HORIZON EUROPE PROGRAMME

TOPIC HORIZON-CL5-2022-D5-01-08
Clean and competitive solutions for all transport modes
GA No. 101084046

Zero Emission flexible vehicle platform with modular powertrains serving the long-haul Freight Eco System

ZEFES - Deliverable report

D2.3. Feasibility study on new vehicle flexible concepts

Funded by
the European Union

Deliverable No.	ZEFES D2.3	
Related WP	WP2	
Deliverable Title	Feasibility study on new vehicle flexible concepts - for payload capacity up to 100% for next LHDV generations	
Deliverable Date	2024-06-07	
Deliverable Type	REPORT	
Dissemination level	Public (PU)	
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Status	Final	2024-06-07

Publishable summary

This deliverable reports the outcomes of task 2.5 titled as '*Feasibility study on further improvement of the flexible vehicle platforms and their powertrains to maximize the payload capacity up to 100%*' in the work package 2. As shown in Figure 1 , the tasks have been performed to fulfil the objective 1 - to improve modular heavy duty battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs) – by employing the design optimization tool/framework (sub-objective 1.3) in ZEFES project.

With the strong demands from the fleet operators/logistics companies and their needs on increasing the payload capacity of the zero emission (ZE) heavy-duty vehicle (HDV) to be close to 100%, this task will perform a feasibility study on improving the flexible vehicle platforms/concepts (for BEV and FCEV) and on optimizing their powertrains to achieve 100% payload capacity and to investigate the trade-off solutions with good cost-effectiveness and high performance. Using the tools and models from T2.1 to 2.3, the new vehicle architectures/concept platforms will be optimised, providing the OEMs the new flexible vehicle architecture/concept for next long-haul heavy-duty (LHD) vehicle generations for higher payload capacity up to 100%.

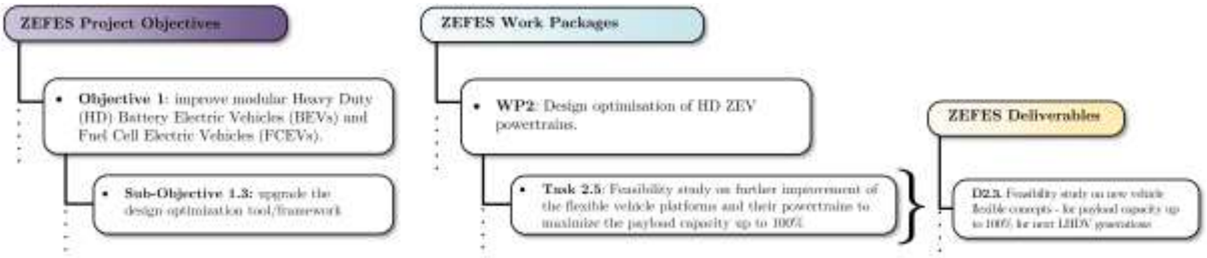

Figure 1. Deliverable workflow for the realisation of project objective.

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Abbreviations & Definitions

Abbreviation	Explanation
HDV	Heavy-Duty Vehicle
ZEV	Zero tailpipe Emission Vehicle
BEV	Battery Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
ICE	Internal Combustion Engine
OEM	Original Equipment Manufacturer
VECTO	Vehicle Energy Consumption Calculation Tool
GCW	Gross Combination Weight
ZE-HDV	Zero tailpipe Emission Heavy Duty Vehicle
WPL	Work Package Leader within ZEFES project
BE-HDV	Battery Electric Heavy-Duty Vehicle
FCE-HDV	Fuel Cell Electric Heavy-Duty Vehicle
ISO	Interchangeable container as defined in the ISO-Norm 668
SWAP	Interchangeable container accommodating Euro-pallets for road and rail transport
Reefer	Loading unit to transport temperature-controlled cargo
USP	Unique Selling Proposition (uniqueness of ZEFES use cases)
EMS	European Modular System, HDV carrying standardised loading units for intermodal freight transport
T	Tractor unit
R	Rigid unit
ST	Semi-trailer
TR	Trailer
D	Dolly
e-ST	Electric semi-trailer
e-D	Electric dolly
CCS	Combined Charging System
MCS	Megawatt Charging System
HRS	Hydrogen Refuelling Station
Vkm	Vehicle kilometres
tkm	Tonne kilometres
DTP	Digital Twin Platform
DT	Digital Twin
	Abbreviations of project partners, see **Acknowledgement** section

1 Introduction

1.1 Project Objectives

Within the Green Deal, Europe commits itself to be the first CO2 neutral continent, by 2050. To achieve this, a first milestone is defined as an overall CO_2 reduction target of 55% by 2030. For the road transport sector, the target is set at 30% less CO_2 emissions by 2030, following Regulation (EU) 2019/1242. The regulation requires that manufacturers of heavy-duty (HD) vehicles deliver more efficient vehicles: a reduction of CO_2 emissions for the newly produced fleet of 15% in 2025 and 30% in 2030.

The use of zero tailpipe emissions vehicles (ZEVs) for long distance heavy transport is an important part towards achieving the above targets. In this project, such vehicles are Battery Electric Vehicles (BEVs) and Fuel Cell Electric Vehicles (FCEVs). Until now, these vehicles have a fairly limited range: this makes it difficult to use them effectively as replacements for vehicles with an internal combustion engine (ICE). An increased range reduces range anxiety and gives more flexibility in the re-charging or re-fuelling planning of BEVs and FCEVs. In addition, the weight of the batteries in such long-distance vehicles affects the available payload. This is likely to change thanks to rapidly increasing battery energy density, which is rising at about 7% per year[1]. Further, the EU Weights & Dimensions Directive gives ZEVs an additional weight allowance of 2 tonnes[2]. **Hence, it is expected that ZE HDV payloads will equal or surpass those of comparable ICE vehicles in the future**. Additionally, the effectivity will come even closer since the cost of batteries is falling sharply, by about 13% per year[3].

There are rapid developments in the field of batteries. Besides the cost, battery energy density is one of the most important factors. Energy density has a major influence on the weight of the batteries and thus the payload that a truck can take on a journey. Given the highly competitive edge of this factor, it is somewhat difficult to find accurate public information about it. Figure 2 shows the increase in battery energy density (on pack level) from roughly 150 Wh/kg in the base year to around 260 Wh/kg at the end of the project in 2026. This was found by Ricardo Energy & Environment, ifeu and E4tech in a report commissioned by the European Commission, DG Climate Action in 2020.

The Strategic Research and Innovation Agenda (SRIA) of BATT4EU/Batteries European Partnership Association (BEPA) shows similar energy density developments[4]. There, BEPA's SRIA shows a target for Generation-3 Li-ion batteries with a volume energy density at cell level of 350-400 Wh/kg, whilst the cost at pack level is below 100 EUR/kWh and a market introduction indicating the year 2025+. This seems in line with the (battery pack energy density) in Figure 2. As mentioned, the energy density is expected to become higher due to developments in battery technology (this is outside the scope of the project). The improvements result in an expected payload of over 90% for a 2026 BEV with a 750 km range[2].

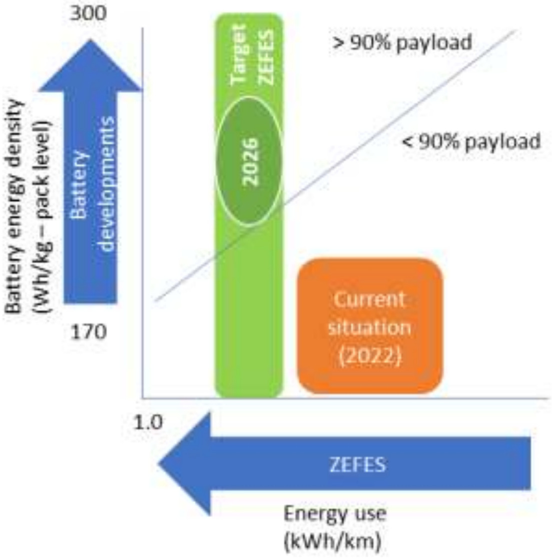


Figure 2. 100% payload target in ZEFES thanks to battery technology advancement.

1.2 Project Methodology

The project methodology is developed in Figure 3 to provide measures to compensate the weight of battery and FC systems. The aim is the creation of concepts and architectures for a future vehicle design to achieve a payload of 100%. First, the vehicle simulation platform will be updated in T2.2 to permit the simulation of 100% payload. Second, the codesign optimization framework (COF) tool developed in T2.3 will be used to optimise the powertrain components' sizing. The definition of the cost functions and their constraints will be re-formulated. OEMs will provide feedback about the feasibility of the different modifications proposed to the vehicle platforms and architectures.

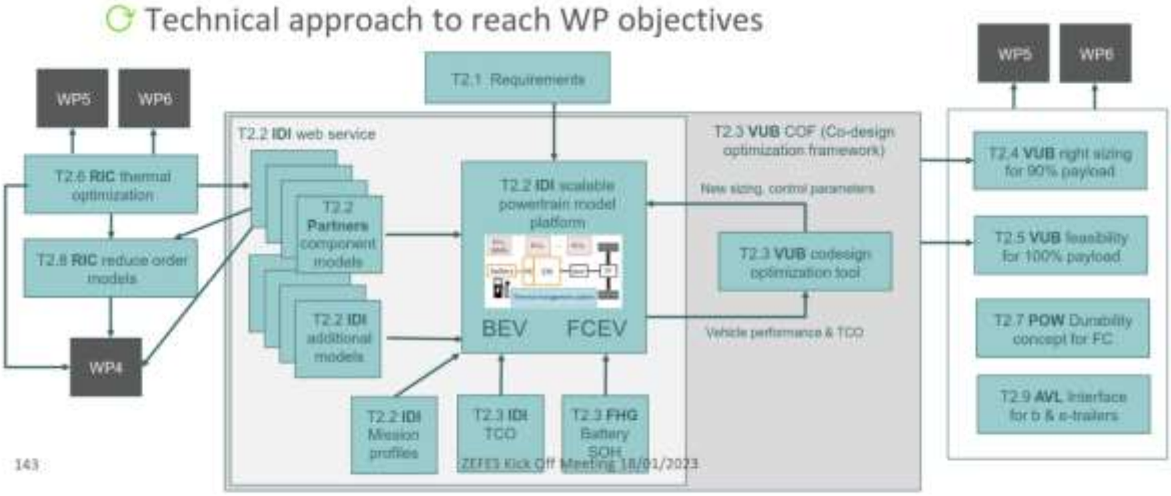


Figure 3. WP2 technical approach in general and T2.5 specifically.

Figure 4 shows the overview of the methodology to study the feasibility of 100% payload for BEV and FCEV HDVs. First step is a literature review on examination of existing research and case studies relevant to BEV and FCEV technologies, focusing on payload capacities, powertrain efficiencies, and vehicle architectures. Step 2-4 is designed for technical and economic analysis. In these steps, the simulation tools and modelling are utilized to predict performance outcomes based on modifications in vehicle design and powertrain configurations. Stakeholder feedback engages the industry experts and stakeholders to gather qualitative insights and validate quantitative findings.

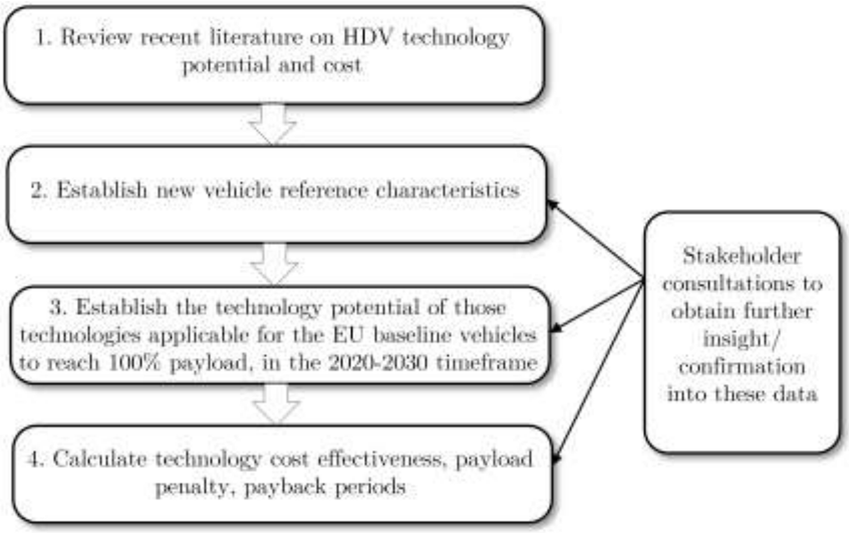


Figure 4. Overview of methodology for the feasibility study.

2 Future Technologies Impacting Payload

To assess the technical feasibility of achieving a 100% payload for BEV and FCEV long-haul trucks, multiple dimensions are under consideration: battery technology and its evolution, load capacity implications, the operational framework including charging infrastructure, and the specific demands of long-haul applications.

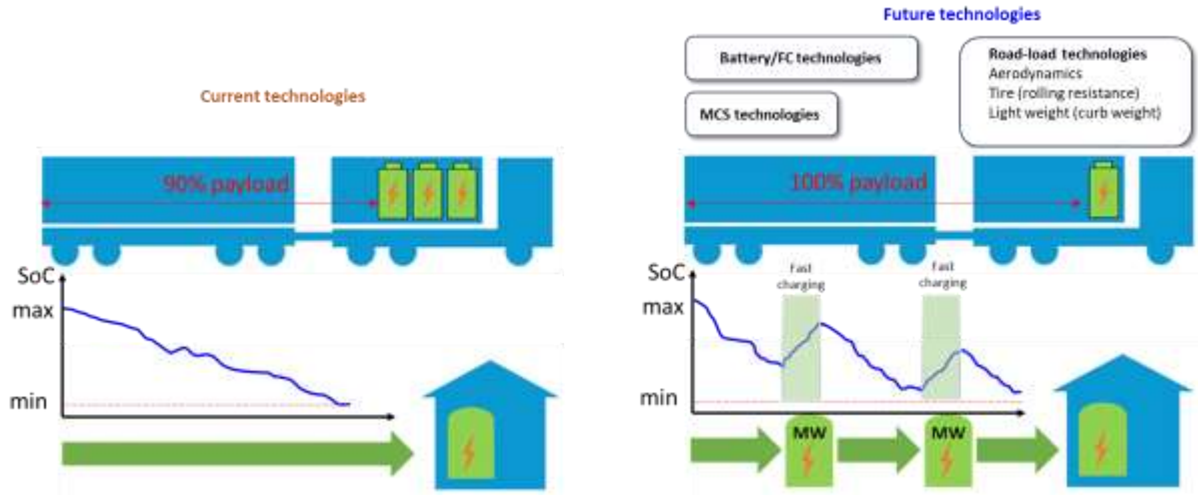


Figure 5. Impact of future technologies on the improvement of payload for HDV BEVs and FCEVs.

2.1 Battery Technology

Recent advancements in battery technology, particularly with lithium-ion batteries, have significantly improved energy density and cycle life while reducing costs. Parameter sets range from conservative (300 USD/kWh, 1,000 cycles, 125 Wh/kg) to optimistic scenarios (100 USD/kWh, 5,000 cycles, 175 Wh/kg) [5]. These improvements directly enhance the payload capacity as they allow for larger batteries without proportionally increasing the weight.

2.2 Fast Charging MCS Technology

The integration of high-power fast charging (up to 1 MW) is pivotal. This development would alleviate range concerns by enabling quicker/shorter charging stops, thus making long-haul BEV trucks more competitive against diesel trucks. The operational feasibility of BEVs heavily relies on the availability and strategic placement of these charging stations, which must align with common truck routes to ensure minimal disruption.

2.3 Road-load Technologies

2.3.1 Aerodynamics (updated drag coefficients in simulation)

The energy dissipated by aerodynamic drag during traction operation can represent around 40% of mechanical energy needs [6]. Aerodynamic drag energy dissipation is proportional to the square of the vehicle speed, making it particularly significant in long-haul operation due to the higher speeds encountered under such driving conditions. This study simulates a range of tractor-trailer aerodynamic drag coefficients (C_D) from an actual value of 0.5 improving down to 0.35 in the future. Such values are expected to be reached by 2030 in the United States by the SuperTruck program [7], as well as by concept trucks in the European Union, which have achieved C_D values around 0.3 [8].

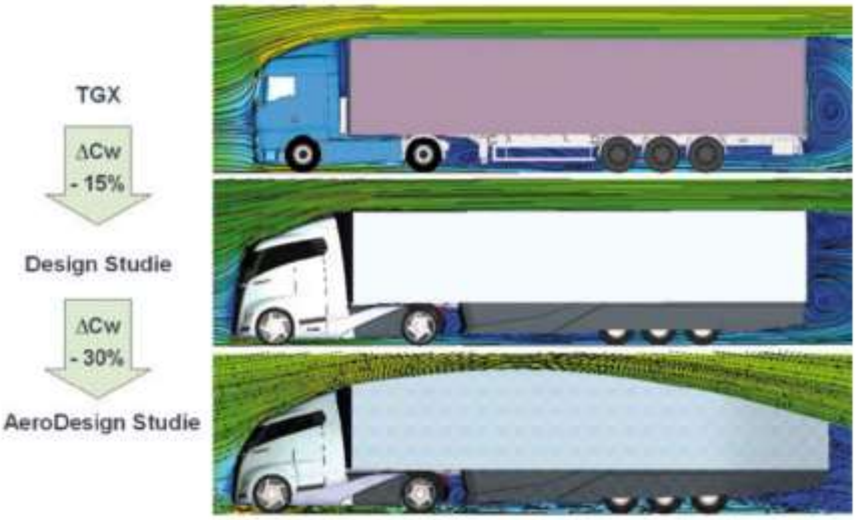


Figure 6. The creation of a future-oriented vehicle concept [8].

2.3.2 Tires (updated rolling resistance coefficients in simulation)

The energy dissipated by the tires due to rolling friction resistance can represent around 40% of the mechanical energy needs over the long-haul cycle [6]. This energy load is proportional to the tire rolling resistance coefficient (RRC), which depends on the tractor-trailer weight and speed. Consultants commissioned by the ICCT reported that the RRC reduction rate is at about 2% per year [9]. Compared to the reference RRC currently at 0.005, a 27% reduction is expected by 2030 yielding to an RRC value of 0.004, consistent with commercially available tires with an A efficiency labelling.

2.3.3 Vehicle Weight Reduction (updated curb weight in simulation)

Use of advanced lightweight materials, such as carbon fiber composites and high-strength aluminium alloys, can reduce the vehicle weight without compromising structural integrity. Utilizing lightweight materials to reduce vehicle curb weight can impact vehicle energy efficiency and demands in different ways. For tractor-trailers that operate at their maximum allowable payload, light-weighting permits an increase in the maximum allowable payload without changing the total energy consumption of the vehicle. For vehicles that are volume constrained, the light-weighting of the truck’s structure enables the use of larger batteries, if needed. Previous studies show that a curb weight reduction of over 2 tonnes is possible by 2030, mainly through the substitution of iron and steel with advanced high-strength steel and aluminium/magnesium for various chassis and powertrain components, as well as an additional use of some composite materials [10].

Table 1. Summary of future technologies.

	Technology	Current	Future
Road-load	Drag coefficient	0.5	0.35
	Rolling resistance coefficient	0.005	0.004
Weight	Tractor	5,850 kg	5,150 kg
	Trailer	7,400 kg	6,208 kg
	Battery	130 Wh/kg	260 Wh/kg
Transmission efficiency	Gearbox	98.5%	99.1%
	Differential	97%	98%

Table 2. Tractor-trailer component weight.

Component	Current	Future
Truck body and structure	1,551 kg	1,350 kg
Suspension	1,388 kg	1,207 kg
Chassis	980 kg	852 kg
Wheels and tires	816 kg	726 kg
Trailer	7,400 kg	6,200 kg

Table 3. Powertrain component weight.

Component	Specification		Specific weight	
	BEV	FCEV	Current	Future
Battery pack	Defined by range	72 kWh	0.14 kWh/kg	0.23 kWh/kg
FC system	-	200 kW	0.6 kW/kg	
Hydrogen tank	-	Defined by range	0.046 kg H2/kg (700 bar)	
Electric drive	350 kW		0.4375 kW/kg	
Power electronics	350 kW		3.6 kW/kg for BEV 5kW/kg for FCEV	
On-board charger	44 kW		0.95 kW/kg for high power 1.12 kW/kg for low power	
Air compressor	6 kW		0.087 kW/kg	
Steering pump	9 kW		0.072 kW/kg	
Air conditioning unit	10 kW		0.91 kW/kg	
Heater	10 kW		1 kW/kg	
BMS	350 kW		3.5 kW/kg for BEV 7.14 kW/kg for FCEV	

3 ZEFES Feasibility Study Framework

As developed in T2.2 and T2.3, IDI has been developing the simulation platform which can simulate longitudinal performances and give energy consumption estimations based on simulation for the ZEVs demonstrators considered for this project. Figure 7 shows the 100% payload feasibility study framework, which is incorporated between IDI web-based simulation platform and VUB's sizing optimization loop. Technical feasibility will focus on the analysis of current and emerging technologies in battery systems and fuel cells that could support 100% payload capacity. This includes advancements in battery chemistry, energy density, and fuel cell efficiency. On the other hand, an economic feasibility study will assess the cost-benefit analysis considering the TCO model, including initial investments, maintenance, and operating costs compared to traditional diesel trucks.

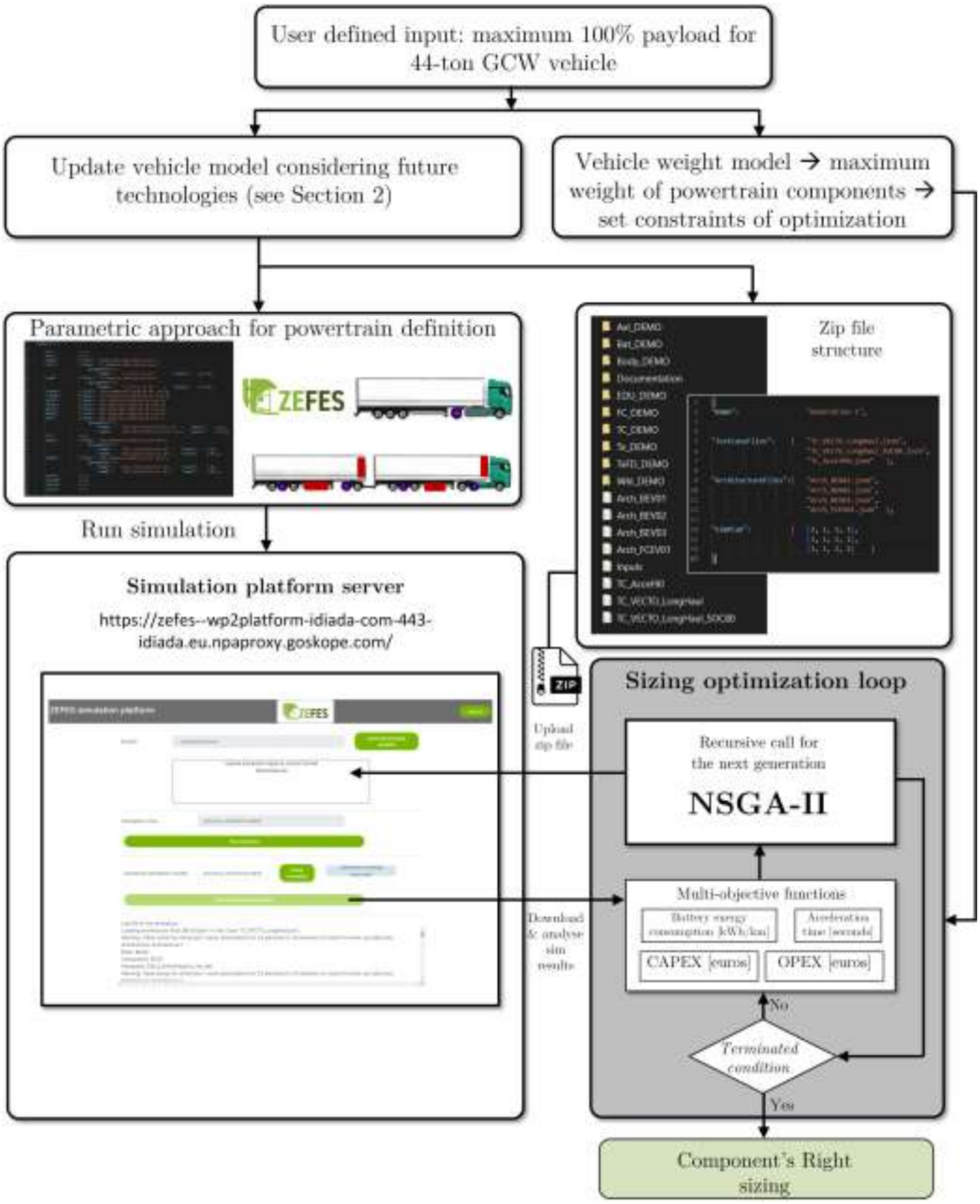


Figure 7. Powertrain optimisation flowchart.

Table 4. TCO cost formulation.

	Description	Parameter	Unit	Value/Equation
Vehicle	Payload	m_{load}	[kg]	**User input**
CAPEX	5-year depreciation	Depr_{5y}	[%]	55
	Taxes (Euro 3 or above until 2025)	C_{tax}	[€/quarter]	81-325
	Taxes (Euro 3 or above after 2025)	C_{tax}	[€/quarter]	> 81 - >325
	Administrative costs (Euro 3 or above after 2025)	C_{admin}	[€/year]	926
	Insurance	C_{insu}	[€/year]	-
	Driver salary (Average NL)	C_{wage}	[€/month]	1,600
	Investment	C_{invest}	[€]	110,000-280,000
	Life cycle	$Life_{dist}$	[km]	1,450,000
	Annual driving	$Drivg_{ann}$	[km/year]	130,000
	Annual utilization	$Util_{ann}$	[%]	$\left(\frac{Drivg_{ann}}{Life_{dist}}\right)*100$
	Estimated vehicle service life	$Year_{serv}$	[years]	11.15
	Expected residual value (resale) after 5 years	$C_{residue}$	[€]	$C_{invest} - C_{invest}\frac{\mathrm{Depr}_{5y}}{100}$
	Annual Depreciation	Depr_{ann}	[€/year]	$(C_{invest} - C_{residue})/5$
	Annual CAPEX	$CAPEX_{ann}$	[€/year]	$(4*C_{tax}) + (12*C_{wage}) + C_{insu} + \mathrm{Depr}_{ann} + C_{admin}$
OPEX	Electricity cost (Oct 2022) (VAT included)	C_{elec}	[€/kWh]	0.2
	Energy consumed in trip	E_{cons}	[kWh]	**From simulation**
	Trip length	$Dist$	[kms]	**From simulation**
	Tolls and fees	C_{toll}	[€/year]	-
	Repair and maintenance (Incl. tires) per km	C_{repair}	[€/km]	0.1577-0.2123
	Fuel cost per trip	$C_{fueltrip}$	[€/trip]	$C_{elec} * E_{cons}$
	Fuel cost per 1000 kms	$C_{1000kms}$	[€/1000km]	$\frac{C_{fueltrip}}{Dist} * 1000$
	Annual repair and maintenance cost	$C_{repair(ann)}$	[€/year]	$C_{repair} * Drivg_{ann}$
	Annual fuel costs	$C_{fuel(ann)}$	[€/year]	$\frac{C_{1000kms}}{1000} * Drivg_{ann}$
	Annual OPEX	$OPEX_{ann}$	[€/year]	$C_{fuel(ann)} + C_{repair(ann)} + C_{toll}$
TCO	**TCO per year**	TCO_{ann}	[€/year]	$CAPEX_{ann} + OPEX_{ann}$
	TCO per km	TCO_{km}	[€/km]	$\frac{TCO_{ann}}{Drivg_{ann}}$
	TCO per tonne per km	$TCO_{ton.km}$	[€/tonne. km]	$\frac{TCO_{km}}{m_{load}/1000}$

4 Feasibility Analysis

Figure 8 shows the relation between the payload capacity and GCW in tonne. The maximum payloads of 25,200 kg and 27,100 kg are selected for the BEV with a gross vehicle weight of 44 tonnes for current and future technologies, respectively.

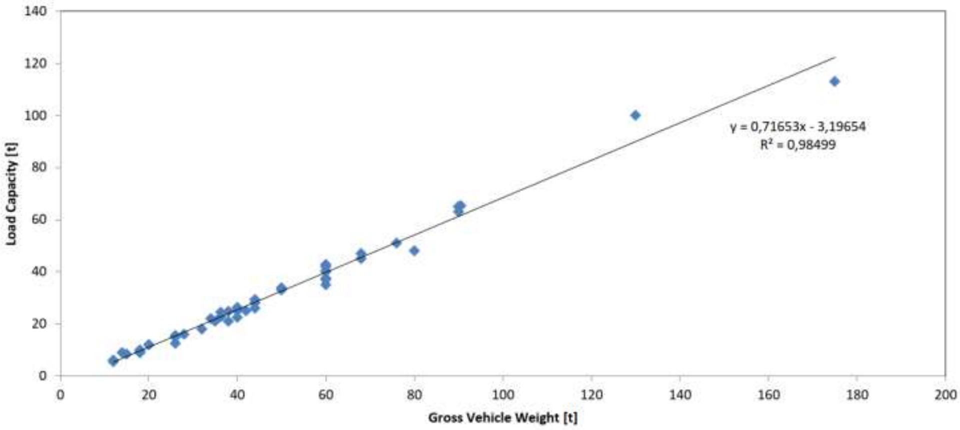
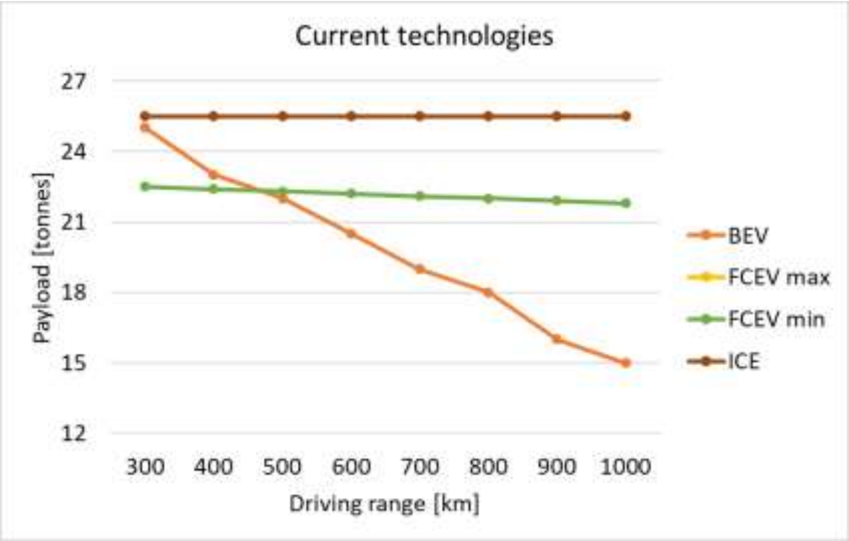


Figure 8. Load capacity as a function of gross vehicle weight.

The trade-off between electric driving range and maximum allowable payload, that is the payload penalty, is one of the critical issues commonly brought up when discussing the limitations of HD BEVs. Figure 9 shows the maximum allowable payload as function of the driving range for both current and future vehicle technologies. At a 500 km driving range, which is sufficient to cover 70% of applications without the need for opportunity charging during operation and 95% of cases with a 45-minute charging event during the day.



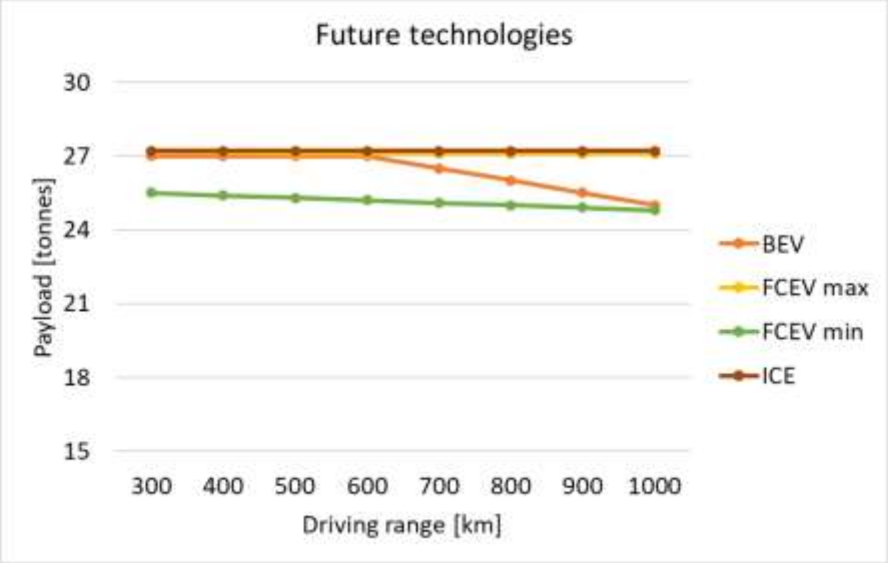


Figure 9. Payload capacity of BEV, FCEV, and ICE trucks at different driving ranges under current and future vehicle technologies.

The maximum payload of the electric truck decreases proportionally with the increase in its driving range due to the increase in battery weight. With the current technology, an 11% reduction in the maximum payload for electric tractor-trailers is observed, that means 90% payload. However, with future technology improvement, namely chassis light-weighting and battery energy density increase, an electric truck with a 750 km driving range would not result in any payload penalty when compared to its diesel counterpart.

Table 5. Powertrain sizing comparison between current (90% payload) and future technology (100% payload) for BEVs and FCEVs with 44-tonne GCW and 750 km driving range.

Use-case	UC7.2.2, 7.2.3, 7.3.1, 7.3.3, 7.3.4		UC7.3.2, 7.3.3, 7.6.1, 7.6.2, 7.6.3	
Parameter	BEV current technology (90% payload)	BEV current technology (100% payload)	FCEV current technology (90% payload)	FCEV current technology (100% payload)
Battery capacity	956 kWh	830 kWh	300 kWh	350 kWh
Battery weight	7353 kg	4150 kg	2307 kg	1750 kg
Energy consumption	1.3 kWh/km	1.1 kWh/km	1.3 kWh/km	1.1 kWh/km
FC power rating	-	-	220 kW	200 kW
Hydrogen consumption	-	-	58.5 kg	46 kg
FC H2 efficiency	-	-	7.8 kg/ 100km	6.2 kg/ 100km
EDU power	628 kW	600 kW	628 kW	628 kW

Table 5 compares the powertrain sizing between current technology (90% payload) and future technology (100% payload) for BEVs and FCEVs with 44-tonne GCW and 750 km driving range. These simulations and comparisons are executed with the simulation framework explained in section 3 of this deliverable, using the ZEFES tools as depicted in Figure 7. For the BEV with current technology (130 Wh/kg), the required battery capacity of 956 kWh leads to a significant weight of 7,353 kg. This large battery size is necessary to achieve a 750 km range but is heavy, impacting vehicle efficiency and carrying 90% of payload capacity. The motor power rating of 628 kW ensures the vehicle can maintain highway speeds. Considering the future technology, with improvements in battery energy density (200 Wh/kg) and consumption (1.1 kWh/km), the required battery capacity reduces to 830 kWh, and the battery weight significantly drops to 4,150 kg. This makes the future BEV more practical and efficient.

Considering current technology for FC EV, the hydrogen consumption rate of 7.8 kg/100 km results in a total requirement of 58.5 kg of hydrogen for a 750 km range. The FC system is sized at 220 kW to manage continuous loads, complemented by a 300 kWh battery for hybrid system support. In the future, with advancements in FC efficiency (6.2 kg/100 km hydrogen consumption), the total hydrogen requirement reduces to 46 kg. The fuel cell power rating can be reduced to 200 kW, and the battery capacity is increased to 350 kWh to leverage fast charging capabilities.

5 Conclusion

Given the rapid technological advancements and decreasing costs associated with high-capacity batteries, the feasibility of achieving 100% payload capacity for long-haul BEV trucks is approaching a viable threshold. However, achieving this depends heavily on continued improvements in battery technology, the deployment of fast-charging infrastructure, and operational adaptations specific to long-haul needs. The transition towards fully electric long-haul trucks will also require significant investment in charging infrastructure and potentially new operational strategies to accommodate the unique requirements of electric long-haul freight.

This deliverable D2.3 reported the outcomes of tasks 2.5 in WP2. The conclusions are listed below:

- Technical achievability concludes that with ongoing advancements in battery and hydrogen fuel cell technologies, achieving 100% payload capacity is technically feasible within the next decade.

- Economic analyses suggest that while initial costs are high, the TCO could be competitive with diesel trucks due to lower operating and maintenance costs.

6 Deviations from Annex 1

This task has suffered a delay due to the complexity of the development of the simulation platform in the task 2.2.

Based on the actual drive cycles from the OEMs and continued updated versions of the simulation platform, new optimization simulations shall be conducted for the benefit of the partner’s use cases with 100% payload and presented and discussed at the next General Assembly meeting.

7 Risks and interconnections

7.1 Risks/problems encountered

Risk No.	What is the risk	Probability of risk occurrence[1]	Effect of risk[1]	Solutions to overcome the risk
1	oversizing of powertrain's components to satisfy the higher payload (med./low)	2	2	Close collaboration with the OEMs to tune the objective function and its vehicle constraints in order to have the right trade-off (volume, cost and weight).

1) Probability risk will occur: 1 = high, 2 = medium, 3 = Low

7.2 Interconnections with other deliverables

The results obtained from this deliverable, mainly the simulation platform, will be used as the basis for T4.2, and consequently D4.1.

8 References

[1] BloombergNEF, “Electric Vehicle Outlook 2023,” 2023. https://about.bnef.com/electric-vehicle-outlook/

[2] REGULATION (EU) 2019/1242 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, “Setting CO2 emission performance standards for new heavy-duty vehicles and amending Regulations (EC) No 595/2009 and (EU) 2018/956 of the European Parliament and of the Council and Council Directive 96/53/EC,” *Off. J. Eur. Union*, 2019.

[3] R. (EU) 2019/1242 O. T. E. P. A. O. T. COUNCIL, “On the harmonisation of certain social legislation relating to road transport and amending Council Regulations (EEC) No 3821/85 and (EC) No 2135/98 and repealing Council Regulation (EEC) No 3820/85,” *Off. J. Eur. Union*, 2006.

[4] BATT4EU, “Strategic Research & Innovation Agenda,” 2021.

[5] J. Van Mierlo *et al.*, “Beyond the State of the Art of Electric Vehicles: A Fact-Based Paper of the Current and Prospective Electric Vehicle Technologies,” *World Electr. Veh. J.*, vol. 12, no. 1, p. 20, Feb. 2021, doi: 10.3390/wevj12010020.

[6] O. Delgado, F. Rodriguez, and R. Muncrief, “Fuel Efficiency Technology in European Heavy-Duty Vehicles: Baseline and Potential for the 2020–2030 Time Frame.,” *Int. Counc. Clean Transp.*, 2017.

[7] O. Delgado and N. Lutsey, “The U.S. SuperTruck Program: Expediting development of advanced HDV efficiency technologies,” *Int. Counc. Clean Transp.*, 2014.

[8] S. Kopp, S. Schönherr, and H. Koos, “The Design and Aerodynamics of Commercial Vehicles,” *ATZ Worldw.*, 2009.

[9] J. Norris and G. Escher, “Heavy Duty Vehicles Technology Potential and Cost Study,” *Ricardo Energy Environ.*, 2017.

[10] N. Hill *et al.*, “Light weighting as a means of improving Heavy Duty Vehicles’ energy efficiency and overall CO2 emissions,” *Heavy Duty Veh. Framew. Contract – Serv. Req. 2*, 2015.

9 Acknowledgement

The author(s) would like to thank the partners in the project for their valuable comments on previous drafts and for performing the review.

Project partners:

#	Partner short name	Partner Full Name
1	VUB	VRIJE UNIVERSITEIT BRUSSEL
2	FRD	FORD OTOMOTIV SANAYI ANONIM SIRKETI
4	KAE	KASSBOHRER FAHRZEUGWERKE GMBH
5	REN	RENAULT TRUCKS SAS
6	SCA	SCANIA CV AB
7	VET	VAN ECK TRAILERS BV
8	VOL	VOLVO TECHNOLOGY AB
9	ABB	ABB E-MOBILITY BV
9.1	ABP	ABB E-MOBILITY SPOLKA Z OGRANICZONAODPOWIEDZIALNOSCIA
10	AVL	AVL LIST GMBH
11	CM	SOCIEDAD ESPANOLA DE CARBUROS METALICOS SA
11.1	APG	AIR PRODUCTS GMBH
12	HEPL	HITACHI ENERGY POLAND SPOLKA Z OGRANICZONA ODPOWIEDZIALNOSCIA
13	MIC	MANUFACTURE FRANCAISE DES PNEUMATIQUES MICHELIN
14	POW	PLASTIC OMNIUM NEW ENERGIES WELS GMBH
15	RIC-CZ	RICARDO PRAGUE S.R.O.
15.1	RIC-DE	RICARDO GMBH
16	UNR	UNIRESEARCH BV
17	ZF	ZF CV SYSTEMS HANNOVER GMBH
18	ALI	ALLIANCE FOR LOGISTICS INNOVATION THROUGH COLLABORATION IN EUROPE
19	DPD	DPD (NEDERLAND) B.V.
20	COL	ETABLISSEMENTEN FRANZ COLRUYT NV
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23.2	PGA	PROCTER & GAMBLE AMIENS
24	PRI	PRIMAFRIO CORPORACION, S.A.
25	PTV	PTV PLANUNG TRANSPORT VERKEHR GmbH
26	Fraunhofer	FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV
27	HAN	STICHTING HOGESCHOOL VAN ARNHEM ENNIJMEGEN HAN
28	IDI	IDIADA AUTOMOTIVE TECHNOLOGY SA
29	TNO	NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO
30	UIC	UNION INTERNATIONALE DES CHEMINS DE FER
31	CFL	CFL MULTIMODAL S.A.
32	GSS	Grupo Logistico Sese
33	HIT	Hitachi ABB Power Grids Ltd.
34	IRU	UNION INTERNATIONALE DES TRANSPORTS ROUTIERS (IRU)
35	RIC-UK	RICARDO CONSULTING ENGINEERS LIMITED

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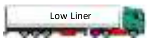
10 Appendix A1. Summary of Vehicle Configurations and ZEFES Use Case Demonstrations

Table 6. Summary table of vehicle configurations and ZEFES use case demonstrations.

	Use Case	Vehicle configurations		Payload	Goods to be transported	Shipper	Battery Electric HDV	Fuel Cell Electric HDV	Rigid Unit (R)	Tractor Unit (T)	Semi-trailer (ST)	Dolly (D)	e-Dolly (e-D)	Semi-trailer (ST)	e-Trailer (e-T)	Cooled e-Trailer (e-reefer)
7.2 VOLVO	**7.2.1**	FC-1		64t GCW	Steel Scrap	Ovako		X	X		X					
	7.2.2	BEV-1		44t GCW	Automotive parts	Volvo Logistics	X			X	X					
				64t GCW	Automotive parts		X			X	X	X		X		
	7.2.3	BEV-2		64t GCW	Partly Hazardous goods	PG	X			X	X		X	X		
				44t GCW	Temperature-controlled goods	Primafrio	X			X						X
	7.2.4	BEV-3		48t GCW	Parcel distribution	DPD	X		X				X		X	
7.3 SCANIA	**7.3.1**	BEV-4		44t GCW	Automotive parts	Scania Logistics	X			X					X	
	7.3.2	FC-2		44t GCW	Temperature-controlled goods	GRU		X		X						X
	7.3.3	FC-2		44t GCW	Temperature-controlled goods	Primafrio		X		X						X
		BEV-4					X			X						X
	7.3.4	BEV-5		44t GCW	Automotive goods	GSS	X			X	X					
				64t GCW			X			X	X	X		X		
7.4 Renault	**7.4.1**	BEV-6		44t GCW	Automotive components	Renault + Michelin	X			X	X					
	7.4.2	BEV-6		44t GCW	Parcel distribution	DPD	X			X	X					
				64t GCW			X			X	X			X		
7.6 FORD	**7.6.1**	FC-3		44t GCW	Automotive components	Ekol		X		X	X					
	7.6.2	FC-3		44t GCW	Parcel distribution	GBW		X		X	X					
	7.6.3	FC-3		44t GCW	Partly Hazardous goods	PG		X		X	X