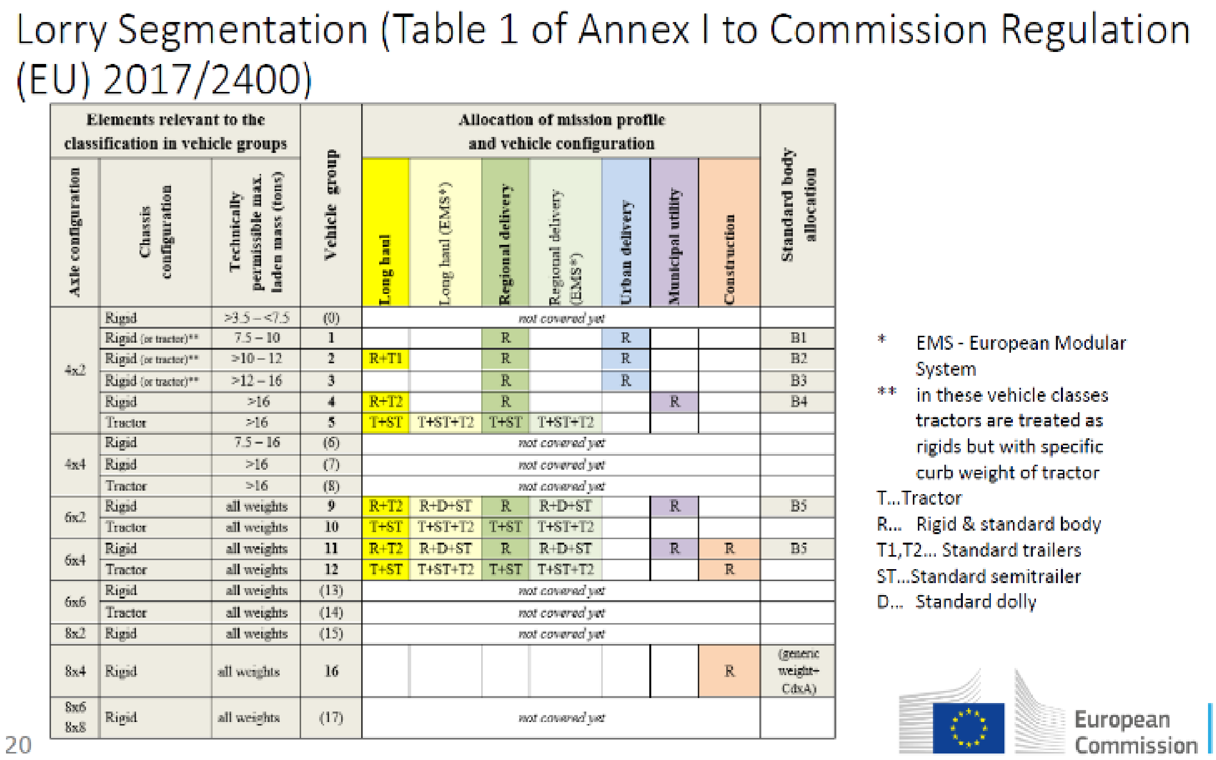


Figure 5 – Schematic description of the digital platform

The Digital Twin (DT) platform will include modules (Digital Twins - DT), provide tools such as “life-cycle assessment”, “assignment and routing”, “vehicle performance”, “vehicle condition/system ageing”, “logistics performance” etc. A DT here is a virtual representation of an object or system, possibly spanning its lifecycle, that is updated using real-world, possibly real-time data. Such a DT uses simulation, machine learning and reasoning to help decision-making [6]. The data that is made available/generated by the demonstrations is used for the management of fleets with regard to daily operation along the route (fuelling, parking, navigation etc.) and for efficient assignment of tasks (routes, charging strategies, assignments etc.); for planning maintenance, or repair, i.e., for the condition monitoring of the vehicle; for monitoring the performance of the vehicle itself (for forecasting purposes).

Objective 4: demonstrate missions on cross-border, TEN-T corridors, fulfilling the requirements for range and payload, and comparing the deploy ability of BEVs and FCEVs for different mission profiles.
The efficient vehicles from the previous objectives are used to show how to drive effective missions and to compare the use of FCEVs and BEVs. The demonstrations will show how the vehicles can be used, in terms of energy use, payload, cooling of refrigerated goods etc. The ZEFES vehicle combinations will represent the vehicle group 9- 10 and 11– 12 of VECTO Tool, whereas the vehicle groups 4 and 5 do not suit vehicle weights above 40t GCW. See figure 6 for the total overview of VECTO vehicle classes. The collected data of the demonstrations will be used for comparisons and to make it clear to logistic companies that it is possible to use these ZEVs. Next to that, the data is used to make better configurations of vehicles.

Objective 5: define pathways for a significant price reduction and volume increase.
Pathways are created that show the steps for the cost reduction/price reduction of components and volume increase towards mass production, which can be achieved due to the help of the modularity and standardisation of components in the project. Cost reductions, because of market uptake and technical improvements, will be assessed by considering potential synergies with other industries and modes of transport, such as buses,
taxis, trains, forklifts and, especially for FC option, maritime applications.



Lorry Segmentation (Table 1 of Annex I to Commission Regulation (EU) 2017/2400)

Elements relevant to the classification in vehicle groups			Vehicle group	Allocation of mission profile and vehicle configuration							Standard body allocation
Axle configuration	Chassis configuration	Technically permissible max. laden mass (tons)		Long haul	Long haul (EMS*)	Regional delivery	Regional delivery (EMS*)	Urban delivery	Municipal utility	Construction	
4x2	Rigid	>3.5 – <7.5	(0)	not covered yet							
	Rigid (or tractor)**	7.5 – 10	1			R		R			B1
	Rigid (or tractor)**	>10 – 12	2	R+T1		R		R			B2
	Rigid (or tractor)**	>12 – 16	3			R		R			B3
	Rigid	>16	4	R+T2		R			R		B4
	Tractor	>16	5	T+ST	T+ST+T2	T+ST	T+ST+T2				
4x4	Rigid	7.5 – 16	(6)	not covered yet							
	Rigid	>16	(7)	not covered yet							
	Tractor	>16	(8)	not covered yet							
6x2	Rigid	all weights	9	R+T2	R+D+ST	R	R+D+ST		R		B5
	Tractor	all weights	10	T+ST	T+ST+T2	T+ST	T+ST+T2				
6x4	Rigid	all weights	11	R+T2	R+D+ST	R	R+D+ST		R	R	B5
	Tractor	all weights	12	T+ST	T+ST+T2	T+ST	T+ST+T2			R	
6x6	Rigid	all weights	(13)	not covered yet							
	Tractor	all weights	(14)	not covered yet							
8x2	Rigid	all weights	(15)	not covered yet							
8x4	Rigid	all weights	16							R	(generic weight+CdxA)
8x6 8x8	Rigid	all weights	(17)	not covered yet							

* EMS - European Modular System
** in these vehicle classes tractors are treated as rigids but with specific curb weight of tractor
T...Tractor
R... Rigid & standard body
T1,T2... Standard trailers
ST...Standard semitrailer
D... Standard dolly

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European Commission

Figure 6 – Overview segmentation vehicle classes for the VECTO Tool [7]

Objective 6: analyse the impact on business, society, and energy efficiency.
Part of the project is to assess the impact that is caused by the introductions of ZEVs for heavy-duty transport in long-haul missions, including the improvements made in ZEFES. The business models of integrating BEVs and FCEVs in the fleet of the operators of the demonstrators are also part of ZEFES. A lifecycle assessment (LCA) is used to systematically record and analyse the impact on the environment throughout the entire life the of vehicles, including the carbon dioxide which is emitted during the vehicle construction and its disposal at the end of its life.

2.3. Working plan

The overall workplan of the ZEFES activities can be grouped in 6 building blocks.

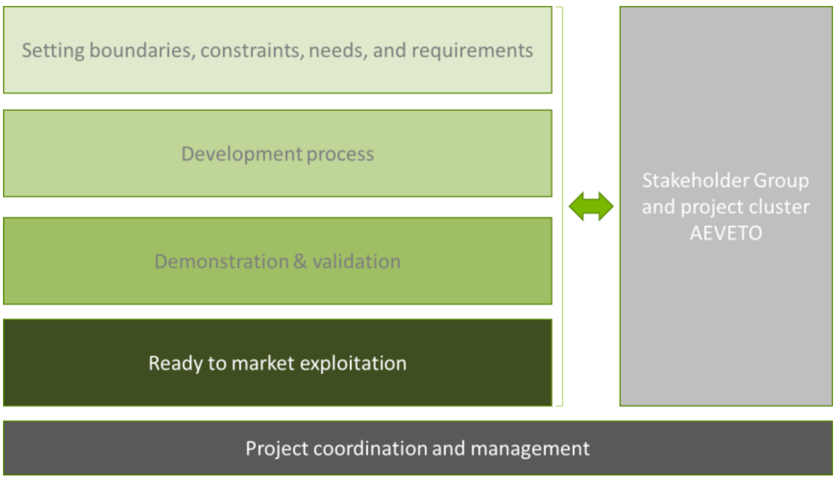


Figure 7 – Workplan ZEFES activities

2.3.1. Setting the boundaries, constraints, needs and requirements.

The first 9 months. Setting the boundaries, constraints, needs and requirements for a Zero Emission Freight EcoSystem from an environmental, health & safe, societal and logistics point of view; the Co-design of vehicles, Infrastructure charging and re-fuelling technologies and concepts, fleet management strategies and connectivity, development of charger hardware; the real-world applications covering long-haul and regional/national logistic use cases.

2.3.2. Development process.

The second phase up to month 27. Development process creating optimised and efficient zero emission drivetrain concepts, the build of flexible and highly efficient 9 demonstrators (6 BEV and 3 FCEV), and the digital services/tools for fleet implementation, fleet & logistics operations, and predictive maintenance, including the assessment models,

2.3.3. Demonstration & Validation.

The third phase will last up to month 40. Demonstrations & Validations based on the 9 demonstrators in 15 real-world logistics missions over a period of 15 months. Covering long-haul cross border distances up to 1,300 km daily to destination, and national / regional distances up to 700 km daily. A functioning infrastructure for charging, re-fuelling, meeting the operational and logistics requirements. A functioning digital set of tools ensuring smooth & reliable operations. The validation of the demonstrations results in a state of the art vs. beyond state-of-the-art comparison, and the assessment of the impact and feasibility for future implementation by 2028/2029.

2.3.4. Ready to market exploitation.

The fourth phase up to month 42. Ready to market exploitation, definition of clear measures and milestones to conclude market feasibility and sustainable business case, and the pathways towards mass production of the products and services/tools developed within ZEFES, the scale up market introduction on a European scale, and finally the dissemination including project Clustering (AEVETO Cluster) with 4 other projects in the same topic.

2.3.5. Project coordination and management.

The project coordination and management also cover the ZEFES Data Management Plan, covering define need for data, data interface, formatting, signalling; installing hardware to collect data; IOT system; connectivity, commissioning, format of messages, etc., collection of data and clustering the data and analysis of data.

2.3.6. Stakeholder Group and Project cluster AEVETO cluster

An interdisciplinary and high-quality **Stakeholder Group** has been established to cover the input ZEFES needs from the outside on needs and requirements and to include representatives of the most relevant networks in the EU in the electromobility domain, other OEMs, Tier1 and 2 suppliers, the providers of systems for the charging infrastructure (charging point operators), shippers, policy makers including authorities and regulatory bodies.
The **AEVETO cluster** - aims at virtually clustering independent R&D projects. The winning projects of the call CL5-2022-D5-01-08 and already running funded project; ZEFES, ESCALATE, EMPOWER, NextETRUCK, H2HAUL. Thanks to synergies across projects, they can jointly achieve a higher level of impact beyond project level, contributing more strongly to the further development and adoption of BEV and FCEV in the heavy-duty sector. This will bring about the transition towards the next generation of electro mobility in Europe by 2030-40, in alignment with the targets and timeline defined in the 2ZERO partnership [9].

2.4. Expected outcomes

The figure 8 gives an overview of the expected outcomes of the ZEFES activities. After the duration of the project, the impact on the medium (2030) and long-term period (2050).

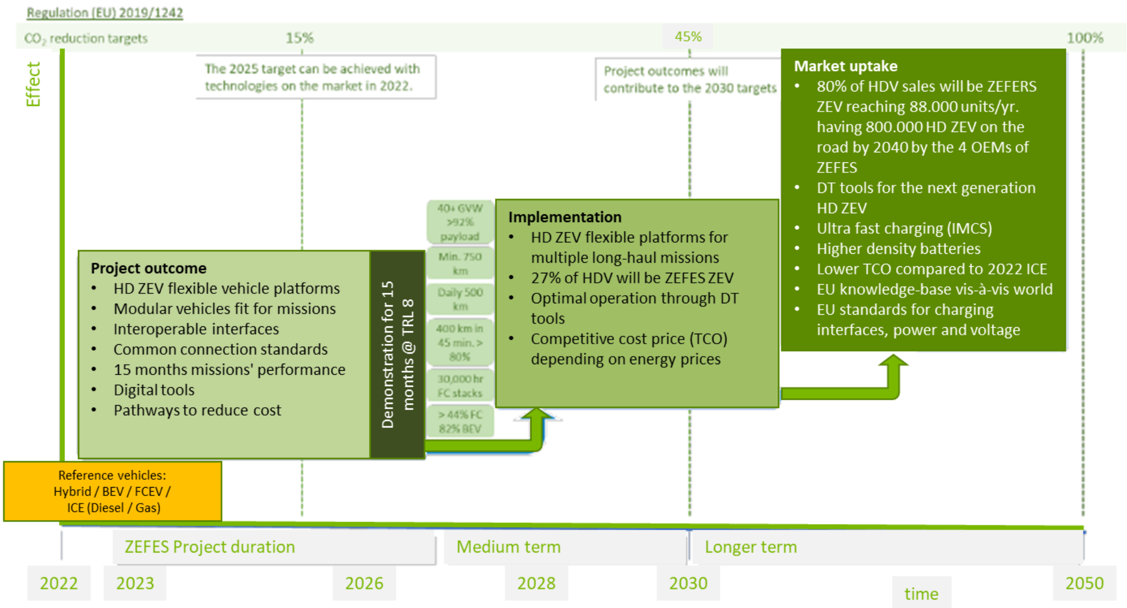


Figure 8 – Expected outcome ZEFES project

ZEFES delivers HD ZEV platforms at TRL8. Modular vehicles of 4 OEMs plus connected Trailers: eTrailer, bTrailer, eCooled, in 9 vehicle configurations, suitable for use in selected regional & national long haulage missions of at least 500km daily, and multi modal & cross border long haul missions up to 1300 km single route. Competitive cost price scenarios (TCO) will be investigated. Next to that, the optimal operation of DT tools which includes charging strategies will be achieved. In ZEFES a lifetime of 30,000 hours is targeted for the FC. ZEFES verifies all these technologies in operation on public roads. The data obtained from these demonstrations allows a detailed impact assessment and a collection of learnings to feed into the future development and operation of HD ZEV, e.g., further optimisation of the sizing of battery packs. Bringing all aspects together in one digital twin platform, to cover the vehicle buying decisions, the mission planning, the vehicle application within the logistics mission, the twinning of the model and the real-world data to provide a seamless information stream and the predictive maintenance tools specifically for ZEV, is a main contribution of ZEFES. This platform will allow the shippers to maximise the use of their fleets and will optimize mission planning regarding the infrastructure availability, vehicle range, charging time and payload, and balance the available vehicle applications with the orders of goods (including their timely delivery), whilst helping to establish the best trade-off between cost effectiveness, payload, punctuality, and sustainability.

3. First results 1. phase up to month 9

As the project just started (January 2023), it is only possible to present first preliminary results out of the workshops, interviews with project partners and stakeholders which will be the input for the second phase commencing November, the time the HVTT is holding its symposium. During the symposium it will be possible to present an update of the needs & requirements and first insides of the second project phase, the development process. The link https://zefes.eu/ gives access to up-to-date results of the project. Below a summary of first results which can be shared the moment of writing the paper.

3.1. Workshops with use case owners

The use case owners are the logistic service providers, the shippers, and the carriers. All use cases will be led by the 4 OEMs, supplying the 9 demonstrators, see figure 9, including the necessary type approval, road allowances, and permits. Agreed is to supply 6 HD BEVs and 3 HD FCEVs in 9 configurations.

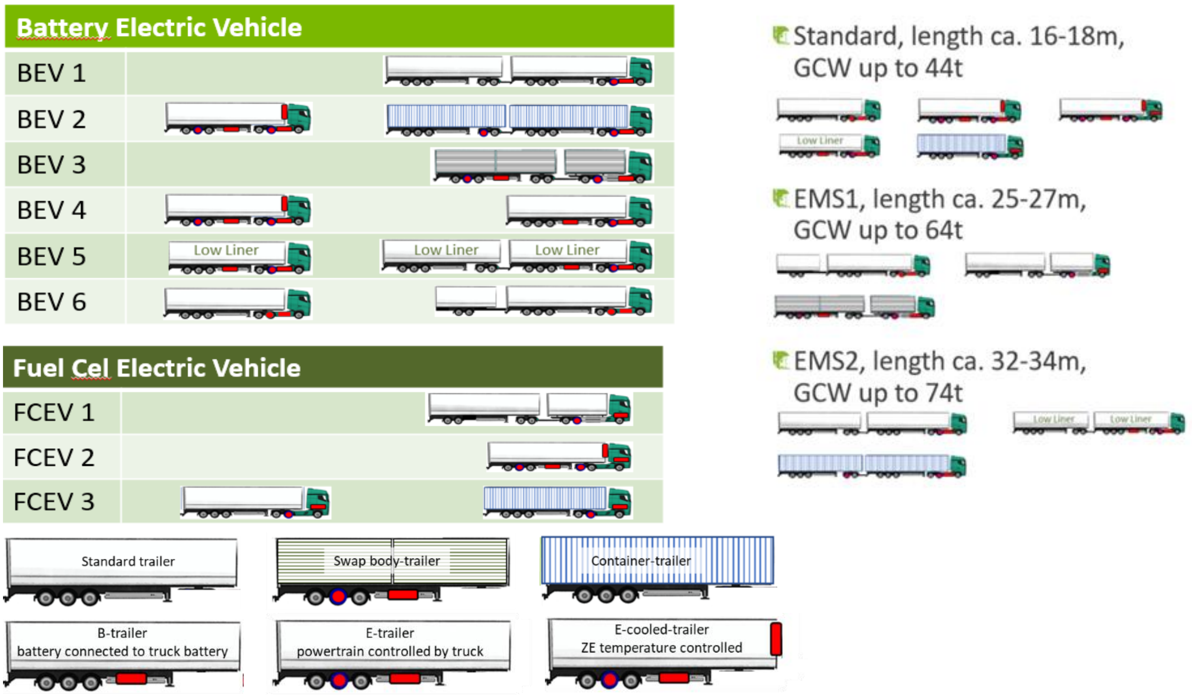


Figure 9 – Overview of ZEFES BE- and FCE-HDVs

Different trailers are specified to suit the logistics missions. Standard trailers, BDF trailer for swap bodies and container trailers. New trailer concepts equipped with propulsions like a battery as range extender, an e-axle and battery to operate a cooling unit (reefer), and a full e-propulsion integrated in the powertrain of the prime mover. A task force is working on the final concept for the e-trailer, meeting the needs & requirements form the logistics, the European standards according to weight & dimensions, braking and propulsion directives. The task force is expected to publish the result by October this year.

The logistic service providers, shippers, and carriers will operate the demonstrators within their daily real time logistics missions, mapping major EU TEN-T corridors, see figure 10. As the shipper cannot guarantee or confirm yet the details of the logistics missions, due to internal purchase process and market dynamics, a fallback scenario must be developed to enable a switch of and or an adaptation of use cases. The final and detailed plan of the demonstrations depends on the mitigation activities to counter the challenges and barriers the project is faced with. This plan needs to be ready by month 24 to enable a start of the demonstrations by month 27.

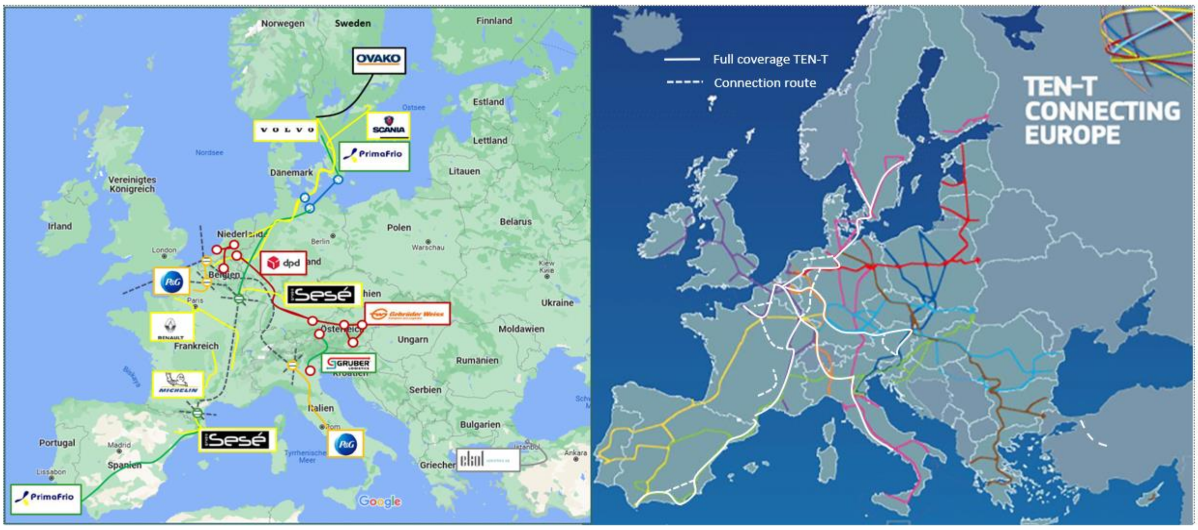


Figure 10 – Overview of ZEFES demonstrations and mapping EU TEN-T corridors

To specify the powertrains of the demonstrators, desk research was undertaken to define the installed usable energy capacity for the demonstrations. In the long-haul transport sector, the energy use per kilometre highly depends on topography, climate conditions, traffic density, vehicle weight & dimensions, and driver behaviour. A study "Energy Distribution Diagram Used for Cost-Effective Battery Sizing of Electric Trucks", [10] was found appropriate to define the basics of the powertrain energy capacity of the demonstrators. The figure 11 below gives a short overview of the basics of the study.

Agreed between the OEMs is to install a usable energy capacity of 600kWh for the HD BEV and 56kg hydrogen for the HD FCEV. Expected cost and availability of components, curb weight of the vehicles and ability for platform usage have been looked at.

During the ZEFES project developments, period M6-M18, the installed energy capacity might be redefined to meet targets of at least 80% recharge, and adding 400km range within 45 min., using fast-charging concepts and achieving a range of more than 750 km for the truck-trailer combination between charging a/o refuelling.

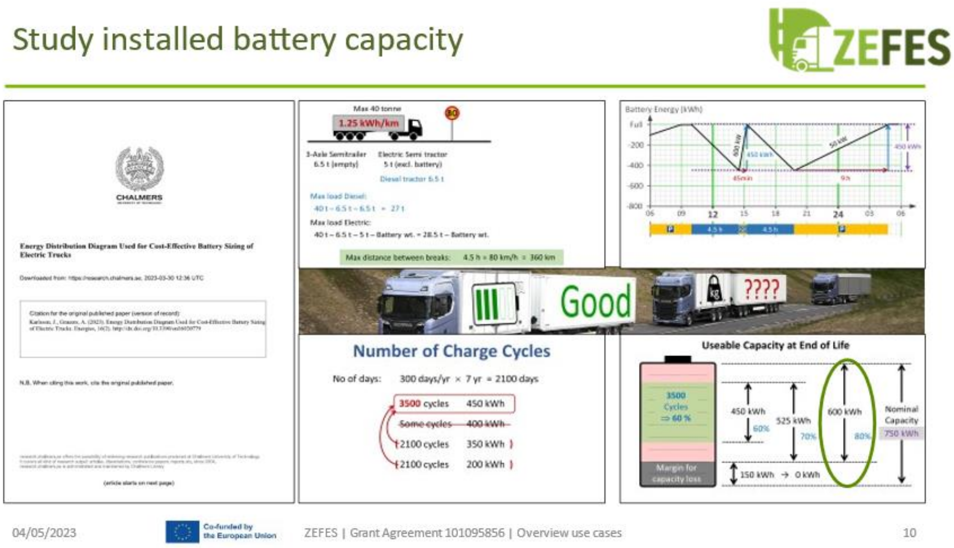


Figure 11 Study installed battery capacity in ZE-HDV @ 44t GCW

Knowing the logistics missions and the vehicle configurations enable the project team to determine a first draft of the required energy infrastructure, charging (CCS & MCS) and refuelling (HRS). The figure 12 gives an overview of the enroute charging and refuelling locations expected to be a minimum of 8 CCS, 12 MCS, and 8 HRS. Ideally a 100% coverage 13 CCS, 21 MCS, 13 HRS stations. This is a preliminary overview and will change during the coming period up to Month 24 as we are depending on external organizations and authorities responsible for permits, invest, works, availability of equipment. A second task force is working on this, finding investors and services station managers / operators willing to collaborate with the ZEFES project and prepared to invest in future charging CCS/MCS and refuelling HRS.

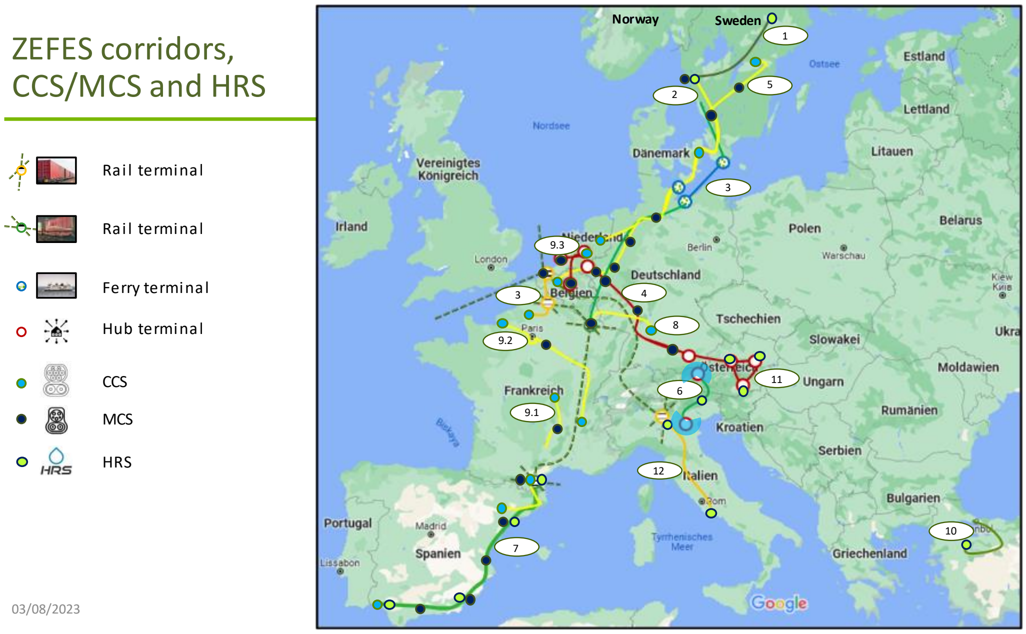


Figure 12, overview charging and refuelling locations along ZEFES corridors

3.2. Workshops with stakeholders

The stakeholders participated in the workshops were logistic service providers, shippers, and carriers having already experiences with ZE HDV in urban and regional missions. The main observations made are summarized below.

1. Orchestration of different technologies will create new, future business models in the transport industry.
2. Dynamics in a day-to-day context will increase. Examples are dynamic charging prices over the day, dynamic access management to roads & e-infrastructure, at gates or ports etc.
3. Digital connectivity is a key enabler towards resilient operations.
4. Higher net weight of HDEV, charging as well as resting times and other related technologies are creating higher costs. To avoid an increase of trucks to transport the same cargo, more flexibility on legal as well as on contractual/procurement side is needed.
5. Charging infrastructure is expensive and related power supply demands for extra and costly installations. Need for constant (24h) operation to pay off. Need for selling power to trucking companies inside depots while waiting at ramp is complicated.
6. To cope with present operational models highly efficient electrified models are needed: Design and shape new TaaS business models (Transportation as a Service).

7. No universal/versatile truck in the future. Change to job (mission) specific profile and configurations.
8. Classical business model of long-distance SME is questioned. SME trucking companies might be limited to providing driver as vehicle capacity, IT and charging infrastructure is already provided by service providers (EINRIDE, truck OEM, 3PL)
9. Upscaling of HDEV depends on capacity of grid and alternative fuels.
10. Service providers to differentiate by offering configurations of vehicle and battery, mission profile and charging infrastructure.

3.3. Barriers and challenges

The challenges. The growth of freight transport by 2040 is nearly doubled compared to 2010. A recent study by DLR, Deutsche Zentrum für Luft- und Raumfahrt, involved in the EU funded AEROFLEX project[7] shows a massive growth of freight transport and the split by the modes, rail, road, and inland water ways. Road transport is by far the most used mode.

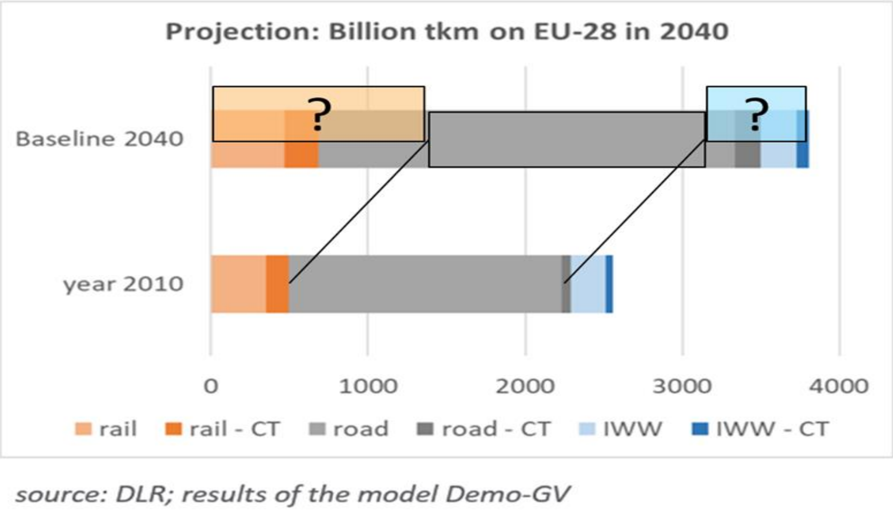


Figure 13 – DLR Study growth of freight transport in Europe 2021

Even when rail and water will double their capacity, road remain most the important mode. This forces the logistics and transport industry to do more with less. Logistics need to become more efficient to reduce transport. All modes (rail, road, water, tube, air) need to become more efficient and compatible regarding the weight & dimensions and handling of loading units. Road is inevitable and that will be for long, by that it needs to become as efficient as possible (use of vehicles and infrastructure) ensuring compatibility with other modes.

The **barriers** are grouped in four blocks. The legislative situation in Europe, the intermodally of freight transport, trust and availability of new technologies and the digitalization.

Legislation. Europe has not by far a harmonized legislative framework. At European level directives are defined, where at national and regional level the rules and conditions are defined. This hampers the opportunity using optimized vehicles concepts saving number of road vehicles and a more efficient multimodal transport. On top the pricing of energy is up to local authorities hampering a clear energy strategy for vehicles.
Intermodal transport. Criteria used for the transportation of freight are till today limited to duration, probability, and costs. ZEVs are limited in range ensuring a cost/benefit regarding

payload and avoiding an increase of vehicles to transport the same amount of freight. By that, the use of ZEVs forces the operator to also include criteria such as weather conditions, traffic density, access to parking, charging, and refuelling.
Hubs and terminals need to offer parking, charging, and refuelling in future to ensure access for ZEVs. Rail and Water need to offer charging capabilities for ZE-vehicles (e.g., trailers with batteries) during the transport.
Technologies. Trust, user acceptance is still an issue as concerns are raised regarding safety. The OEM industry need to work on closing the knowledge gap at the end user site. The energy infrastructure, charging and refuelling is seen as key to a successful implementation of ZE-HDVs. Today refuelling along the highways is possible every 35kilometers. Private investors need to be incentivized to invest in the infrastructure, and to standardize on charging and fuelling technologies and payments systems.
Digitalization. To cope with the above barriers, a digital platform connecting the legislative framework, the operation of freight transport, the use of vehicles and infrastructure is a must to handle the complexity due to the increased numbers of variables.

Within the logistic sector the sender and receiver of goods and services have contractual agreements. Delivery quantity, delivery quality, delivery time and delivery cost are key parameters. For the carriers, those who perform the transport of goods must ensure the delivery of goods within these parameters. In addition, they need to ensure that the probability of delivery on time is given. This implies the choice of the right transport mode, the right timing of the transport within the right transport cost. Planning and adaptation due to daily changes of all kinds ask for intelligent digital support. The figure 14 shows a simplified supply chain of goods between sender and receiver.

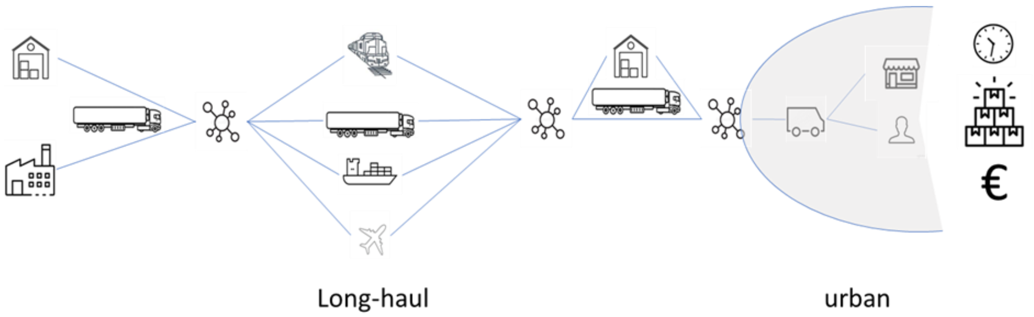
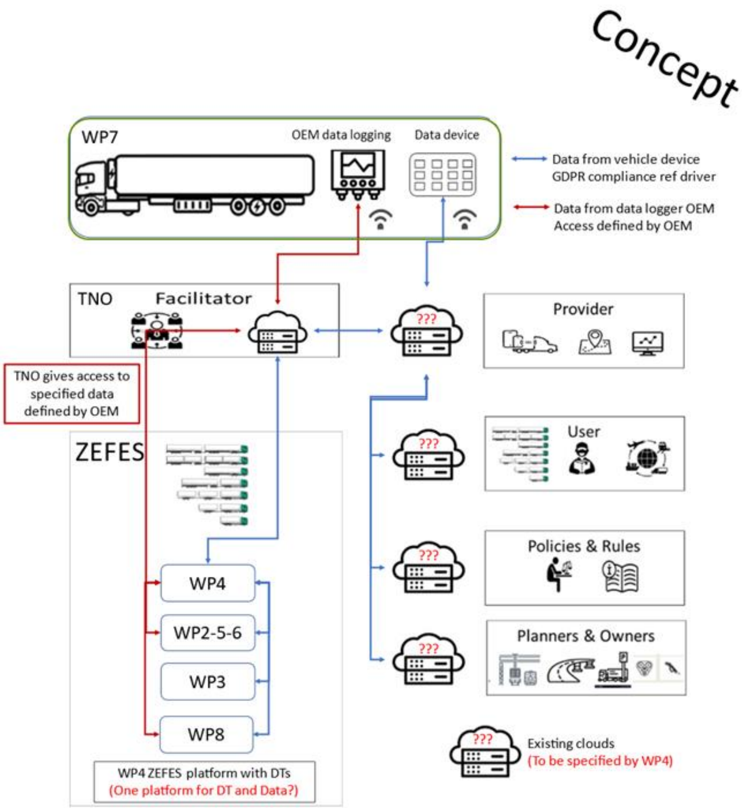


Figure 14, schematic view supply chain

Today a wide variety of digital services is available, all connected through clouds, modems, devices, etc. by defined protocols and interfaces. Most HDVs are equipped with a data device sending and receiving data for a smooth logistics operation. The data refer to routing information, traffic information, missions' profiles, and vehicle performance as defined by the FMS standards. Implementation of ZE-HDV into current fleets force the carriers to handle additional information as the ZE-technologies and energy infrastructure require additional data. Available energy on board of the ZEV (electric and or hydrogen), availability of charging and filling service stations, reservation of parking, road use allowances, weather conditions, all being additional key parameters to ensure smooth operation of ZE-HDVs.
The above clearly explains the need for data logging / streaming within the ZEFES project. Data to perform the developments (powertrain design, CCS/MCS/HRS, tools to perform missions, e.g., road permits & type approvals, diagnostics and predictive maintenance, routing, parking, and navigation, build & commissioning of BEV & FCEV demonstrators), to execute the demonstrations and to perform the evaluations and assessments.

An agreement is needed to share vehicle specific data between specified ZEFES project partners as these data are sensible and should not be available for other partners than agreed. The validation of the missions and the performances of the vehicles will be done in close alignment with the relevant OEMs (truck and/or trailer). The evaluation and assessment will be done using the ZEFES Digital Twin Platform (DTP).
To ensure a proper data exchange and compliancy with the GDPR regulation Data Protection Directive 95/46/EC, an independent appointed ICT team at TNO Netherlands will act as facilitator for collecting data and making data available for the specified partners.
The first challenge is to align the specific needed data for the ZEFES project, and the daily needed data. Secondly, if not already planned by the OEM's, the need of a specific data logger needs to be discussed and agreed with the OEMs or alternative solutions can be agreed. The third challenge is to create an interface between the ZEFES DT platform and the different clouds to ensure a smooth operation of the logistic missions and the ability to validate and to assess the impact of ZE-HDVs compared to the todays ICE-HDVs.

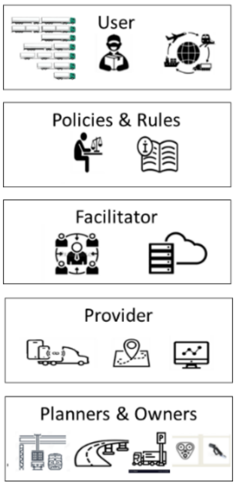


The figure 15, shows a possible concept of data exchange within the ZEFES project. The data logging collecting ZEFES specific data, and a commonly used Data Device sending and receiving data to & from clouds.

Figure 15, overview possible data exchange within ZEFES project

The clouds representing the digital service providers, see also figure 17, "Provider", the "User, the "Policies & Rules", the "Planners & Owners". The "TNO cloud", the facilitator, to handle ZEFES data, GDPR compliance and agreed between ZEFES project partners and connected with the different clouds collecting and exchanging operational real-time data. The box "WP4" represents the ZEFES Digital Twin Platform (DTP), incorporating all DTs (Digital Twins) to be used by the ZEFES project partners during the ZEFES project. The box "WP2-5-6" represent the design powertrain, the BEV & FCEV demonstrators. The box "WP8" represent the assessment and validation work.

The user, the logistic service provider, the shipper, and the carrier.



The policies & rules, the authorities, and organizations to check compliances.

The facilitator, the trust between all stakeholders ensuring correct handling of data exchange.

The provider, the supplier of IT systems, e.g., navigation, tracking, performance, etc.

The planner & owner, the infrastructure (road, parking & fuelling), hubs & terminals to access other modes, energy supply (electricity, hydrogen, and other fuels).

Figure 16 – Overview stakeholders relevant for freight transport

4. Acknowledgment

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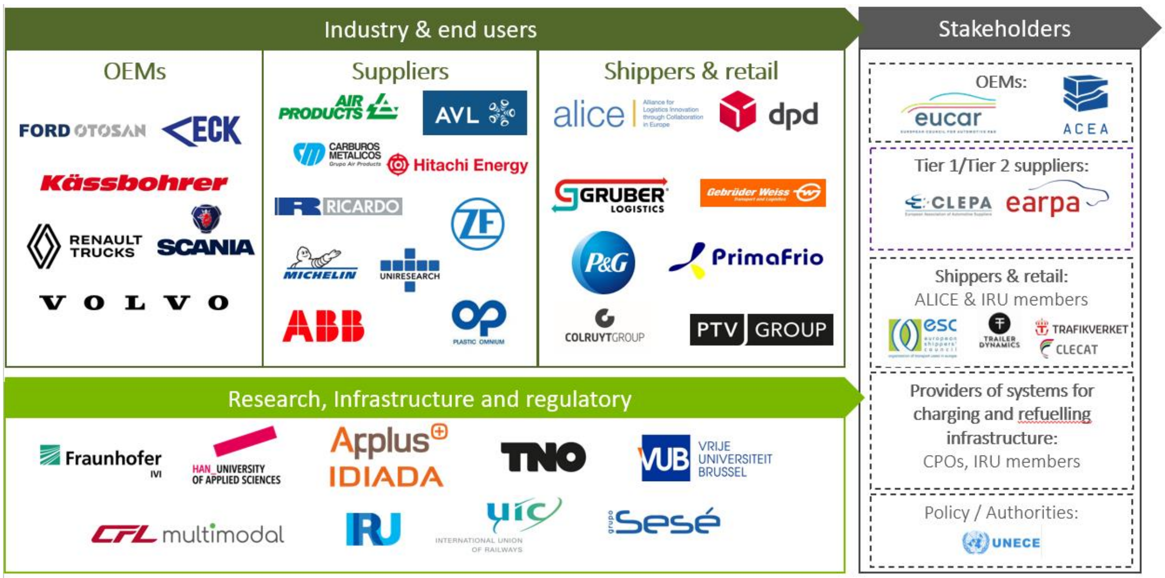

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