2ZERO PARTNERSHIP

SRIA

STRATEGIC RESEARCH AND INNOVATION AGENDA 2021 - 2027

Co-funded by the European Union

Strategic Research and Innovation Agenda (SRIA)

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Executive summary

The Partnership will set an ambitious research programme to accelerate the development of zero tailpipe emission road transport in Europe via a system approach. It will develop a common vision and deliver a multi-stakeholders roadmap for a climate-neutral and clean road transport system. This will improve air quality, the mobility safety of people and of goods, hence ensure future European leadership in innovation, production and services. By paving the way to a climate-neutral road transport system, the Partnership will make a key contribution to the success of the European Green Deal.

TABLE OF CONTENT

List of acronyms

2Zero	*Towards zero emission road transport*
AC	*Alternating Current*
AI	*Artificial Intelligence*
ALICE	*Alliance for Logistics Innovation through Collaboration in Europe*
BEV	*Battery Electric Vehicle*
BRT	*Bus Rapid Transit*
CCAM	*Cooperative, Connected and Automated Mobility*
CE	*Circular Economy*
CEF	*Connecting Europe Facility*
CET	*Clean Energy Transition*
CF	*Cohesion Fund*
CH	*Clean Hydrogen*
Chips -JU	*Chips Joint Undertaking*
CPO	*Charging Point Operators*
DC	*Direct Current*
DSO	*Distribution System Operators*
DUT	*Driving Urban Transition*
EC	*European Commission*
EFFRA	*European Factories of the Future Research Association*
EGCI	*European Green Cars Initiative*
EGVI	*European Green Vehicles Initiative*
EGVIA	*European Green Vehicles Initiative Association*
EGVIAfor2Zero	*European Green Vehicles Initiative Association for the 2Zero Partnership*
eMaaS	*Electric Mobility as a Service*
EIB	*European Investment Bank*
EIC	*European Innovation Council*
EIT	*European Institute of Innovation & Technology*
ELT	*End of Life Tyres*
EMC	*Electro Magnetic Compatibility*
EMF	*Electro Magnetic Field*
EMSP	*Electric Mobility Services Providers*
EoL	*End of Life*
EPoSS	*European Technology Platform on Smart Systems Integration*
ERDF	*European Regional Development Fund*
ERTRAC	*European Road Transport Advisory Council*
ETIP-SNET	*European Technology and Innovation Platform – Smart Network for Energy Transition*
ETP	*European Technology Platform*
EU	*European Union*
EV	*Electric Vehicle*
FCEV	*Fuel Cell Electric Vehicle*
FCH-JU	*Fuel Cell and Hydrogen Joint Undertaking*
FP7	*7^{th} Framework Programme for R&D*

GHG	*Green House Gas(es)*
GWP	*Global Warming Potential*
HDV	*Heavy-Duty Vehicle*
HMI	*Human Machine Interface*
ICE	*Internal Combustion Engine*
KDT	*Key Digital Technologies*
KIC	*Knowledge and Innovation Communities*
LCA	*Life-Cycle Assessment*
L-Cat	*L-category vehicles*
LCI	*Life-Cycle Inventory*
LCSA	*Life-Cycle Sustainability Assessment*
LCV	*Light Commercial Vehicles*
LEZ	*Low Emissions Zone*
MaaS	*Mobility as a Service*
MHDV	*Medium and Heavy-Duty Vehicle*
MEA	*Membrane and Electrode Assembly*
NGOs	*Non-Governmental Organisations*
NMS	*New Mobility Services*
OEM	*Original Equipment Manufacturer*
PHEV	*Plug-in Hybrid Electric Vehicle*
PPP	*Public Private Partnership*
PTW	*Powered Two-Wheelers*
RES	*Renewable Energy Sources*
ROI	*Return on Investment*
RRF	*Recovery and Resilience Facility*
RTO	*Research and Technology Organisation*
SDG	*Sustainable Development Goals*
SECAP	*Sustainable Energy and Climate Action Plan*
SME	*Small and Medium Sized Enterprise*
SRA	*Strategic Research Agenda*
SRIA	*Strategic Research and Innovation Agenda*
SSM	*Safe and Sustainable Mobility Partnership*
SULP	*Sustainable Urban Logistics Plan*
SUMP	*Sustainable Urban Mobility Plan*
UMP	*Urban Mobility Package*
TCO	*Total Cost of Ownership*
TRL	*Technology Readiness Level*
TSO	*Transmission System Operators*
V2G	*Vehicle to Grid*
V2X	*Vehicle to Infrastructure*
WPT	*Wireless Power Transfer*
ZEV	*Zero Emission Vehicle*
ZEZ	*Zero Emission Zone*

1. Developing the SRIA: a consultative approach

The Towards Zero Emission Road Transport (2Zero) Strategic Research and Innovation Agenda (SRIA) document has been prepared with a large group of stakeholders who represent the diverse areas covered by the Partnership. It is strongly based on the content of the Partnership proposal, as published by the European Commission on the Horizon Europe Partnership candidates dedicated webpage[1].
The 2Zero SRIA includes a description of some of the research and innovation activities needed to achieve a climate-neutral road transport. It further details the technical and specific objectives, sets milestones and provides a timeframe for such R&I activities and their expected outcomes.

The drafting phase has been coordinated by EGVIAfor2Zero in a transparent manner, with input from all stakeholders willing to actively contribute to the preparation of the document. The process for the SRIA preparation started with a first plenary meeting, open to all stakeholders, on the 14th of May 2020. Following this first meeting, four Working Groups have been created to gather stakeholder's input on research and innovation priorities in the coming seven years in the areas covered by the 2Zero Partnership, then leading to the four pillars of the Partnership:

- **Pillar 1:** Vehicle technologies and vehicle propulsion solutions for Battery Electric Vehicles (BEV) and Fuel Cell Electric Vehicles (FCEV)
- **Pillar 2:** The integration of BEV into the energy system and related charging infrastructure
- **Pillar 3:** Innovative concepts, solutions and services for the zero-tailpipe emission mobility of people and goods
- **Pillar 4:** LCA approaches and circular economy aspects for sustainable and innovative road mobility solutions

Several pillar meetings have been organised to exchange views with the various stakeholders involved in the SRIA preparation. A 2nd "Plenary" meeting has been organised on the 15th of June 2020 to provide an overview of the work advancement to all participating organisations.

A broad stakeholder involvement has been ensured thanks to the direct participation of a large variety of public and private organisations (more than 500 contributors to the pillars) and support from Technology Platforms and European associations, serving as multipliers for the community. For the public sector, different levels have been represented, including national authorities and representatives of local authorities (cities and regions). The 2Zero Partnership received support from various European Technology Platforms, namely ERTRAC[2], EPoSS[3], ETIP-SNET[4], ALICE[5] and Batteries Europe[6]. EGVIAfor2Zero members have been invited to contribute to this exercise, particular attention has been paid to include all stakeholders along the value chain, including, amongst others, TSO, DSO, public authorities, end-user associations, transport operators and the logistics-related industry. Discussions have also been organised with other Partnerships to ensure consistency, avoid duplication of activities and disseminate information.

[1] https://ec.europa.eu/info/files/european-partnership-towards-zero-emission-road-transport-2zero_en
[2] European Road Transport Research Advisory Council (https://www.ertrac.org/)
[3] European Platform on Smart Systems Integration (https://www.smart-systems-integration.org/)
[4] ETIP Smart Networks for Energy Transition (https://www.etip-snet.eu/)
[5] Alliance for Logistics Innovation through Collaboration in Europe (https://www.etp-logistics.eu/)
[6] ETIP Batteries (https://ec.europa.eu/energy/topics/technology-and-innovation/batteries-europe_en)

A specific meeting has been organised with the Member States on the 3rd of June 2020 to further detail their possible contribution to the governance of the 2Zero Partnership.

The update of the document followed the same, open approach: a kick-off meeting has been organised on 26th January 2023 to compile inputs from all interested stakeholders and various follow-up meetings in smaller groups have been organised to receive more precise feedback and compile written inputs.

This multi-stakeholder SRIA will be the basis for the identification of the priorities to be covered by the 2Zero Partnership and the definition of annual research priorities.

2. Context definition (scientific, policy …) and related challenges to be tackled by the Partnership

2.1 – Context presentation

The mobility of people and goods is the lifeblood of an integrated European single market, territorial cohesion and an open and inclusive society: it is the backbone of economic growth across the continent, enabling prosperity, freedom of movement and employment, thus contributing significantly to the well-being of European citizens. However, transport, mobility and their related services still need to improve their environmental performance. Indeed, all transport is responsible for nearly one quarter of the European GHG emissions today, with road transport being accountable for approximately 72% of these emissions[7]. In addition, road transport is one of the major sources of pollutant emissions in cities, generating increasing concerns about the impact of road transport on human health. The impact of road transport on the environment is a challenge the European Commission addressed in various plans and communications over the past decades, including the Transport White Paper[8], the Strategy for Low Emissions Mobility[9], "Europe on the Move", the support to the definition of Sustainable Urban Mobility Plans (SUMPs), and the promotion of Low Emission Zones (LEZs) as one of the ways to curb local air pollution.

On the 11th of December 2019, European Commission President Ursula von der Leyen presented the new European growth strategy: the European Green Deal, a plan to make Europe the first climate-neutral continent by 2050 and to achieve a 55% emissions reduction by 2030. The Green Deal is the EU integrated strategy to reduce GHG emissions, including those from road transport: it mainstreams environmental policy by bringing together and improving several existing policies, initiatives and funding programmes that are dedicated to addressing sustainability and climate change. Despite the significant improvements achieved over the past ten years particularly in road transport, further developments still need to be done for the European Union to deliver on the Paris Agreement targets "*to avoid dangerous climate change by limiting global warming to well below 2°C and pursuing efforts to limit it to 1.5°C*".
As stated by Commission President Ursula Van der Leyen, "*The European Green Deal is our new growth strategy. It will help us cut emissions while creating jobs*". This new growth strategy is detailed in the EC Green Deal industrial plan, summarising initiatives proposed by the EC to support EU competitiveness, economic growth and job security in the transition phase by implementing a predictable and simplified regulatory environment, speeding up the access to finance, enhancing skills and open trade for resilient supply chains. More specifically for road transport, a balanced approach between profound changes offering a new road mobility system and innovations, that have immediate impact on the transition towards zero emission, will be needed.

In September 2020, the European Commission released the 2030 Climate Target Plan, presenting a renewed climate ambition, with a target to reduce EU-wide Greenhouse Gas (GHG) Emissions by 2030 by at least 55% (including emissions and removals) compared to 1990 levels. All transport sectors – road, rail, aviation and waterborne transport – will have to contribute to the 55% reduction

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[7] https://op.europa.eu/en/publication-detail/-/publication/f0f3e1b7-ee2b-11e9-a32c-01aa75ed71a1
[8] "Roadmap to a single European Transport Area — towards a Competitive and Resource-efficient transport system" (COM (2011) 144 final)
[9] "A European Strategy for Low-Emission Mobility" (COM (2016) 501)

effort. In order to support this ambition, the EC published the "Sustainable and Smart Mobility Strategy"[10] together with 82 measures detailed in the related Action Plan to accompany the transition of the EU transport system in its green and digital transformation, aiming for an "irreversible shift to zero emission mobility". Nearly all cars, vans, buses as well as new heavy-duty vehicles will be zero emission by 2050, with a key milestone of 30 million zero emission vehicles on our European roads by 2030.

The "Fit for 55" package[11] provided a coherent and balanced framework for reaching the EU's climate objectives. Main legislative proposals directly concern transport were the standards on CO_2 emissions for cars and vans and for trucks and buses[12], and the Alternative Fuels Infrastructures Regulation (AFIR).[13] While the revised CO_2 emissions standards have the ambitious objective of ending of the sales of light-duty vehicles with an internal combustion engine by 2035 and strongly incentivising zero emission heavy-duty vehicles, the AFIR shall ensure an adequate publicly accessible infrastructure for users. It sets mandatory targets for the deployment of the recharging and refuelling infrastructure to support zero tailpipe emission road transport, and at the same time to achieve full interoperability of the infrastructure, allowing travellers to move with ease throughout Europe. The European Commission also published an update of the TEN-T Regulation [14].

The CoVId-19 pandemic had significant effects on the global economy, travelling habits, mobility and transport needs and possibilities, across Europe and globally. Industries have been required to adapt their work along the whole value chain in order to meet strict hygienic standards and respect the new government regulations. These effects have been especially challenging for the road transport sector.

The consequences of the pandemic crisis might still take many forms, and impact road transport in the short and longer term at different levels:

- **Economic level**: production has been slowed due to the lockdown, putting many jobs at risk. A strong recovery package has been put forward as a supporting tool for the Union to overcome the crisis; supporting the road transport industry in keeping its leadership worldwide and becoming the leader in upcoming technologies will be critical to save jobs and support the whole value chain.
- **Mobility choices**: The CoVId-19 pandemic may have had a negative effect on the expected modal shift to public transport, with an unexpected reluctance to rely on and use public transport, and with possible impact on the development of new business models such as sharing systems (car sharing services have been heavily impacted by the crisis, given the sanitary problems this business model foresees), potentially leading to an increase in the

[10] https://transport.ec.europa.eu/transport-themes/mobility-strategy_en

[11] https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/#:~:text=for%2055%20package%3F-,What%20is%20the%20Fit%20for%2055%20package%3F,Council%20and%20the%20European%20Parliament.

[12] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R0851; https://ec.europa.eu/commission/presscorner/detail/en/qanda_23_763

[13] https://eur-lex.europa.eu/resource.html?uri=cellar:dbb134db-e575-11eb-a1a5-01aa75ed71a1.0001.02/DOC_1&format=PDF; https://www.consilium.europa.eu/en/press/press-releases/2023/07/25/alternative-fuels-infrastructure-council-adopts-new-law-for-more-recharging-and-refuelling-stations-across-europe/

[14] https://ec.europa.eu/transport/themes/infrastructure/ten-t_en

demand for personal mobility[15]. "Active" modes of transport and micromobility, such as walking or cycling, became more and more attractive but cannot answer all mobility needs.

- **Logistics:** The sanitary crisis highlighted the importance of a functioning goods delivery system all across Europe (including in remote areas) and the growing willingness of consumers towards home deliveries. The change in consumption channels (including e-commerce) is driving an increase in demand for parcel deliveries, increasing the traffic of delivery vehicles and is accelerating digitalisation, resulting in a growing need for environmentally and socially responsible solutions based on zero emission vehicles and an acceleration towards shared and interconnected logistics networks.

When defining the research and innovation priorities for the coming years, several trends and long-term targets should be considered:

- As of today, more than 70% of passenger journeys are made by car, and 75% of all the goods transported across Europe are delivered by road freight transport. Estimates suggest that passenger transport will increase by 42% and freight transport by 60%[16] by 2050, making it even more difficult to achieve Europe's environmental targets. As road transport will continue to be the backbone of mobility for people and goods in the foreseeable future, particular attention should also be paid to develop affordable and clean mobility solutions for all use applications.
- Despite the variety of business models proposed in the last years (e.g. battery leasing model, Mobility-as-a-Service, car sharing, etc.), light-duty passenger mobility is still a market dominated by the individual ownership model, although an increased share of the population is steering more and more away from it and embracing soft mobility and a sharing culture.
- By 2050, it is expected that more than 84% of the European citizens will live in urban areas[17]. This will generate continued challenges related to local (urban) air pollution and noise, including their impacts on health, but also logistics and the delivery of goods in cities, urban space occupation, parking possibilities, charging points deployment and many more. Traffic congestion will remain a key issue, even if more intensive teleworking is likely to have a positive influence. Urbanization will also have important impacts on rural transport systems which may face the issue of economic viability in more sparsely populated areas.
- Europe is striving for resource efficiency and sustainable productivity, to decouple economic growth from the exploitation of resources, and to transform itself towards a green economy. Resource efficiency needs to be increased by a factor of 4 to 10 to meet demand for, e.g., raw and scarce materials in 2050. Already today, essential raw materials are scarce and their price volatility has a negative impact on the economy.[18]
- While Europe is facing a drastic transition of its mobility system, requiring major investments, the current economic and geopolitical crisis, inflation and potential bottlenecks

[15] Car and Driver: "CDC Says Cars Are Better Than Mass Transit during CoVId-19 Crisis", 31 May 2020, looked up 26 July 2020; https://www.caranddriver.com/news/a32723125/cdc-cars-safety-rules-coronavirus/#

[16] *Transport in the European Union. Current Trends and Issues.* European Commission. DG Mobility & Transport (2019)
https://ec.europa.eu/transport/sites/transport/files/2019-transport-in-the-eu-current-trends-and-issues.pdf

[17] https://ec.europa.eu/knowledge4policy/foresight/topic/continuing-urbanisation/developments-and-forecasts-on-continuing-urbanisation_en_

[18] Roadmap to Resource Efficient Europe, European Commission (COM(2011) 517 final)

in availability of (critical) raw materials (including issues related to production and processing) will need to be correctly taken into account.

- Europe needs in fact to achieve climate neutrality by 2050. This implies, amongst other measures, phasing out the use of fossil energy carriers, such as conventional fuels. This is also supported by the Green Deal, that targets the transport sector as a whole to reduce its GHG emissions by 90% compared to 1990 levels[19]. In order to meet its complete future energy needs, Europe might still partly rely on renewable energy imports, which might use direct electric transmission and necessitate chemical energy carriers, e.g. renewable hydrocarbon and non-hydrocarbon chemicals and/or fuels. The use of these "carbon-neutral" fuels might also extend to road transport, where alternative and more efficient solutions (such as electrification) are not suitable. To ensure climate neutrality, the use of carbon-neutral fuels should also limit other GHG (e.g. methane and nitrous oxides) with high global warming potential.
- Finally, Europe also aims to achieve zero pollutants, covering not only the current regulated tailpipe pollutants but also any health-impacting pollutants that might result from current or future technologies, whilst also reducing non-tailpipe emissions.

EU funding concerning road transport will be exclusively supporting research and innovation activities related to zero tailpipe emission vehicles in their system, in order to accelerate the development of a climate-neutral road transport system.
To cover the transition period, to develop competitive and sustainable solutions suitable for all use-cases, all applications and all across the world, the counterpart of the EC in the Partnership will continue to investigate all renewable energy carriers and zero-impact emission options – without EU funding support, as detailed in Chapter 3.3, since these areas are not recognised by EC as R&I priorities.
European stakeholders, especially the automobile industry, are now investing huge resources in electrification but are facing an increased international competition in this area. The sustained EU global leadership in the road transport sector is now challenged, not only by Asia and the USA but also by new contenders from the digital services sector, which are entering the arena with disruptive innovations. Building on profound existing European knowledge and leadership, expanding the scope to include a holistic system approach will be the way to remain at the forefront of the international competition and take the lead on new pathways to a global, sustainable, road mobility. It will require further development of expertise in innovative components (batteries, software, semi-conductors, etc.), infrastructure and services, and will generate new types of jobs requiring new skills.

2.2 – Past achievements and identification of gaps

The two predecessors of 2Zero, namely the European Green Cars Initiative (EGCI) and the European Green Vehicles Initiative (EGVI), resulted in 186 funded projects in the following areas:

- Electric Vehicles (EVs) integration into the grid and transport system
- Vehicle concept and design
- Batteries
- Vehicle hybridisation & alternative fuels, optimisation of internal combustion engine (ICE) powertrains

[19] A Clean Planet for all (COM (2018) 773 final)

- Low emission ICE powertrains
- Energy management
- EV drivetrains
- Modelling and testing
- Emission measurement
- Powertrain control
- Weight reduction
- Aerodynamic trucks.

The EGVI 10 years' impact assessment[20], published in 2019, had highlighted the many benefits brought by the Partnership at European level:

- Helping achieve CO_2 emissions reduction;
- Accompanying the growth of automotive R&D spending;
- Supporting the European industry to enter and take a leading position in the race of Green Vehicle technologies;
- Fostering new technology developments to ensure Europe keeps its leadership in automotive innovation and low emission vehicles.

Despite these successes, potential for improvements were identified and taken into account in the definition of the 2Zero Partnership. In particular, the integration of the complete value chain has been enhanced in 2Zero, with increased participation of Small and Medium Sized Enterprises (SME) and EU-13 stakeholders, proposed a wider debate and update of the roadmaps.

The impact assessment study[21] that was commissioned by EGVIA to external experts (Strategy Engineers) conducted during the first semester of 2023 concluded that EGVI has successfully achieved its objectives, leaving a lasting impact on the EU transport technology research and innovation landscape. The initiative played a pivotal role in advancing road transport decarbonisation by integrating cutting-edge technologies, hence contributing to the achievement of 4.6 million electrified vehicles on the public roads in the EU by 2020. Notably, the study reports that EGVI projects demonstrated tangible advancements in battery pack and cell energy density, as well as holistic energy efficiency for passenger cars and heavy-duty trucks, surpassing market trends by several years. Looking forward, the initiative is projected to lead to a decrease of 9 million tonnes of CO_2 emissions by 2030, which is equivalent to taking 6 million passenger cars off the road for a year.

EGVI's legacy is claimed to extend beyond technological achievements, providing enduring economic growth and employment benefits for the EU. The initiative directly cultivated essential skills, knowledge and capabilities, contributing to EU competence overall, supporting academic and training curricula development. EGVI projects improved the time-to-market capability by approximately 12 months for relevant technologies, giving the EU a competitive advantage in the rapidly evolving global landscape. The potential commercial benefits from the skills and technologies developed during EGVI could reach up to €30 billion from 2024 to 2030, with a return on investment of up to 40 times the initial EGVI funding. This increased value-add revenue is

[20] EGVI 10 years impact assessment (https://egvi.eu/wp-content/uploads/2019/04/Impact-Assessment-2019-digital-version-1.pdf)
[21] EGVI Impact Assessment, 20214-2024, authored by Strategy Engineers, https://www.2zeroemission.eu/wp-content/uploads/2023/10/EGVI-Impact-Assessment-2014-2020.pdf

expected to generate a demand for 16,000 high-value jobs in the green vehicle technology sectors within the EU, bolstering growth and benefiting the wider economy.

Furthermore, EGVI played a key role in fostering collaboration between various stakeholders, knowledge sharing and strategic alignment within the EU-wide research community. This collaborative environment has resulted in more targeted research and development activities, significantly reducing the level of R&D risk. The initiative also contributed to the development of EU regulations and standards, acting as a catalyst to define industry approaches and targets.

However, lessons learned from EGVI highlighted areas for improvement in future EU-funded programmes. Challenges, such as lengthy project initiation periods and the need for more ambitious targets, especially in rapidly evolving areas such as AC-DC inverter power density, have been identified. The importance of affordability and a focus on reducing development costs for broader technology adoption, such as battery cell cost reduction, is emphasised. Overall, EGVI success underscores the need for continued strategic planning and adaptation in future initiatives, to maximise their impact on European innovation and sustainability.

Furthermore, challenges were identified by the gap analysis performed as part of the FUTURE-RADAR[22] funded project, on the R&I areas covered by the joint ERTRAC, EPoSS and ETIP-SNET roadmap for "Electrification of Road Transport", originally published in 2012 and updated in 2017:

- Light and conventional passenger cars predominated in research and development (although buses were also considered), as these vehicle types had been seen as a favorable initial step for the electrification of road transport. However, the electrification of heavy vehicles, such as trucks or coaches, will be important in future to achieve the advantages of a fully electrified road transport system.
- The analysis revealed gaps in the topics of charging, battery cell recycling, vehicle-to-grid as well as electric road system.
- Moreover, the majority of previous projects were focused on component, sub-system and vehicle level improvements to reduce consumption rather than on the comprehensive optimization of, e.g., energy efficiency at an energy or transport system level.

All these aspects have been reflected in setting-up the 2Zero Work Programmes 2021-2024.

Although zero tailpipe emission technologies are available in the market, in most vehicle segments and with a more and more acceptable range, their initial purchase price within the current business models, the implementation path of the recharging infrastructure and a lack of services are preventing faster deployment. Zero tailpipe emission vehicles are becoming a strong market in most countries, achieving double digit sales figures in some. At the same time, it is becoming increasingly evident that the transition of the entire vehicle market towards zero emission will require more than just a direct switch of drivetrain technologies. All aspects of the mobility system should be questioned and, possibly, re-engineered. Simply attempting to reproduce the exact performance targets of conventional vehicles might lead to higher costs without delivering sufficient value to the customer: specifically, greater installed range could mean higher monetary costs for the increased battery capacity as well as higher environmental cost due to the additional resources and energy required for the production of the components. Research is still needed to address and mitigate these aspects, in

[22] https://egvi.eu/what-we-do/support-action/

order to increase the energy efficiency and circularity of components and the whole vehicle, whilst reducing cost and material intensiveness, and resolving the cost versus range dilemma.
Adopting a complete system approach, with a broader diversification of vehicle concepts and their performance targets for different use-cases, is one of the ways to close the gap. In order to enable the rapid and effective transition to zero tailpipe emission road transport, aspects related to vehicle development and manufacturing (especially those where design decisions may have a significant impact, for instance on cost) should be considered with a system perspective.

The importance of life-cycle assessment and applying circular economy approaches in all areas of EU citizens daily life have been recognised over past decades. Consequently, dedicated standards and norms have been developed, Europe-wide initiatives such as the European Platform on Life-Cycle Assessment and the EU Single Market for Green Products Initiative have also been set-up. However, the life-cycle inventory made available through those initiatives is only investigated for a limited number of products (about 28, including rechargeable batteries for mobility) showing the complexity and challenges of a holistic assessment of the ecological footprint over the life-cycle.
Although the measures with respect to life-cycle analysis (LCA) and the circular economy have been accompanied by R&I projects, the transport sector is still struggling to adopt LCA and circular economy approaches. This is particularly so when encompassing the entire cradle-to-grave scope, as well as to get access to real data or use coherent system boundaries and methods, which makes it difficult to achieve standardised and comparable results. Instead of performing a LCA retrospectively, strategies and tools are needed to target the environmental footprint, circularity and associated costs in advance and along the development process, to be verified by real, living data. The recent battery regulation[23] is an example of this: the whole EU supply chain has to report on their products' carbon footprint using an LCA approach.

2.3 – Problems definition

Several technical advancements have been achieved in the field of the electrification of road transport in the past decade, thanks to the work carried out in both the European Green Cars Initiative and the European Green Vehicles Initiative, and following the internal strategies of stakeholders all along the value chain. However, despite the technological progress, several challenges remain and require better solutions (at vehicle, infrastructure and system integration levels), to increase user acceptance and accelerate the uptake of EVs:

- Sales of BEVs in the EU have already reached significant shares of total sales in many MS, but some users might still be reluctant to switch to zero emission vehicles.
    - Potential customers may be discouraged to make the switch and invest in an EV if the initial purchase price is not affordable or the total cost of ownership is not competitive with current vehicles.
    - User friendliness, particularly for recharging, still needs to be improved, with a specific focus on the development of solutions for easier payment and for cities with low private parking availability as well as for strategically located fast charging options. Transparency of recharging, standardisation of recharging modes and regulations to

[23] Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries, amending Directive 2008/98/EC and Regulation (EU) 2019/1020 and repealing Directive 2006/66/EC (Text with EEA relevance)

   - harmonise the system will also be needed to improve user experience.
   - In order to further increase the user acceptance of EVs, the interoperable charging infrastructure needs to be improved and the number of charging spots in Europe needs to be increased with a suitable advance with the growth of the fleet.
   - Users may have usage models where they doubt the reliability of EVs during different seasons of the year (battery behaviour at very high or very low temperatures).
   - The right engineering trade-offs have to be identified to satisfy various user needs, future vehicle usage patterns and guarantee users' priorities (e.g. cost reduction versus the desire for longer range with a single charge).
- Customer mobility demands should be satisfied by a mix of suitably dimensioned, zero tailpipe emission vehicles and technological solutions, whilst avoiding excessive costs and resource usage.
   - Charging time and convenience need to be improved to offer a better travel experience to customers, with the target to change their "refuelling" mind-set from ICE to BEV by having diverse refuelling/charging opportunities (at home, work, parking place, etc.) that are more convenient than the current refuelling option.
   - The added value of new technologies, such as smart charging or Vehicle-to-Grid (V2G) or advanced operation strategies, should be further developed and business models should be established for the benefit of the end-users.
   - The variety of vehicle architectures and configuration should match customer mobility demands.
   - Charging times should be reduced to meet user's expectations and efficiency in some applications.
- Vehicles and infrastructure should be developed in collaboration and take into account new business models, ownership models and new constraints defined by public authorities to address citizens' concerns (e.g. city access restriction, noise reduction, reduction of pollutant emissions, etc.).
- Individual research activities on components and sub-systems have been performed but their interaction and integration have not been sufficiently addressed at a system level, also considering the interactions with the grid, to answer the various usage models in the most efficient way.
- The cost / benefit ratio of the developed solutions should be optimised whilst considering environmental impact and resource efficiency.
- Users want to be informed about overall environmental impacts and the use of resources (mining, carbon footprint, waste, use of water, critical raw material throughout the vehicle/equipment life-cycle, recycling and second life, etc.). These aspects shall be considered in more depth and reduced by optimising the choice of materials and technologies in the design phase.
- Specific issues with heavy-duty vehicles (HDV) should be considered in order to develop affordable zero emission solutions:
   - Range and payload (and other performance) limitations for HDV along with specificities of certain applications.
   - Competitiveness of zero tailpipe emission vehicles (their total cost of ownership (TCO)) compared to conventional vehicles.

- Lack of tools to manage a variety and/or combination of vehicle types within fleets to set assignments properly.

- Specific issues on logistics should be considered ensuring positive business models for operators.

Having in mind road transport from a system point of view (addressing vehicle technologies, infrastructure, optimal interaction with the grid and business models in a holistic approach for both people and goods mobility), solving these challenges will require a multitude of solutions to accelerate zero tailpipe emission road transport in urban, peri-urban and rural areas.

Leveraging the combination of the different R&I areas needed to achieve the Green Deal objectives will enable the 2Zero Partnership to take a holistic approach to achieve a zero tailpipe emission road transport system, with optimised components, vehicles and subsystems.

3. Vision / objectives / scope of the Partnership

3.1 – Vision

A climate-neutral and clean road transport system is possible by 2050. The 2Zero Partnership is strongly committed to achieve the use of 100% renewable energy carriers in road transport and share the vision of Europe becoming the first climate-neutral continent by 2050. A high rate of introduction of zero tailpipe emission powertrain vehicles (BEV and FCEV) is one of the key elements for climate neutrality within the transport sector.

This responds to the pathway, also identified as a priority in the Green Deal communication, to put sustainability and the well-being of EU citizens at the centre of economic policy, and sustainable development goals at the heart of the European policies and related actions. Road transport should become drastically less polluting, especially in urban areas. Achieving sustainable transport also means putting users first and providing them with more affordable, more accessible and cleaner alternatives to their current mobility options.

To make this vision a reality, all stakeholders within road transport have to bring substantial contributions: the automotive industry, the energy providers, the TSO and DSOs, RTOs and universities, the public and private (charging) infrastructure, and public authorities.

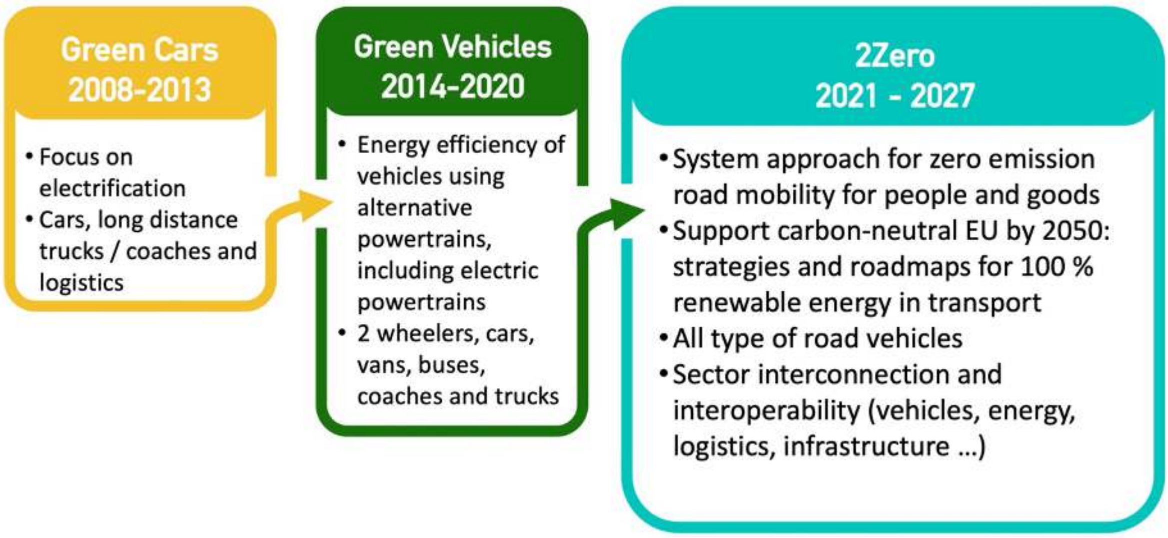


Figure 1 – From the European Green Cars Initiative to the 2Zero Partnership: the evolution of the Partnership

As illustrated in the *figure above*, the Public Private Partnerships (PPP), the European Green Cars Initiative (EGCI) under FP7 and its successor the European Green Vehicle Initiative cPPP (EGVI) under Horizon 2020, strongly supported the development of green vehicles and innovative mobility solutions for the future.

Since 2008, over 1 billion Euros of European funds have already been invested into R&I aspects of green vehicles, reflecting the importance of reducing the environmental impact of road transport in Europe, and contributing to supporting the European road transport eco-system in the transition towards decarbonisation and zero emission. Many aspects of vehicle energy efficiency improvement and emission reduction have been investigated, including the development of batteries for use in electric road vehicles.

Whilst pursuing the improvement of road vehicles, future research will have to tackle the systemic and cross-sectoral nature of the challenges: therefore, a multi-stakeholder collaboration, sharing a joint commitment towards the climate neutrality of road transport, is needed. Technology development will remain a strong driver but success can only be achieved by developing system-level solutions, covering multiple mobility aspects, recharging infrastructure development and reinforcing the user acceptance of any new solutions. New paradigms will require a careful consideration of various aspects, such as territorial planning, behavioural patterns of the users, user friendliness and social inclusion, particularly when rolling-out the charging infrastructure or when implementing zero emission MaaS solutions.

The results of R&I under the 2Zero Partnership will accelerate the transition towards a climate-neutral and clean road transport system. In Horizon Europe, 2Zero will be allocated in Pillar 2 "Global challenges and industrial competitiveness of Europe" and in the Cluster 5 "Climate, Energy and Mobility", reinforcing the cross-sectoral links with the energy sector and highlighting 2Zero's contribution to the European economy by establishing better recycling of used goods and waste, creating jobs and economic growth, reinforcing strategic independence and environmental friendliness from saving natural resources and optimising energy use in mobility and industry. Therefore, 2Zero will be an integral part of the strategy for making Europe the first climate-neutral continent by 2050 and of the European Green Deal.

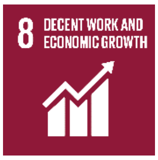
The 2Zero Partnership will make a significant contribution to achieving the following Sustainable Development Goals[24] (SDG):

By drastically reducing CO_2 and other GHG emissions from road transport, thanks to its focus on zero tailpipe emission vehicles, it will make a decisive contribution to the SDG 13 – Climate Action.

By supporting the development of multiple solutions, alternatives to conventional vehicles, and the related recharging / refuelling infrastructure, whilst leading the way to the use of 100% renewable energy carriers in road transport, the Partnership will contribute to the SDG7 "Affordable and clean energy".

By improving air quality in cities and limiting noise it will bring the SDG11 "Sustainable cities and communities" a step closer to reality.

[24] https://ec.europa.eu/info/strategy/international-strategies/sustainable-development-goals/eu-approach-sustainable-development-0_en



By reinforcing European competitiveness, it will support sustainable economic growth across the continent, whilst improving the quality of jobs in the road transport area, and will contribute to SDG8 “Decent work and economic growth”.

By considering the overall life-cycle of the vehicles, and by implementing circular economy concepts, the 2Zero Partnership will bring us a step closer to the SDG 12 “Responsible consumption and production”.

The overall vision of the 2Zero Partnership is a climate-neutral and clean road transport system thanks to zero tailpipe emission road mobility for people and goods. To achieve its vision, the Partnership’s activities are structured around four main pillars, interacting to provide R&I priorities:

- Vehicle technologies and vehicle propulsion solutions for BEV and FCEV, to build the best suited zero tailpipe vehicles for different use-cases in the future.
- The integration of BEV into the energy system and related charging infrastructure, to ensure ease of use of new vehicles and attractive business models for BEV, thanks to large-scale development of smart charging and V2G technologies.
- Innovative concepts, solutions and services for the zero tailpipe emission mobility of people and goods, to identify relevant use-cases, develop future business models and foster market uptake.
- LCA and circular economy approaches for sustainable and innovative road mobility solutions, to ensure long-term sustainability of the developed solutions.

By addressing and combining these four R&I pillars in a system approach, the 2Zero Partnership will make a significant contribution to the Green Deal, as shown in *Figure 2* below. Only a combined approach, leveraging synergies across the different domains will allow maximisation of the benefits from each domain.

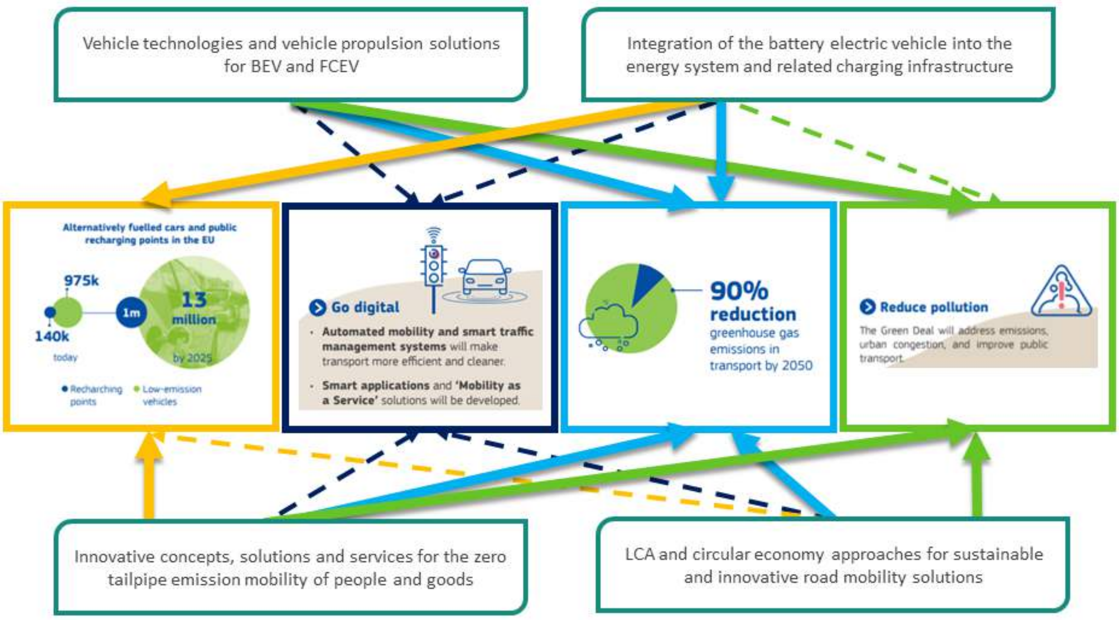


Figure 2 – Contribution of the 2Zero Partnership to the Green Deal targets

The 2Zero Partnership is addressing the development of a multi-technology portfolio of solutions that meet the demands of diverse user groups, maximising affordability and cost effectiveness also by considering new business models, new ownership models and innovative mobility solutions whilst remaining competitive at the global scale. This system perspective is needed to accelerate the transition towards the large-scale uptake of cleaner mobility solutions, considering the different use-cases in concert with the necessary push for the interoperable infrastructure development and the cost competitiveness aspects of European solutions. Reinforcing the integration capability of vehicles in their environment (in the energy system and in the overall transport system) will be one of the objectives of the 2Zero Partnership: this will contribute to tackle the challenges and hurdles still preventing a larger uptake of electric vehicles in the market.

The future development of EVs (and Heavy-Duty FCEVs) in 2Zero will include optimised solutions through improvements of the multi-purpose vehicle models whilst also addressing innovative mobility concepts with mission-specific, "fit-for-purpose" right-sizing, raising the utility of all vehicles. These developments will target novel, specific use-cases in order to expand and enrich the overall portfolio of mobility solutions offered.

Such a system approach, 2Zero in collaborative projects, adds a new development scope that goes beyond the classic development methods and procedures for components, subsystems and vehicles. Vehicle technologies should be strongly linked with use-cases, usage models and patterns, as well as capitalising on potential new mobility and ownership models, the future role of information and communication technologies and, especially, artificial intelligence. These aspects could influence vehicle requirements, impact design and operation, subsequently components and subsystems, in the current and future mobility.

Since no single sector will be able to solve all the issues independently, 2Zero will bring together a strong and coordinated pan-European initiative providing the complete R&I eco-system needed to achieve a truly sustainable, zero tailpipe emission road transport. By building on the solid foundation of the existing, highly successful EGVI Partnership, 2Zero will also serve to boost the competitiveness of the European automotive industry at the global scale.

3.2 – Objectives

This Partnership will address programme objectives stated in the proposed framework programme (Article 3) of Horizon Europe:

- to support the creation and diffusion of high-quality, new knowledge, skills, technologies and solutions to global challenges;
- to strengthen the impact of research and innovation in developing, supporting and implementing Union policies, and support the uptake of innovative solutions in industry and society to address global challenges;
- to foster all forms of innovation, including breakthrough innovation, and strengthen the market deployment of innovative solutions.

The objectives of the Partnership are shown in *Figure 3* below and listed here.

General objectives of the Partnership:

- Contribute to Europe having the first carbon-neutral road transport system by 2050;
- Ensure technology leadership supporting economic growth and safeguarding jobs, creation all over Europe;
- Ensure European competitiveness thanks to solutions for an integrated carbon-neutral road transport eco-system;
- Improve the health and quality of life of EU citizens and ensure mobility for people and goods.

Specific objectives of the Partnership:

- Develop zero tailpipe emission, affordable user-centric solutions (technologies and services) for road-based mobility all across Europe and accelerate their acceptance to improve air quality in urban areas and beyond;
- Develop affordable, user-friendly charging infrastructure concepts and technologies that include vehicle and grid interaction;
- Demonstrate innovative use-cases for the integration of zero tailpipe emission vehicles and infrastructure concepts for the road mobility of people and goods;
- Support the development of life-cycle analysis tools and skills for the effective design, assessment and deployment of innovative concepts in products/services in a circular economy context.

Operational objectives of the Partnership:

- Development of affordable innovative Battery Electric Vehicles (BEV) and HD Fuel Cell Electric Vehicles (FCEV) concepts and technologies;
- Demonstration of zero emission Light-Duty Vehicles (LDV), passenger cars and commercial use, to reduce total cost of ownership compared to conventional vehicles by 20% for the widest usages.
- Demonstration of zero emission Heavy-Duty Vehicles (HDV) matching the performance and TCO (Total Cost of Ownership) of current vehicles for most of the relevant use-cases, including new usage models;
- Development and demonstration of affordable new vehicle solutions, charging technologies and services for the mass market, to enable 1000km long distance trips with no more than 10% additional time compared to conventional solutions, considering economic and environmental assessment.
- Development and demonstration of solutions for pervasive, user-friendly, low cost and interoperable low-power (<22 kW) and efficient high (~150kW) and/or ultrahigh-power (300 kW) charging infrastructure[25];
- Development and demonstration of interoperable smart charging and bi-directional energy services and solutions accepted by the users and providing services to the energy grid;
- To have a broad stakeholder coverage over the different sectors involved;
- A number of SMEs in projects funded by the Partnership;
- To support standardisation activities;

[25] Rapid technological advancements might require a redefinition of "ultrahigh-power" charging infrastructure for solutions >300 kW, up to Megawatt Charging Systems.

- A number of patent application and IPR generated in projects funded by the Partnership;
- A number of publications in projects funded by the Partnership;
- To provide scientific input for informed regulation;
- To ensure a wide dissemination of activities and results;
- To contribute to the education of future workers and the public about the new mobility.

Figure 3 – The hierarchy of objectives of the 2Zero Partnership

The table below aims to present, in a concise way, the different objectives (general, specific and operational) of the 2Zero Partnership and the Key Performance Indicators identified to monitor the advancements. As 2Zero will take a system approach, interconnections between the different items might lead to duplication in the table.
Being successful in achieving the outcomes suggested in the table will not entirely rely on the 2Zero actions; additional activities, not falling under 2Zero responsibility, will need to be carried out in parallel to the Partnership activities (policies, regulations, etc.).
The 2Zero Partnership will also bring a major contribution to broader additional outcomes not listed in the table (for example the transformation of the EU road transport system, zero emission urban areas, market accessibility, leadership position in exports, etc.).

European Partnership 2Zero				Monitoring and evaluation framework, [March 2024]	
Overall vision: The 2Zero Partnership will set an ambitious research programme to accelerate the development of zero tailpipe emission road transport in Europe with a system approach. It will improve air quality, the mobility safety of people and of goods, hence ensure future European leadership in innovation, production and services. By paving the way to a climate neutral road transport system, the Partnership will make a key contribution to the success of the European Green Deal.					
Objectives		**What is a measure of success?** Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	**Which is the data source and methodology used?** [project data, study, ….]	**Who is responsible for monitoring and providing the data / information?** **When will it be collected?**	**Baseline and target**
General objectives	**Contribute to Europe having the first carbon-neutral road transport system by 2050;**	Proportion of climate related spending (climate mainstreaming) in Horizon Europe spending	CORDA Reporting	EC Part of the ex-post evaluation	Baseline 2020
	Technology leadership supporting economic growth and job creation all over Europe;	FTE jobs supported in entities involved in Horizon projects addressing the European Green Deal per year	Horizon Dashboard	EC Part of the ex-post evaluation	Baseline 2020
	Ensure European competitiveness thanks to solutions for an integrated carbon neutral road transport	Reduction of CO_2 emission from road transport for all types of vehicles	EEA report	EC / Association Part of the ex-post evaluation	Baseline 1990 Contribution to the overall target of 55% reduction of CO_2 emission in 2030 (public target) e.g. number of projects contributing to CO_2 reduction

Objectives		What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used? [project data, study, ….]	Who is responsible for monitoring and providing the data / information? When will it be collected?	Baseline and target
	eco-system; **Improve the quality of life of EU citizens and ensure mobility for people and goods.**	Number of new vehicle registration of zero tailpipe emission vehicle in Europe in 2030, both for passenger cars/light duty vehicles (L Cat. included) and for commercial vehicles	ACEA report ACEM	Association Part of the ex-post evaluation	Baseline 2020 At least 30mil BEVs will be on the roads by 2030[26] At least 280.000 zero-emission HDV will be on the roads by 2030, 180.000 of these trucks are for long-haul use[27]. More than 50% new vehicle registration for urban mobility PTW will be electric vehicles, provided that enabling conditions are met[28].
		Increased affordability of the zero tailpipe emission vehicles	Publicly available information (market studies)	EC, Association Part of the ex post evaluation	Contribution to a reduction of at least a 60% reduction of the sale price differential between conventional vehicles and zero emission vehicles by 2025 and 90% by 2030[29].

[26] Not withstanding the need to fulfil the enabling conditions on charging/refuelling infrastructure and to prevent major disruptions and shortages.
[27] Not withstanding the need to fulfil the enabling conditions on charging/refuelling infrastructure and to prevent major disruptions and shortages.
[28] The following enabling conditions will be necessary (all dedicated to PTWs): investments in breakthrough battery policies, reducing cost; mandatory number of electric vehicles charging points; standardisation and deployment of interoperable swappable batteries and related infrastructure; positive incentive schemes for zero emission vehicles and for charging infrastructure.
[29] Provided that a drastic cost reduction of batteries occurred.

Objectives		What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used? [project data, study, ...]	Who is responsible for monitoring and providing the data / information? When will it be collected?	Baseline and target
		Number of (publicly available) electric recharging and hydrogen refuelling stations available in the EU in 2030	CEF report Dir 20014/94/EU (AFID) related reporting (National Implementation Reports – NIRs) EAFO	EC Part of the ex-post evaluation	Baseline 2020 Contribution to achieve 3 million public charging points in 2030 (public target)
Specific objectives	**Develop zero tailpipe emission, affordable user-centric solutions (technologies and services) for road-based mobility all across Europe and accelerate their acceptance to improve air quality in urban areas and beyond;**	Ability of determining realistically and reliably the energy intensity (tank-to-wheel)	Projects results via digital twin[30]	Association / EC / CINEA / funded projects (biannual)	Baseline 2020 Targets: Reduction of GHG and energy intensity of mobility by 30% for personal mobility and 25 % for freight by 2030
		Reduce GHG of mobility of people and goods (expressed in ton CO_{2eq} /pkm or tkm and toe[31] /pkm and toe/tkm)	Projects results via digital twin	Association / EC / CINEA / funded projects (biannual)	
		Reduction of development time and effort	Projects results analysis	EC / CINEA / funded projects / Association (biannual)	Estimated 20% decrease of development time and effort including via digitalisation

[30] Provided that a common methodology is agreed among stakeholders.
[31] tonne of oil equivalent.

Objectives		What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used? [project data, study, ….]	Who is responsible for monitoring and providing the data / information? When will it be collected?	Baseline and target
	Develop affordable, user-friendly charging infrastructure concepts and technologies that include vehicle and grid interaction;	Improvement of the integration of EVs into the grid (and related improvement on the load curve management and integration of Renewable Energy Sources)	Projects results analysis Dir 20014/94/EU (AFID) related reporting (National Implementation Reports – NIRs) Directive 2009/28/ EC (RES) related reporting	EC / CINEA / funded projects / Association (biannual)	Baseline 2020 Targets: Commonly agreed charging protocols enabling V2G options for BEV options by 2030 100% of new BEV and infrastructure offering smart charging possibilities by 2030
		Improvement of charging efficiency demonstrated - For slow charging (3kW up to 22kW) - For fast (>150 kW) and ultra-fast charging (> 300 kW)	Projects results analysis Directive (EU) 2018/2002 on Energy Efficiency of 11 December 2018 related reporting	EC / CINEA / funded projects / Association (biannual)	At least 25 % reduction of energy losses during charging (considering both charger and vehicle) by 2030 for all types of chargers[32]

[32] For fast off-board charging devices with rectification, reduce system losses from grid to vehicle's plug-bay to less than 5% of the rated power at 18°C and/or reduce system losses in derated charging operation and cabinet climatising losses by at least a quarter as compared to SoA. For slow on-board chargers losses should not exceed 10%.

Objectives		What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used? [project data, study, ….]	Who is responsible for monitoring and providing the data / information? When will it be collected?	Baseline and target
	Demonstrate innovative use-cases for the integration of zero tailpipe emission vehicles and infrastructure concepts for the road mobility of people and goods;	Development of well-established decision-making tools and stakeholder engagement practices to implement integrated deployment strategies for boosting e-mobility as project follow-ups	Projects results analysis SUMPs reports SECAP reporting (Covenant of Mayors)	EC / CINEA / funded projects / Association (biannual)	Baseline 2019 Decision-making tools and stakeholders engagement practices developed in funded projects are part of the SUMP guidelines and are implemented by at least 30 cities, also taking into account the mission "100 Climate Neutral cities"
		Well established fleet managerial tools to smoothly incorporate zero tailpipe vehicles in transportation fleets	Public reports Projects results analysis	EC / CINEA / funded projects / Association (biannual)	Successful demonstration of cities with logistics emissions free by 2030 (>150.000 inhabitants)
		Number of (public and private) transport operators implementing zero tailpipe business models and use-cases for freight transport and people mobility Demonstrated innovative use-cases using zero tailpipe trucks for regional, medium and long-haul addressing payloads from 7.5 tn to 40+ tn by 2025-2027	Projects results analysis	EC / CINEA / funded projects / Association (biannual)	30 companies involved in the demonstration of innovative use-cases over lifetime of the Partnership demonstrating the zero tailpipe emission vehicles 30 passenger transport and freight transport and logistics use-cases demonstrated in projects over the lifetime of the Partnership.

Objectives		What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used? [project data, study, ….]	Who is responsible for monitoring and providing the data / information? When will it be collected?	Baseline and target
					70-80 % of the volume of the current use cases/freight transport needs are addressed in projects
	Support the development of life cycle analysis tools and skills for the effective design, assessment and deployment of innovative concepts in products/ services in a circular economy context.	Commonly accepted LCA approach	Projects results analysis	EC / CINEA / funded projects / Association (biannual)	Baseline 2020 Reliable and consistent tools and methodologies available with reduced uncertainties supporting the applicability of LCA/CE strategies
		Implementation of an LCI database	Projects results analysis	EC / CINEA / funded projects / Association (biannual)	
		Feasibility of advanced circular economy strategies in zero-emission mobility solutions demonstrated by performed use cases	Projects results analysis Benchmarks conducted in projects	EC / CINEA / funded projects / Association (biannual)	20% of the vehicle mass is linked to CE-based product design demonstrated at project level

Objectives		What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used? [project data, study, ….]	Who is responsible for monitoring and providing the data / information? When will it be collected?	Baseline and target
Operational objectives	**Development of affordable innovative LD Battery Electric Vehicles (BEV)**	Demonstration of technologies, components, systems and their integration in vehicles enabling affordability, high efficiency and fast charging capability	Projects results analysis	EC / CINEA / funded projects / Association	Baseline 2020 Targets Technologies and mass market vehicles[33] achieving: • WLTP Vehicle consumption 12 kWh/t/100km • Charging time per 100 km WLTP, 8 minutes with minimal impact on battery degradation
	Demonstration of zero emission Light Duty Vehicles (LDV), passenger cars and commercial use, to reduce total cost of ownership compared to conventional vehicles by 20% for the widest usages	Demonstrator vehicles and concepts realised in 2Zero with an optimised cost vs. benefit and an expected positive impact on cost drivers such as for example • energy consumption in production, in use and at the end-of-life; • material used • production steps and number of parts • Usage models and productivity (for commercial cases) • Usage models and willingness to pay	Projects results analysis with their effect on cost drivers	EC / CINEA / funded projects / Association	Baseline MY 2020 Targets Successful demonstration of zero emission Light Duty Vehicles (LDV) in representative use cases by 2Zero projects with an expected outcome of 20% cost reduction in 2030 compared to the 2020 baseline.

[33] Targets are defined using the following assumption: vehicle with 20 kW.h/100km, 1.7 ton vehicle and standard reference battery pack of 50 kW.h (note: this would require more than 3C). Main focus will be on B and C segments vehicles for mass market.

Objectives		What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used? [project data, study, ….]	Who is responsible for monitoring and providing the data / information? When will it be collected?	Baseline and target
	Demonstration of zero emission Heavy Duty Vehicles (HDV) matching the performance and TCO (Total Cost of Ownership) of current vehicles for most of the relevant use cases, including new usage models	Demonstrator vehicles and concepts realised in 2Zero with an optimised cost vs. benefit and an expected positive impact on cost drivers such as • energy consumption in production, in use and at the end-of-life; • material used • production steps and number of parts • Usage models and productivity	Projects results analysis	EC / CINEA / funded projects / Association	Baseline 2020 standard HDV Successful demonstration of zero emission Heavy Duty Vehicles (HDV) in relevant use cases covered by 2Zero projects with an expected outcome of nearly cost parity per tonne.km in 2030 compared to the 2020 baseline. FCEV powertrain efficiency (TtW): ~10 - 15% better than conventional ICE; BEV powertrain efficiency (TtW): ~ 35- 45% better than conventional ICE

Objectives		What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used? [project data, study, ….]	Who is responsible for monitoring and providing the data / information? When will it be collected?	Baseline and target
	Development and demonstration of affordable new vehicle solutions, charging technologies and services for mass market to enable 1000km long distance trips with no more than 10% additional time compared to conventional solutions, considering economic and environmental assessment	Demonstration of technologies, components, systems and their integration in vehicles enabling affordability, high efficiency and fast charging capability	Projects results analysis	EC / CINEA / funded projects / Association	Baseline 2020 M1 BEV Targets Demonstrators (including M1 vehicles up to C-segment and according technology packs) enabling 1000 km trips with less than a 10% door-to-door time penalty with respect to a conventional vehicle[34] • Vehicle consumption 12 kWh/t/100km • Charging time per 100 km, 8 Minutes with minimal impact on battery degradation
		Optimal balance between battery size, user needs and recharging infrastructure capabilities identified from EU funded projects			
	Development and demonstration of solutions for pervasive, user-friendly, low cost and interoperable low-power (22 kW) and efficient high (~150kW) / ultrahigh-power (~300 kW) charging infrastructure	More efficient technologies and solutions developed in EU funded projects for the development of low-power charging infrastructure (<22 kW) and high/ultrahigh-power charging (>300 kW.h, up to 1MW for long-haul trucks)	Projects results analysis	EC / CINEA / funded projects / Association	Baseline 2020 Targets At least 25 % reduction of energy losses during charging (considering both charger and vehicle) by 2030 for all types of chargers[35]

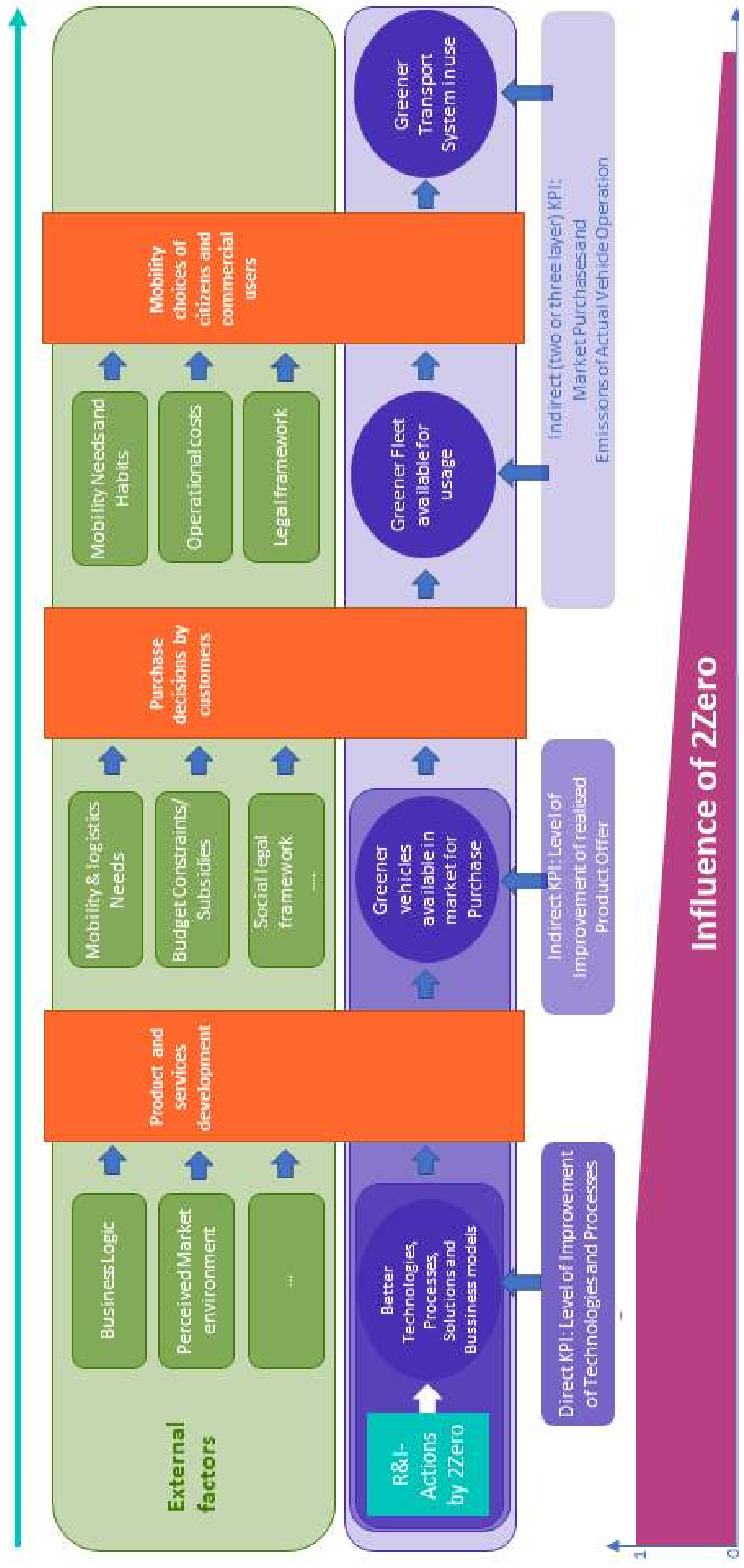
[34] Target are defined using the following assumption: vehicle with 20 kW.h/100km, 1.7 ton vehicle and standard reference battery pack of 50 kW.h (note: this would require more than 3C). Main focus will be on B and C segments vehicles for mass market.

[35] For fast off-board charging devices with rectification, reduce system losses from grid to vehicle's plug-bay to less than 5% of the rated power at 18°C and/or reduce system losses in derated charging operation and cabinet climatising losses by at least a quarter as compared to SoA. For slow on-board chargers losses should not exceed 10%.

Objectives		What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used? [project data, study, ….]	Who is responsible for monitoring and providing the data / information? When will it be collected?	Baseline and target
		Safe, secure and smooth communication exchange between vehicle and charging infrastructure, including communication with the grid and roaming platforms (including access of third parties to the charging infrastructure)	Projects results analysis	EC / CINEA / funded projects / Association	Interoperable charging solutions are available in Europe
	Development and demonstration of smart charging and bi-directional energy services solutions accepted by the users and providing services to the energy grid	Definition of dynamic load management profiles for specific smart and bidirectional charging scenarios (office building, private house/garage, public space) by EU funded projects, allowing effective grid load management that can lead to increase RES penetration	Project results analysis	EC / CINEA / funded projects / Association	Baseline 2020 Targets Development and testing of commonly agreed protocols for V2G for efficient integration with the grid, storage and smart charging Number of projects delivering deployment plan of parking spots and logistics facilities combined with smart charging strategies
		Demonstrated charging operations answering the freight and logistics requirements avoiding logistics losses	Projects results analysis	EC / CINEA / funded projects / Association	

Objectives		What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used? [project data, study, ….]	Who is responsible for monitoring and providing the data / information? When will it be collected?	Baseline and target
	Support a broad stakeholder coverage over the different sectors involved, including a good representation of industrial SMEs in projects funded by the Partnership	Breakdown of EU funding across stakeholder types	CORDA	EC	n/a
		Breakdown of members in the association	Association report	Association	
		Share of funding going to SMEs	CORDA	EC	
		Number of organisations reached in the engagement activities of projects: Advisory boards, dissemination activities.	Project reports	CINEA	
	Support standardisation activities in close cooperation with standardisation bodies	Number of projects launching standardisation activities	Projects report / Horizon EU dashboard	EC / CINEA / funded projects	n/a
		Number of standardisation committee working on topics related to the Partnership area	CEN CENELEC reports	EC / Association	
	Number of patent application and IPR generated in projects funded by the Partnership	IPR (Patent / Utility Model / Industrial Design / Copyright / Trade Mark / Confidential Information) generated in funded projects	Horizon EU dashboard	EC / CINEA	n/a
	Number of publications in projects funded by the Partnership	Number of publications from funded projects	Projects report / Horizon EU dashboard	EC / CINEA / funded projects	n/a

Objectives	What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used? [project data, study, ….]	Who is responsible for monitoring and providing the data / information? When will it be collected?	Baseline and target
Provide scientific input for informed regulation and related Union policies	2Zero contribution to roadmaps preparation	Association report	Association / EC / CINEA / funded projects	n/a
	SRIA updates	Association report	Association	
	Number of policy recommendations issued by funded projects	Projects reports	CINEA	
Ensure a wide communication and dissemination of activities and results, as well as of the potential of new vehicles, mobility and logistics systems to the public for further acceptance	Total number of events organised by funded projects	Projects reports / Horizon EU dashboard	EC / CINEA / funded projects	n/a
	Number of events organised by the Association	Association report	Association	
	Number of events organised by supporting platforms	Public information	Supporting platforms	
Contribute to the education of future workers and the public about the new mobility and logistics usage	Number of professionals trained in funded projects	Project results analysis	EC / CINEA / funded projects	n/a
	Number of training materials provided by funded projects	Project results analysis	EC / CINEA / funded projects	
	Number of members of the public reached by funded projects	Project results analysis	EC / CINEA / funded projects	


External factors
Business Logic
Perceived Market environment
...
Product and services development
Mobility & logistics Needs
Budget Constraints/ Subsidies
Social legal framework
...
Purchase decisions by customers
Mobility Needs and Habits
Operational costs
Legal framework
Mobility choices of citizens and commercial users
R&I-Actions by 2Zero
Better Technologies, Processes, Solutions and Bussiness models
Greener vehicles available in market for Purchase
Greener Fleet available for usage
Greener Transport System in use
Direct KPI: Level of Improvement of Technologies and Processes
Indirect KPI: Level of Improvement of realised Product Offer
Indirect (two or three layer) KPI: Market Purchases and Emissions of Actual Vehicle Operation
Influence of 2Zero
1
0

3.3 – Activities to be covered by the Partnership

In order to power green road vehicles, different technologies will be used and developed in the coming years. The need for complete decarbonisation and climate-neutral road transport, considering all technologies, will be the basis for prioritising funding of 2Zero from the Horizon Europe budget. In concrete terms:

- As to propulsion technologies, Horizon Europe funding allocated to 2Zero will support only R&I for zero tailpipe emission technologies (i.e. BEV and FCEV).
- Within 2Zero, one of the priorities will be to develop drivetrains for zero emission heavy-duty long-haul vehicles.

Nevertheless, the members of the 2Zero Partnership can undertake joint research activities in areas that go beyond the scope of Horizon Europe funding for 2Zero. This means in particular:

- The vehicle manufacturing industry will be open to all technologies in order to stay competitive and support the transition to the goals of the European Green Deal.
- The 2Zero partners will continue developing strategies and roadmaps covering other propulsion technologies (e.g. PHEV with renewable, synthetic fuels), without EU funding.
  - Only the designated areas of the strategies and roadmaps that belong to the scope of the 2Zero Partnership will be taken into consideration for funding by the Partnership.

Private and national funding sources could be used to support areas not funded under the 2Zero Partnership.
With regard to renewable, synthetic fuels, R&I will be taken forward in other parts of Horizon Europe.

4. Identified R&I funding areas

To achieve these short and medium-term objectives, the Partnership will focus on the required research and innovation for the development and substantial penetration of next generation energy-efficient and affordable zero tailpipe emission road vehicles (battery electric vehicles for all use-cases and fuel cell electric vehicles for heavy-duty applications), mobility solutions and their cost-effective recharging infrastructures (from slow to fast to ultra-fast). It will also ensure a strong link with other support measures to facilitate the zero tailpipe emission vehicle technology deployment through effective mobility and logistics solutions for urban, peri/inter-urban and rural mobility. In particular, the selection and implementation of solutions and technologies based on their environmental and social impact becomes elementary: this must become a commonly accepted approach.

Hence, the Partnership will address several layers of research and innovation activities: technologies, process, operational and business model innovation, in order to truly take a system approach to tackle the decarbonisation of road transport.

The following pillars will be funded under the scope of the 2Zero Partnership:

a. **Vehicle technologies and vehicle propulsion solutions for BEV and FCEV;**
b. **Integration of battery electric vehicles into the energy system and related charging infrastructure;**
c. **Innovative concepts, solutions and services for the zero tailpipe emission mobility of people and goods;**
d. **LCA approaches and circular economy aspects for sustainable and innovative road mobility solutions.**

All types of road transport vehicles shall be included (e.g. two or three wheelers, passenger cars, vans, trucks, coaches and buses) as well as the system integration with infrastructures and services (i.e. micro-mobility services, logistics, etc.). Zero tailpipe emission solutions remain particularly challenging for HDVs and the 2Zero Partnership will bring a substantial contribution to make long-haul zero tailpipe emission a reality in the future. All types of applications, especially the integration and interaction of these will be covered: urban, suburban, interurban, rural areas and long-haul. In order to reach affordable mobility and improve the quality of life for all the EU citizens (air quality, choice, comfort, etc.), the cost of the proposed solutions is a key parameter and will be addressed all along the process (development, manufacturing, etc.).

The proposed 2Zero eco-system is made up of the four abovementioned main pillars. The activities to be covered by the Partnership will be transversal, allowing consideration of different aspects of the challenges in a single, integrated system approach. 2Zero is a rare opportunity to foster and promote multi-sector R&I concepts towards optimal solutions, to respond to different use-cases. In this context, 2Zero should provide or create opportunities for the sectors to work closely together and hence combine the 2Zero focus areas in order to explore new routes to reach solutions for the complex multi-goal optimisation task. This will exploit all the benefits of each being able to adopt a holistic, multi-stakeholder approach and by drawing on the extensive experience matured through the European Green Cars and Green Vehicles Initiatives.

This chapter presents the details of each of the pillars (focus areas) from their perspective, but also linking them strategically. The strategic links may be explicit, such as battery charging and the need for a stable infrastructure, or implicit, such as the impact of usage models on the vehicle specification and hence user's expectations. It is intended that the future Horizon Europe Work Programmes should reflect both the necessary technological details and combine the pillars to identify, develop and demonstrate novel holistic optimal solutions.

A system perspective, as described above, is needed to accelerate the transition towards the large-scale uptake of zero tailpipe emission mobility solutions, considering the different use-cases in concert with the necessary push for the infrastructure development and the cost competitiveness aspects of European solutions. Reinforcing the integration capability of vehicles in their environment (in the energy system and in the overall transport system) will be one of the objectives of the 2Zero Partnership and will contribute to tackling the challenges and hurdles still preventing a larger uptake of zero tailpipe emission vehicles in the market.

The transformation towards zero tailpipe emission road mobility will deliver tangible benefits including, at the local scale, pollutant emission reductions, cleaner air (including unregulated pollutants, nanoparticles and secondary pollutants), reduced noise and more liveable urban and peri-urban spaces. Further, major benefits for citizen's health, their quality of life will be generated and European economic growth supported, hence a solid base for new business opportunities. On a global scale, the reduction of CO_2 and other GHG emissions will contribute to mitigating climate change.

The relationships of these items to other aspects of the Partnership are shown in *Figure 4* below.

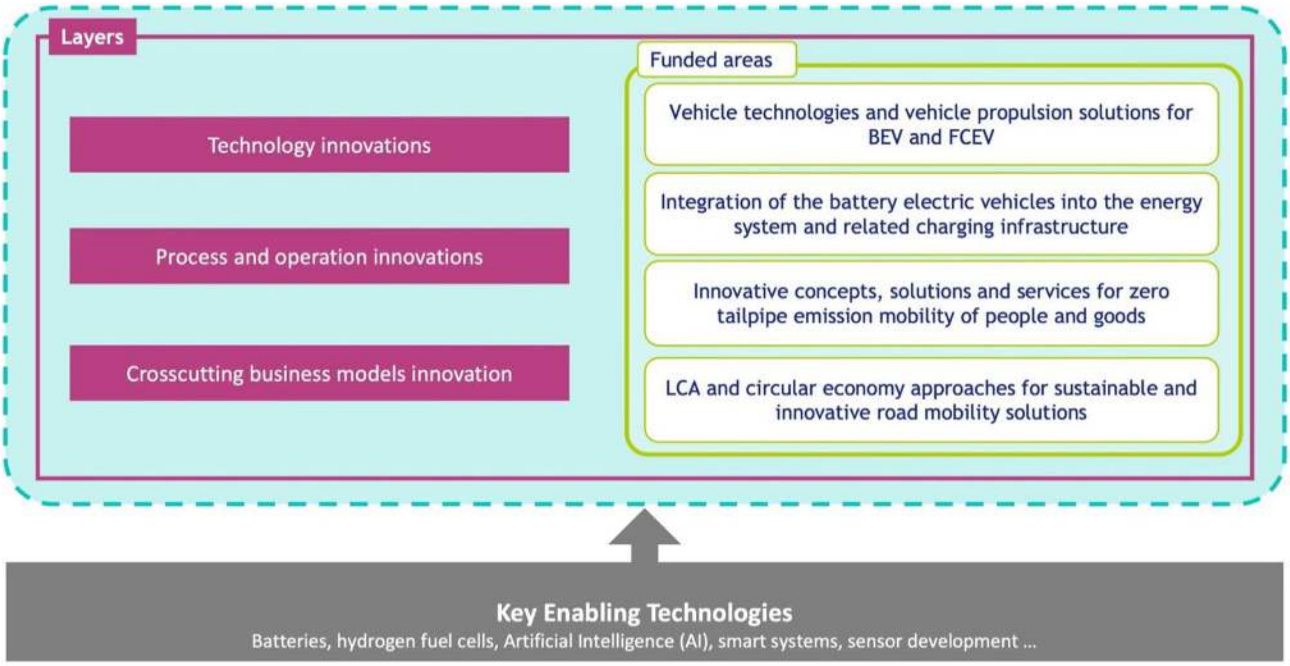


Figure 4 - 2Zero Partnership funded activities and their interactions

4.1 Vehicle technologies and vehicle propulsion solutions for BEV and FCEV

R&I funding pillar for vehicle technologies and vehicle propulsion solutions is partially dependent on a common understanding of the situation in its entirety, including urgent R&I needs as well as relevant boundary conditions, to ensure alignment with longer-term needs and a high impact of the results. The focus of this R&I area will be on both the vehicle and the vehicle operating in an eco-system, hence it includes usage models and usage patterns as addressed in more detail in Chapter 4.3.

The final success of new concepts depends on fulfilling the needs, including TCO, and expectations or preferences (including the perceived preferences) of users and operators. This is a prerequisite to accelerating the uptake of zero tailpipe emission vehicles.

The BEV and FCEV technologies envisaged are by definition "clean" (no tailpipe emissions); compared to internal combustion engine vehicles (thanks to the elimination of clutches and the extensive use of regenerative braking) the remaining emissions issues concern friction systems (e.g. tyres and brakes), as well as electromagnetic compatibility (EMC) and noise.

a. Specific challenges and objectives related to the R&I area (including both items that are and are not covered by the EU funding)

An overview of the relevant challenges for this chapter is given below:

Identifying optimal favoured powertrain concepts to achieve the Green Deal objectives

- To achieve a robust scenario and topology portfolio amongst the multitude of variations and, subsequently, the identification of the critical R&I issues associated with these topologies.
- To create, demonstrate and validate systematic approaches that tackle the vehicle and system optimisation from multiple perspectives, which result from including infrastructure aspects and energy sources, as well as the use-cases to ensure a user-centric system.

Achieving affordability to accelerate market uptake

- To develop novel electric vehicles that are efficient both in operation and in the use of resources, and that are acceptable for mainstream users:
  - Cost parity over the entire life compared to fossil fuel vehicles with comparable user requirements.
  - Satisfying user's priority expectations and needs.
- To develop vehicle architectures, powertrain subsystems and components, with refocused requirements, hence reduced costs, is the main issue to achieve EV initial cost parity with conventional vehicles by 2030, specifically in the mid-lower segments.
- To identify not only mainstream use-cases and usage models but, therewith, to identify vehicle architectures and battery/charging time performance packages capable of best satisfying the main, defined use-cases and usage patterns, whilst also providing good performance in less frequent situations.
- To integrate the solutions into the product development, along the supply and value chain, to maximise overall system potential, is a challenge because of the dependencies in the value chain and the fact that the chain overall needs to evolve in a unified manner.

Achieving usable solutions and high user acceptance, especially in close cooperation with new mobility and business models

- To understand user's needs and interests, identify and derive the primary common denominators that will have direct impact on the market uptake of solutions, considering how new mobility models can influence user's interests and acceptance, and especially the future needs of users and society.
- To develop and establish a user-centric system approach, which is based on use-cases and considers the effort/benefit, to identify the optimal solutions that can be efficiently and effectively deployed for an overall positive local and global impact.
- To determine how to quantify commonly accepted and robust usability and utilisation rates, in order to support decisions on engineering trade-offs that are a vital part of the vehicle development process.
- The system approach entails an active response to the flexibility needs of the grid in adapting smart charging and V2X solutions, hence the vehicle should have the intelligence and technologies to facilitate such an active response, which can reduce collectively the electricity costs to off-peak levels and that can be:
  - of substantial duration within a 24-hours period reaching typically 8 hours
  - of substantial price differential, which can be up to 30% lower the peak price.

Enhancing reliability and safety

- To satisfy user's needs during the design optimisation for future vehicles of all categories through design for reliability.
- To address future challenges with respect to embedding innovative vehicles in the transport system and ensuring that they are as safe and reliable as the vehicles they replace: ensuring the functional safety of critical powertrain functions and components in ZEVs, safe on-board storage of hydrogen, post-crash safety including fire extinction for batteries, research on prevention measures for fire safety of electric vehicles and associated recharging infrastructure in particular in constrained spaces, such as covered parking areas, and improving the safety of personal light electric vehicles (PLEVs) through their conceptual design.

Specific operational objectives

- To establish innovative BEV and FCEV concepts and technologies, for implementation in the generations of vehicles coming after 2025 and 2030. Other, alternative propulsion systems should also be investigated, using other sources of funding. The following items will be considered for integration at a vehicle level:
  - High efficiency. low cost and eco-designed powertrain components, sub-systems and systems, capable of slow to ultra-fast and, possibly, dynamic charging:
    - Battery packs and systems
    - Electric motors and gearboxes
    - Power electronics.
  - For the heavy-duty commercial vehicle sector, BEV powertrain systems are being developed for both short and long-distance applications; in addition, innovative hydrogen fuel cells systems exclusively for long-distance applications are investigated

- within the Clean Hydrogen (CH) Partnership, whilst the integration of powertrain in vehicles is covered by the 2Zero Partnership. (see Chapter 5.2).
- Ancillaries and energy management (especially for heating and cooling systems for the cabin and vehicle components), looking also at the potential of higher voltage to improve global efficiency, reduce weight and copper use.
- Connectivity, together with cooperative, connected automated mobility (CCAM) and in consideration of the common European Mobility Data Space[36], to access data relevant for optimising systems and their integration (architecture) as well as for maintenance.
- Technologies for efficient, slow and fast charging whilst minimising battery degradation.
- Specific zero tailpipe emission vehicle safety and emissions aspects (tyres, brakes, usage profile optimisation to maximise efficiency and recuperation whilst minimising particle and noise emissions).

Each of these items has to be demonstrated and proven at the vehicle and its application level.

- To create and validate user-centric vehicle concepts in all categories that fulfil user's and operator's needs, including both innovative, multi-purpose vehicles and new, tailored, right-sized solutions for specific applications, considering also eco-system aspects beyond vehicle design:
  - Vehicle size and category responding to prioritised use-cases as detailed in Chapter 4.3 (*Innovative concepts, solutions and services for the zero-tailpipe emission mobility of people and goods*)
  - New architectures and/or modular solutions for people, goods and services that enable adaptability and optimised vehicle utilisation, depending on user-centric needs and use-cases (including combined passenger and goods transport).
  - New operational models and modes, in close cooperation with the CCAM Partnership, in particular by collecting external dynamic data (e. g. via a common, shared data space) necessary for vehicle motion optimisation and improved driver support.
- To create validated tools and digital twins for accelerated product development:
  - Digitalisation of design and production processes, which accelerate the uptake of emerging and advanced technologies for zero tailpipe emission vehicles.
  - Enabling modular, flexible and individualised optimal vehicle concepts.
  - Virtual verification, validation (testing) and comparison to increase the rate of zero tailpipe emission vehicle uptake in the system (link to Chapter 4.4. *LCA approach and circular economy aspects for sustainable and innovative road mobility solutions*).

b. Expected outcomes by 2030

- Accelerated uptake of all zero tailpipe emission vehicle concepts, in cooperation with new mobility solutions and logistics models.
- New vehicle concepts demonstrate the potential of innovative vehicle technologies, as a development reference for future generations of climate-friendly vehicles (for both established and new players) and future mobility systems.
- The industry is able to adapt and adopt technological innovation twice as quickly as current

[36] https://digital-strategy.ec.europa.eu/en/policies/mobility-data

development and industrialisation activities. It has the speed and flexibility to react to new constraints and changing boundary conditions.

c. Scope of actions

c.1 – covered by EU funding

Advanced vehicle concepts for zero emission road transport

The anticipated changing mobility needs and concepts (e.g. emission-regulated areas in cities, car sharing and pooling, etc.) as well as the diversity of global markets will lead to having far more diverse user needs and mobility models, so that a design conversion of existing combustion-engine vehicles is no longer economically viable. Instead, a more optimised design becomes essential.

In future vehicle concepts, reflecting new needs and boundaries due to changes in the perspective and understanding of the vehicle, as an interacting element within the transport and energy systems, shall be considered. At the same time, modularity and scalability must be taken into account, based on the common parts strategy, which is already practised, and the next generation technologies, to reduce both the initial and total cost of ownership over the different stages of the entire product life-cycle. More than ever, advanced vehicle concepts need to be safe and sustainable whilst generating a high level of usability and covering multiple purposes. In this context, new sustainable vehicle concepts, enabled by new design tools and new high-performance material and process technologies, will be essential for a sooner-to-market introduction of zero tailpipe emission vehicles (ZEV). Overall, research and innovation is needed in the following areas.

Conceptual vehicle design

The system approach (e.g. linking the vehicles directly to the mobility system) requires considering the vehicle and its interactions. This consideration can include the infrastructure, from charging to connectivity, as well as operational modes (such as automation) that consider various use-cases and potential new business models. These interactions, as well as an optimised balance of all demanded targets, will have an impact on vehicle architecture and vice-versa. This can include vehicles optimised for urban usage but not necessarily conform with current vehicle categories.

Conceptual vehicle design and advancements in vehicle systems involve both the operational aspects as well as the physical design characteristics (such as vehicle volume and weight), energy-efficient components, reduction of raw material use by design (circular economy, in cooperation with Pillar 4), user-centric needs and maintenance. They will need to be matched with improvements in the infrastructure but also create links with increasing intelligence in infrastructures, such as dynamic traffic control (to be developed in CCAM). Additionally, it may be necessary to design dedicated ZEV and system concepts for individual and mass transport, that go beyond the adaptation of already existing platforms (for example using new materials, with new on-board space management, etc.) in order to optimise the TCO attractiveness for both, private vehicle owners and fleet operators: e.g., high capacity buses, on-demand small buses and vehicles for shared service or taxi operations.

Future ZEV architectures and designs, for both passengers and goods vehicles, might depend more strongly on use-cases and usage models, e.g. on-demand services, as mobility models and boundary conditions (such as access restrictions or service too low-density areas with low availability of charging infrastructure) evolve. This results in challenges regarding the demanded high degree of modularity and adaptability, which allows a broad range of architectures (from multi-purpose to highly customised). Yet, these use-cases and models also offer the opportunity for a re-think of current vehicle architectures towards concepts optimised for ZEV. Design-for-purpose, to tackle these challenges and the changing conditions, will use intelligent system solutions that balance any resulting design limitations, in order to meet the user's needs and expectations. Research and demonstration of conceptual vehicle designs must enable and utilize "push and pull" effects within the transport system.

The range of ZEVs that can be addressed covers road vehicles of all sizes down to personal light electric vehicles (PLEVs including electric scooters without seats, self-balancing vehicles and other zero tailpipe emission vehicles requiring no type approval). The conceptual design of such ZEVs needs to be improved, in particular from a safety perspective, so that their potential as zero tailpipe emission, last-mile solutions, interfacing with and even allowing access to collective transport systems in fully intermodal journeys, can be fully leveraged.

Due to the constantly changing requirements of daily mobility, it is inevitable to assess if there are new ways to meet the new needs of the passengers. For example, within urban and suburban areas, there is an increased use of shared mobility forms. Solutions specifically tailored to these needs must, therefore, take into account usage scenarios, driving profiles and traffic situations in order to offer attractive personalised solutions. New types of affordable electric vehicles may be advantageous, through right-sizing and combining features from L- and M-category vehicles, allowing for both upscaling-L and downscaling-M, whilst capitalising on the technologies developed for BEVs in the last decade. Research should answer the question of what type of right-sized concepts are needed to compete with their conventional counterparts, to determine the optimal trade-off between diverse and challenging requirements from society, legislator, user and vehicle producer, without compromising vehicle performance with respect to the intended usage model and considering new measures that can be implemented in the operational environment. Smaller and resource conserving vehicles have many advantages for urban/peri-urban applications hence a better understanding of specific requirements for these usage models, user acceptance and the design effort needed is crucial for successful implementation in the future; focusing in particular on the level of safety (see Safety section) and safety perception (drivers preferring large vehicles for safety reasons), which needs to be achieved cost-effectively in the development, production and approval with respect to the relevant boundary conditions.

Zero emission Heavy-Duty Vehicle

Priority action

Given that trade and freight development forecasts suggest that global freight demand might triple from the beginning of this decade to the end of 2050, it becomes clear that addressing road freight transport emissions should be a top priority. Battery (BEV) and hydrogen Fuel Cell (FC) electric vehicles are being developed for these applications, although each of these technologies needs to address specific issues to respond to these demanding use-cases, particularly in the case of long-range missions.

BEV can cover both short and long haul: some first solutions are already available on the market, and current developments in batteries show rapid progress towards strong cost reductions, also for instance due to new battery chemistries. FC vehicles can be suitable for long-distance use due to the conception of the propulsion system. Their limitations regarding payload and range are lower than those of battery-electric vehicles due to the high energy density of the hydrogen storage (e.g. compressed, liquid or other storage technologies (metal or complex hydrides)). The higher system costs, related to the cost and availability of clean hydrogen and to the infrastructure definition, need further investigation and research. In addition, the implementation of advanced vehicle network architectures shall enable the development and optimisation of powertrain and holistic energy management systems, in terms of performance, efficiency and energy/power densities (also including energy consumers such as refrigerated cargo compartments, hotel loads and other ancillaries) and interaction with recharging infrastructure.

R&I actions shall cover both battery electric (short to long-range) and hydrogen Fuel Cell (FC) electric solutions for long-range.

Heavy-Duty Battery Electric Vehicles (HD BEV)

Novel design for next generation of HD BEV, considering the optimised placement of the battery pack and the cooling, and innovations in terms of transmissions, improved architectures, topologies and the sizing of components are needed.

This can support the right-sizing of components and systems, and enable higher levels of integration of advanced electric powertrains, thermal management concepts, smart high power fast charging and vehicle control strategies within the HD BEV. Prioritising the use of digital twins, as a means to optimise the balance between topology, sizing and control, are needed.

High efficiency HD BEV vehicles shall maximise the driving range between recharging events for the intra-city and regional transport of people and goods, considering opportunity charging and specific use-cases depending on fleet operations, such as mandatory break times, that allow the extension to longer-range missions. Synergies with light-duty vehicles, for last mile delivery, and HD service vehicles can be considered.

Heavy-Duty Fuel Cell Electric Vehicles (HD FCEV)

Building on the synergies with the CHE Partnership, the FCEV activities in 2Zero will focus on integrating the storage and fuel cell systems, developed in the CHE Partnership, into the HD FC vehicles.

The integration of fuel cell systems in vehicles will need to consider geometrical constraints and modular concepts (including multi-powertrain concepts for battery and FC models on the same platform), with activities focusing on optimising the overall thermal management of the vehicle. Due to the HD driving operation characteristics, i.e. continuous operation at nearly peak load and often high torque at low speed, overheating of the FC system might occur. Hence, the optimal energy split management and optimal sizing of fuel cell systems, energy storage and powertrain components, especially the size of the battery compared to the size of the fuel cell stack, need to be considered, in particular with regard to usage models and TCO. Improvements in power, performance, durability and lifetime of the FC have to be addressed in detail in CHE, with adequate specifications considered in the vehicle design and development phases. Although the focus of FCEV related activities in 2Zero will be on heavy-duty and long-haul, including buses and coaches, synergies with light-duty FC vehicles can also be investigated.

Energy-efficient and user-centric interiors

The user-centric design and functionality of vehicle interiors are essential factors for the vehicle range and the user acceptance of future vehicle concepts (from private and commercial point of view), and for the widespread market adoption of BEV and FCEV. Within this context, a user-centric interior design, aiming for an increased energy efficiency ("bottom-up") with advanced insulation and interior climate control (HVAC) systems including pre-conditioning, needs to be further improved, in order to provide adequate performance with enhanced energy efficiency, which can have a significant direct influence on the range of BEVs in extreme weather conditions.

Advance lightweight design for zero emission

One of the main challenges, in terms of optimising the design of zero emission vehicles, relates to the need to determine the optimal balance between multiple performance targets and users' needs. In electric vehicles, one measure for increasing the range was to reduce weight; at the same time, the added weight of the battery system is significant and, over the coming years, might not be completely compensated by advances in battery technologies. Correspondingly, a decisive factor will be to find the best compromise between the range of the vehicle and right-sized battery, especially taking future potential usage concepts (that may benefit from solutions such as battery swapping) into account. Further development of battery characteristics, such as gravimetric and volumetric energy density, will also contribute to reducing the weight of both the battery system and the overall vehicle.

In all vehicles, the mass is governed primarily by the choice of materials and a material specific design, both being dictated by the need to respect a series of performance specifications, such as crashworthiness, and other essential criteria, including circular economy requirements and affordability. However, with respect to electric vehicles in particular, aiming to minimise weight together with the opportunity to save raw materials and investigating opportunities to integrate multiple functions within the structure, gives rise to the potential for developing and adopting a new holistic eco-design approach involving the use of novel, advanced, lightweight, easy to separate and recycle multi-materials offering multi-functional integration; this in turn will involve the uptake of advanced manufacturing technologies selected as a function of the required production volumes of these new electric vehicles. The aim is to develop new reliable and affordable solutions which are tailor-made for zero emission vehicles, which do not introduce compromises in terms of safety and performance (including noise and vibration).

Digitalisation enabled advanced design methods

In future vehicle product development, the full value chain from material to production as well as the use phase and End-of-Life (EoL) must be taken into account from the beginning, to shorten the development time, to bring zero emission solutions sooner to market, to reduce costs at increased quality, to maintain (functional) safety and reliability levels, whilst ensuring a desired vehicle range and, especially, considering diverse user needs, all together increasing the acceptance of zero tailpipe emission vehicles. The multitude of new and diverse demands, as well as demanding requirements for zero emission and circularity, can be met through digitalisation linking design, production, use phase and EoL by means of innovative concepts, such as digital twins.

Consequently, research and innovation are needed on the required methods and tools, so as to enable the desired degree of digitalisation. Besides enabling a holistic optimisation of the vehicle design, advancements in digital twins shall enable efficient, reliable and trusted experimental plus virtual verification and validation (including frontloaded evaluation of potential solutions) of lightweight, zero emission vehicles and their operation within a transport system. Furthermore, concepts and methods for advanced and validated digital twins, e.g. for feeding back real-life data into product development, will have to be developed and demonstrated to exploit further, e.g., lightweighting potential and to optimise the functionality of a design based on user experience. Understanding vehicle usage patterns, already within the product development, will lead to improved, reliable specifications, ensuring right-sizing.

Efficient and affordable drivetrains and control strategies for BEV and FCEV

There is no single and ideal powertrain solving the demands of sustainable mobility, that is addressing both the environmental impacts and the requirements of global markets (whilst maintaining European competitiveness). However, electric vehicles (BEV and FCEV) are identified as very promising parts of the solution to achieve the Green Deal targets. The large-scale deployment of zero tailpipe emission powertrains calls for low cost, lightweight and highly integrated components, maximising synergies to achieve economies of scale. Advanced drivetrain concepts (wheel or axle motor concepts) open new opportunities in vehicle design (ranging from space saving to efficiency and reducing the amount of material needed). Future research activities on modular and scalable architectures for electric drivetrains will play a key role for EV concepts, in terms of cost reduction and having potential for mass-production, also in terms of efficiency and wise use of resources. Within this context, research and innovation are needed in the following areas:

Efficient control of vehicle operations

The evolution of vehicle architecture and design, and the potential transition towards multi-purpose mission execution with optimised vehicles (possibly combining passengers, goods and professional needs), will have an important impact on vehicle operations, control, energy use and maintenance. Further optimisation in the use phase, complementary to advances in powertrain technologies, will address the challenges of efficiency and affordability by linking internal as well as external data to the vehicle hardware and, especially, by developing means to maximise the use of the data with new tools, in particular:

- With internal and extended data in cooperation with CCAM (e.g. data sharing with V2X and external data services impacting vehicle mission and efficiency), vehicle operations can be tailored to vehicle missions (link to R&I Pillar 3), applying innovative data mining methods and, potentially, artificial intelligence to accurately predict and optimise the energy use (e. g. predictive battery management systems (BMS)), and also to understand the evolution of driver mobility needs for their benefit. Based on a better understanding of mobility needs, mobility patterns and driver performance, improved vehicle control strategies (e.g. predictive eco-routing, eco-driving, etc.) as well as operations, can be realised, to achieve right-sized systems and vehicles, to better manage mobility usage peaks for both passenger and goods.
- By contributing to the optimisation of vehicle operation via the seamless integration of sensors to support predictive maintenance (e.g. battery and fuel cell components (filters, membranes)) and reducing cost and material consumption by switching from systematic parts replacement to an only on-per-need basis.

Powertrain modularity and integration

Integrated and compact powertrains in future electric vehicles will lead to specific challenges, such as: improving the power density (in kW/l or kW/kg) of subsystems or components (such as power electronics, electric motors, transmission systems, etc.), lightweighting and cost reduction, where fitting the modular powertrain to multiple vehicle platforms could play a key role due to their flexibility, but at the same time tackling the challenge of minimising “overhead” required for interfacing. Due consideration to standardisation might also be given to assess its potential for cost reduction. Integrated functions in the design of the drivetrain have significant advantages, such as a lower number of components, less installation space or even lower costs. Nevertheless, the potential offered by modularity and the need for recycling-friendly designs must also be taken into account. Due to this, it is necessary to analyse and find the right balance between modularity, standardisation, integration concepts and recyclability for the next generation of 2Zero vehicles. The main challenge is to find solutions that allow a rapid transition from modular to integrated systems, as market acceptance and, thus, the pressure to reduce costs in mass production applications increases, whilst at the same time, considering the use and reusability of available resources.

To overcome these challenges for the current powertrains, to improve and optimise the operation of BEV and FCEV powertrains, advanced and new integrated powertrain concepts are, necessarily, to be developed. These concepts should have lightweight, right-sized, compact and highly efficient components and sub-systems, together with alternative materials, and include strategies for thermal management, energy recovery (for a higher overall energy efficiency and lower TCO) and reduced resources use. However, new and innovative integrated powertrains with highly efficient components could also provide extra reliability challenges, hence **powertrain design for modularity and reliability** (including failure mechanisms) is a key element to ensure functional safety with lower costs. Considering the reliability aspects early in the design and development phase of powertrains (components, connections, busbars, protection circuits, control units and sensing units) will ensure higher functional and operational safety.

New and modular E-axles, with innovative cooling concepts, integrated power electronics, the introduction of wide bandgap (WBG) technologies (such as SiC or GaN and beyond), and their control systems for the next vehicle powertrain generations (with different voltage levels, e.g. 48V for light vehicles, 400V, 800V and higher for heavier vehicles), present further integration challenges. Modular e-axles are the right direction towards more energy-efficient powertrains with high performance and reliability, maintainability, and always considering the effort versus benefit trade-off.

New manufacturing techniques and, moreover, the demonstration of circularity (including reuse, recycle, etc.) at the prototype level are key elements to enhance the environmental performance of the powertrain components.

Achieving innovative compact integrated solutions will be both a strong lever for future scale economies and a strong advantage for flexibility in new vehicle concepts that satisfy user’s needs and increase acceptance.

Integration of battery systems

Priority action

New challenges for future battery systems will be posed by future use-cases for electric vehicles, such as fast charging, extended usage time due to automated driving with new and highly efficient on-board charging concepts, integration of electric vehicles in the energy grid, cost-effective and second-use applications. New technologies must mitigate the negative effects of these use-cases on lifetime, performance, costs and safety, considering the already existing challenges, such as improving the energy density (kW.h/l or kW.h/kg), power density (kW/l or kW/kg) and battery system efficiency, whilst simultaneously reducing the overall battery system costs. Thus, depending on cell technologies, specific choices for connections, cooling system concepts and materials for housing play a crucial role in the target improvements. Therefore, the development and integration of structural, thermal and mechanical aspects (at different levels of modularity or integration), with intelligent battery management with smart balancing systems, will enhance the overall battery system efficiency, resulting in high energy and power densities for the whole battery pack.

Modularity at a battery module level could offer opportunities to improve battery system costs with scale economies. However, single pack architectures offer density advantages, and attempts to standardise modular battery modules and systems in the past were not successful because of differing vehicle platform requirements (exclusive battery vehicle platforms versus ICE-shared platforms). The assessment of the degree of standardisation, for the best trade-off between integration versus modularity, is required to achieve cost reduction as well as OEMs acceptance. Minimising interface

overheads, whilst taking into account future value, seamless dismantling and second-use applications in battery modules, will also pose challenges regarding mechanical, electrical and communications interfaces. Fields of development are, for example, smart integrated sensor systems, novel cooling system concepts, materials for battery housing, smart system interfaces and functional integration.
Considering fast charging use-cases in the design of battery system will require dissipating high waste heat loads during standstill, when the air flow for the cooling is only provided by fan operation. Reducing the waste heat by decreasing the internal resistance of future battery cells will be considered by the battery Partnership. Thus, novel cooling system concepts must be able to dissipate the waste heat of optimised cells and components in the battery system, ensuring minimal impact on system mass and costs, especially taking into account the thermal and electrical interfaces of cell geometries (e.g. pouch, prismatic or cylindrical) and the aforementioned modularity considerations.
Smart thermal management systems (for both heating and cooling), with smart interfaces to the vehicle systems, including energy-efficient preconditioning, using internal or external energy facilities whilst charging, will contribute to further improvements in the overall battery system efficiency and optimising the overall battery system.

Thermal management

Thermal management covers fields from cabin temperature management (heating and cooling), air quality (ventilation, CO_2, particle concentration) to component thermal effects control (heating and cooling in the powertrain including energy storage), it also includes load temperature control: the new vehicle powertrains and energy carriers offer further opportunities for thermal management, with new heat sources and sinks, especially within FCEV for heavy-duty.
Lowering the vehicle energy needs is particularly challenging because of the interaction of many cross-system domains. It brings together a lot of specific electrified vehicle challenges such as battery size, energy use efficiency, charging efficiency, charging duration, range robustness in cold or hot conditions and, finally, costs.

Dedicated thermal management actions will be undertaken for:

- The cabin temperature management (including under extreme environmental conditions), designing high-performance systems using on-board energy and dedicated system control-laws, including preconditioning the cabin during charging phases for example and/or addressing cabin heating in a selective way (e.g. heating only where necessary or requested by the user, alternative heating systems e.g. thermal storage systems could be of additional use). This is an important application field for HD and particularly critical for buses, where power and energy needs are important.
- The thermal exchange and control strategy in every component that needs to be conditioned (e-motor, power electronics, battery, chargers, fuel cells and components, etc.) with a holistic approach at a vehicle level. This will open new design ways, allowing electronic components to operate at lower temperatures and, thus, be less thermally stressed,
- The development of components with longer lifetimes, highly compact, integrated and lower cost (less demanding temperature under running conditions). This will also contribute to fast charging, enhancing efficiency and the thermal conditions for batteries and chargers. Acoustic effects, inside and outside of the vehicle, for these systems are also to be addressed, as they may be the major acoustical perturbation left after the internal combustion engine is removed.
- Dealing with the low temperature gradient exchange (running electronic component temperatures are lower than ICE ones) that limits the efficiency of current solutions.

FCEVs also require dedicated actions. The operating temperature directly affects the performance and health of the fuel cell and, therefore, needs to be monitored and controlled. Currently, thermal management is a problem when integrating FC systems into heavy-duty commercial vehicles, due to the large difference with respect to conventional heat exchanger dimensioning. As a result of the low operating temperature of the fuel cell and the associated higher heat dissipation into the coolant, the dissipation of heat losses in the narrow available vehicle space is a true technical issue and major challenge. Besides re-dimensioning and optimisation of the vehicle cooling system, a possible solution could be implemented with the FC system operating at higher temperatures (with non-negligible impact on the membrane material selection, overall durability and the cost and efficient use of critical raw materials, especially precious metals such as Platinum Group Metals (PGMs)). This would be a lower TRL investigation requiring redesign of PEMFCs in terms of stack design and fuel cells components, including the membrane and electrode assembly (MEA), and lies within the responsibility of CHE.

For BEVs, the thermal management of the powertrain is inherently included in the challenges, a particular emphasis is given already for cabin climatisation for passenger cars but even more for buses. In turn, the cabin heating of FCEVs can benefit from the heat rejection of the fuel cells, but the thermal management of the fuel cell system, with low temperature differences to ambient, requires special attention. Finally, the need to ensure the durability of all auxiliaries for both vehicle concepts is often neglected and needs to be addressed especially within the context of harmonising life-cycles in the overall system.

Charging systems: Fast, wireless

This research area establishes a connection between vehicle and infrastructure and, therefore, requires work in both Research Pillar 1 (Vehicle) and Research Pillar 2 (Infrastructure). Fast charging or wireless charging are major factors enhancing the usability of electric vehicles but remain a challenge with respect to energy efficiency. Whereas conductive charging allows higher charging power than wireless charging, it still faces limitations at contact surfaces regarding current and because of thermal losses, plus detrimental effects to the battery cells. The weight and the bulkiness of charging cables increase with the maximum charging power offered by the installation and may become discriminatory to small or handicapped people. Wireless charging dramatically improves the comfort of charging, independent of weather conditions and dirt, but efficiency and charging power need to be increased significantly. Whilst increasing coil-to-coil gap width per se is not necessarily lowering the efficiency of Wireless Power Transfer (WPT) to EVs, field forming is necessary for wider gaps. The latter is, however, not easily adaptable to a variety of EVs (SUVs and small city cars), thus an optimum of gap width, energy transfer efficiency and interoperability must be found. Automatic recognition of the distance of the EV's receiver coil may become thinkable, although it may increase cost. The research in this area should be without any prejudice to integrate multiple e-mobility service providers, not linked to a specific vehicle manufacturer, so as to allow for transparent and open development of e-mobility and charging services.

Research that implicitly integrates only one service provider, through soft or hardware at the charging points, linked to the technologies chosen by the vehicle manufacturer, should be avoided, to prevent creating distortions in market development and technology limitations for future market developments.

The following focuses on the vehicle-side measures to ensure interoperability with different infrastructure conditions in order to enable maximum user satisfaction with the product. Charging time and charging comfort, hence user acceptance, need to be improved by enabling higher charging rates in conductive and inductive modes, without compromising safety, including the following aspects:

- On-board power electronics with new technologies (such as SiC or GaN) and control systems for dedicated voltage/current profiles that minimise battery ageing. Connectors handling currents beyond 350A standards and battery management systems enabling charging at voltages up to 1500V shall foster the acceptance of right-sized batteries via briefer charging stops. These higher charging powers inevitably go hand in hand with demands on the charging infrastructure, which also need to be specified.
- For contract-based charging and related payments, ensure that appropriate communication protocols with the charging infrastructure are in place, so as to allow for multiple e-mobility service providers to connect with the vehicle. This will include vehicle-side human machine interface (HMI) to let the user enter its requests such as, e.g., the target state of charge (SoC) at a target time with V2G charging at low-power.
- Particularly for wireless charging/Wireless Power Transfer (WPT), reduced electromagnetic stray-fields shall ensure high efficiency, good EMC, EMF and no health effects, especially adhering to radio frequency regulations, e.g. by field forming and automatic positioning of vehicle and/or receiver and shielding.
- New vehicle layouts for maximising induction plates to raise WPT to levels suitable for fast charging.

For dynamic charging, technical approaches in vehicle and infrastructure for charging on the road must be robust, safe and hardened against misuse. This includes reducing wear and particle emissions from vehicle power connectors for dynamic conductive charging, as well as automated driving functions for vehicle positioning and avoidance of obstacles.

Further key R&I actions

Tyres and brakes

Tyres and brakes play a vital role in all vehicles used for road transport, being required to fulfil demanding performance specifications which address reliability, safety and efficiency aspects over their entire operational lifetime. Whilst the need to reduce the environmental impact of brakes and tyres is common to all road vehicles, a number of specific issues are directly associated with zero emission vehicles and their electric drivetrains.

Tyres

Electric motors generate very high torque at low speeds, right from a standing start and, if not properly controlled, this can give rise to very high loads on the tyres (similar to those in sports cars); in addition, regenerative braking, if not properly controlled, can also cause a torque distribution transient on the tyres, which is significantly different from conventional braking, hence impacting vehicle grip and tyre tread wear, both of which need to be managed. This can be managed either through control or through tyre optimisation.

The main impact of EV on tyres is the mass increase and change in weight distribution compared to ICE vehicles. The first solution applied to this matter, for the first EVs produced since 2010, has been to increase the tyre size, just as with ICE-powered SUV, but it is not possible to go further for future small EVs (OEMs even request to have smaller tyres for their future generations of EVs).

Carrying the load of an EV with tyres having similar size than ICE vehicle requires the introduction of a new load index category (high load category, HLC) on top of the actual XL category, that has

been introduced in 2022 by ETRTO (European Tyre and Rim Technical Organisation) in order to carry more load with the same tyre dimensions (https://www.michelin.co.uk/auto/advice/ev-guide/high-load-capacity-tyres). An HLC tyre of a given size will, hence, have more constraints and, with actual tyre architecture and technical solutions, its performances will decrease, particularly in terms of rolling resistance, handling and durability, thus compromising vehicle safety, reliability and environmental impact.
Correspondingly, R&I actions addressing the development of tyres that are specific to zero tailpipe emission vehicles with a new load index are required in the following areas:

- Identify the EV tyre operating points and analyse the specific impact on each of the key performance criteria.
- Develop new technical solutions for EV tyres to ensure optimised rolling resistance and wear behaviour under increased load involving new materials (elastomers, rubber mixtures and reinforcements) and new tyre designs.
- Minimise tyre emissions by developing optimised acceleration and deceleration profiles, minimising tyre slip hence abrasion.

Brakes

The capacity of electric motors to recover kinetic energy means that the use of the friction brakes can be limited to the relatively rare situations in which the required braking force exceeds the performance limits of the electric motors or the friction potential of the drive axle. However, this generates a challenge in terms of the need to maintain the disc brakes ready for these rare events despite oxidation processes, dust collection on the discs, etc., whilst drum brakes suffer less from these problems, they have other performance constraints. At the same time, this new requirement profile for friction brakes enables the development of lighter systems (reducing unsprung mass) using new materials and the potential for greater integration with other systems via a systemic optimization design process, whilst optimised brake blending and application profiles can minimise particles emissions by avoiding, for instance, the conditions which can generate nanoparticles (avoiding high temperature that vaporise the plastic matrix).
Correspondingly, R&I actions addressing developments that are specific to zero tailpipe emission vehicles are required in the following areas:

- Optimise the control of the deceleration profile to minimise particulate emissions from brakes by further limiting their use: this can be achieved by widening the regeneration capacity, exploiting the opportunities for high-rush currents with the development of fast charging, and by optimising the blending with friction braking to avoid particle-producing events.
- Develop EV-specific braking systems (lighter and with optimised particulate emissions) focusing on residual braking tasks not accomplished by recuperative braking with **electric motor(s) (e.g. emergency braking) including system-level solutions for long** down-hill rides with a full battery, i.e. smart charging at a system level.

Safety

Trust in the safety of zero tailpipe emission vehicles is an important pre-condition for their acceptance by users. Intensive R&I has already been done on the crash safety of electric vehicles, with a focus on the structural integrity of battery packs. R&I should focus on the crash safety of the energy storage and supply systems on-board the vehicles (in particular HDV FCEVs), taking into consideration future package and structural integration concepts, especially those enabled by the new design flexibility that electric drives offer. Moreover, the use of hydrogen raises subjective safety concerns which are not always fact-based. The extent to which this can be an obstacle to social acceptance needs to be investigated and, if necessary, addressed through the development of fact-based communication. For small affordable electric vehicles combining features from L- and M-category vehicles research should answer the question what level of safety can be realised under the above-mentioned boundary conditions [see section on Conceptual Vehicle Design] taking into account safety systems for collision avoidance (active safety) as well as protective safety measures (passive safety) and possibly considering the potential of dedicated infrastructural measures for such vehicles especially in high-risk sections of road, that are beyond the scope of 2Zero.

The post-crash safety of electric vehicles has not been an important focus of European research but there are already activities addressing this highly visible issue. Further R&I is needed on innovative fire extinguishing media, systems and improved extinction procedures for batteries and prevention fire safety measures for electric vehicles and associated recharging infrastructure, particularly in constrained spaces such as covered parking areas. Moreover, the more intensive consideration of rescue procedures already in the design phase of BEVs and FCEVs should be prepared by future R&I, avoiding or managing any potential risks from critical components, such as energy storage systems. The exchange of best practices should be facilitated among relevant authorities and practitioners across Europe on extrication procedures for such vehicles as well as on the transport, handling and disposal of crashed BEVs and their batteries. Potential needs for further research should also be identified in the framework of 2Zero.
The consolidation of the main findings from the R&I, in guidelines and in recommendations for standardisation and regulation, will play a particularly important role in the safety context, in addition to the implementation of results in future product development.

c.2 – not covered by the 2Zero funding

Hydrogen ICE (not considered a priority for R&I by the EC)

One of the key challenges for hydrogen I CE is to get efficiency and performance at least aligned to state-of-the-art, “conventional” ICE (see past projects such as HyICE), targeting peak efficiencies around 50%. Of course, pollutant emissions of the hydrogen ICE have to comply with all emissions legislations globally. The scope is to:

- Develop solutions to maximise efficiency (targeting to be at least close to state-of-the-art conventional ICE, and as close as possible to FC), performance and durability for LD and HD / long-distance / inter-urban applications, being complementary to other zero tailpipe emission technologies whilst minimising TCO and enhancing customer experience. Light vehicles, mainly in the heavier segments (e.g. SUVs and LCVs), could be also of interest as a second stream, if the cost of H_2 goes down significantly in the next years.
- Focus on close to zero pollutants (such as NO_x, unburned hydrogen and nanoparticles).
- Develop, in parallel, solutions for retrofitting engines to accelerate decarbonisation of existing fleets.
- Get advantages through reusing existing resources and capabilities with a resulting favourable LCA (production and recycle) for a short time to market.
- To further increase efficiency, develop energy recovery from heat and other sources.
- Develop improved materials and design to overcome durability concerns.
- Integrate with innovative hybridisation/electrification architectures to get the overall efficiency as close as possible to FC hybrid vehicle architectures.
- Develop new, enhanced control strategies focused on fuel efficiency and performance.

- Understand and resolve all the possible risks related to hydrogen combustion and costs, to guarantee safety.
- A second usage stream would also benefit the deployment of hydrogen refilling infrastructure.

PHEV (also with e-fuels or H_2) (not considered a priority for R&I by EC)

One of the key challenges for PHEV is their high purchase price and long payback period for the customer. Also, there is the risk that customers may run with too high a share of ICE operation instead of in pure electric mode.
The scope of this action is to:

- Develop dedicated PHEV-ICE powertrain technologies (with reduced operating ranges and reduced requirements, such as transient response, load gradients, etc.) to minimise purchase price, make the TCO attractive for customers, optimise the range in pure electric mode, minimise combustion mode usage (hybrid mode) and enhance the customer experience.
- ICE and electrified components should be highly integrated to reduce costs and maximise efficiency over a wider range of operating conditions by exploiting their complementarity.
- The ICE should take advantage of being part of electrified systems and should get higher efficiency over a wider range of operating conditions.
- Develop ICE for various fuels, including e-fuels, or integrate above mentioned H_2 engines.
- Understand and resolve all the possible risks related to hydrogen combustion and costs to guarantee safety.
- Develop new, enhanced control strategies focused on fuel efficiency and performance.
- Focus on close to zero pollutants during ICE operation modes, as well as non-tailpipe emissions
- To further increase efficiency, develop energy recovery from heat and other sources.

Transversal aspects of tyres and brakes (including environmental impact) (analysed in other sections of the Horizon Europe Work Programme)

Priority action

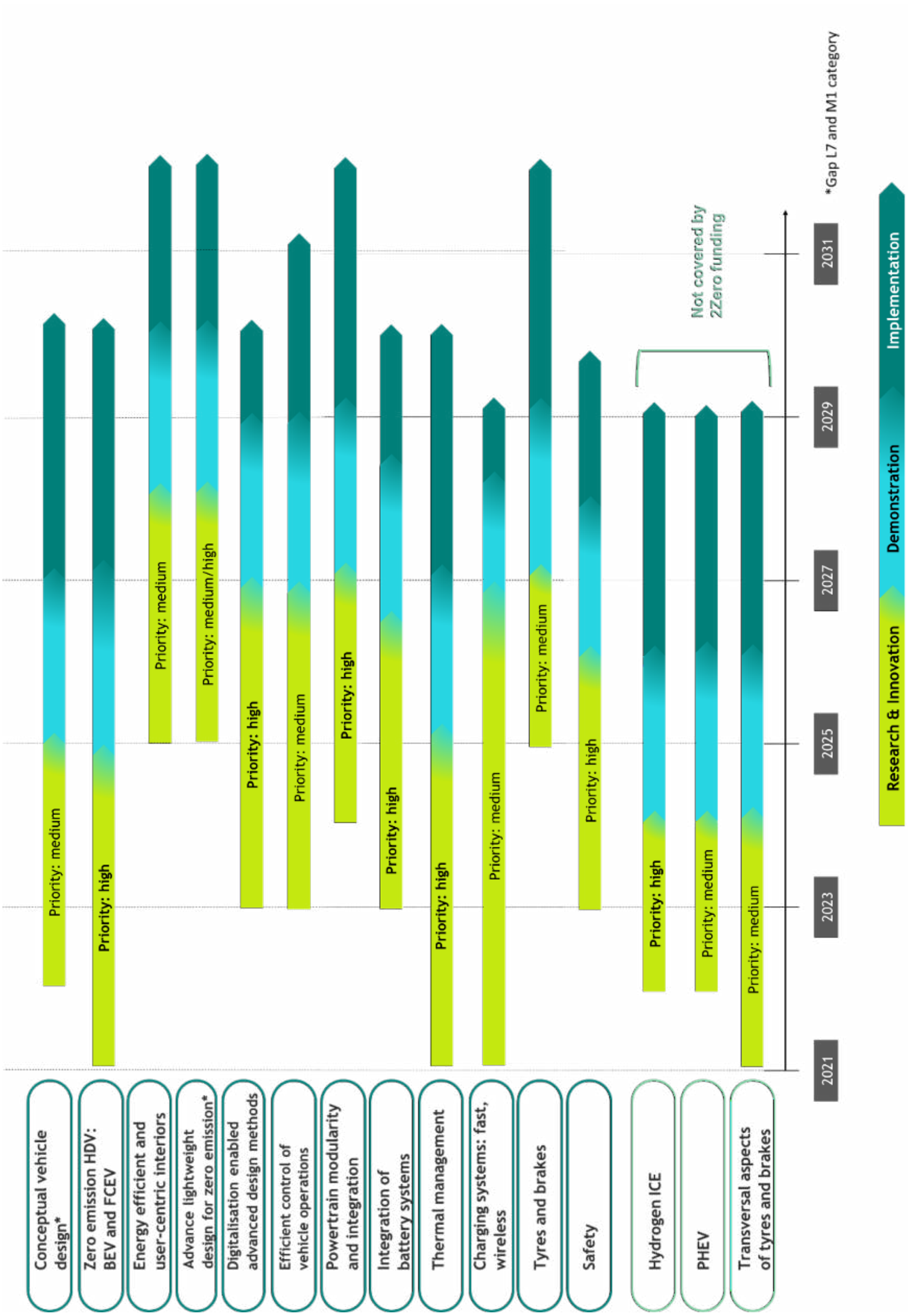
General R&I actions for tyres and brakes, not specific to electric vehicles, are included in this section. The R&I actions undertaken here for tyres and brakes need to be aligned and based on overall generic vehicle developments and studies performed in other parts of Horizon Europe, such as:

- Develop new, sustainable materials to replace petrol-based polymers used in tyre compositions (to improve CO_2 impact measured by LCA, aligned with the 4^{th} R&I Pillar).
- Understand the emissions impact (particulate matter and noise) and develop solutions (tyres and brakes) to improve, to reduce them whilst still ensuring driving safety.
- Continuous improvement of tyre performance (rolling resistance combined with grip handling, noise and wear) and brake technologies.
- Reduce tyre and brake global usage impact on the environment and health (non-exhaust emissions to improve air quality / exterior noise).
- Reduce the use of raw materials and develop biomaterials for tyres.
- Recycling processes for ELT (End of Life Tyres).
- Connected tyres and brakes.
- Innovative and efficient manufacturing processes to take into account extended diversity and small series (consequences of new usages and dedicated specific tyres) whilst minimising energy consumption.
- Simulation tools taking into account tyres and brakes behaviour at the system level.
- Develop a cost-effective brake disc with improved wear performance. New solutions should

assure the reduction of brake disc and pad wear. This will result in a system lifetime improvement (double expected) and a considerable reduction of fine dust emissions.

- Develop solution to collect all dust and particulates resulting from the friction system brake and brake pad (e.g. casing or dust extractor or filter) whilst maintaining performance targets (e.g. thermal stability, resistance to water, snow, mud, etc.).

d. Roadmap


Conceptual vehicle design*
Zero emission HDV: BEV and FCEV
Energy efficient and user-centric interiors
Advance lightweight design for zero emission*
Digitalisation enabled advanced design methods
Efficient control of vehicle operations
Powertrain modularity and integration
Integration of battery systems
Thermal management
Charging systems: fast, wireless
Tyres and brakes
Safety
Hydrogen ICE
PHEV
Transversal aspects of tyres and brakes
Priority: medium
Priority: high
Priority: medium
Priority: medium/high
Priority: high
Priority: medium
Priority: high
Priority: high
Priority: high
Priority: medium
Priority: medium
Priority: high
Priority: high
Priority: medium
Priority: medium
Not covered by 2Zero funding
2021
2023
2025
2027
2029
2031
*Gap L7 and M1 category
Research & Innovation
Demonstration
Implementation

4.2 Integration of battery electric vehicles into the energy system and related charging infrastructure

The integration of battery electric vehicles (BEVs) into the energy system brings both challenges and opportunities. To properly tackle these challenges, an unprecedented level of coordination will be needed across stakeholders who are not currently used to working together: automotive players, grid operators, charging point operators, roaming platforms, electro-mobility service providers, buildings operators and end-users for street and private home charging solutions will need to interact to define the most relevant solutions.

User acceptance of charging options is key for the fast development of the EV market. That implies that the following challenges should be tackled:

- Future charging solutions should be ubiquitous, for all vehicle types, paralleling the growth of EV sales and become a seamless process: easily accessible for all EV users including, e.g., elderly or impaired people, available at any time, whilst charging durations should be responsive to the user's needs.
- Technological developments, such as smart charging and vehicle-to-grid (V2G) solutions, will need to be implemented in larger scale enabling the cross-sector synergies among e-mobility (EV user, CPOs, eMSPs) and energy stakeholders (i.e. system or network operators, flexibility aggregators, market operators), creating a flexible, sustainable, affordable and efficient charging environment and grid operation.
- Upcoming charging solutions should be interoperable, in terms of physical interface and information exchange, enabling different charging solutions to satisfy multiple user needs built upon an eco-system with an open architecture. Data interoperability should be considered for the different applications (passenger vehicles, buses/trucks, LEVs, etc.) in respect to the system approach needs.
- New digital solutions are expected to contribute to improve charging planning and to better display charging prices, giving to the customer an accurate and real-time perception of the final cost of the service, as is the case currently for fuels.
- Power quality and network stability and security should be maintained. Charging planning and operation shall support and optimise grid capacity and planning and the potential to improve system resilience.
- Charging stations should be able to serve the operation needs in a cost-effective way.

The appropriate mix of charging options and solutions (public or private charging points, high or low-power, static or dynamic, wireless or conductive technology) should be determined based on the geographical area and the most favourable business models. The need for charging big fleets of BEVs of all categories (light vehicles, passenger vehicles, heavy-duty vehicles, coaches and buses) requires careful design of charging strategies and components, in order to prevent peak demand and power quality problems that could also lead to an inadequate sizing of the electric system.

This chapter of the SRIA addresses the important challenge of linking e-mobility with the electricity grid in an architecture that will tackle both the opportunity for BEVs to play an active role in the interconnected grid whilst providing attractive benefits for the end-user. As described below, this chapter will investigate how the system approach architecture can seamlessly integrate the BEVs in the functioning of the interconnected electricity grid utilising innovative services, through emerging actors with complementary roles in the electricity market, that can generate important benefits for the system and pass on to the end-users the gains thus achieved. Activities described in this chapter build on the technical capabilities of future BEVs as presented in the "*Vehicle technologies and vehicle propulsion solutions for BEV and FCEV*" chapter and will strongly interact with activities covered under the 3rd pillar "*Innovative concepts, solutions and services for the zero tailpipe emission mobility of people and goods*".

a. Challenges and objectives

Charging infrastructure

One of the main challenges for the EV market growth in Europe is to achieve a sufficient quantity of adequately distributed charging points across Member States and at the locations that best suit the end-user. Whilst the number of charging points will continue to increase, in a more rapid manner during the next years, the dynamics vary from region to region, which calls for a thorough assessment of the installation locations and the proper technology mix targeting a comprehensive charging network aiming at maximising the benefit to both users and operators. Methodologies to plan the deployment of different EV charging options answering the needs of all users are needed, as well as real-life tests of different business models to ensure the viability of the solutions to be performed in close collaboration with the third pillar of 2Zero activities.

To ensure optimal accessibility, locations should be chosen based on a series of factors such as expected demand, population density, geographical accessibility (close to home, supermarkets, gyms, public places and workplace), grid capacity and other socio-economic variables. Private charging infrastructures (i.e. home, workplace, depots, private commercial business) should also be considered given that the proper infrastructure visibility exists. Furthermore, business models should be established for less densely populated areas (where decisions geared principally towards maximising profitability in the short-term) at the same time that EV charging infrastructure accessibility in TEN-T corridors and urban areas continues to grow. Whilst European requirements for chargers in new buildings are evolving towards EV charging integration by design, major challenges exist concerning the most effective implementation of the charging solutions in existing buildings, to respond to real-case scenarios. Smart charging and bidirectional charging are the key enablers for the energy system integration of buildings[37]. Smart charging functionalities need to be ensured where electric vehicles typically park for extended periods (residence or workplaces) to optimise the exploitation of the grid capacity. Bidirectional charging is an important enabler for the clean energy transition, by partially serving the grid storage capacity needs (at the building or system level) for an increased share of renewable electricity production.
A key challenge is to respond to the needs in metropolitan areas, where most homes do not have access to a garage or to off-street parking[38]. Supported by systematic, large-scale urban renovation processes, low-power charging stations (up to 22kW where needed and optimal charging capabilities dictate it) could be made available at a reasonable cost for users (on-street, office, underground parking, etc.), whilst at the same time reducing the need for additional energy distribution infrastructures. Considerations for further reducing the cost with smart charging solutions and grid-oriented services should be taken into account. Such mobility hubs will need to optimise not just BEV usage but will have to integrate public transport, collective taxis, urban utility vehicles, e-scooters and e-bikes demand at the same time, sharing energy resources with functioning infrastructures, commercial and recreational areas.

[37] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021PC080
[38] Mckinsey and Company (2014). Electric vehicles in Europe: Gearing up for a new phase?, April 2014 | Report

A special attention should be given to include in the designs of charging infrastructure the special needs of electric L-category vehicles[39] for passengers and goods, since these are strong candidates for effective widespread of electromobility in cities. The standards and systems for this vehicle category need to be assessed and developed as regards their appropriateness for charging light vehicles, considering the diversity of products in the L-category (from mopeds to quadricycles). The objective of R&I in this field is to reach a universal approach for building and operating the required systems to facilitate interoperable systems and solutions for the family of light vehicles.

The challenge for other charging solutions will need to be deeply explored, including:

- Battery swapping charging service is being revamped as B2B and B2C solution for (sharing) LEVs, this might be extended to larger vehicles. The viability of such charging solutions requires further elaboration on the interoperability/standardisation aspects as well as AI-based solutions (automated swapping, predictive services, etc.) to enhance user convenience and swapping experience.
- Electric road systems (inductive dynamic wireless charging, overhead power supply via pantographs or ground level power supply through conductive rails) constitute solutions with multiple applications but the feasibility and economic viability of large-scale deployment and integration in the urban context and other geographical areas still need to be carefully analysed and investigated, also pollution is to be considered (optical, noise, electromagnetic fields, fine dust in the case of conductor contacts, etc.).
  Whilst wireless static and dynamic (infrastructure embedded in the road) charging minimises the visual impact on the surrounding area, there are still relevant issues regarding power transfer or installation costs that prevent a widespread deployment. Technologies are already being tried out but extensive research work is needed to bring them to commercialisation whilst ensuring interoperability and the seamless use of solutions. A wide adoption of such technologies will generate various concerns on EMC and health safety that will need to be addressed through R&I. In both cases (conductive and wireless) managing and balancing the grid with this dynamic "loading" is challenging, especially during periods of peak loads, with respect to the local grid capacity.

System approach to EV charging

The challenge of EV charging in its broader perspective is to be an active component of the integrated grid, utilising the fundamental characteristics of the on-board battery for achieving optimal solutions for the benefit of the end-users and improving the carbon footprint of e-mobility. Inevitably, such an approach will require charging modes that meet the needs of the user on the one hand but are aligned with the interconnected system capabilities calling for smart charging solutions (as opposed to direct and immediate charging from the moment the vehicle is plugged into the charging point) on the other.

The energy transition implies increasing RES share combined with storage capacity to ensure security and reliability. Research should investigate possible links between the RES uptake (on the location of the charging point -private or public- or at system level) and EV batteries behaving as

[39] ePTWs: electrically Powered-Two Wheelers. From a market perspective, the range of ePTW may vary from the smallest electric mopeds up to the larger high-performance motorcycles, all encompassed under the European Framework Regulation 168/2013 (from 1.1.2016 repealing the old Framework Directive 2002/24/EC) for Type Approval, including also 3 and 4 wheelers.

distributed storage units. Furthermore, research should focus on the system integration of battery swapping points and stationary batteries at the location of the (fast) charging stations, which could contribute to peak-shaving and provide the stored energy when needed for charging. Aside, business models inviting vehicles to schedule charging when peak-shaving of available RES in the grid is appropriate since they can reduce the need for back-up power fed into the grid in off-peak times.
This need is primarily dictated by the user's needs, leading to low system cost solutions that will enhance the advantages of BEVs as opposed to other forms of transport. R&I needs in this field are of high priority and timely, since optimal operation of the interconnected systems requires the active contribution of the connected EVs following modes that do not violate the comfort needs of end-users and, at the same time, achieve low cost solutions that will guarantee an affordable mobility, contributing to increase BEV penetration and to support the energy transition objectives.

Boosting the system approach through smart and bi-directional charging

Adopting **smart charging solutions** can lead to dynamic load management, which is a pivotal concept to create customer benefits from the intelligent recharging of EVs. Smart charging has the ability to automatically distribute the available power between the charging points and the electric vehicles that are being charged simultaneously. Consequently, through such advanced systems, energy flows can be effectively managed in order to have a positive effect in the use of local resources. This will lead to an integrated grid capable of smoothing peaks and maximising the use of the developed smart infrastructure serving all connected users through optimal energy prices for the benefit of the end-users. R&I should keep the focus on multi-parametric, predictive smart charging concepts which will consider simultaneously the user's needs, preferences and constraints (Pillar 3), energy costs, battery degradation and grid capacity.
Hence, as opposed to traditional blind charging, smart charging allows to exchange information, allowing monitoring and management of the energy consumption. As a result, smart charging strategies can lead to the following advantages[40]:

- improved utilisation factor of low or high power charging infrastructures;
- decrease the need for investments for grid reinforcement by a factor of two compared to a situation with no smart charging and, hence, increasing the number of BEVs charged from the same infrastructure;
- generate tradeable flexibility to the grid and/or electricity markets, offering tangible benefits to the users (in terms of cost reductions and ease of charging) since they are the providers of the flexibility;
- reduce the prospective peak load for the generation plant and grid by up to 25%, which can lead to improved utilisation rates of the electricity distribution infrastructure and additionally improve the stability of the integrated grid.

Therefore, it is expected that smart charging will become a widely applied solution in the coming years. However, the implementation of smart charging solutions in the different potential use-cases, such as at public spaces, at home or at office buildings, remains a major challenge. It is fundamental for the adoption of smart charging to obtain a clear perspective on which use-cases will have the bigger impact in the long term, exploring all the prerequisites and features that will be necessary to make sure the possibilities it offers are fully applicable.

[40] N.N. "Enjeux du développement de l'électromobilité pour le système électrique", https://assets.rte-france.com/prod/public/2020-06/electromobilitee%20syntheese.pdf, visited 2023-05-12, pp. 54-61, May 2019, France.

Vehicle-to-grid (V2G) is a technology that enables to feed energy from the battery of an electric car to the grid or other uses. V2G goes one step further than smart charging and, therefore, enables to balance variations in energy production and consumption, making use of EVs energy storage capacity. A particular use-case of V2G is vehicle-to-home (V2H) where the energy from the BEV battery is supplied directly to a house or, possibly, commercial buildings (V2B). Bi-directional energy flow can provide multiple benefits to the electricity system given that the right incentives and respective market provisions are put in place. At early deployment phase, bidirectional power flow was supported only by CHADEMO. However, recent research activity focused on alternative technological enabler such as DC-CCS-type 2[41] and AC-Type 2[42].
The additional investments needed for the V2G service into charging infrastructure and metering (behind the meter) should be addressed in respect to flexibility capacity and the realistic amount of expected flexibility capacity needed by System Operators.

R&I challenges in V2G solutions are multiple and fall in the wider category of flexibility services to the integrated grid for optimal operation of resources. Through this process, V2G can deliver financial benefits to end-users, hence enhancing the EV deployment and contributing to the energy transition towards low carbon solutions.
Today, however, the (estimated) state of charge of EVs is known only by the car manufacturer, hence the aggregation function is performed either directly by the OEMs or by parties (aggregators) linked to the OEMs. The role and the costs versus benefits for the EV owner need to be better clarified, particularly regrading their relationship to the aggregator, in the different use-cases.
Thus, this avenue uses the generated flexibilities in support of the integrated grid incorporated in the day to day functioning of the system, capitalising on smart charging practices to provide system needs such as:

- Flexibility trading;
- Balancing market needs through appropriate aggregation;
- Ancillary services through the portfolio of an aggregator.

Extensive R&I work is needed to address these issues; using BEV as an effective means of storage through combinations of V2G and smart charging, possibilities can deliver important financial benefits to all stakeholders, including the end-user (who is the provider of the facility and the one potentially giving up a part of the life of their battery in the process).
When using smart charging, the possibility of balancing the grid ends when the battery is fully charged, whereas V2G can continue grid balancing for all the time the vehicle is plugged in. A better understanding of different use-cases and the formulation of best-case scenarios is required.

High power (fast) charging(>50kW)
At the technical level, reliable high-power charging solutions are available for light vehicles, whilst for some categories of vehicles they are still in the development phase, needing more R&I, particularly to increase the maximum charging power without compromising the BEV equipment and battery lifetime during the charging process.
Particular attention should be paid to the real needs of end-users, including optimised infrastructure positioning, ease of use and interoperable protocols that do not hinder universal use across different countries.
The coordinated operation of high-power charging infrastructures with local energy sources, such as

41 https://doi.org/10.3390/en15197364
42 http://www.davidpublisher.com/Public/uploads/Contribute/597afe6907a12.pdf

RES and storage capacity, should be considered to minimise their grid impact, especially at depots, and offer ancillary services to the system, the network and market operators.
Medium and heavy-duty Vehicles (MHDV), such as buses, coaches and trucks, account for a high percentage of transport energy use in Europe. To meet the specific needs of these vehicles, high-power charging solutions (well above the powers of the current ones) should be developed, generating R&I needs of crucial importance to achieve the objective of 2Zero.
The main challenges of MHDV compared to light vehicles are the need to maximise their utilisation (and, therefore, have low flexibility when it comes to wait-before-charging time and downtime), the higher batteries capacities, the high charging power (750+kW) requirements, the need for simultaneous charging of several vehicles at terminals and truck stops, and the higher uncertainties in arrival times due to loading and traffic conditions, making it difficult to schedule the charging in detailed time slots.

EU-wide solutions for seamless use of EVs

The seamless use of BEVs throughout the EU is critical for e-mobility to pick-up and play its role in the energy transition. End-to-end communication compatibility, along the whole service chain, is needed to ensure an effective and user-friendly experience.
Information on the state-of-charge or energy need (size of battery and the extent to which it is charged), the time of departure (or the time the consumer needs the battery to be fully charged), the vehicle type, the charging rates (threshold values for the minimum and maximum power for charging), driver preferences (for example, minimum range that must be guaranteed) should be available at all times. Such information is needed to enable price transparency for the final user and to facilitate smart charging and V2G. To achieve this, Eu-wide interoperability and payment facilities should be made available, involving all stakeholders in the supply chain.
Hence, BEV owners would be able to charge their vehicles seamlessly in any European country they may travel to.

b. Expected outcomes by 2030

Based on addressing effectively the above identified specific challenges and objectives, the following outcomes can be considered as achievable by 2030:

- System operational analysis includes needs and contribution of BEVs through proven static and dynamic models.
- Smart charging solutions and efficient bi-directional energy services enabled through a proven system approach and appropriate market mechanisms.
- Interoperability of charging infrastructure along the value chain, enabling smart services throughout the EU.
- Coordinated charging solutions covering at least 30% of the interconnected grid in all the Member States with embedded interoperability features.
- Solutions to provide an economic level of security of electric mobility for local distribution in case of grid failure events (e.g. maintain 50% electric mobility during a 24h shutdown)
- Use of V2G to participate in ancillary service market in the interconnected grid in the EU by 20% (of total system) by 2025 and 50% (of total system) by 2030.

c. Scope of actions

To address the above challenges and the identified outcomes by 2030, the following research and innovation areas should be covered in the 2Zero Partnership. These themes are looking for solutions on the system side utilising the smart solutions developed in Chapter 4.1 "*Vehicle technologies and vehicle propulsion solutions for BEV and FCEV*". To be responsive to this need, careful consideration of the seamless active contribution of BEVs to the integrated grid is fundamental to maximise the utilisation of the on-board battery of BEVs without being a handicap to the needs of the end-user and, at the same time, generating system benefits.

Charging infrastructure

As e-mobility develops, the charging infrastructure which is going to be used daily, should be easily accessible and to the required quality standards. For this to happen, vehicles should be equipped with the appropriate battery and associated components (i.e power electronics, battery management, etc.), as developed through the smart solutions proposed in Chapter 4.1 of this SRIA, ready to link with the active integrated electrical grid through suitable adapted infrastructure, adding minimal cost to the system to achieve the targeted affordable solutions. The targeted solutions are covered in this section of the SRIA, calling for appropriate R&I themes that can deliver the innovation required.

- Development and demonstration of easy-to-use and secure charging stations for passenger vehicles, LEVs and motorcycles, without affecting the urban space and noise environment. Cyber security is a key issue regarding end-to-end communication and smart charging, as interfaces between actors can be weak security points from the cyber security perspective. This requires cooperation between all participating stakeholders and affects the wider smart grid development, where communication protocols remain a challenging, open issue. The system must prevent access by unauthorised parties whilst at the same time facilitating an open market with freedom of user choice in combination with a seamless service.
- Improving the charging points visual impact and use of public space. To achieve this, it is vital that appropriate disciplines collaborate in developing technically sound solutions to be as much as possible invisible (integrated in the sidewalk or underground, for instance) or visually integrated with the local environment, and utilising spaces that are not vital for other services.
- In particular, in order to avoid some possible foreclosure of vertical integration of parties being connected (OEMs, Charging Point Operator (CPO) and EMSP), explore charging infrastructure schemes that may be procured by the agglomerations, the cities and only the service part is tendered out for provision of e-mobility services (some cities already practice this scheme). Improving charging solutions beyond the state-of-the-art by delivering improved performance and lower operational costs for operators to satisfy the needs of each user group (residential, businesses (including logistics operators) and public authorities (utility vehicles)).
- Establish enhanced testing of EVs for interoperability (being able to charge on all charging points), power quality (grid pollution) and smart charging (monitoring of control signals) for wider routine testing procedures by the industry.
- Coordinated planning of the charging network with the grid planning.
- For buildings:
    - Develop private home smart charging stations supporting the direction towards nearly zero-energy buildings based on the minimum threshold implied by the EU directive "Promotion of e-mobility through buildings policy": optimise and coordinate the BEV charging within different private home facilities, including other type of energy storage system (static battery, heat, RES, etc.) enabling V2X services, (i.e. V2B, V2H, etc.). The

end-user is protected by electricity supply provisions whilst charging at home, and can choose an aggregator different to the electricity supplier.
    - Enable smart charging and bidirectional charging services to reduce charging energy cost, support renewable energy integration and enable grid services.
    - Develop and evaluate the efficiency and acceptance of residential buildings smart charging solutions.
    - Develop and evaluate the efficiency and acceptance of office buildings smart charging solutions.

- Increase interoperability of the charging points and their multi-type-vehicle charging capacity to enable the use of the same charging point for MHDV and light BEV (for MHDV see the specific section below).
- Enrich development using open standards to achieve interoperable solutions that will safeguard wider use and enhance the development capabilities of non-restricted vendors.
- Support innovation in pervasive on-street charging, catering to progressive high-EV penetration scenarios.
- Support innovation for mobile and/or temporary charging solutions (quick installation) for events.
- Develop automated connectors for charging infrastructures, such as specialised robots or pantograph solutions, for all levels of charging. R&I work should address power capabilities and adapted automated solutions for effective charging.
- Develop multipurpose and multi-category electric road system solutions and study their applicability to different categories, including for each the optimisation of power and efficiency, EMC issues, communications and control of the impact on the grid of conductive and, in particular, wireless battery chargers (demands linked with the short charging duration, the dynamic nature of charging, etc.).
- Demonstrate interoperable wireless charging infrastructure and study issues linked to EMC and safety, including with parties that are not directly linked to OEMs.
- Demonstrate alternative, close-to-market, interoperable charging solutions, such as selective wireless charging in waiting lines for taxis, circular shared roads, etc.
- Investigate trading, pricing and tariff systems that can form the basis of smart charging of vehicles through their active participation in the interconnected electrical grid, taking due care of the following, with the objective of delivering an exhaustive portfolio of market participation of BEVs singly or aggregated:
    - Assessment of where and when the smart charging and/or V2G concepts should be implemented.
    - Improving the variety of technical and business model solutions allowing an automatic (allowing to charge when the user is working or sleeping) and transparent charging schedule with any charging point in user proximity (home, office, etc.).
    - Improving the profitability of business models in urban and semi-urban areas, allowing city authorities, building and parking managers, and developers to implement the proposed solutions.
    - Demonstration of public blockchain solutions for smart energy trading at enterprise and user levels, including active distribution/transmission grid hierarchical control to manage local and regional needs, and safeguard the quality of supply and push back to end-users.
    - Active participation in the prevailing energy and flexibility markets.

The system approach for battery based e-mobility

In the transition towards electric mobility, BEVs will play a leading role calling for innovative solutions that will maximise the benefits of the end-user, lowering running costs to the minimum possible through the benefits of a system architecture, as detailed in this SRIA. For this reason, it is of critical importance that we act now to safeguard, as a minimum, the following:

- Considering the impact of energy-driven house renovation processes (incentives, large investors, etc.) some pilot sites should be built, embedding charging facilities as part of the distributed flexibility of the system.
- Infrastructure is being built and, for this reason, it is vital that the solutions implemented are adaptable to interoperability needs with minimum disruption. R&I should concentrate, as a priority, on delivering solutions that will minimise stranded investments yet ensure security.
- The built environment should be equipped with facilities that can host the charging infrastructure with the minimum disruption. This affects all types of development, especially private buildings, office areas and public building areas. These charging systems should be smartly embedded in the local grid, to avoid grid over sizing and to maximise the benefit for the end-user (benefiting from lower energy costs).
- The interconnected power grid should be smartened, to the degree that can offer the required solutions for smart charging and vehicle to grid connectivity. The sizing of the equipment to be used should take into consideration storage facilities offering the required services to the interconnected grid.
- Telecommunication systems and data analytics, handling, repositories and services should be designed and developed with the needs of e-mobility in mind. The interconnected system will be everywhere: homes, public buildings, work depots and offices, commercial buildings, public areas, services and roadways.
- Define the concepts and mechanisms that allows the efficient integration of private charging stations (e.g. home chargers) in different energy markets in a transparent way.

Planning the BEV connectivity to achieve a system approach

The challenge of EV charging in its broader perspective is to be an active component of the integrated grid, utilising the fundamental characteristics of the on-board battery for achieving optimal solutions for the benefit of the end-users and reducing the carbon footprint of e-mobility. The system of 2030 and beyond will be RES based primarily, with power electronics and storage offering the complementarity required for energy quality and continuity. Thus, the battery of a BEV falls within the enabling technologies that can play an active role in balancing, stabilising and actively contributing to the quality of supply throughout the year. Inevitably, this will require charging modes that are aligned with the system needs, leading to smart charging solutions as opposed to direct and immediate charging from the moment the vehicle is plugged into the charging point.

V2G solutions will become more important as the penetration of RES grows, with the bidirectional flow of electrical energy as an enabler to manage intermittency and mismatch between source availability and use. To this effect, it is important to develop and test solutions for low cost alternating current (AC) bidirectional charging or for low-power direct current (DC) charging that will open the window to more use-cases to benefit from flexibility schemes.

Big data platforms will play an important role for V2G implementation. The establishment of a robust data collection infrastructure will be key to apply algorithms and develop advance analytics to predict charging patterns and shape grid optimisation.

The following research and innovation areas should be considered for **unrestrained charging, smart charging and V2G** options as appropriate:

- Testing of V2G protocols - based on interoperable architecture, in line with V2G advancements in the automotive industry, extending the family of solutions available that include non-OEMs providers.
- A better understanding should be gained by system and network operators regarding the behavioural profile of V2G enabled EV fleets to support system and network operation.
- Improving the understanding of BEV user's needs for charging solutions, including city residents, businesses (including logistics operators) and city authorities (utility vehicle users): focusing on cost, convenience, ease-of-use, home to office proximity and the visual aspects of the optimal technical solutions.
- Developing forecasting, planning and assessment methods and tools for developing the interconnected system in which BEVs are an integral contributor, with appropriate remuneration for the benefit of the end-user. This development work should consider:
    - Grid operational needs, development of the planning of the public charging infrastructure to maximise transport and grid synergies and the uptake of smart solutions;
    - The interaction of different vehicle types (e.g. taxis, commercial vehicles or privately owned cars), parking space pricing and management, charging needs, public transport development;
    - Best practices for mobility hubs and other complementary solutions for urban development, including for the appropriate mixes of usages in such hubs and cooperation between urban, transport, space and parking planning authorities and distribution grid planners;
    - EV users' needs (charging demand, location and time), battery state-of-charge and electricity price forecasting based on demographics, home-work commute routes and user profiles, and overlapping this demand map with the existing parking infrastructure, on the street, at home and in the office;
    - Informing the EV user of the most convenient price schemes, of price peaks;
    - Testing schemes with user engagement, in particular through the choice of aggregator, in respect of flexibility services.
- Reinforcing the role of BEVs in the mix of aggregators, in support of the emerging flexibility market. This shall contribute to the optimisation exercise by aggregators and others, such as CPOs, for whom one of the key topics is choosing the right location, taking into account the impact on the grid of their customer's charging times and locations, as function of usage forecasts, battery SoC and electricity price forecasts, which influence the available quantities of flexibility that can play an important role in reducing the costs for the benefit of the end-user.
- Improving optimisation by electricity generation, supply and grid companies for planning and operating generation, storage, balancing energy/capacity and grids for the optimal integration of BEVs, utilising appropriate digitalisation means through appropriate sensors in addition to smart meters (that are going to be rolled out in the very near future). This optimisation exercise of the referred stakeholders requires appropriate models of BEVs to be included in the design of the

analytical tools, to provide the required analytical accuracy that will optimise development and operational plans that reduce the overall system cost for the benefit of the end-user.

- As above, testing of V2G protocols, standardisation (voltage standardisation, mobility hub size and design) and demonstration of approaches for the efficient integration of high-power charging stations in the energy system, e.g. traditional solutions, innovative solutions such as DC chargers fed from DC network, or micro grids and storage.
- Enabling the communication of system parameters and status, including market details in the electromobility value chain, to support smart charging services and enable price transparency for the user.
- Address smart charging by developing applications equipped with advanced, centralised and decentralised control techniques, having to deal with different interfaces and management levels, namely battery/vehicle, vehicle/charging point and charging point/grid, to control and optimise the load curve for optimal exploitation of the network infrastructure. Approaching the system integration from this angle will offer all connected users the comfort of their choices (i.e. point of charge that best suits the time of charge and level of charge, etc.) and at the same time supports solutions for higher utilisation of the interconnected infrastructure. This will lead to a reduced system cost, for the benefit of all actors.
- Development of high efficiency, bi-directional, energy transfer (V2G) functions to benefit the electricity system and promote end-user acceptance, by providing transparent information on battery life impact and cost.
- Consideration of the impact of autonomous vehicles on required charging infrastructure, aiming to optimise its development and minimise the potential risk of assets being stranded.
- Improving grid-friendly characteristics in the charging infrastructure, optimising its integration in the grid, including V2G, and linking EV recharging time to the periods of the lowest power price for the user.
- Decision support tools for defining the optimal locations and technology mix for a charging network should take into consideration EV demand needs as well as grid capacities.

High power charging

Smart, high-power charging facilities and accurate Artificial Intelligence (AI) forecasting techniques are required to pave the way to the high penetration of passenger BEVs and electric MHDVs in the mobility system for passengers and goods. An efficient, very high-power charging infrastructure will be required for passengers and MHDV, to minimise the charging time (out-of-service time) as well as the battery pack's (weight).

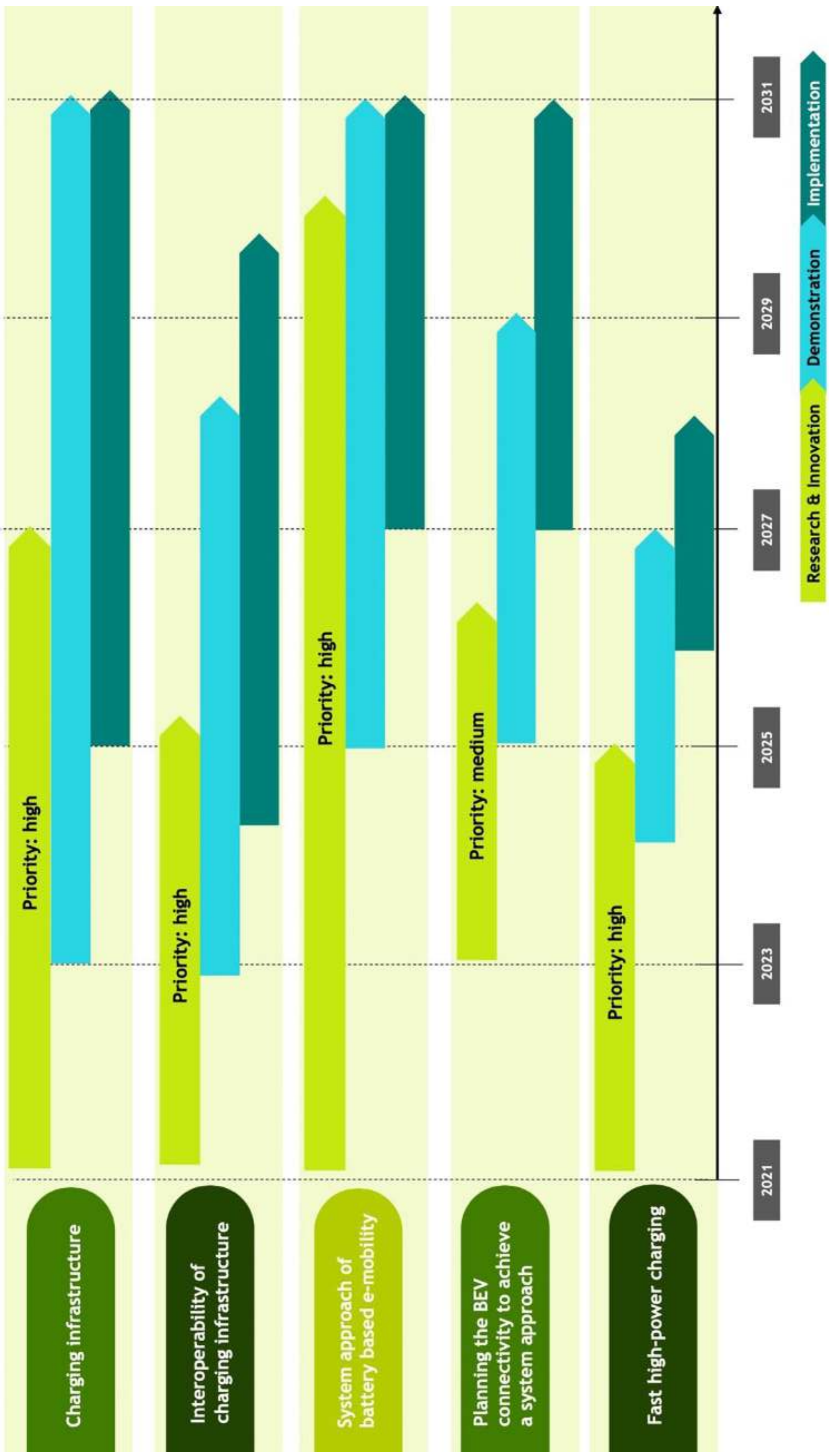
Specifically, for the MHDV category, three options need to be considered for developing adequate charging solutions:

- Charging at depot or truck stop locations overnight, over 6 hours;
- Charging at logistical terminals and hubs for 45-120 minutes (where possible to group with other services) when driver breaks and/or changes are taking place;
- Charging at an adequate charge level on highways for times that do not in general exceed 45 minutes, utilising the legislated driver work time rules with a mandatory break of 45 minutes after maximum 4.5 hours driving.

Based on the above, the following are considered appropriate R&I themes that can deliver the innovation required:

- Study the specific infrastructure needs for passenger vehicles and MHDV, including an optimisation study for finding solutions to the siting of charging infrastructure that can meet the needs of the users with the minimum cost. This exercise should be wide and deliver an easy-to-use tool that can form the basis of planning and operation of the interconnected system. As input to the optimisation study, the targeted locations such as service or depot locations, bus service networks, logistics hubs and highways beyond the current limits should be available. The developed tool should have the capability to map out the optimal locations for a high-power charging infrastructure (service centres, depots, logistics hubs and on highways), offering planning options to the developers of the targeted infrastructure.
- Design and propose tests for high-power charging systems and their impact on the BEV equipment and batteries, to avoid interoperability problems and power quality issues of the BEV during high-power charging.
- Specifically, for the MHDV category, there is a technical challenge to transition from 150kW to 800kW–1MW charging systems, to decrease charging time for heavy-duty vehicles from 9 hours, currently, to less than 45 minutes by 2025.
- Design and implement enhanced smart charging systems and V2G services for HDV at depots to reduce the grid impact of high-power charging by exploiting local RES energy and storage capacity.

d. Roadmap


Charging infrastructure
Priority: high
Interoperability of charging infrastructure
Priority: high
System approach of battery based e-mobility
Priority: high
Planning the BEV connectivity to achieve a system approach
Priority: medium
Fast high-power charging
Priority: high
2021
2023
2025
2027
2029
2031
Research & Innovation
Demonstration
Implementation

4.3 Innovative concepts, solutions and services for the zero-tailpipe emission mobility of people and goods

It is key to consider the users' operational and services perspectives, to effectively integrate the technological and non-technological advancements needed to enhance the up-scaling and extensive adoption of zero tailpipe emission vehicles. The accessibility of the mobility system as well as its inclusiveness are to be considered. Hence, this chapter focuses on user-centric innovative concepts, solutions and services for the zero-tailpipe emission road mobility and logistics. In following a system's approach, vehicle concepts, technologies and propulsion systems development (Chapter 4.1) and the integration with the charging infrastructure and the energy system (Chapter 4.2) are to be complemented with user-centric usage models, operations and services that facilitate zero tailpipe emission vehicles adoption.

Zero tailpipe emission vehicles are more and more available in the market, with very competitive TCO[43] and performance. However, their deployment is not uniform across Europe: the 2Zero Partnership needs to bring solutions to accelerate broad market uptake and allow the transition of the whole continent towards zero emission mobility in a harmonised way. As zero tailpipe emission vehicle's operational and maintenance costs are lower compared with conventional vehicles (BEV in particular), the TCO is currently mostly favourable in use-cases with an intense usage.

Concerning public transport and shared mobility solutions, zero emission buses are today operating in several cities across Europe. The fleet renewal towards zero emission solutions is in place, though at different rates in different European countries. In addition, more importantly, not every operation can be covered with the existing solutions, in an affordable way or matching the actual user needs. Regarding shared and on-demand zero emission mobility, some solutions and services have been implemented in European cities, gradually replacing ICE based schemes thanks to the longer range of new EV models.

Whilst ZEVs are entering the market for local and regional missions, the limited availability of competitive zero tailpipe solutions is more challenging for long-distance heavy commercial vehicle operation, with access to adequate charging and/or refuelling facilities to ensure smooth operations. Currently, the TCO[44], the lack of infrastructure, the range and the performance of vehicles (e.g. payload, managing slopes, operational speed) are preventing a large-scale adoption since current solutions are not yet proven to match logistics operational and business models. In addition, due to their flexibility, coach buses are used to an increasing extent for longer distance trips, to complement for example regional rail services. Yet, there remains the need for fast-charging network and large-scale adoption.

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[43] Some countries in Europe (such as the UK) have already a lower TCO (for private vehicles) than petrol or diesel alternatives.

[44] The Total Cost of Ownership may be lower in future compared to current solutions when i) there is a large amount of zero tailpipe emission vehicles in operation, being mass produced; ii) vehicles are more energy efficient; iii) adapted solutions are available maximising benefits of these vehicles; and iv) the necessary charging infrastructure to provide proper operation in geographical areas is in place; Marg. McCall, A. Phadke (2019) *California semi-truck electrification:Preliminary assessment of infrastructure needs and cost-benefit analysis.* International Energy Studies Group Energy Analysis and Environmental Impacts Division. https://ies.lbl.gov/publications/california-semi-truck-electrification

The new Regulation for the deployment of alternative fuels infrastructure (AFIR) sets mandatory deployment targets for electric recharging and hydrogen refuelling infrastructure for the road sector[45], and shall support widespread network on the TEN-T corridors.

New concepts, solutions and services for mobility and logistics involving zero tailpipe emission vehicles and charging/refuelling infrastructure, which could include battery swapping modules and schemes for different vehicle types, for which performance and socio-economic benefits are demonstrated, need to be developed, tested and integrated.

Potential enablers to accelerate the transition to zero tailpipe emission road transport include co-creation including users and stakeholders, collaborative and shared usage (vehicles and infrastructures), the Physical Internet[46], mixed cargo and passenger concepts, e-mobility hubs, multipurpose modular vehicles/infrastructure/swappable bodies, and shared charging schemes. Additionally, avoiding congestion, broader operating time windows (e.g. off-peak/night deliveries for freight or high frequency and flexible bus services) or more automated solutions, may also contribute to leverage benefits and accelerate the adoption of zero emission road transport systems. The integration of zero tailpipe emission vehicles in these more holistic concepts will be exploited in collaboration with the CCAM Partnership.

An iterative approach (define requirements, develop, test and develop again) is proposed. Current and future capabilities of zero tailpipe emission vehicles are considered to manage the transition in a flexible and cost-effective way, developing user-centric future proof solutions for people and goods. This iterative approach includes feedback loops, in terms of user needs and requirements collection for vehicles (Chapter 4.1) and infrastructure (Chapter 4.2), together with testing and validation of zero tailpipe emission system solutions and services in real-life operational conditions. It is key to engage and develop strong support from OEMs, public transport, mobility, freight transport and logistics companies, cities and regions, in order to bring forward a holistic approach to develop harmonised solutions that can create impact at scale. Due to this overarching and iterative approach, the Partnership is able to embrace and incorporate future disruptive mobility solutions and services.

a. Specific challenges and objectives related to the R&I area (including items not covered by the EU funding)

It is critical to understand the context and framework for the integration of zero tailpipe emission vehicles into mobility and logistics systems. The following aspects need to be addressed:

Zero emission zones have started within cities and are expanding to broader areas[47] to answer societal needs (health and environment). These require substantial adaptation from end-users, mobility and logistics operators in order to perform their activities.

By nature, ***the mobility and logistics landscapes are fragmented at large due to, amongst others, the large number of different stakeholders involved. A wide range of scenarios, regional needs***

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45 https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1867

46 Ballot, E. et al. (2014). *The Physical Internet: The Network of Logistics Networks*. Paris, France: La documentation Française.

47 https://www.euractiv.com/section/electric-cars/news/denmark-to-ban-petrol-and-diesel-car-sales-by-2030/ and a synthesis here https://theicct.org/sites/default/files/publications/Combustion-engine-phase-out-briefing-may11.2020.pdf

and use-cases needs are to be addressed for people mobility and freight logistics considering the great variety of vehicles, missions (see with Action 1) and geographical coverage.

A systemic urban approach to transport in planning infrastructure and energy for zero tailpipe emission road mobility and logistics is not in place. The urban planning for the transport and energy infrastructure should be addressed holistically, with urban development plans considering zero tailpipe emission vehicles as the backbone for the road mobility and logistics system.

Specific challenges

This R&I area will address the following specific challenges related to zero tailpipe emission road transport vehicles, their integration into mobility and logistics systems:

- Identify and capture actual user needs, related use-cases and scenarios, translating them into workable requirements for the development of vehicle concepts, usage models, service concepts and charging infrastructure.
- Adoption of zero tailpipe emission solutions in public and shared passenger mobility is growing, especially for short-distance and urban passenger mobility. It is also important to cover all operations and services, such as demand responsive, regional and long-distance mobility solutions, which can help cities and regions to reduce emissions and noise pollution to the expected levels.
- Overcome the performance and range trade-offs of zero emissions vehicles for freight applications. New concepts, solutions and usage models are to be developed, considering current and future capabilities, performance (payload, energy management for a variety of driving ranges, weight and dimension, axle load and optimal operational speed) and the range of zero tailpipe solutions. Modular mobility solutions can close several of these gaps.
- Lack of operational models also for regional application, blueprints for business models and tools to support decision makers, fleet managers and drivers to manage the capabilities and constraints of zero tailpipe emission vehicles, and lack of skills in working with such tools to come to evidence based decisions on mobility related investments and strategies.

To address these challenges, **specific operational objectives** pursued within this R&I area are to:

- Develop and support the evidence-based deployment of integrated strategies and solutions (vehicles, infrastructure, and operations) allowing quick and effective roll-out and upscaling of zero tailpipe vehicle fleets (people and goods services) in cities, regions and corridors.
- Develop and expand the portfolio of zero tailpipe emission mobility and logistics use-cases, with emphasis on feasible and higher socio-economic and financial impacts cases. Different business/operational scenarios, usage alternatives and user needs should be addressed, such that zero tailpipe emission vehicles are affordable and usable in a wider range of applications. The ambition is to leverage the integrated system's approach (e.g. vehicle, infrastructure, operations and services) to serve the transport demand effectively with zero emission vehicles.
- Demonstrate and validate zero tailpipe emission fleets and their associated infrastructure (charging/refuelling) in connected, shared and on-demand mobility and logistics networks.
- Demonstrate and validate zero emission fleets in high frequency, on-demand and high-capacity bus services and approaches to support large-scale implementation as well as high demand freight transport corridors.
- Test and learn from use-cases to identify and overcome adoption barriers: operational, user driving behaviours, user acceptance and legal/regulatory aspects and providing input to further vehicle and infrastructure developments.

- Build capacity and make R&I based policy recommendations for the effective transition towards zero tailpipe emission road transport. As a result of R&I, propose evidence-based policy recommendations and regulatory frameworks following the innovation principle[48], to accelerate the adoption of new concepts and solutions.

b. Expected outcomes by 2030

The main expected outcome of this 2Zero R&I Pillar, supporting and integrating the previous ones, is to contribute to develop a climate-neutral road mobility and logistics system by addressing usage models making zero tailpipe emission vehicle offerings and services suitable to all users' requirements, whilst supporting their uptake and deployment in cities, regions[49] and the main transport corridors.

As a result, it is expected that the demonstrated portfolio of tested and validated use-cases will bridge the existing gap between zero tailpipe emission and conventional vehicles capabilities / costs, making the transition towards zero emission vehicles affordable for citizens and society. Specifically, we expect to achieve the following **outcomes**:

- Broad stakeholder consensus on zero emission tailpipe emission vehicles adoption pathways towards 2030, 2040 and 2050. By 2025, identify and propose the most cost-effective and positive impact scenarios and pathways for the deployment of zero tailpipe vehicles in different segments and applications: e.g. transport operations and geographical areas (long-haul, regional, rural, peri-urban and urban) building on previous general roadmaps[50].
- A broad real-life test and demonstration portfolio of use-cases, applications and solutions for zero emission mobility and logistics is available for a range of segments and applications that address user needs and are suitable for all operative scenarios, from very busy bus lines in cities or freight corridors, where high frequency and high capacity is required, to rural areas.
- New zero emission road shared mobility and logistics concepts and solutions boost the usage of electric vehicles and accelerate their adoption.
- Developed zero tailpipe emission mobility and logistics solutions and services that are interoperable across Europe and beyond.
- Stakeholders have reliable tools for services provision, infrastructure planning, decision making and fleet management regarding zero tailpipe emissions vehicles.

c. Scope of actions

The **geographical and operational scope** for the research and innovation actions are:

- Urban, peri-urban, rural and intercity individual and collective mobility.
- Long distance, regional and urban freight, and logistics (waste, parcel, retail, construction, service trips, etc.)

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[48] https://ec.europa.eu/info/news/innovation-principle-makes-eu-laws-smarter-and-future-oriented-experts-say-2019-nov-25_en

[49] See: https://chargedevs.com/newswire/new-report-identifies-high-priority-regions-for-electrifying-trucks/

[50] ERTRAC, EPoSS, SMARTGRIDS (2017) *European Roadmap Electrification of Road Transport;* ALICE and LEARN EU project (2019). Roadmap towards Zero Emissions Logistics 2050. https://www.etp-logistics.eu/?p=3152 , ERTRAC (2019) *Long Distance Freight Transport: A Roadmap for System Integration of Road Transport;* ERTRAC, ERRAC, ALICE (2017) *Integrated Urban Mobility Roadmap.* ITF (OECD/ITF (2018) *Towards Road Freight Decarbonisation.*

- Mixed use-cases for people and goods.

The actions require the specific contexts and frameworks for the integration of zero tailpipe emission vehicles into the mobility and logistics system to be addressed. Closed environments, logistics hubs and smart communities quarters - including the 15 Minute City - may be considered in demonstrations, for instance in collaboration with the mobility sector within the DUT Partnership.

c.1 – receiving EU funding

Action 1 – Understanding user's needs and pathways towards zero emission mobility and logistics.

This action details the requirements and capacity building to accelerate the integration and adoption of zero tailpipe emission vehicles, including integrated strategies and (non-) technical solutions. A sustainable and future-proof zero emission transport system needs to bring clarity to the different stakeholders and build trust for future investments. This will be approached in three connected and complementary phases:

1. Identification and direction/priority setting, scenarios and pathways,
2. Development and capacity building, and
3. Integration, evaluation, assessment and recommendations.

1. Define zero emission tailpipe emission vehicles adoption and deployment scenarios, strategies, priorities and pathways towards 2030, 2040 and 2050

This phase will focus on the understanding of user's needs and, subsequently, identification and definition of the new mobility and logistics system concepts and their related use-cases that have the potential to accelerate the adoption of zero tailpipe emission vehicles. This task will serve as input for the rest of the actions and will consider previous efforts and ongoing works, incorporating the 2Zero Partnership developments of Actions 4 and 5 explained later. The identified concepts need to be assessed and prioritised according to their potential to generate socio-economic benefits, affordability and potential to constitute a business case (financial viability). It is key to involve all relevant types of stakeholders in this assessment, to build consensus and set priorities. As part of these activities, it is expected to:

- **Develop an understanding of users' needs** for future mobility solutions and services, both for passenger transport and goods logistics. This understanding, including user requirements and hesitations, is to be based on daily needs and should cover users from across Europe, with different backgrounds, education and affiliations. The focus will be on the trip (mission), instead of on technical issues, so including trip time vs vehicle range.
- **Develop medium to long term roadmaps and deployment strategies** and pathways for mobility and logistics services operated with zero tailpipe emission vehicles, including public procurement, spatial and infrastructure planning, fleets operation and maintenance, built on the understanding of actual user needs.
- **Perform large-scale simulation of market transition scenarios** for the adoption of zero-tailpipe emission vehicles, in different regions and segments, quantifying the emission reduction projected to be achieved.
- **Identify new or renewed mobility and logistics services** operating with zero tailpipe emission vehicles (use-cases and solutions), which are socio-economically and financially viable and can

serve different key transportation markets in the different domains: urban, peri-urban, regional and long-distance transport, whilst achieving climate and environmental targets.

- **Provide tools to create transparency about CO_2 emissions** of operation, including its related harmonised reporting, as well as assessment of actual emission savings.

2. Development and capacity building tools for the seamless adoption of zero tailpipe emission vehicles

The second phase will support the development of the necessary instruments and tools to support the adoption and integration of the innovative concepts, solutions and services developed, as well as replication, at urban, regional and national dimensions[51].

- To provide **local and regional administration** with effective decision-making tools, models and methods that will allow:
  - the establishment of sustainable multi-modal inner and inter-urban transport, regional mobility and spatial planning, accounting for the dimensions of transport, spatial planning and energy in a multi-actor setting.
  - the roll-out of innovative charging infrastructure concepts (including charging prices transparency, interoperability and the booking of charging points) for the different types of vehicles, fleets and their respective operations.
  - the assessment of the financial, social, environmental and health aspects.
  - data management and the exchange of information, also with other means of transport where necessary, smart access to Zero Emission Zones.
- **Skills, capacity-building and exchange at cities and mobility players**, building their knowledge by integrating the decision-making, modelling, assessment and monitoring tools developed under this R&I area, considering different time horizons (2030, 2040 and 2050), which represent different scenarios of technology, fleet, transport system and infrastructure evolutions, supporting synergies and complementary initiatives such as the Mission on Climate Neutral and Smart Cities, the DUT Partnership and the EIT-Urban Mobility KIC.
- **Capacity building at commercial fleet owners and skills development for professional drivers:** develop decision-making tools matching the needs and the most suitable vehicle and managerial tools to define and set-up the correct operational cycle (trips and stops) with zero tailpipe emission vehicles whilst exploiting load/unload and resting times with effective use for charging at the same time. Capacity building and skills development for drivers so that they can extend the range and optimise the usage of energy.
- The analysis and engagement of users to develop strategies and understanding that support **conscious decisions of the users towards zero emission mobility and logistics services**. The strategies should include several decision factors, such as travel time, travel cost, environmental considerations and health benefits. Policies, developed by the joint work of the involved stakeholders, should provide recommendations to several types of stakeholders, such as travellers, companies, municipalities and transport operators. These recommendations would also be a useful return for industries, to continuously improve offers, and institutions to develop the means to support and implement winning policies. These should feed broader initiatives

[51] As background for this activity, the leverage of project(s) funded under call MG-4.8.2020: *Advanced research methods and tools in support of transport/mobility researchers, planners and policy makers* (link) needs to be considered.

such as the Mission on Climate Neutral and Smart Cities, the DUT Partnership and the EIT-Urban Mobility KIC.

3. Evaluation, assessment and recommendations for the accelerated adoption of zero tailpipe emission vehicles

This third phase focuses on assessing the benefits of the tested and demonstrated concepts solutions and services, carried out under the Actions 4 and 5, and on providing recommendations to accelerate the adoption of zero emission road systems. This will be mainly achieved by:

- The results of the large-scale testing and demonstration (detailed in Actions 4 and 5) of innovative concepts will be analysed as elements of the whole mobility scenario, in order to identify and evaluate their contribution to the European priorities and Partnership objectives.
- Development of business models to ensure outlooks on viable business cases for uptake and implementation of, e.g., fleets (people and goods), as well as of new concepts including battery swapping for different vehicle types, using the phase 1 result of users' needs understanding. This should take into account new factors such as Value Trip Time.
- Evaluation, assessment and refinement of the innovative solutions and concepts once they are integrated in the real-life environment. Evidence based policy recommendations, standards and roadmaps for optimal transition, in support of zero emission road mobility and logistics adoption, in particular for the seamless and duly integration of zero emission road mobility and logistics in the Sustainable Urban Mobility Plans (SUMPs)/Sustainable Urban Logistics Plans (SULPs) (recommendations on the integration of the newly developed concepts into them) and/or SECAPs[52], urban planning and urban climate-neutral energy roadmaps. This approach will aim at accelerating the adaptation processes required in the regulatory framework to smoothly deploy the new concepts and services.

Action 2 – Connected, Cooperative, Automated shared e-services for people and goods mobility (in collaboration with the CCAM Partnership

CCAM (Connected Cooperative Automated Mobility) concepts could have a leverage factor on the adoption of zero tailpipe emission technologies. CCAM could bring the opportunity of the vehicles to be used extensively and zero tailpipe emission concepts bring operational and maintenance cost opportunities. For example, autonomous last mile e-deliveries[53, 54] that could be used and combined with people mobility. Mixed people mobility and freight use could be an important leverage factor for zero emission solutions which could be further explored and researched (e.g. people during the day and goods by night in optimised performance and by utilisation of a single vehicle). Combining CCAM and 2Zero advancements may also create new ways to perform mobility and logistics taking the system perspective into consideration. For example, autonomous freight-pods in 24/7 operation for hub-to-hub logistics or autonomous shuttles in feeder traffic at terminals and ports.

Within this action, which is closely linked to **Action 1**, it is expected to:

[52] Bertoldi, P. (2018). *Guidebook 'How to develop a Sustainable Energy and Climate Action Plan (SECAP)'*. European Commission. JRC Science for Policy Report.

[53] https://www.valeo.com/en/ces-2020-in-a-world-first-valeo-is-unveiling-its-autonomous-electric-delivery-droid-developed-in-partnership-with-meituan-dianping-chinas-leading-e-commerce-platform-for-services/

[54] https://www.emove360.com/meet-renault-ez-pro-a-robo-vehicle-and-a-concierge-for-last-mile-delivery-video/

- **Assess and test connected, cooperative and automated modular and scalable zero tailpipe emission vehicle concepts** with the potential to accommodate both passengers and freight (urban and non-urban), in coordination with public transport, addressing combined people and freight logistics use-cases for different geographical areas. Test and demonstrate use-cases of high potential impact in real-world applications and develop and assess novel service concepts in the urban domain.
- **Evaluate different models for shared public and private charging infrastructures** for the different kind of applications (people, freight and mixed for city, regional and long haul services etc.), including the modelling of the charging infrastructure roll-out strategies and their life-cycle, assessment for different types of vehicles/applications (from L1 to intercity coaches), Maas and TaaS applications (Mobility-as-a-Services and Transport-as-a-Service) and traffic environments (urban, peri-urban, rural and interurban), including for logistics applications.
- **Develop accompanying supportive infrastructure strategies** for the PDI (Physical and Digital Infrastructure). For example, automatic loading and unloading, recharging, energy management), reliable systems and safety provisions (sensors, actuators, identification and autonomous control as well as traffic management) to hand over goods at unattended hubs or to the end-user. Here, actions can be deployed in alignment with the CCAM Partnership.

Action 3 - Define right-sized vehicles and infrastructure requirements according to users' needs and usage models for people mobility and freight logistics

- **People mobility.** The development of right-sized transport will aim at meeting the mobility requirements, optimising public and private vehicle ownership in all sectors and levels of the society. For people mobility, it will be vital to offer passengers flexibility, in terms of vehicle size, use mode and related price. In particular:
  - Different types of platforms (e.g. knowledge databases) will bring together stakeholders and collect individual needs and requirements for people mobility.
  - Broad integration of users and their needs into the development and testing of new concepts for people mobility, to evaluate social acceptance and quantify user needs and usage patterns. Further investigation on how the modularity concepts and multi-usage (e.g. use of one vehicle for different purposes) can be integrated and boosted, based on users' needs and requirements.
  - Demonstration of the new concepts and mobility systems, taking into consideration different geographical and environmental conditions.
  - Evaluation and showcasing the important role of right-sized and user-oriented infrastructure in future mobility systems (e.g. in collaboration with cities), based on systemic simulations of mobility systems (patterns) and customer behaviours, user needs and usage[55], also considering developments in the R&I Pillar 1.
- **Freight logistics.** Trucks offer the potential to reduce emissions if well utilised, meaning they may be more efficient in terms of traffic and congestion generation. On the other hand, there are other factors such as spatial distribution of the demand, reducing size of shipments volumes that are promoting the use of smaller vehicles within cities.

[55] Results from projects under MG-4-3-2018 are relevant as a baseline: DIAMOND, TINNGO, MoTiV and STARS.

The actual needs and requirements from the different use-cases will be assessed in collaboration between end-users (freight transport and logistics companies, shippers and retailers), OEMs, energy providers as well as charging infrastructure, to ensure a clearer overview of the different segment's needs, vehicle and charge point development, usage models and operational priority constraints (e.g. payload versus range) to feed requirements to vehicles (Chapter 4.1) and infrastructure (Chapter 4.2). In particular, the following aspects will be considered:

- Purpose and applications-oriented approaches, in terms of dimensions and other performance characteristics of vehicles and charging points according to the actual usage of these vehicles in urban, regional and long-haul applications (e.g. according to driving and resting time regulations).
- Segmentation for different type of goods and industries is required, so "low hanging fruit" sectoral needs can be addressed in the shorter term (e.g. Fast-Moving Consumer Goods, automotive, textile and retail).
- Demonstration of the new concepts and freight logistics systems, taking into consideration different geographical and environmental conditions.
- Evaluation and showcasing the important role of right-sized and user-oriented infrastructure in future freight logistics (e.g. in collaboration with cities), based on systemic simulations of mobility systems (patterns) and customer behaviours, user needs and usage, also considering developments in the R&I Pillar 1.

Action 4 – Innovative zero emission people mobility solutions in urban, peri-urban and rural areas, to support large-scale implementation

The adoption of zero emission solution to all types of operation requires the development of tailored solutions at infrastructure, charging, vehicles and operations levels, and their integration with other and new mobility services, as well as integration of active travel modes. Rural areas (commuter feeders) needs should also be addressed.

This action will:

- **Support the identification, development and ultimately the large-scale integration of the innovative concepts** including mixed cargo and passenger concepts. Making mobility for people sustainable and efficient, leading to the reduction of air and noise pollution, tackling high cost, infrastructure and performance limitations, complementing Actions 2 and 3.
- **Investigate and describe the users' and stakeholders' behaviour, needs and requirements**, ensuring a user-centric, inclusive, affordable and accessible approach in solutions for the mobility of people, and considering the differences in needs in urban, peri-urban and rural areas.
- **Advance the new concepts and related use-cases to testing in real operation, accelerating full zero emission mobility.** The objective is to ensure the adoption of zero emission solutions to all types of passenger needs, by integrating the tailored solutions at the levels of infrastructure, charging, required facilities (Chapter 4.2), vehicles (Chapter 4.1), in operation and intelligent management, maintenance and repair processes, as well as procurement, business models and governance. This covers those mobility areas where, today, zero emission solutions are not available or not tested in full operation:

- Develop and demonstrate new service concepts to improve the integration and acceptance of zero emission mobility and zero emission vehicles based on innovative technologies (e.g. service robotics or digitalisation).
- Develop new business models to ensure the economical attractiveness of ZEVs for people mobility (public and private), and mixed passenger and goods transport solutions. Use the business models to develop guidance and tools to facilitate large-scale implementation.
- Demonstrations in real operations, proving the multimodality concepts and integrating zero tailpipe emission vehicles into existing mobility systems (e.g. mass transit or shared mobility), including active travel modes as well as interfacing long-haul with urban / rural transport zero tailpipe vehicles, together with mobility services with shared and on-demand solutions.
- Large-scale demonstration of entry-level mobility concepts for car-free cities, in urban and peri-urban areas, and integration in existing systems.
- Large-scale demonstration of on-purpose design mobility systems and vehicle concepts for taxi, shared and on-demand service in urban, peri-urban, rural as well as for long-haul transport, to showcase the leveraging effects in vehicle design (Chapter 4.1), allowing scale-up and offering zero tailpipe emission solutions also to MaaS platforms.
- Demonstration, in full operation, of the innovative zero tailpipe emission Bus Rapid Transit System (BRT), providing reduced costs and better services for people mobility. By adopting a holistic approach at the system level, this use-case aims to evolve current European BRTs into high capacity and high frequency services, as well as operating with zero emission technologies such as full electric or fuel cell hydrogen powered buses.

- **Integration of zero tailpipe vehicles into solutions for urban and peri-urban people mobility.** In a full and multimodal mobility scenario, 2Zero will contribute to the development of policy-responsive and user-centric integration of innovative mobility solutions (including MaaS) that could lead to higher integration of zero tailpipe emission vehicles as shared vehicles, favouring their return on investment (RoI).
  - Integrate and evaluate different concepts of innovative and user-centric mobility solutions (including MaaS) that will boost the uptake of the zero tailpipe emission transport of people. It should increase vehicle occupancy and avoid negative shifts away from active modes and public transport in urban areas and relevant corridors. Solutions should allow the different mobility service providers to obtain the relevant information to optimise their services and management of fleets, also taking account of, e.g., charging requirements.
  - Develop demand management strategies for zero emission solutions[56]. These solutions could consider the mobility demand in relation to mobility generators, such as work, schools, hospitals and places related to care, retail or leisure, and consider ways to reduce the need to travel and the distance travelled to access services. The interaction between goods delivery and people mobility should be considered, as well as nudging techniques, marketing and social innovations.

[56] Transport demand, in terms of distance travelled, is by far the most determinant factor in the CO_2 increase, as seen in France between 1960 and 2017. Ref. Scientific article «Stratégie nationale bas-carbone : peut-on faire l'économie d'un ralentissement des mobilités?» consulted on 23rd June 2020. https://fr.forumviesmobiles.org/mobilithese/2020/06/18/strategie-nationale-bas-carbone-peut-faire-leconomie-dun-ralentissement-des-mobilites-13345?utm_source=nl_fr&utm_medium=email&utm_campaign=2306_SNBC

- Develop combined approaches for an integrated traffic and charging management system for the adoption of zero-tailpipe emission vehicles.
- Develop efficient dynamic fleet management tools and processes for zero emission vehicles fleets.
  - For fleets providing public, on-demand or shared transport services, the vehicle SOC depends on several factors beyond operation: traffic, load, use of the heating, ventilation and air-conditioning (HVAC) systems. Therefore, the access to the charging points needs to be regulated dynamically by the fleet operator (like in the aircraft landing queuing process).
  - Mobility service platforms (including MaaS) should develop AI based tools to manage, in optimal way, the use of zero emission resources provided by different fleets, for example managing the right distribution of vehicles and the process of charging (independent of the provider), in order to support demand.

- **Create a collaborative framework and knowledge base sharing for testing and demonstration of innovative concepts, services, use-cases and business models** with the wide participation of stakeholders, to accelerate the transition towards zero tailpipe emission mobility for people.
  - Develop a reference knowledge base for living labs, projects and initiatives for zero tailpipe emission vehicle adoption in people mobility in different areas or applications (urban, regional and long haul) and for different mobility services.
  - Develop advanced data structures and technical frameworks and integrate the ones from previous projects and initiatives for cities and operators, to provide suitable, optimised and more environmentally friendly transport services. This concerns specific data requirements that have to be shared by the different stakeholders in a zero emission environment. Standards should emerge and a data-sharing framework should be established, for the overall optimisation of demand and supply.
  - Monitor international relevant initiatives that should be considered as well as identify opportunities for exploiting mobility models worldwide, using also new and advanced business models.

Action 5 – Logistics concepts and solutions for zero tailpipe emission vehicle deployment acceleration

Whilst electric van fleets are well demonstrated for parcel delivery solutions, major operational challenges are still to be faced in waste collection, construction, general cargo and retail urban and regional freight transport, and for long-haul transport. The characteristics and capabilities of vehicles suggest that battery electric trucks require a trade-off between range and payload, whilst FCEV could be a suitable solution for long-haul freight transport and high payloads. Strategies for zero tailpipe emissions solutions should be explored for hard-to-abate logistics use-cases, such as demanding heavy-duty long-haul in regions where there is a lack of charging and/or hydrogen infrastructure. Moreover, dynamic charging solutions could be viable for very intensive usage in road freight corridors.

The interim limitations of these vehicles and TCO structures could be compensated, managed and addressed by new logistics concepts and solutions (including fleet management and routing aspects) addressing the user needs for specific use-cases for which these new vehicles - including mixed cargo and passenger concepts - could match and outperform conventional ones. Innovative freight and logistics concepts, capitalising on zero emission operational and maintenance costs, need to be envisioned in different segments (urban, regional and long-haul) and for different types of flows: waste, construction, services, parcel, general cargo and retail stores. Specific approaches need to be implemented for the different segments, to benefit from the broad variety of vehicles to match operational demands in an efficient way.

This action will:

- **Analyse future users' needs and map the potential capabilities and performance characteristics of zero tailpipe emission vehicles and infrastructure.**
    - Based on requirements and users' needs for urban, regional and long-haul freight transport with different freight origin-destinations, volumes, types of flows, terminals, service levels define the most suitable zero tailpipe approach building on the complete vehicle range (from cargo-bikes to HDV) as well as the appropriate charging strategy and required infrastructure.
    - Identify typical use-cases that would benefit from the current and next generation capabilities of zero tailpipe emission vehicles, including the combination of different types of powertrains for optimal performance in a broader portfolio of use-cases. TEN-T networks and main logistics hubs (for charging infrastructure) will be the primary area of application for long-haul applications.
    - Modelling and simulation of freight services using zero tailpipe emission vehicles from cargo-bikes to HDV (including modular systems beyond 44tonnes): utilisation, energy consumption, charging times, traffic situations, etc.
- **Identify and prioritise zero tailpipe emission vehicles-based use-cases and develop solutions, testing and demonstrating them in real freight and logistics operations** addressing different freight and logistics flows (hub to hub, waste, construction, services, parcel, retail stores, etc.) and domains (urban, regional and long-haul). This aims to overcome limitations, such as current/future vehicle cost, infrastructure and performance limitations and constraints with a systemic approach considering vehicles, infrastructures and operations.
    - Identification and prioritisation of suitable use-cases representing typical and diverse logistics flows in Europe.
    - Develop large-scale testing schemes together with commercial users for urban, regional and long-haul applications, namely:
        - Demonstration and fleet roll-out of zero tailpipe emission (battery electric with zero tailpipe emission range extender) trucks at the regional level for different payloads up to 44tonnes supported by charge points with enough capacity or strategies not to introduce any time losses in the logistics operations. Typical applications in the retail, municipal waste collection and construction activities need to be addressed.
        - BEV and Fuel Cell Hydrogen trucks test and demonstration for regional and long-haul with payloads up to 44tonnes and applications in real conditions.
        - Off-peak and night deliveries, addressing the challenge of no/low-noise load/unload process operations as well as the possibility to deliver (hub, retail outlets, restaurants, individuals, etc.) even without these places being open and attended. The TCOs can benefit from extended hours of delivery in city centres.

- Develop tools such as HGV ZEV routing and planning.
- Testing and demonstrating zero tailpipe emission trucks fleets operating in ports and hubs, and in other application domains such as regional distribution and high demand corridors (e.g. manufacturing plants to distribution centres).
- Testing interoperable configurations, including trucks with load container and battery modules that can be supported by different charging strategies (e.g. charge station localisations, charging at depots, charging hubs), meeting the requirements of different logistics operations, hence broadening the portfolio of applications of the vehicles.
- Develop scalable models and seamless integration strategies of cargo bikes and L-category e-vehicles for last mile logistics concepts. Light Electric Freight Vehicles (LEFVs) could replace 10-15% of delivery vehicle movements[57], so it is key to demonstrate the new generation of electric L-category vehicle uses for an extended portfolio of freight transport and logistics applications.

- **Develop zero emission shared freight transport and logistics solutions**, by:
  - Developing new concepts and solutions, smartly combining zero-tailpipe-emission vehicles requirements and capabilities (charging, range, etc.) with other logistics operational aspects, such as loading docks (charging), routing, etc.
  - Making optimal use of the required vehicle "stops" during their working period and developing appropriate management systems for scheduling a daily list of jobs (=trips) considering all vehicles/charging/refuelling conditions and other requirements.
  - Demonstrate the potential benefits of zero tailpipe emission vehicles applied in shared and open freight logistics networks, combining flows, ensuring heavy use of the vehicles and providing access to automated (in collaboration with CCAM) vehicles fleets.
  - Creating business concepts around open access to a shared zero tailpipe emission fleet, or other alternatives to buying/operating zero emission trucks.
  - Support developments in Chapter 4.2 to define the infrastructure requirements in future logistics networks and evaluate the potential of new technologies (e.g. automation or digitalisation) to optimise holistic logistic networks and reduce vehicle distances travelled.
  - Design the minimum viable recharge stations European network - to be aligned to main freight corridors and logistics parks. Investigate the role of logistics sites as "power stations", exploiting load/unload times (i.e. combined of trucks and trailers, ensuring 45 minutes is enough for an 80% recharge allowing 400km of range).
  - Develop collaborative approaches between infrastructure managers, transport management systems and freight carriers to maximise charging infrastructure utilisation without incurring in waiting times and logistics losses (stops for charging should last no more than 45 minutes, aligned with necessary driver breaks).

- **Develop the collaborative framework and knowledge base sharing** for testing and demonstration of innovative concepts, services, solutions, use-cases and business models in controlled, real-life implementation environments, with broad stakeholder participation to accelerate the transition towards zero tailpipe emission logistics.
  - Develop a reference knowledge base for living labs, projects and initiatives of zero tailpipe emission vehicles adoption in freight transport and logistics in different applications

[57] W.P. van Amstel et all (2018) *CITY LOGISTICS: LIGHT AND ELECTRIC*

(urban, regional and long-haul) and for different application flows (payloads, ranges, type of goods: waste, construction, retail, parcels, FMCG, including sectorial needs, etc.).

- Development of managerial tools for fleets operators that can handle, seamlessly, different type of vehicles, capabilities and requirements.
- Develop driving guidelines for zero tailpipe emission commercial vehicles.
- Monitor international relevant initiatives that should be considered, as well as identify opportunities, for exploiting freight and logistics models overseas.

c.2 – not covered by the EU funding

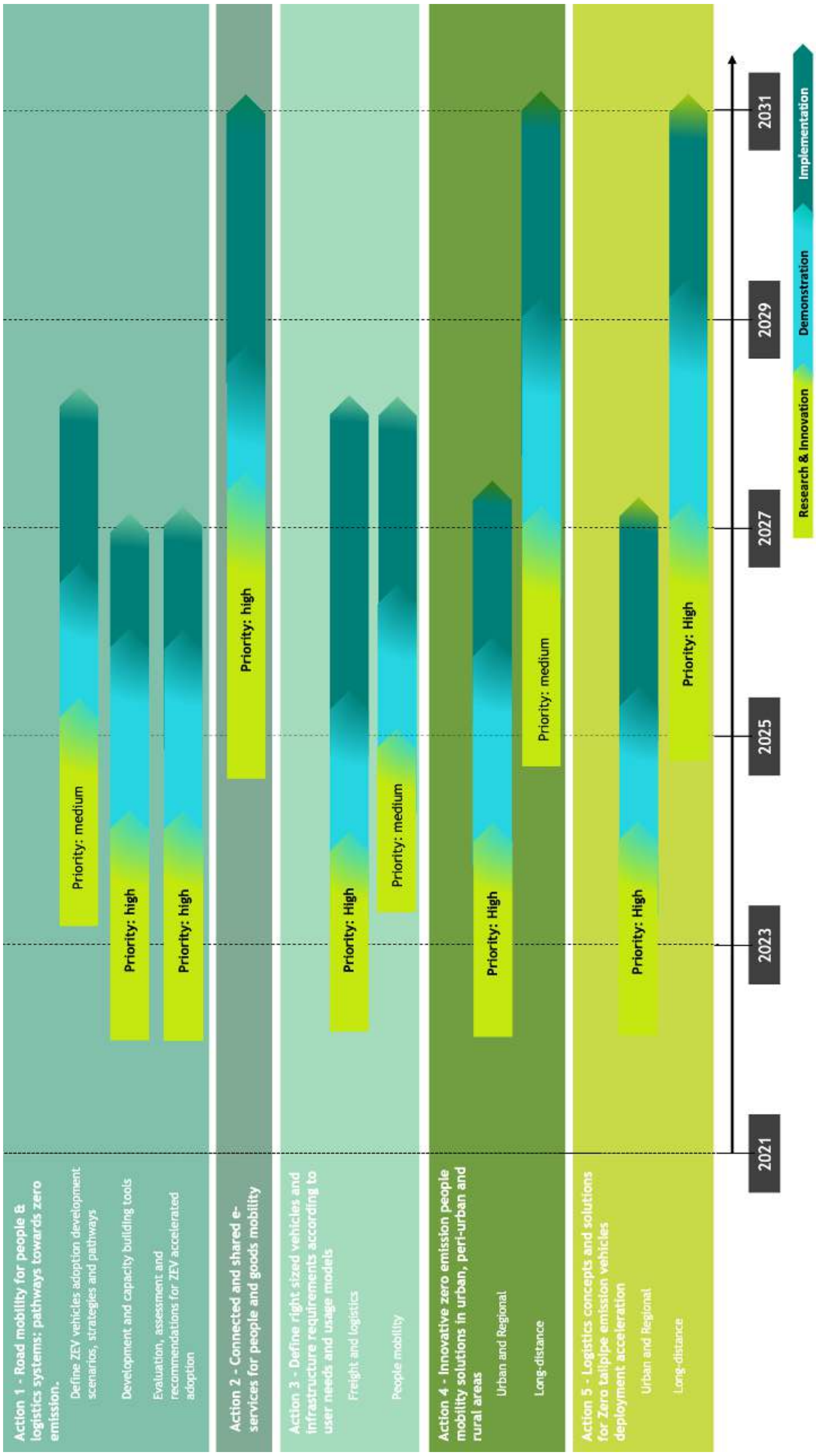
The 2Zero Partnership funded areas are focussed on zero tailpipe emission vehicles. Additional R&I actions at mobility and logistics levels, scoped for other type of vehicles and solutions, focussed on system efficiency, could also have a leverage towards the adoption of zero tailpipe emission vehicles. In particular, the higher efficiency of the mobility and logistics is linked with an intense use of the vehicles and the infrastructure, hence the more beneficial the business case is towards electrification. It is expected that other instruments within Horizon Europe Programme as well as country and industry initiatives can support the development of these models and the implementation of the following roadmaps:

- The Integrated Urban Mobility Roadmaps[58]. Roadmaps paving the way towards an integrated Urban Mobility Resilience and New Mobility Services
- The ALICE Roadmap towards Zero Emission Logistics 2050[59] includes a variety of solutions to decarbonise freight transport and logistics and related challenges that need to be overcome through research and innovation.
- The ERTRAC Long Distance Freight Transport Roadmap: A roadmap for System integration of Road Transport[60].
- The report on the Truly Integrated Transport System for Sustainable and Efficient Logistics[61] was developed in the frame of the EU-funded project SETRIS[62] and supported by all transport European Technology Platforms.
- The ERTRAC Connected, Cooperative and Automated Mobility Roadmap[63].
- The ERTRAC mapping of technology options for Sustainable Energies and Powertrains for Road Transport Towards Electrification and other Renewable Energy Carriers[64].
- The ALICE Roadmap to the Physical Internet[65] developed in the frame of EU-funded project SENSE.
- The ALICE & POLIS Guide for advancing towards zero emission urban logistics by 2030[66].

[58] ERTRAC, ALICE, ERRAC (2017) Integrated Urban Mobility Roadmap.
[59] ALICE and LEARN EU project (2019). Roadmap towards Zero Emissions Logistics 2050. https://www.etp-logistics.eu/?p=3152
[60] ERTRAC (2019) Long Distance Freight Transport: A roadmap for System integration of Road Transport;
[61] ACARE, ALICE, ERTRAC, ERRAC and WATERBORNE. (2017) *A truly Integrated Transport System for sustainable and Efficient Logistics.* http://www.etp-logistics.eu/?p=1298
[62] Strengthening European Transport Research and Innovation Strategies, SETRIS. *H2020 project. Grant agreement ID: 653739.*
[63] https://www.ertrac.org/wp-content/uploads/2022/07/ERTRAC-CCAM-Roadmap-V10.pdf
[64] https://www.ertrac.org/wp-content/uploads/2022/12/ERTRAC-Fuels-Powertrains-Research-Needs-Mapping-Final-Version-December2022.pdf
[65] http://www.etp-logistics.eu/?page_id=292
[66] https://www.etp-logistics.eu/polis-and-alice-launch-their-joint-guide-for-advancing-together-towards-zero-emission-urban-logistics-by-2030/

Furthermore, relevant work will target the development of robust GHG emissions measurement and reporting tools at company, city, regional, national levels, to measure progress in a holistic way.

d. Roadmap



Action 1 - Road mobility for people & logistics systems: pathways towards zero emission.
Define ZEV vehicles adoption development scenarios, strategies and pathways
Development and capacity building tools
Evaluation, assessment and recommendations for ZEV accelerated adoption
Action 2 - Connected and shared e-services for people and goods mobility
Action 3 - Define right sized vehicles and infrastructure requirements according to user needs and usage models
Freight and logistics
People mobility
Action 4 - Innovative zero emission people mobility solutions in urban, peri-urban and rural areas
Urban and Regional
Long-distance
Action 5 - Logistics concepts and solutions for Zero tailpipe emission vehicles deployment acceleration
Urban and Regional
Long-distance
Priority: medium
Priority: high
Priority: high
Priority: high
Priority: High
Priority: medium
Priority: High
Priority: medium
Priority: High
Priority: High
2021
2023
2025
2027
2029
2031
Research & Innovation
Demonstration
Implementation

4.4 LCA approaches and circular economy aspects for sustainable and innovative road mobility solutions

Our mobility system is evolving quickly; major trends are disrupting the road transport system (new propulsion systems will take a bigger market share, there is a need for strong investment in infrastructure, there will be new ownership models and new user/consumer behaviour, etc.). In order to make the best, most informed choices in terms of sustainability and considering the many challenges still ahead, it is of upmost importance to have the right tools to assess technologies, non-technical measures (e.g. measures leading to changes in mode and mobility in general, or measures influencing the attractiveness of different options) and product life-cycle processes in a holistic way and as a continuously monitored development target.

To select the right technologies for a clean and sustainable mobility, at the vehicle and at the system level, the ecological footprint and the impact of technology on society have to be assessed at an early stage of development and planning. Thus, research and innovation based on a LCSA[67] approach is needed, to expand the existing complexity of an environmental LCSA to assess also the economic and societal impact of solutions in a holistic way (from component to system integration, from cradle to cradle reflecting the needs of a circular economy).

A coherent assessment of the ecological footprint must be accompanied by circular economy (CE) strategies as one of the cornerstones necessary for achieving climate-neutral transport, enabling advanced resource-efficient and sustainable solutions (e. g. minimising material uptake and energy consumption). Furthermore, a widespread uptake of CE strategies following the 9R principles[68] contributes to the resource sovereignty of our road transport industry. Within this context, research and innovation is needed along three axes: assessment, minimisation of the ecological footprint over the entire life-cycle including extension of lifetimes (e.g. through advanced repairability or adapted usage profiles) and ensuring circular resources in desired quality and quantity as needed for widespread implementation in vehicle designs.

Due to its cross-cutting nature and relevance for the entire value chain and life-cycle, R&I on LCSA and circular economy approaches will have to complement actions foreseen under other 2Zero pillars and be harmonised with other Partnerships under Horizon Europe (see Chapter 5.2) as well as the European Commission recommendation for environmental footprint methods[69] or the ELV directive[70] currently under revision. This chapter is highly linked with the others on vehicle technologies, integration of BEV into the system, and mobility concepts and services for people and goods. On the one hand, Chapter 4.4 provides a framework for the sustainability assessment of technologies and solutions considered in the other pillars. In order to match the demands of those pillars, the development of the LCSA approaches and CE aspects will have to be done iteratively, applying the outcomes from the other 2Zero activities as validation cases. On the other hand, requirements and constraints, the LCI data of developed solutions, as well as mobility scenarios will come from Pillars 1 to 3, upon which projects within the identified R&I action will build.

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[67] LCSA = Life-Cycle Sustainability Assessment; which encompasses environmental, social and cost aspects, see https://www.lifecycleinitiative.org/starting-life-cycle-thinking/life-cycle-approaches/life-cycle-sustainability-assessment/

[68] European Commission, Categorisation System for the Circular Economy, Brussels March 2020, doi:10.2777/172128.

[69] European Commission, Commission recommendation on the use of the Environmental Footprint methods to measure and communicate the life-cycle environmental performance of products and organisations, C(2021) 9332 final, Brussels, 16.12.2021.

[70] https://environment.ec.europa.eu/topics/waste-and-recycling/end-life-vehicles_en

a. Specific challenges and objectives related to the R&I area

Towards a zero tailpipe emission road transport, the availability and accessibility of reliable, comparable and usable real-life data functional to LCSA represents *condition sine qua non* to validate holistically the actual sustainability of different solutions and technologies.

In particular, zero tailpipe emission solutions (such as BEVs) shift emissions from vehicle and fuel use (including extraction, transport and refining, more relevant for ICE vehicles) to its manufacturing (e. g. battery production), electricity generation and, partially, to the end-of-life, extending the application field from the vehicle level up to the system level (including infrastructure). Although the availability of databases functional to LCSA is quite large, many gaps still exist[71]. The existing databases require a great amount of data from companies related to foreground and background processes[72] (i.e. not specifically related to the product system) to be kept updated. Both these processes involve input flows (such as materials and resources) and output flows (such as wastes and emissions) that introduce different variables (in terms of productivity, logistics, quantities of materials and energy used, etc.) to be considered during the data compilation. Within this context, widely acknowledged criteria to assess LCA process data quality are still missing, as well as the interoperability and comparability of different databases, so that makes their accessibility and extendability to all practitioners difficult. The data come from different sources and are provided in different formats with consequent difficulties in their import into various LCSA software environments. The adoption of a representative and reliable dataset, when the data sources are different, is needed to guarantee a serious LCA-based decision-making process. The way to face the representativeness (or uncertainty in terms of reproducibility and repeatability) of data presents an issue not yet completely resolved for many years. In this regard, the uncertainty scenarios can vary significantly, depending on different parameters involved in a LCSA study, such as the definition of the functional unit and system boundaries, the choice of the allocation procedures or time horizons, respectively in inventory and impact assessment phases. Even the ISO 14044 standard does not propose suggestions on how to deal with an uncertain estimation and data quality characterisation in data inventory. Reliable datasets based on real product data are needed for CE strategies as well. In order to select the optimal End-of-Life (EoL) strategies real-life data on material, the product itself and its use are needed from all life-cycle stages complementing the data required for LCSA.

Another challenge to be overcome within the 2Zero Partnership is to advance and adapt existing methods and tools, to integrate them into product development and mobility planning tools. The methods and tools must become an integral part of eco-design strategies including repairability and maintainability aspects and must allow usage without prior expert knowledge. In addition, the aspect of circular economy must be introduced into the design and development of technological solutions at a vehicle and a system level, as one measure to lower the ecological footprint and improve overall resource efficiency. Methods, tools and processes are needed to support the design for a circular economy based on the 9R principles and climate-neutral production, complementing the LCSA approaches. It will be important to incorporate the circular material flow and supply chain management into the tool chains, as well as into the LCSA, considering regional, interregional and

[71] E. g. for some advanced key materials/processes such as carbon fibre secondary/recycled materials little or no good data are available. Here, it is also referred to the recent study Vehicle LCA study issued by European Commission, DG Climate Action (ISBN 978-92-76-20301-8, doi: 10.2834/91418).

[72] The foreground system consists of processes which are under the control of the decision-maker for which an LCA is carried out. The background system consists of processes on which no or, at best, indirect influence may be exercised by the decision-maker for which an LCA is carried out. Source: www.lifecycleinitiative.org

worldwide material flows, and to maximise the benefit for the EU by helping retain key materials. Overall, material recovery not only in view of critical raw material and re-use and re-manufacturing must be maximised increasing the amount of high-value material and products recovered from ELVs. Thus, LCSA and CE approaches considering the full transport system and associated value chain will favour production and recycling within the EU, thus increasing European competitiveness and enhancing resource sovereignty.

Besides developing datasets, methods and tools for circular economy and LCSA, the assessment of the current as well as the future road mobility systems, as a guiding element for the transformation of our mobility system, remains a challenge. Areas where new technologies will have a significant leverage on emission reductions must be identified early and implemented in an accelerated way. Starting from a system point of view, considering the potential of new mobility solutions for reducing the ecological footprint and improving resource efficiency, the life-cycle assessment needs to be broken down from a vehicle level to its individual components. That will require the identification of suitable, harmonised methods and the definition of use-cases adapted to each mobility segment, and the access to performance and emission data in real-use for the considered technologies and their evolutions. Although the impact assessment is primarily focussing on emissions (GWP in terms of $CO_{2eq.}$, local pollutants nanoparticles and noise) and resource efficiency (e. g. cumulative energy demand, depletion of mineral and metal resources, etc.), social aspects such as the impact on workforce and working conditions, affordability and costs, including externalisation of costs, as well as legislation must be included in view of the acceptance of developed solutions.

Whilst LCSA has been practised for a long time and international standards exist, there is a lot of variability in the quality and availability of both foreground and background datasets; the practitioners, particularly in public funded projects, have a great degree of freedom for making their own choices, which poses problems in both the comparability and the accuracy of LCSA[73] (see also Chapter 2.2 on past achievements and gaps).

The identified specific challenges can be summarised as follows:

- **Standardised and comparable (real) data are missing:**
  - Lack of harmonised, sharable data and ontology for a consistent life-cycle inventory along the value chain and full life-cycle for LCSA and CE purposes;
  - Assumptions, baselines and boundaries can differ significantly not allowing comparison of data and LCSA;
  - Many data are provided at a laboratory or prototype level, not for mass production, circularity or everyday use;
  - No harmonised use-cases for the assessment and data generation;
  - Limited access to performance and emission data in real use from considered use-cases;
  - The reliability and correctness of data is not guaranteed;
  - The prediction or extrapolation of data, for assessing new mobility concepts or business models, is not harmonised;
  - The acceptance of sharing data is low, due to missing business models or concepts ensuring confidentiality and compliance aspects;
  - Reflecting regional or behavioural particularities in a globalised world and within the EU is not taken into account.

[73] Which has been confirmed by the recent Vehicle LCA study issued by the European Commission, DG Climate Action (ISBN 978-92-76-20301-8, doi: 10.2834/91418).

- **Harmonised methods and tools for affordable (in terms of cost and time) and easy-to-handle assessment of the ecological footprint:**
  - Integration into the product design and development along the supply and value chain (not only from LCSA/CE point of view) is missing;
  - Management and control of LCSA data and CE over the life-cycle (e. g. ownership of process), particularly over the use phase and EoL, is not possible;
  - Enabling a system point of view accounting for new mobility concepts and operations;
  - A lack of accounting for costs and social aspects;
  - A lack of ability to account for all factors impacting the ecological footprint;
  - For a consequential LCA, a harmonised approach across value chains is missing.
- **Strategies, definitions and technologies** for consistent circular economy approaches (e.g. categories such as the share of recovered materials, energy efficiency of EoL process, automation of EoL processes, 2^{nd} life, etc.),
  - A lack of secondary materials (volume) meeting automotive standards;
  - High costs due to low degree of automation hindering widespread implementation of secondary materials in vehicle design;
  - Lack of data for selecting optimal EoL processes to ensure high degree of circularity.
- **Knowledge and skills** for LSCA and CE are lacking,
- LCA- and circular economy-based solutions are not implemented at a wide scale;
- Communication and acceptance of LSCA- and circular economy-based solutions.

Based on these challenges, the **specific objectives** to be addressed within the 2Zero Partnership can be defined as:

Coherent and systematically harmonised assessment of the ecological footprint of technologies, non-technical measures and product life-cycle processes

- Enabler for the selection of the right technology, measures or processes (development, production and mobility solutions);
- Frontloading of the assessment as well as continuous monitoring over the life-cycle;
- Considering vehicle, infrastructure, mobility concepts and operations for both people and goods (system level point of view down to relevant items within a system);
- Harmonised approach of collecting, providing and sharing needed data, including a description of use-cases to be considered;
- Taking into account costs (LCC/TCO) and social aspects (Social LCA) over the entire life-cycle;
- Defining boundaries, impact factors, criteria to be considered with priority focus on global GHG emissions but not excluding other aspects, such as resources, air pollution, primary energy, noise or social aspects; however, appropriate boundaries and impact factors for the LCSA will have to be defined within 2Zero, in close harmonisation with other Partnerships;
- Complementing attributional with an increased consequential assessment where this is appropriate (e.g. where accounting for 2^{nd} life batteries), also in the longer term (i.e. balancing the benefits with the increased complexity).

Implementation and anchoring of circular economy strategies, as a measure to lower the ecological footprint (including value and supply chain) and enhancing resource sovereignty

- Definitions of circular economy criteria at a vehicle and system level (e.g. categories such as the share of recovered materials, energy efficiency of recycling process, etc.);
- Identifying harmonised factors influencing the defined CE criteria;
- Defining harmonised strategies for consistent circular economy approaches involving all relevant stakeholders (OEMs, supply industry, EoL market, legislation, etc.);
- Strategies and technologies to ensure the required volume availability of circular resources;
- Exploiting alternatives complementing CE, such as carbon-neutral or carbon-negative resources;
- Definition of a use-case(s), representative of real-world conditions (e.g. for activity, lifetime, impacts linked to the specific duty-cycle and accounting for user behaviour), to validate CE methods and tools.

Accelerating the uptake of sustainable solutions towards a zero emission road transport system

- Providing tools and methods for minimising the life-cycle environmental impact and contributing to a CE to product development;
- Demonstrate the feasibility of circularity of automotive products with acceptable cost/TCO and positive social impacts.

b. Expected outcomes by 2030

- Harmonised and commonly accepted life-cycle inventory (LCI) database with reliable, correct and transparent data, and use-cases reflecting the needs of all stakeholders;
- Commonly accepted robust methods and tools incorporated into the development process and mobility planning;
- Frontloading of impact assessment demonstrated and increasingly applied in product development;
- Feasibility of advanced circular economy strategies in zero emission mobility solutions demonstrated by performed use-cases;
- Capacity build-up enabling higher degree of circularity at affordable costs;
- Harmonised CE strategy enabling circularity along supply chains and across value chains;
- Accounting for regional and behavioural particularities;
- Recommendations towards legislation, standardisation and skills development.

c. Scope of actions

Overall, three clusters with nine R&I actions have been identified, each of which address the transport of people and goods at the same time, as described briefly in the following. The identified R&I actions strive for a Europe-wide, harmonised LCSA- and CE-strategy and, as such, should be funded as part of Horizon Europe.

Data for comparable and reliable assessments

Life-cycle inventory (LCI) database
Priority: high (2021 – 2023)
There is an urgent need for standardised and comparable (background and foreground) data, as well

as defined use-cases for the assessment. To overcome this gap, a harmonised ontology and certified database(s) will have to be derived for the data and use-cases needed for a holistic LCSA-based zero emission mobility solution. For this, a tailored Data Quality System and Indicators to guarantee the usefulness and reliability of LCSA outcomes is needed. The ontology and database(s) must reflect the needs of the different stakeholders, such as partial confidentiality (e.g. in the view of material compositions, costs and TCO) whilst ensuring the correctness and transparency of the data. Since LCSA approaches should be applied in developing zero emission[74] mobility solutions for a global market, advanced models and simulation environments are needed as well, to predict and generate the required data. Furthermore, defining processes for continuously updating data and adapting to new, upcoming technologies, measures and behavioural aspects is of importance for the usability of the intended database(s).

Track & Trace of products and their use over their life-time
Priority: high (2024 – 2027)
The impact of LCSA methods and tools as well as of EoL strategies depends on the accuracy of data as outlined already. Access and analysis of such data will not only improve continuously the quality and baseline of required data sets for an assessment (LCSA and CE), it will also allow a scientific-base analysis of the effectiveness of measures and their interdependencies as well as an ex-post assessment of solutions. As such, these data will form the basis for the design and development of advanced, next generation zero emission mobility solutions.
For selecting the optimal EoL strategy (e.g. reuse, remanufacturing, closed-loop versus open-loop recycling), adequate information on the use phase and the state of health at EoL of relevant components will be key as well. For this, each vehicle or important sub-assemblies should have a unique identifier. However, with respect to implementation it is unknown to which level down identifiers are required and are feasible. Furthermore, a detailed understanding is needed what a component has been endured over its use phase (operational loads, repair and maintenance measures) and how it is degraded. These data must be made available, e.g. through a digital product passport to all stakeholders in an EoL market, on a need-to-know basis.

Methods and Tools

Methods and tools for LCSA tailored to the transport sector
Priority: high (2021 – 2023)
Existing methods and tools need to be advanced and adapted towards a LCSA including infrastructure data and effects, enabling a Life-cycle Design of vehicles and mobility concepts and operations. Within this context, it becomes essential that the harmonised methods and tools become an integral part in the product development and mobility planning tools without prior expert knowledge. Furthermore, mandatory, transport-specific impact categories have to be defined, so as to be considered in future LCSA. To stimulate green technologies (current and future zero emission supporting technologies and measures) harmonised weighing factors or incentives for beneficial approaches must be implemented in such methods and tools, allowing an efficient and reliable comparison of technologies and mobility concepts and operations. Since the LCSA performance of the transport system and its items (infrastructure, vehicle, operational concepts, etc.) varies over time, the methods and tools must be able to account for changes over time. Furthermore, the methods and

[74] Zero emission is understood as zero tailpipe emissions and reduced non-powertrain related emissions and transport-related noise.

tools must enable a scenario modelling of mobility concepts and operations, accounting for new, lower emission technologies not in place at the time being, as well as related shifts in relevant related sectors (particularly energy supply and materials production).

Social LCA for the transport sector
Priority: medium (2025 – 2027)
A dedicated focus is needed on the social impact of zero emission mobility solutions. Methods and tools have to be derived to enable the social impact assessment of future zero emission vehicles and mobility concepts within a decarbonised transport system. Assessment should provide guidance for non-technical measures, for city planning, for identifying the workforce skills needed, as well as for minimising the social impacts of emphasising BEV and FCEV as one element of the transformation of the transport sector. The methods and tools must be adapted to different mobility segments so as to also capture fleet and system aspects.

Methods, tools and processes for circular economy
Priority: medium (2021 – 2024)
The design, production phase and End-of-Life become more important with the increased use of carbon-neutral/renewable energy vectors during the in-use phase, requiring additional measures such as circular economy strategies. As such, complementing the LCSA, circular economy strategies have to be applied in zero emission mobility solutions, as an important measure to minimise the ecological footprint over the full life-cycle (cradle to cradle). Within this context, methods, tools and processes are needed to support the design and production of CE-based transport and vehicle systems, not only accounting for materials and associated manufacturing solutions but also considering extended lifetime, 9R principles, material flows and the supply chain management (e.g. further building on the PEF[75] Circular Footprint Formula approach). Additionally, mobility concepts and operations must be designed for CE strategies which requires new methods as well.

Capacity building for circular economy
Priority: medium (2024 – 2027)
In order to ensure desired capacities of secondary material and product resources, all stakeholders (OEMs, suppliers, dismantlers and recyclers) must collaborate intensively providing new solutions for EoL processes. Particularly for reuse, remanufacturing and closed-loop recycling dismantler and recyclers must work hand in hand with the OEMs and suppliers to ensure economically viable solutions. In view of affordability, automation of the dismantling and recycling processes are needed relying on data to be provided by the OEMs or suppliers (e.g. by means of a digital product passport). In terms of closed-loop recycling, the OEMs and suppliers must overcome product specific, tailored material compositions to enable the use of recyclates across companies thus scaling up the economy for secondary materials. Regarding reuse and remanufacturing, new business models and technologies (e.g. automated assessment of state of health) are needed allowing OEMs and suppliers to implement these approaches into their own CE strategy.

Development of approaches / methods and tools for system-wide life-cycle and CE strategy modelling
Priority: medium (2024 – 2027)
It is not sufficient to only consider LCSA and particular CE strategies at a product/vehicle level in order to fully capture the benefits of these approaches. It is also necessary to broaden the application,

[75] Product Environmental Footprint.

to carry out system-wide modelling (particularly for consequential aspects), at the very least in the transport sector (also to better characterise infrastructure elements), but also for certain aspects more broadly than this. For example, current LCA impact categories do not adequately capture the importance of key critical materials for EV batteries (e.g. lithium and cobalt), which can only be suitably assessed using a system flow analysis including the assessment of inputs and outputs to EU vehicles as they enter/leave the fleet, and are either recaptured through recycling, reutilised in 2nd life batteries, or lost to the EU when vehicles/batteries are exported. Similarly, a whole-system approach is needed to properly account for the many (economy-wide) demands for renewable energy sources, to help maximise the benefits of limited resources. Only in this way can wider resource implications be adequately explored, to complement the product-level assessments. R&I work is needed to help define tools and approaches, integrated also with the earlier methods, to more fully account for such system-wide effects, as well as for different time-scales. R&I work is likely to link also with other 2Zero pillars (e.g. R&I Pillar 2 on the integration of BEV into the energy system).

Assessment and demonstration

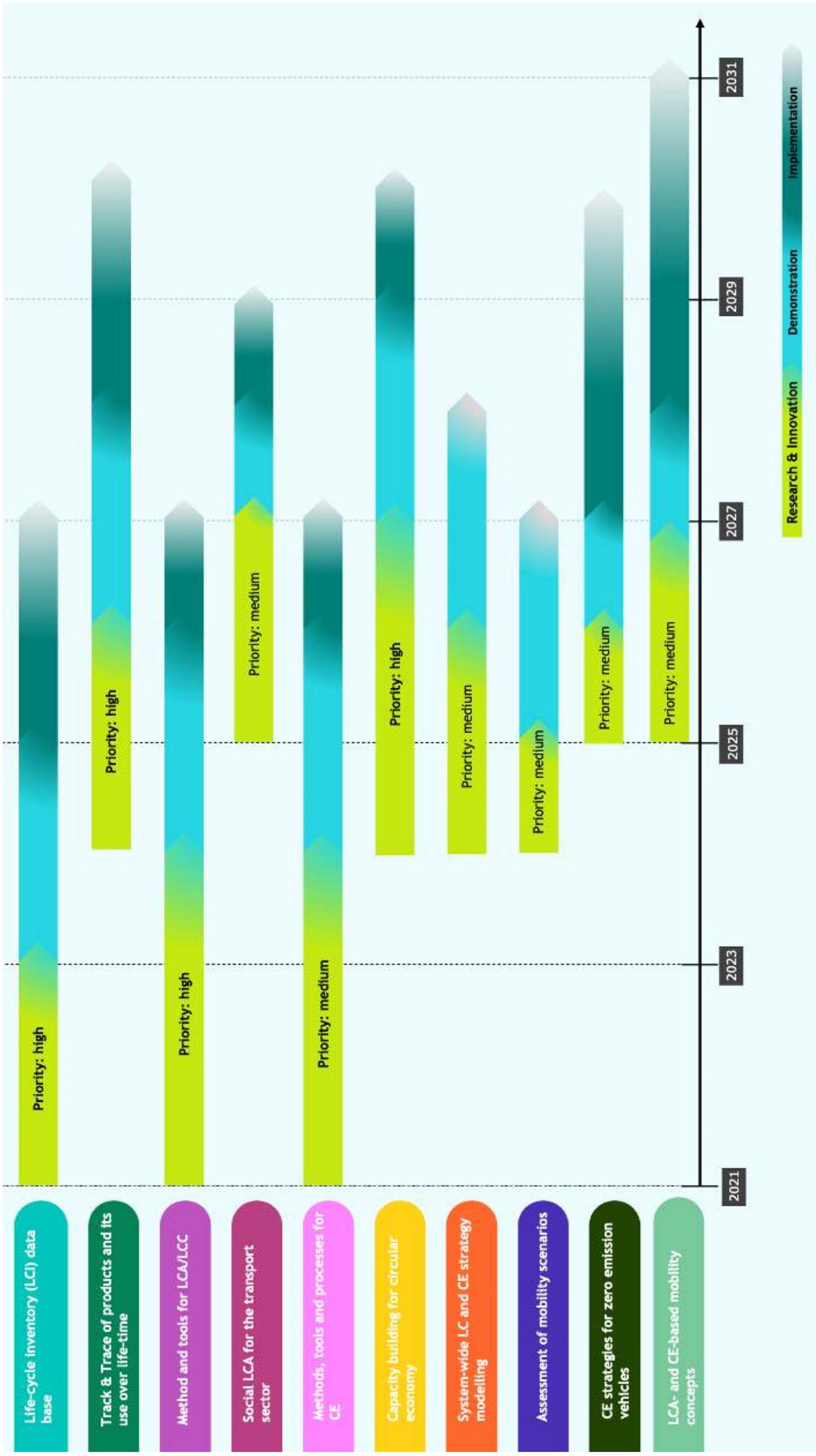
Assessment of mobility scenarios
Priority: medium (2024 – 2027)
For demonstrating the effectiveness of a LCSA and to increase the acceptance of LCSA- and CE-based solutions, the actual assessment and benchmarking – through defined use-cases – of the ecological footprint and the TCO of mobility concepts is needed. For the reason of comparison and the meaningfulness of the assessment and benchmarking, all varieties of vehicle types relevant for the considered use-case (mobility concept or operation) must be included. As part of defining the assessment and benchmarking, suitable targets and threshold must be defined.

Development and demonstration of CE strategies for zero emission vehicles
Priority: medium (2025 – 2027)
Vehicle concepts reflecting LCSA and CE principles already in the conceptual design phase will directly impact the GHG emission/GWP balance of the road transport system. As such, LCSA - and CE - viable vehicle concepts need to be developed and demonstrated, not only to actually reduce the ecological footprint of vehicles but also as a means to increase the acceptance of such solutions. Such vehicle concepts have to take into account circular economy principles, e.g. implementing secondary or bio-based materials, as well as 2nd life use and recyclability concepts, without penalties regarding weight, safety and costs. This R&I action is highly linked with the R&I Pillar 1 on vehicles technologies.

Development and demonstration of LCSA- and CE-based mobility concepts and scenarios
Priority: medium (2025 – 2027)
It is not sufficient to reflect LCSA and CE strategies in the vehicle design only. Following a system approach within the 2Zero Partnership, mobility concepts and operations must be designed as well, applying LCSA principles and enabling circular economy strategies also at a system level. The consideration of interdependencies of mobility concepts and operation with material flow and logistic aspects within a circular economy will be important. Highly linked with R&I Pillar 3, LCSA and CE principles will have to be applied in the development and design of novel mobility concepts (mainly for transport of people) and operations (mainly for the logistics of goods) and the feasibility and benefits demonstrated in defined use-cases.
Besides the outlined R&I actions, the transfer of knowledge on LCSA and CE as well as the training

and education of skills required for an accelerated implementation of LCSA and CE viable concepts in the transport industry must be strengthened. Since both aspects have a strong national relevance, the development and implementation of supporting actions could be organised in strong cooperation with national activities, and could be one of the areas for MS involvement in the 2Zero Partnership.

d. Roadmap


Life-cycle inventory (LCI) data base
Track & Trace of products and its use over life-time
Method and tools for LCA/LCC
Social LCA for the transport sector
Methods, tools and processes for CE
Capacity building for circular economy
System-wide LC and CE strategy modelling
Assessment of mobility scenarios
CE strategies for zero emission vehicles
LCA- and CE-based mobility concepts
Priority: high
Priority: high
Priority: high
Priority: medium
Priority: medium
Priority: high
Priority: medium
Priority: medium
Priority: medium
Priority: medium
2021
2023
2025
2027
2029
2031
Research & Innovation
Demonstration
Implementation

5. SRIA Implementation

5.1. - Budget and related investments

Achieving climate neutrality will be one of the biggest challenges faced by the European Union in its recent history. Achieving carbon neutrality in the road transport sector will be a condition *sine qua non* to be successful. Pooling European strengths and capabilities and incentivising stakeholders from different sectors to work collaboratively in the Partnership will only be the first step to achieving this objective.

Providing the necessary resources at the EU level to fulfil the roadmap objective will be the second step. To properly address the challenges identified in this Partnership proposal and, considering the extension of the scope compared to previous initiatives, the resources to be allocated to the 2Zero Partnership cannot be less than what has been allocated to the European Green Vehicles Initiative. The challenge to be tackled in the 2Zero Partnership has to be successful to put Europe on the right path to achieve its climate ambition. Based on the scope description, it is estimated that the challenges covered by the Partnership proposal cannot be properly tackled with a budget lower than €1bn; although only €615 million of EU funds will be allocated to the 2Zero activities over the lifetime of the Partnership.

The third step will be the additional contribution from stakeholders, who are expected to further deploy and transfer successful concepts into industrial products and services, demonstrating the impact of the R&D&I industrial spending of the concerned sectors.
The counterpart of the EC in the 2Zero Partnership will invest the additional necessary resources to contribute to the objectives of the Partnership. These will include:

- A direct financial contribution in funded projects: following the rules of participation in Horizon Europe, all 2Zero project participants will provide in-kind contributions to the funded projects, corresponding to the share of budget not covered by the EU funding. This share of in-kind contribution can vary according to project participants and types of projects (Research and Innovation Actions, Innovation Actions, Coordination and Support Actions, etc.);
- Additional contribution for activities foreseen in the SRIA and not directly covered by the EU funding, with a specific focus on the activities related to a wider dissemination and exploitation of results in line with 2Zero objectives (e.g. large-scale dissemination of information on project results, test drive opportunities in public events in various EU locations, involvement of stakeholders, wide dissemination of activities and results, exchange with relevant standardisation bodies, monitoring of relevant activities related to patents, etc.);
- Additional investments in operational activities going beyond the work foreseen in the SRIA. This scale-up phase for BEV and FCEV will require investments estimated at around five times the overall Partnership budget. Important additional investments will be done in areas contributing to a climate-neutral road transport but not covered by the EU funding (hybridisation, powertrain adaptation to carbon-neutral fuels), representing an important additional external contribution to the achievement of the Green Deal.

The road transport and electricity sectors have already confirmed their willingness to support the transition towards more focused investments into both zero tailpipe emission vehicles technology and smart charging solutions[76]. In particular, recent announcements by vehicle manufacturers are ambitious. Investments are already high, with the automotive sector investing over €60 billion in R&I on a yearly basis[77], and continuously increasing its investments, making it the largest R&I investing sector in Europe. Battery manufacturing is also undergoing important transitions, including major investments to expand EU-based production. TSOs, DSOs, charging point operators, charging hardware manufacturers and other power sector stakeholders are also boosting their investments in charging infrastructure.

In order to fully enable the decarbonised mobility for the coming decades, the deployment of strategically located, smart, intelligent and customised charging infrastructure and services is essential. Members of the 2Zero Partnership will commit to invest the necessary resources to make the Partnership itself a success whilst continuing to invest in higher technology readiness level (TRL) developments to accelerate the market uptake of the innovations developed within the European collaborative projects. This could include demonstration activities (TRL7 and above), taking project results closer to market, either thanks to other type of funding (European or national) or via direct investments from the organisations. Members of the 2Zero Partnership will ensure the continuity of activities funded in project thanks to a number of activities, such as building large-scale demonstrators, real-life testing activities, etc. They will also facilitate the needed cross-disciplinary integration and widely disseminate the activities of the Partnership.

5.2. - Cooperation with other European Partnerships

Based on the successful experience of the European Green Cars and European Green Vehicles Initiatives, several contacts have already been established with other European initiatives, including Partnerships, as shown in *Figure 6* below.

The coordination with co-programmed and institutional Partnerships funded under Horizon Europe and having a direct impact on 2Zero will be implemented. The coordination will mainly address exchange of information and avoidance of duplication of activities.

[76] European Automobile Manufacturers' Association (ACEA), Eurelectric and Transport & Environment (T&E) Joint call to action for the accelerated deployment of smart charging infrastructure for electric vehicles
International Energy Agency, Global EV Outlook 2019

[77] https://iri.jrc.ec.europa.eu/scoreboard/2022-eu-industrial-rd-investment-scoreboard

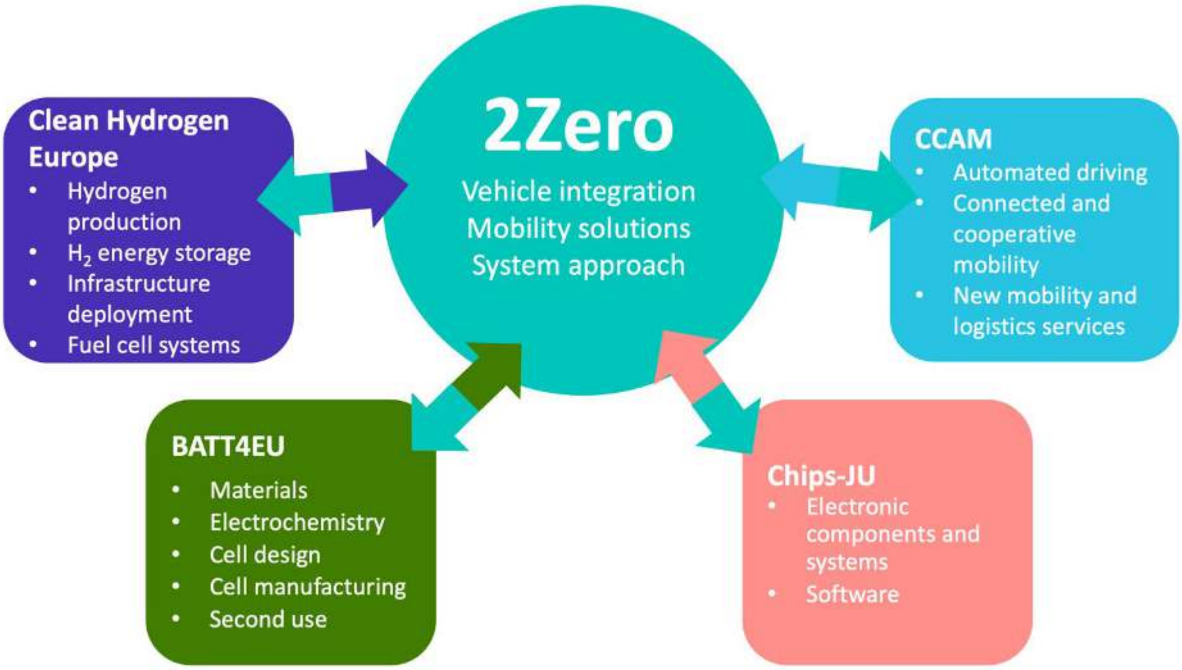


Figure 6 - The interaction of the 2Zero Partnership with other key co-programmed and institutional Partnerships

a. BatteriesforEurope (BATT4EU)

The batteries landscape and structures in Europe evolved very quickly following the launch of the European Battery Alliance by Commissioner Šefčovič in 2017. Several new initiatives have been supported to accelerate the establishment of a battery production base in Europe: road transport is one of the main applications of this enabling technology. Hence, a strong coordination with the ***BatteriesforEurope*** Partnership is needed.

As shown in *Figure 7* below, the proposed breakdown of activities is in line with the batteries value chain: the Batt4EU Partnership will cover activities from mining to recycling whilst the 2Zero Partnership will address topics related to modules and pack integration at the vehicle level; modules and battery management system related activities could also be covered by the Batt4EU Partnership, as an interface with 2Zero. A regular exchange of information will be needed to ensure that 2Zero provides the necessary requirements to the Batt4EU Partnership and that the advancements of the latter are brought to the attention of the 2Zero community for the integration activities.

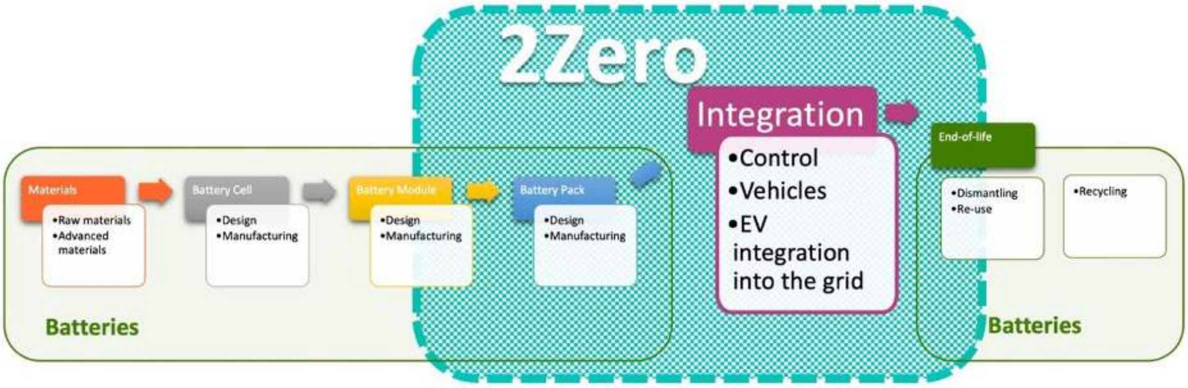


Figure 7 - The interaction of the 2Zero and Batteries Partnerships

A close cooperation will be organised, to ensure a smooth transfer of information and avoid duplication of activities. This could include the following activities (non-binding list):

- Common technical workshops to exchange on the latest achievements of R&I activities funded at the EU level and to identify the upcoming challenges.
- Regular meetings at Board level to exchange on general activities at EU and national levels in the common fields of interest. These meetings could be organised in parallel to the meetings of supporting ETPs/ETIPs meeting.
- One Board member or representative of the Partnership secretariat to be invited to the 2Zero Partnership Board meeting, to be aware of the latest calls for proposals under discussion. *Invitation would be personal, strictly limited to one representative and invited participants would have no opportunity to contribute to the topic writing.*
- Joint calls for proposal across the two Partnerships (clearly marked as joint activities to ease the dissemination of information towards stakeholders) providing that, ahead of the call publication, the following items are agreed between the EC and representatives of stakeholders from both Partnerships:
  - Budget breakdown;
  - Responsibilities for the evaluation phase (guidelines, selection of experts, etc.);
  - Responsibilities for the reporting and assessment of the achievements of the selected projects (aligned with the monitoring frameworks set by each Partnership).

Two joint calls have already been published, one in 2021 and one in 2023.

b. Clean Hydrogen

Existing links (common statement paper published in 2017[78]) with the "***Clean Hydrogen***" Partnership (the former FCH-JU) will need to be reinforced and reorganised, to ensure a smooth transfer of information between the two initiatives and avoid any duplication of activities.
Indeed, the Clean Hydrogen initiative will enlarge its activities to clean hydrogen production pathways, technologies for safe and cost-efficient distribution and storage, as well as demand-side

[78] https://egvi.eu/mediaroom/battery-and-hydrogen-electric-vehicles-for-zero-emission-transport/

technologies (including fuel cells) to produce power and/or heat for mobile and stationary applications. As such, it will bring an important technological contribution (building blocks) to the 2Zero Partnership for integration into the transport and mobility system. A strong coordination of efforts and activities will be needed to ensure a smooth transfer of information between the two Partnerships, including requirements definitions, both for the integration at a vehicle level, for the interface between the vehicle and infrastructure, and for deployment activities.

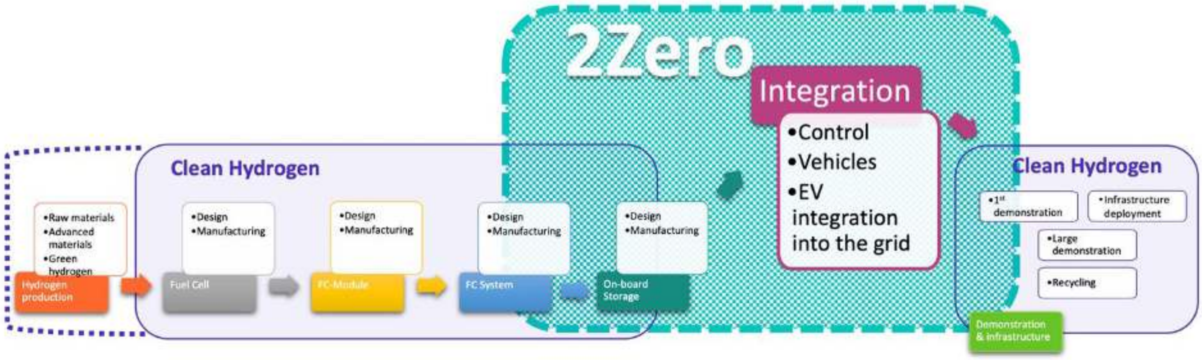


Figure 8 - The interaction of the 2Zero and Clean Hydrogen Partnerships

The following collaboration has been pre-identified for each of the areas, and will be further developed in a specific Memorandum of Understanding.

Area	Partnership in charge	Collaboration
Fuel cell	Clean Hydrogen	
Fuel cell module	Clean Hydrogen	
Fuel cell system	Clean Hydrogen	Medium
On-board storage	Clean Hydrogen	Strong
Homologation	Clean Hydrogen	Medium
Powertrain integration	2Zero	Strong
Prototype demonstration	2Zero	Strong
Large demonstration	Clean Hydrogen	Medium
End of Life	Clean Hydrogen	
Infrastructure & upstream	Clean Hydrogen	

Table 1 – Breakdown of responsibilities and level of cooperation between the 2Zero and Clean Hydrogen Partnerships

The collaboration between the two Partnerships could include the following activities, covering both programming and implementation levels (non-binding list):

- Common workshops to exchange on the latest achievements of R&I activities funded at an EU level and identify the upcoming challenges.
- Appointment of "bridging members" from both sides, to report on respective activities of the Partnership.

- One Board member or representative of the Clean Hydrogen secretariat to be invited to the 2Zero Partnership Board meeting to be aware of the latest calls for proposals under discussion.
  Invitation would be personal, strictly limited to one representative and invited participants would have no opportunity to contribute to the topic writing.

Due to the fact the 2Zero and Clean Hydrogen are two different types of Partnership, some coordination activities will be difficult to implement (i.e. joint calls for proposals are not seen as a suitable option), and particular attention should be paid to the timing of calls publication and SRIA review, to ensure proper information sharing and consultation with stakeholders could be organised.

c. Chips-JU

Links already established with "***Chips-JU***" (former Key Digital Technologies) and EGVI will need to be reinforced. A "soft" coordination between EGVIAfor2Zero and the Chips-JU is already existing, relying on common members, the support from the European Technology Platform to both Partnerships (namely EPoSS), as well as EGVIAfor2Zero participation in the ECSEL, Mobility.E lighthouse.
This coordination of activities will continue, using a similar way forward: closer exchange could be organised depending on each community's need along the way.
A regular exchange of information will be critical to ensure that the Chips-JU community is aware of the specific automotive requirements and that the 2Zero community is kept informed of the latest advancements of the Chips-JU Partnership.

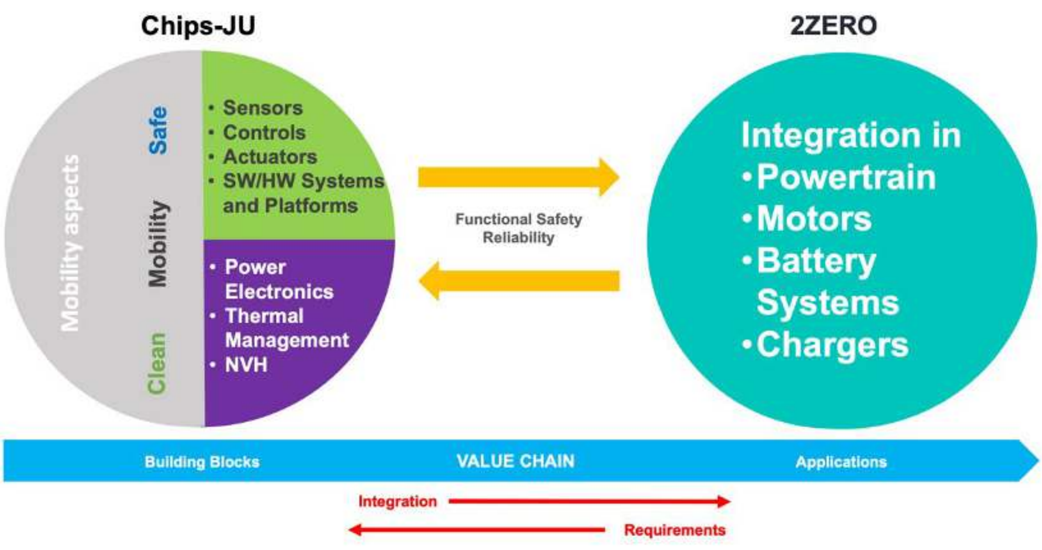


Figure 9 - The interaction of the 2Zero and Key Digital Technologies Partnerships

Due to the fact that 2Zero and Chips-JU are two different types of Partnership, some coordination activities will be difficult to implement (i.e. joint calls for proposals are not seen as a suitable option), and particular attention should be paid to the timing of calls publication and SRIA review, to ensure proper information sharing and consultation of stakeholders could be organised.

The collaboration between the two Partnerships could include the following activities, covering both programming and implementation level (non-binding list):

- Common workshops to exchange on the latest achievements of R&I activities funded at the EU level and to identify the upcoming challenges.

d. CCAM

Alongside decarbonisation, another trend is disrupting road transport: digitalisation and the development of connected, cooperative and automated mobility.
The digitalisation of road transport offers opportunities to further improve transport efficiency (both at a general traffic level with the new road mobility scenario and at the vehicle level with new vehicles design and usage patterns enabled by CCAM), improved logistics operations and the development of new public and/or private mobility services.
One cooperation aspect for 2Zero will be to require access and collect data provided by CCAM, in order to optimise vehicle systems and their integration. In turn, research performed in 2Zero may deliver strategies for energy/emission optimised motion profiles and recommend new V2X functions and interactions for investigation in CCAM.
Since the impact of digitalisation on road transport's energy consumption and related emissions should be further investigated (assessment of electric power consumption, control strategies related to emission reduction, etc.), the 2Zero Partnership should work closely with the CCAM Partnership to develop solutions to minimise the impact of such potential rebound effects.
Whilst collaboration with Batteries, Clean Hydrogen and Chips-JU Partnerships are following a value chain integration approach, the collaboration with CCAM should be organised at the integration level.
The collaboration between the two Partnerships could include the following activities (non-binding list):

- Joint events and workshops to promote exchange of R&I results obtained within CCAM and 2Zero, both for new technologies and new services, or to address specific common topics.
- Joint testing and demonstration activities.
- Joint calls for proposals across the two Partnerships (clearly marked as joint activities to ease the dissemination of information towards stakeholders) providing that, ahead of the call publication, the following items are agreed between the EC and representatives of stakeholders from both Partnerships:
  - Budget breakdown,
  - Responsibilities for the evaluation phase (guidelines, selection of experts, etc.),
  - Responsibilities for the reporting and assessment of the achievements of the selected projects (aligned with the monitoring frameworks set by each Partnership).

A tripartite call for proposal among 2Zero, CCAM and the Cities mission has already been published in 2023.

e. Driving Urban Transition

The Driving Urban Transition Partnership (DUT) addresses the complex set of urban challenges with an integrated approach, to offer decision-makers in municipalities, companies and society the means to act and enable necessary urban transformations. Even though the scope of the DUT Partnership will be much broader than (road) transport related activities, a close cooperation with 2Zero will be needed, particularly regarding the activities to be carried out there in relation to the pillar “Innovative concepts and services for the zero tailpipe emission mobility of people and goods”.

f. Clean Energy Transition

The Clean Energy Transition Partnership is a public-to-public Partnership involving the European Commission and Member States. Building on the SET-Plan implementation plan, it aims at improving the coordination and integration of innovation to support the transition of the EU energy system towards climate neutrality. The CET Partnership will stimulate R&I private investments (pilots, demonstrations and validation of implemented solutions across Europe) and act as a collaborative platform for R&I, funders and policy makers. Interactions with 2Zero, particularly with the second R&I area dealing with the integration of BEV into the energy system, could be investigated.

g. Other Partnerships

The smooth exchange of information will also be ensured with a number of other Partnerships.

- Contacts and the exchange of information previously launched with EFFRA (involved in the ***Made in Europe*** Partnership), through common workshops dealing with various topics, such as advanced manufacturing, advanced materials for automotive applications, robotics and digitisation in manufacturing, will continue. These common workshops, involving various expertise across the value chains, have proven to be a good way forward in ensuring the exchange of information between communities.
- Informal exchange of information with ***Clean Steel*** and ***Circular Economy*** Partnerships, as well as the ***EIT raw materials*** will be ensured. Taking a system approach, the 2Zero Partnership should also consider developments and inputs from upstream activities; particularly when it comes to the LCSA, circular economy aspects of its activities to be able to draw the full picture.
- Whilst 2Zero is working on R&I activities to build the future of zero tailpipe emission road transport, the immediate concerns of end-users should also be considered, to ensure that existing infrastructure, particularly in buildings, can be retrofitted to ensure charging point integration. This activity will be monitored in close contacts with the ***Built4People*** Partnership.
- The exchange of information with the ***Cybersecurity*** Partnership will be organised, particularly on processes and innovation, to ensure the maximum level of security during the charging phase, when the vehicles are connected to the grid.
- Whilst the “EU Mission for 100 climate-neutral and smart cities” is covering many different aspects and industrial areas, mobility will be an important item and the 2Zero Partnership should closely interact with the mission board and platform to provide technology solutions for test in real-life conditions.
  A closer collaboration could be established based on the projects selected for funding under the tripartite topics among 2Zero, CCAM and the Cities Mission.
- Coordination activities could be organised with other Partnerships or platforms, depending on the respective needs.

5.3. - Cooperation with other EU funding instruments

2Zero is funded as part of the Pillar 2 of Horizon Europe "Global challenges and industrial competitiveness" and included in the Cluster 5 activities "Climate, energy and mobility". However,

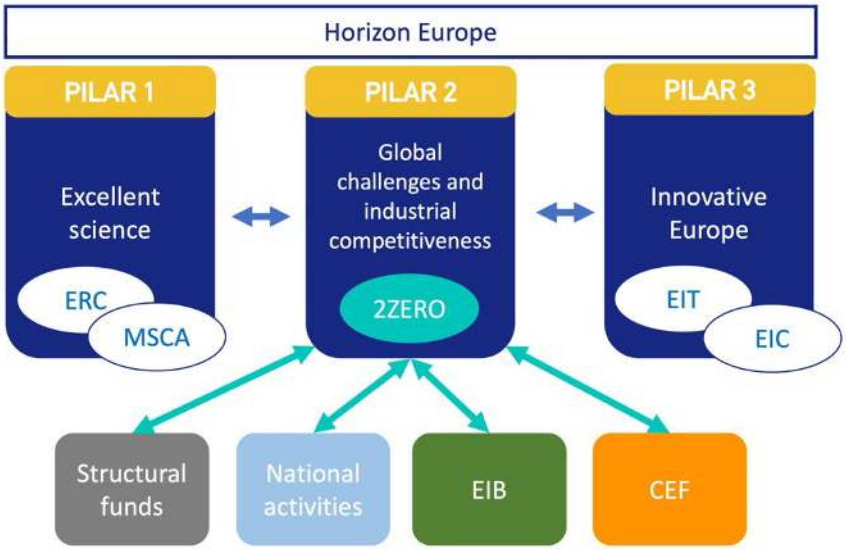


Figure 10 - The possible interaction of the 2Zero Partnership with other Horizon Europe tools

Horizon Europe is only one of the many tools available to support stakeholders and build a sustainable future. Hence, 2Zero will investigate possibilities to interact with other EU funding tools in order to maximise the benefit of R&I actions, as shown in *Figure 10*.

a. Link to CEF

The Connecting Europe Facility (CEF) supports the development of high performing, sustainable and efficiently interconnected trans-European networks in the fields of transport, energy and digital services. The Connecting Europe Facility (CEF) for Transport is the funding instrument to realise European transport infrastructure policy. It aims at supporting investments in building new transport infrastructure in Europe or rehabilitating and upgrading the existing one.
CEF Transport focuses on cross-border projects and projects aiming at removing bottlenecks or bridging missing links in various sections of the Core Network and on the Comprehensive Network. It also supports innovation in the transport system in order to improve the use of infrastructure, reduce the environmental impact of transport, enhance energy efficiency and increase safety.
CEF Transport and 2Zero develop activities in the same thematic area, tackling issues from different perspectives: their results can complement each other. As 2Zero will cover the interaction of vehicles with the infrastructure and integration of BEV into the grid but not the deployment of recharging infrastructure itself, an obvious complementarity with CEF Transport should be envisaged. Technologies becoming available through research actions could be taken up by CEF projects, enhancing the seamless integration of transport modes whilst increasing their capacity and quality.
Different layers of collaboration could be established, to support an information flow that shall help the 2Zero community to better understand the latest developments, and help the CEF projects and actors to receive information on the latest state of the art in the transport field, as well as the outcomes

of 2Zero funded projects. A more direct linking of the initiatives could be foreseen to incentivise and support the adoption and the deployment of successful 2Zero solutions.

b. Link to EIB

The EIB Group is a key partner in financing European priority projects thanks to the implementation of InvestEU, the programme to foster private and public investment in Europe. It builds on the success of the Juncker Plan and the European Fund for Strategic Investments (EFSI) and other existing financial instruments managed and implemented by the EIB Group.
New mobility business models and technologies shall play a crucial role in enabling the transformation of transport towards zero emission standards: this will require large investments. Competitiveness relies also on investment. In Europe, good projects currently struggle to find investment as economic uncertainty stops many investors from taking risks.
To assist this vital transformation process, the EIB Group, as the EU's climate bank, is contributing to the necessary acceleration towards sustainable and green transport. The EIB Group is playing a significant role in the transformation of mobility and transport for a low-carbon future in Europe and beyond. The EIB aims to support a green and competitive economy and accelerate the take-up of sustainable transport solutions by scaling up and attracting private investment and ensuring balanced regional development. Additional initiatives shall be developed in support of the transition towards green and sustainable mobility.
The 2Zero Partnership could act as a facilitator for projects to find resources supporting the development of higher TRL activities and ultimately reaching the market with zero emission innovative products and services, creating links with relevant EIB initiatives related to sustainable transport solutions.

c. Link to structural funds

The European Regional Development Fund (ERDF) and the Cohesion Fund (CF) aim to strengthen economic and social cohesion in the European Union by correcting imbalances between its regions. The ERDF focuses its investments on several key priority areas. This is known as "thematic concentration":

- Innovation and research;
- The digital agenda;
- Support for small and medium-sized enterprises (SMEs);
- The low-carbon economy.

The main focus of the ERDF is on smart growth and the green economy, whilst also supporting other activities such as connectivity, social issues and local development. The Cohesion Fund will continue to focus predominantly on environmental and transport infrastructure.
The 2Zero Partnership will pay a particular attention to reduce the East / West innovation gap in road transport related activities. Activities already launched in EGVI will continue, but a more systematic integration of 2Zero priorities into the national plans could help structure the local eco-systems and contribute to reinforce participation of stakeholders to EU activities.
The 2Zero States Representative Group shall help establishing more linear links and connections with the national and regional funding, for the better integration of innovative and zero emissions road transport solutions.

In response to the CoVId-19 pandemic, the European Commission set up the Recovery and Resilience Facility (RRF) that will help Member States to kick-start their economy after the crisis. In total, the proposal foresees that €675.5 billion will be made available to Member States in grants and loans of which at least 37% will have to include green investments. This represents a unique opportunity for sustainable transport. This funding will be used by Member States on the basis of national plans that will detail the sectors benefitting from such support. Therefore, industry is invited to work closely with national authorities to ensure that transport sector needs are adequately addressed in this framework. The financing from the facility can trigger an accelerated uptake of electric vehicles, especially in those Member States that are currently lagging behind, and the realisation of the target formulated in the European Green Deal: to have 1 million recharging and refuelling points in 2025.

5.4. - Cooperation with national activities

Member States will play a key role in several areas essential to make the 2Zero Partnership a success: supporting complementary research and innovation activities, implementing the "Alternative Fuels Regulation", developing the necessary infrastructures, promoting the development of needed new skills, supporting standards and business models. Therefore, their involvement in the 2Zero Partnership has to be ensured.
As Member States will not be part of the governance structure of the Partnership *per se*, an alternative to keep them involved in the Partnership activities has to be defined. A States Representative Group gathering representatives of the ministries and/or national agencies will be set up as a side-body, as shown in *Figure 11* below. This States Representative Group will have complementary objectives:

- To align European and national priorities, identify opportunities for collaboration, avoid duplication of funding and disseminate information towards national stakeholders;
- To identify outcomes of EU-funded projects of direct interest to national activities and offer demonstration possibilities to innovative solutions;
- To implement complementary measures to the EU funding of projects such as training, standardisation, technology transfer, deployment of innovations and recharging infrastructure, contributing to accelerate the uptake of zero tailpipe emission road transport.

Figure 11 – The integration of Member States in 2Zero

The involvement of Member States will be organised on a voluntary basis and particular attention will be paid to avoid duplication with the Programme Committee. All Member States and representatives of countries associated to Horizon Europe will be invited to join this States Representative Group. During the May 2023 meeting, the 2Zero SRG elected its first Chair, representing Italy who will hold this position for two years. Several configurations of this Board could be planned, according to the specific needs, and it will work in a two-way information exchange:

- Information from EU level to national authorities;
- Information from Member States level towards the European one.

At least one face to face meeting will be organised on a yearly basis and additional meetings could be organised, either face to face or by teleconference, to ensure a good communication across the participating countries.

5.5. - Governance

The governance of the 2Zero Partnership is similar to that applied in EGVI and other co-programmed Partnerships, ensuring a lean and flexible organisation. Various services of the European Commission are involved, under the leadership of DG RTD, and the stakeholders representing the counterpart of the EC are represented by a not-for-profit association, as shown in *Figure 12* below.

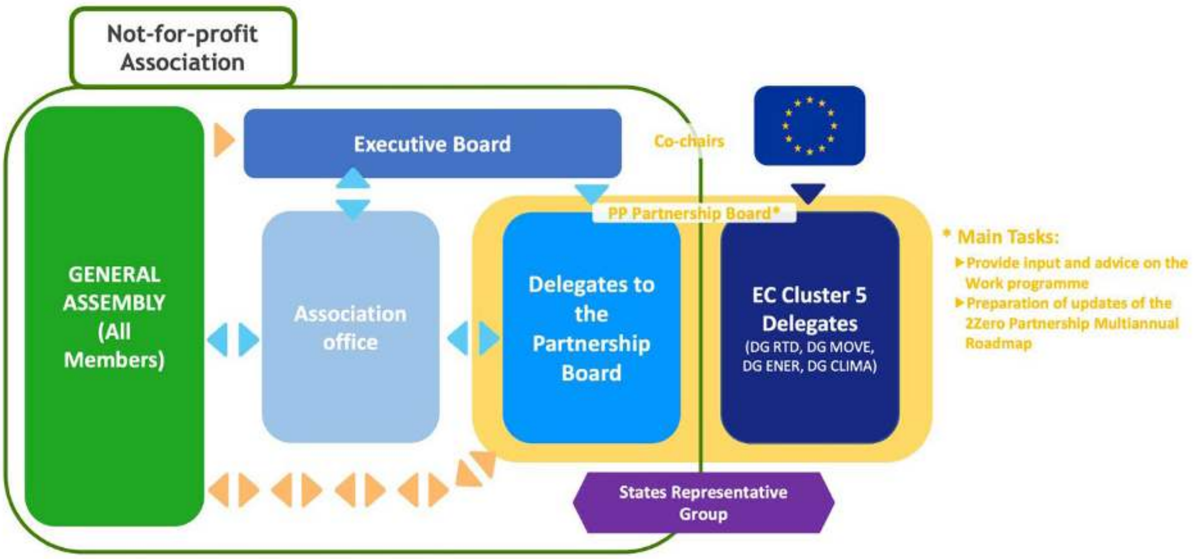


Figure 12 - The 2Zero Governance Structure

a. The not-for-profit association

Stakeholders willing to become member of the 2Zero Partnership are invited to join a not-for-profit association, created under Belgium law, namely EGVIAfor2Zero. This association relies on the pre-existing association engaged with the European Commission in the European Green Vehicles Partnership, EGVIA. The current status of EGVIAfor2Zero membership is as follows:

- ***16 OEMs;***
- ***26 automotive suppliers;***
- ***3 representatives of the smart system industry;***
- ***2 representatives of the smart grid industry;***
- ***1 representative of the logistics industry and freight transport users;***
- ***24 research organisations;***
- ***25 universities;***
- ***18 associate members.***

To achieve the objectives, the Partnership builds on a broad stakeholder base, so to stimulate synergies across the sectors and the technologies and the association will target the stakeholders, as listed below, to properly cover all areas of the 2Zero scope:

- OEMs;
- Automotive suppliers;
- Electronic components and system manufacturers;
- RTOs and universities;
- TSOs and DSOs;
- Electricity and energy suppliers;
- Charging point operators;
- Logistics related industry (operators, retail and solutions providers);
- Battery manufacturers;
- Local and regional authorities;
- Transport operators;
- Non-Governmental Organisations (NGOs) and end-user associations.

In addition, citizen engagement activities could be carried out, if relevant, to achieve the objectives of the Partnership.

Additional members can be included during the course of the Partnership, depending on the evolution of the priorities.

Particular attention will be paid to include stakeholders from the energy, charging and logistics sectors, either by direct membership or by the involvement of sectoral associations. Regional and local authorities will also have a role to play because of their ability to mobilise various actors in their local innovation eco-system including, SMEs and cluster organisations, thus to integrate EU-funded projects into the broader innovation eco-system. Moreover, they could provide valuable knowledge and perspective of their territory, its resources and infrastructures. This will ease the connection between technology and mobility needs and constraints (from a user/operator point of view) and will provide opportunities for testing, demonstration and co-creation.

Whilst no membership category is specifically foreseen for SMEs, their participation is expected to increase in 2Zero, particularly in relation to the development of new business models, where more disruptive innovations could come from smaller players and would represent an asset for the Partnership. Most importantly, additional efforts will be undertaken to reach out SMEs and promote their participation in the funded projects, so they could liaise with other entities throughout Europe and benefit even more from the European innovation eco-system.

The efforts launched towards EU-13 Member States (through the Board visit to local stakeholders and actions to increase their awareness towards the Partnership activities) will be continued, to improve the geographical balance and increase European cooperation.

Membership fees are defined taking into account the different financial capacity of private and public, large and small organisations, to ensure fairness.
The criteria for membership, and the related fees, are detailed in the association statutes and should guarantee that all members:

- Perform research activities in EU Member States (and countries associated to Horizon Europe) to ensure direct benefit of the Partnership for the European citizens;
- Share the vision and the objectives of the Partnership;
- Support collaborative research activities at an EU level.

In order to bring the maximum benefit for the EU citizens, membership in the association is strictly limited to members based in the EU, and in countries associated to Horizon Europe. However, the international dimension should not be left aside and areas relevant for international collaboration should be identified by the Partnership. Specific actions, including possible funded projects, could then be launched. A participation in international conferences will also be ensured, to share information on priorities and activities outside of Europe.
Provided that they respect the criteria for membership as described above, any stakeholder belonging to one of the abovementioned categories could submit an application for a direct membership in the association (in its relevant member category).
The open membership policy, its inclusiveness and transparency shall act as catalyst for the integration of the complete value chain. Possible reviews of the strategic research and innovation roadmap shall increase the needed dynamic eco-system, support effectiveness and efficiency, and the openness of the Partnership to newcomers.

The not-for-profit association is structured around the following bodies:

- Gathering all members, the **General Assembly** is the main decision body of the association, endorsing the publication of documents, electing the Executive Board members as well as members of the Delegation to the Partnership Board. It approves the general policy of the association on the basis of proposals from the Executive Board.
- The **Executive Board** is responsible for the management of the association, chairing the meetings and representing the association in various public events, conferences and towards policy makers at European and national levels. It is supported by the association office in its daily activities.
- **Delegates to the Partnership Board** are elected by the General Assembly. This group of experts will reflect the different sectors represented in the association (automotive, energy and logistics) as well as the type of members. The specific breakdown is detailed in the statutes of the association. Its role is to exchange on priorities for the calls for proposals with the European Commission services and contribute to the SRIA updates. In doing so, it ensures a continuous exchange with the General Assembly to guarantee that all association members have a similar level of information regarding the Partnership activities and ensure transparency.

All members are contributing to the association activities on an equal basis, independently to their size or activity domain. Consultation processes is organised within the association to gather member's views for the preparation of the different inputs to be transferred to the European Commission.

b. The European Commission

To properly cover the different aspects covered by the 2Zero Partnership, the EC delegates are represented by several of the DGs directly involved in the Partnership under Horizon Europe Cluster 5 (DG RTD, DG MOVE, DG ENER and DG CLIMA), along with other services, such as DG ENV, DG GROW, DG CNECT and DG JRC.
The EC services have been directly involved in the definition of the Partnership proposal and the drafting of the SRIA, with DG R&I coordinating the co-creation process with Cluster 5 EC services and additional services expected to be active in the 2Zero activities. In addition, the EC has been involved in the definition of innovative areas to be addressed by the 2Zero Partnership activities, and the needed interactions with other initiatives and activities.

c. The Partnership Board

A Partnership Board has been created as the governing body and the official mechanism for dialogue between the European Commission and EGVIAfor2Zero.

Delegates to the Partnership Board are elected by the General Assembly and represent the association as a whole. Members of the Delegation to the Partnership Board are elected for a defined duration (two years), to ensure all members have the chance to apply and join this body. The Delegation is in constant contact with the office to ensure a good coordination and to reflect the discussions of the General Assembly.
The European Commission services involved in the Cluster 5 (DG RTD, DG MOVE, DG ENER and DG CLIMA) will identify representatives invited to join the Partnership. Additional services, such as DG ENV, DG GROW, DG CNECT and DG JRC could be involved as well, depending on the scope of discussions.
The Partnership Board is responsible for bringing together the stakeholders and the European Commission views on the content of the calls for proposals and SRIA updates. It is the body discussing research priorities and call recommendations, and ensuring that priorities identified to feed the Work Programme are:

- coherent with the state-of-the-art (avoiding duplication of funding and remaining at the forefront of international competition);
- consistent with the Partnership scope (contributing to achieving the objectives of the Partnership);
- in the best interest of European citizens (added value of acting at EU level).

Specific attention will be paid to ensure good coordination with other EU-funded Partnerships.
The Partnership Board meets on a regular basis (at least once a year).

d. States representative Group

A States Representative Group gathering representatives of the ministries and/or national agencies has been set up as a side-body to avoid any duplication of activities with the Programme Committee. This "States Representative Group" has three different objectives:

- To align European and national priorities, identify opportunities for collaboration, avoid duplication of funding and disseminate information towards national stakeholders;
- To identify outcomes of EU-funded projects of direct interest to national activities and offer demonstration possibilities to innovative solutions;

- To implement complementary measures to EU funding of projects, such as training, standardisation, technology transfer, deployment of innovations and recharging infrastructure contributing to accelerate the uptake of zero tailpipe emission road transport.

The involvement of Member States is organised on a voluntary basis. Several configurations of this "States Representative Group" could be planned according to the specific needs and could work in a two-way information exchange, with information from EU level to national authorities and from Member States level towards the European one.

5.6. - Partnership activities

The 2Zero Partnership is expected to make a significant contribution to the transition towards a carbon-neutral mobility system. Funded under the Horizon Europe programme, the 2Zero Partnership focus its activities around research and innovation in all areas involved in the transition towards carbon-neutrality, from low TRL (3-4) up to demonstration activities in real-life environments (TRL 6-7) and, up to TRL 8 where appropriate. This includes identifying, assessing, confirming and updating technical areas and topics where action is needed. Thanks to the involvement of different stakeholders (from industry to R&I, Member States and local authorities), the Partnership shall also foster training, the development of skill and reskill of workers; promote standardisation activities to enable the development of innovative infrastructures and support new business models and services, in cooperation with the "States Representative Group".

As illustrated in *Figure 13* below, the 2Zero Partnership:

- Provides inputs and advice to the EC services for activities that could contribute to achieve the objectives of the Partnership, in particular the identification of ambitious yet realistic priorities for research and innovation to be covered by EU funding.
- Delivers a roadmap identifying the research priorities in the coming years to achieve zero tailpipe emission solutions and carbon-neutrality by 2050. This roadmap shall be revised during the course of the Partnership to take into account advancements from research activities and identify new priorities.
- Monitors the advancements of research and innovation activities performed at a European level in this field and adjusts its recommendation according to the latest developments.
- Ensures close connection with the Pillars 1 and 3 of the Horizon Europe programme:
    - Pilar 1 – "**Excellent science**" aiming at reinforcing and extending the excellence of the Union's science base. The Partnership will consider knowledge generated at lower TRL (1-3) so that frontier research developments are taken up to the next level. This could include exchange of information with other funding schemes at an EU level (i.e. European Research Council or Marie Skłodowska Curie Actions).
    - The Partnership will support the dissemination of project results towards the Pilar 3 – "**Innovative Europe**" which will contribute to stimulating market-creating breakthroughs and eco-systems conducive to innovation. A particular attention will be paid to turning results from research and innovation projects into products; a particular link could be established with the European Innovation Council (EIC) to provide the necessary support to innovations with market creating potential.
- Aligns stakeholders along the priorities identified in the roadmap and support coordination of research efforts at national and regional levels in line with the Partnership objectives.

- Ensures good collaboration with other activities performed at a European level that will have an impact on the development of zero tailpipe emission mobility in Europe. That includes both a reinforced collaboration with other Partnerships (as described in Chapter 5.2) as well as better coordination and exchange of information with other funding programmes, as described in Chapter 5.3.
- Supports projects in putting forward the results from EU-funded projects towards relevant standardisation bodies.
- Builds close links with non-R&I activities, particularly to support the large-scale deployment of the innovations developed in the funded projects and cooperation with living labs.
- Ensures that the activities performed at European level and the outcomes of EU-funded research are both widely disseminated and exploited to/by the stakeholders across Europe.

Figure 13 - The 2Zero activities

To the best of its knowledge and capacity, the Partnership will also support:

- Advancement in the technological readiness of components, systems and solutions accelerating innovation;

- Standardisation activities by putting forward results from EU-funded projects to the standardisation bodies;
- The identification of future skills, support new training schemes and reskilling of workers;
- Exchange of information with activities performed at a national level;
- The involvement of and technology transfer towards SMEs;
- Reinforce the participation of stakeholders from EU-13 Member States in order to reduce the East-West innovation gap;
- Reinforce collaboration with non-European stakeholders and support the development of innovative clean mobility solutions in developing and emerging economies.

The calls for proposals published in 2Zero are following the standard rules of participation of Horizon Europe and no specific criteria (nor administrative or financial) shall restrain an organisation from submitting a project proposal for funding. Being a member of EGVIAfor2Zero is not a pre-requisite for selection for funding. The evaluation of the proposals submitted and projects selected is organised by the European Commission services and Executive Agency, in order to ensure fairness and independence.

The 2Zero Partnership is committed to operate on principles of openness and transparency. It is open for any stakeholder active in sectors which contribute to achieving the goals and objectives of the Partnership, including, but not limited to transport, energy and logistics.

The Association ensures a broad dissemination of results from funded projects; this is organised by different means:

- Sharing of information on the Partnership website and using other digital means (e.g. social media);
- Support projects in their communication and dissemination activities by offering them free of charge dissemination opportunities (publication of articles, information about events, etc.);
- Organisation of public events to disseminate outcomes from 2Zero-funded projects. These could be either specific workshops to investigate more in depth a particular research area or more general events or conferences to present a global picture of the latest achievements.

Funded projects will commit to publicise their activities, via websites and any other means that would seem appropriate.

6. Acknowledgment

Pillar 1: Vehicle technologies and vehicle propulsion solutions for BEV and FCEV, co-lead by:

- Ian FAYE*, Bosch*
- Roland UERLICH, *IKA-RWTH*

Pillar 2: Integration of battery electric vehicles into the energy system and related charging infrastructure, co-lead by:

- Christof SCHERNUS*, FEV*
- Evangelos KARFOPOULOS, *ICCS*

Pillar 3: Innovative concepts and services for the zero emission mobility of people and goods, co-lead by:

- Mats ROSENQUIST, *Volvo Group*
- Margriet VAN SCHIJNDEL, *TU Eindhoven*

Pillar 4: LCA approaches and circular economy aspects for sustainable and innovative road mobility solutions, co-lead by:

- Carsten WEBER, *Ford*
- Thilo BEIN, *Fraunhofer LBF*

7. Annex

Annex 1 - Areas for cooperation between 2Zero and other European Partnerships

Horizon Europe structure	Candidate Partnerships	Areas for cooperation
Climate, energy and mobility	European industrial battery value chain	Integration of modules and packs at vehicle level. Battery Management System.
	Clean Hydrogen	Building blocks integration (fuel cell system, on-board storage) at the vehicle level.
	CCAM	Improvement of the overall transport efficiency (traffic and vehicle levels). Improvement of logistics operations. Development of new mobility services.
	Driving Urban Transitions - DUT	Possibly items related to the 2Zero Pillar 3 “Innovative concepts and services for the zero tailpipe emission mobility of people and goods”.
	Clean Energy Transition	Possibly items related to the 2Zero Pillar 2 “Integration of BEV into the energy system and related charging infrastructure”.
Digital, Industry and Space	Chips-JU	Sensors. Actuators. SW/HW systems and platforms. Power electronics.
	Made in Europe	Advanced manufacturing. Advanced material for automotive applications. Robotics and digitalisation in manufacturing.
	Built4People	Retrofit of the existing infrastructure, particularly in buildings.

Table 2 - Overview of areas identified

Annex 2 - Overview of synergies identified between 2Zero and other EU-funded programmes

Programme	Purpose	Modalities
Connecting Europe Facility (CEF)	Enhance seamless integration of road transport in the infrastructure	Information exchange
EIB	Accelerate the transition to sustainable and green transport by financial support to overcome investments gaps	Information exchange
Structural Funds	Strengthen economic and social cohesion in the EU, particularly focusing on environmental and transport infrastructure for road transport	Information exchange

Table 3 - Overview of synergies identified

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