Towards zero emission road transport

Strategic Research and Innovation Agenda (SRIA)

Draft version V9 – 9th December 2020

Executive summary

If needed, to be updated before the final submission

The 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 develop a common vision and deliver a multi-stakeholders roadmap for a climate-neutral and clean road transport system. 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.

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 representing 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 EGVIA 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 7 years in the areas covered by the 2Zero partnership:

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

Several Working Group 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 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 Working Groups) 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]. EGVIA 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.
A specific meeting has been organised with the Member States on the 3rd of June to further detail their possible contribution to the governance of the 2Zero partnership.

[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)

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 the Communication, the Transport White Paper[8], revised in 2011, setting the ambition, shared by the 2Zero partnership, of realistic and achievable goals for a pathway to "*Halve the use of 'conventionally fuelled' cars in urban transport by 2030; phase them out in cities by 2050; achieve essentially CO_2-free city logistics in major urban centres by 2030*". In addition, as a complementary approach to the White Paper, the European Commission presented a Strategy for Low Emissions Mobility[9] and "Europe on the Move" in 2016, a set of legislative initiatives within the Mobility Packages, whilst the Strategic Transport Research and Innovation Agenda (STRIA[10]) of 2017 proposed research priorities along with measures for the deployment of innovative solutions, with particular emphasis on transport electrification and the use of alternative, clean and renewable fuels.
Aiming at improving the urban transport situation, making cities cleaner and more liveable, the European Commission published the Urban Mobility Package (UMP) in 2013, currently under revision. It included the Communication "Together toward competitive and resource-efficient urban mobility"[11], in which the EC has proposed a set of measures to include the scope of urban logistics, urban access regulations, road safety and urban ITS solutions. The package also includes Sustainable Urban Mobility Plans (SUMPs), wherein citizens, stakeholder engagement and changes in mobility behaviour are central. In line with this approach, the revised SUMP guidelines[12] have endorsed the approach of Low Emission Zones (LEZs) as one of the ways to curb local air pollution[13]. The number of LEZs is expected to grow considerably in the coming years[14]. The concept may include more ambition in the future, looking to Zero-Emissions Zones (ZEZs). ZEZs could become an enabling factor to encourage the integration

[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)
[10] https://ec.europa.eu/transport/sites/transport/files/swd20170223-transportresearchandinnovationtomobilitypackage.pdf
[11] 'Together toward competitive and resource-efficient urban mobility' (COM (2013) 913 final)
[12] https://www.eltis.org/sites/default/files/sump-guidelines-2019_mediumres.pdf
[13] Linking transport and health in SUMPS, Sept. 2019: https://www.eltis.org/sites/default/files/linking_transport_and_health_in_sumps_0.pdf
[14] Low-Emission Zones are a success -but they must now move to zero-emission mobility, Sept. 2019: https://www.transportenvironment.org/sites/te/files/publications/2019_09_Briefing_LEZ-ZEZ_final.pdf

of clean vehicles into the transport system. This concept includes the management of spaces and infrastructures in a more sustainable way, from an environmental but also economic and social points of view.
The European Commission will revise the TEN-T Regulation[15] and the Alternative Fuel Infrastructure Directive[16] to accelerate the deployment of zero and low-emission vehicles. Two new Commission proposals are expected in 2021 to update each legislative framework. The updated provisions are expected to provide an opportunity to accelerate the deployment of the recharging and refuelling infrastructure needed to support the transition towards a climate-neutral and zero tailpipe emission road transport, and, at the same time, to achieve full interoperability of the infrastructure. The regulatory framework and related targets might act as accelerators for the transition towards zero tailpipe emissions vehicles.

On the 11th December of 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 50% emissions reduction by 2030. The Green Deal is the EU integrated strategy to reduce GHG emissions, including those from road transport: it attempts to make environmental policy mainstream by bringing together and improving several existing policies, initiatives and funding programmes that are dedicated to addressing sustainability and climate change. It includes a variety of new proposals, such as reinforcing air pollutant emissions standards for combustion-engined vehicles, legislative options to boost the production and supply of alternative fuels in different transport modes, or a funding call to support the deployment of public recharging and refuelling points (as part of the alternative fuels infrastructure directive). Since making sustainability mainstream in all EU policies, the Green Deal also addresses research and innovation needs. Despite the significant improvements achieved over the past 10 years, particularly in road transport technology, the European Union is committed to going further and delivering on the Paris Agreement targets[17] "*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*". Transforming the energy and transport sectors, whilst preserving economic growth and strengthening the competitiveness of EU industry, will be one of the key challenges for the European Green Deal to succeed. In order to do so, a balanced approach between profound changes offering a new road mobility system and innovations, which have immediate impact on the transition towards zero emission, will be needed.

On the 9th of 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 Emissions (GHG) by 2030 of 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 effort.

The priority for EU funding concerning road transport will be centred on the support of 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

[15] https://ec.europa.eu/transport/themes/infrastructure/ten-t_en
[16] 'Directive 2014/94/EU on the deployment of alternative fuels infrastructure' (JO L307/1)
[17] https://ec.europa.eu/clima/policies/international/negotiations/paris_en

will continue to investigate all renewable energy carriers and zero-impact emission options – without EU funding support, as detailed in Chapter 3.3.
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 …), infrastructure and services, and will generate new types of jobs requiring new skills.

The CoVId-19 pandemic has had significant effects on the global economy, travelling habits, mobility and transportation 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 will take many forms, they will impact road transport in the short and longer term at different levels:

- **Economic level**: production has been slowed due to the lockdown, this will put many jobs at risk in the coming months and years. The sanitary crisis will hopefully soon be over but the economic crisis will hit the European Union in the coming years. A strong recovery package has already 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 current CoVId-19 pandemic may have a negative effect on the expected modal shift to public transport, with an unexpected reluctance to rely on and use public transportation, 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 demand for personal mobility[18]. Public transport systems may need to rethink, as physical distancing could no longer allow a density of up to four persons per square meter (e.g. in buses[19]) and may accept a maximum occupancy rate when respecting physical social distance rules[20]. "Active" modes of transport, such as walking or cycling, are becoming more and more attractive in the current situation 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. E-commerce is experiencing a big increase: this trend will be maintained in the after-pandemic most probably. This change in consumption channels is driving an increase in demand for parcel deliveries,

[18] 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/#
[19] Transformative Urban Mobility Initiative The new findings of the CoVId-19 in public transport 18 June 2020, looked up 26 July 2020, https://www.transformative-mobility.org/news/the-new-findings-of-the-covid-19-in-public-transport
[20] McKinsey & Company: "Restoring public transit amid CoVId-19: What European cities can learn from one another"; 5 June 2020, looked up 26 July 2020; https://www.mckinsey.com/industries/travel-logistics-and-transport-infrastructure/our-insights/restoring-public-transit-amid-covid-19-what-european-cities-can-learn-from-one-another

increasing the traffic of delivery vehicles. Additional potential impacts include: partial regionalisation of supply chains. This may increase regional freight transport, accelerate digitalization, resulting in a growing need for environmentally and socially responsible solutions and an acceleration towards shared and interconnected logistics networks based on low and zero emission transport solutions[21], which could speed up the process of adoption of zero emission solutions.

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%[22] 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.
- Urbanization will be another societal trend to be taken into account: by 2050, it is expected that more than 84% of the European citizens will live in urban areas[23]. 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.[24] Circular economy approaches need to be applied in the road transport sector, not only for sustainability reasons but also to reduce the dependency on raw and scarce materials.
- Europe needs 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[25]. 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 solutions are not suitable. To ensure climate neutrality, the use of carbon-neutral fuels should

[21] Migne, C., Cossu, P. Schurmans, H. Mika, L., Liesa, F. (2020). *CoVId-19: actions to prevent an ecological second wave in the Supply Chain.* ALICE (http://www.etp-logistics.eu/?p=3765)
[22] *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
[23] https://ec.europa.eu/knowledge4policy/foresight/topic/continuing-urbanisation/developments-and-forecasts-on-continuing-urbanisation_en
[24] Roadmap to Resource Efficient Europe, European Commission (COM(2011) 517 final)
[25] A Clean Planet for all (COM (2018) 773 final)

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.

With these trends and objectives in mind, the 2Zero partnership will need to investigate those different multi-sector R&I concepts and solutions that are necessary to achieve zero tailpipe emission road transport in urban, peri-urban and rural areas.

2.2 – Past achievements and the identification of gaps

The EGVI partnership has been recognised as a success, with clear outcomes and concrete achievements. It has been found to have had a positive impact on job creation and skills, contributing to saving time in performing research activities whilst structuring the whole value chain, and coordinating activities to avoid duplication of efforts. EGVI helped create significant interactions between different stakeholders, links to other partnerships and European actions and instruments, resulting in a pan-European network.[26]
The EGVI 10 years' impact assessment[27], published in 2019, highlighted the many benefits brought by the partnership at a European level:
- Helping achieve CO_2 emission 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.

Many promising results have been achieved in Green Cars and Green Vehicles by 186 funded projects in the following areas:
- Vehicle hybridisation & alternative fuelled / internal combustion engine (ICE) powertrains
- Electric Vehicles' (EVs') integration into the grid and transport system
- Vehicle concept and design
- Batteries
- Low emission ICE powertrains
- Energy management
- EV drivetrains
- Modelling and testing
- Emission measurement
- Powertrain control
- Weight reduction
- Aerodynamic trucks.

Despite many successes, potential for improvements have been identified and has been taken into account in the definition of the 2Zero partnership. In particular, 2Zero will make efforts to improve the representativeness of the complete value chain, increase Small and Medium Sized

[26] Mid-term review of the contractual Public Private Partnerships (cPPPs) under Horizon 2020 (SWD (2017) 220 final)
[27] EGVI 10 years impact assessment (https://egvi.eu/wp-content/uploads/2019/04/Impact-Assessment-2019-digital-version-1.pdf)

Enterprises (SME) and EU-13 stakeholder participation, and propose a wider debate and update of the roadmaps.

A gap analysis is currently under finalisation as part of the FUTURE-RADAR[28] funded project, mostly focusing on the assessment of the coverage of R&I areas identified in the joint ERTRAC, EPoSS and ETIP-SNET roadmap for "Electrification of Road Transport". The aim of this roadmap, originally published in 2012 and updated in 2017, is to overcome the biggest obstacles for the user acceptance of EV, which are high price, inconvenient and slow charging and limited range, thanks to the following four big initiatives:

- Operation system dependent EVs in the urban environment
- User-friendly affordable EV passenger car and infrastructure
- No-compromise electric urban bus system
- Sustainable electrified long-distance trucks and coaches.

In summary, the analysis of the roadmap reveals that light and conventional passenger cars predominated in research and development, although buses were also considered. These vehicle types have been proposed as a good starting point 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 reveals 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. In more detail, the analysis revealed the following for each of the big initiatives:

- For the first initiative "Operation system dependent EVs in the urban environment", topics not well covered included automated and high-power charging, sharing platforms, enabler for Mobility as a Service (MaaS) business models and safe parking for lightweight vehicles.
- In the second initiative "User-friendly affordable EV passenger car and infrastructure" The topics thermal management as well as automated parking were not in focus. With regard to the analysed trends over time, certain topics, such as powertrain optimization, battery development, sustainable recycling and fast wireless charging, were not covered in the first projects of Horizon 2020 but have been a focus of most recent calls One of the highlights from the analysis is the lack of the topic sustainable recycling, which remains an important and unsolved problem, especially for battery cells.
- According to the analysis of the third initiative, "No-compromise electric urban bus system", the research and development for the urban bus system was, in comparison to the first two initiatives, less covered by projects. Some important aspects, such as automation of charging operations and multimodal platooning, were not in the focus of the projects.
- Long range and a viable payload are crucial for the electrification of heavy-duty vehicles. The analysis of the fourth initiative, "Sustainable electrified long-distance trucks and coaches", showed that alternative drivetrain concepts were under development, as were the development of business models in order to gain certainty regarding to economic use cases. Currently national project activities are testing the deployment of electric road systems. Research and development efforts for the topic of heavy-duty [29]need to assess what would be the most appropriate alternatives according to each specific use cases.

[28] https://egvi.eu/what-we-do/support-action/
[29] https://www.fch.europa.eu/

Whereas thermal management has not been a special focus of R&I activities carried out under the FCH II JU, several projects of the EGVI partnership have included the combined thermal management of cabin and powertrain in BEV.

Although zero tailpipe emission technologies are available in the market, in most vehicle segments and at a more and more acceptable range, their initial purchase price within the current business models, the insufficient and uneven distribution of the recharging infrastructure and a lack of services are preventing faster deployment. Despite increasing momentum, zero tailpipe emission vehicles are still currently viewed as a fast growing niche market in most countries, whilst they have achieved double digit sales figures in some markets. 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 order to increase the energy efficiency and circularity of components and of 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 and, especially, encompass the entire cradle to grave scope, as well as to get access to real data or use coherent system boundaries and methods, which consequently 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.

2.3 - Problems definition

Several technical advancements have been achieved in the field of 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:

- End users remain reluctant to switch to zero tailpipe emission vehicles
  - Potential customers may be discouraged to make the change and invest in an EV if the initial purchase price and 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 cities with low private parking availability as well as for strategically located fast charging options.
  - In order to increase the user acceptance of EVs, the charging infrastructure needs to be improved and the number of charging spots in Europe needs to be increased.
  - Users may have usage models where they doubt the reliability of EVs during different seasons in 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 ….) that is 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.
  - Efforts towards the interoperability of solutions should be reinforced to increase user acceptance.
  - The variety of vehicle architectures and configuration should match customer mobility demands.
  - Transparency of recharging, standardisation of recharging modes and regulations to harmonize the system will be needed to improve user experience.
  - Long charging times may, depending on the application, not meet the user's expectations and hence hinder customers building trust in the new mobility system.
- 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 …)
- Individual research activities on components and sub-systems have been performed but their interaction and integration has not been sufficiently addressed at a system level 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, scrapping, second life …).
- 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/combination of type of vehicles 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 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 will be 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.

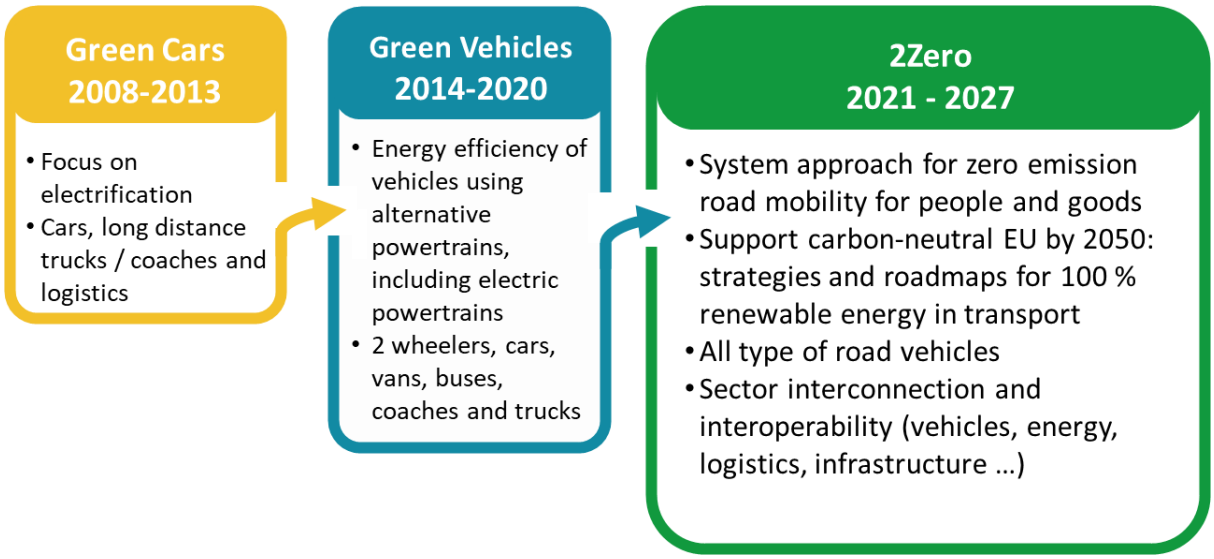


Figure 1 - From the European Green Cars Initiative to the 2Zero partnership: the evolution of the partnership

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.

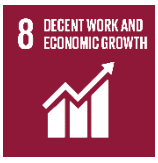
The results of R&I under the 2Zero partnership will accelerate the transition towards a climate-neutral and clean road transport system. In Horizon Europe, 2Zero will be allocated in Pillar 2 "Global challenges and industrial competitiveness of Europe" and in the Cluster 5 "Climate, Energy and Mobility", 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 optimizing 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[30] (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



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"

The improvements in production processes and materials will also support the achievements of SDG12 on "Responsible consumption and production" (energy efficient and environmentally-friendly production processes, such as sustainable use of water, increased use

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

of secondary or bio-based materials, fit-for-purpose approaches as well as increased use of raw material coming from recycled sources …).

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.

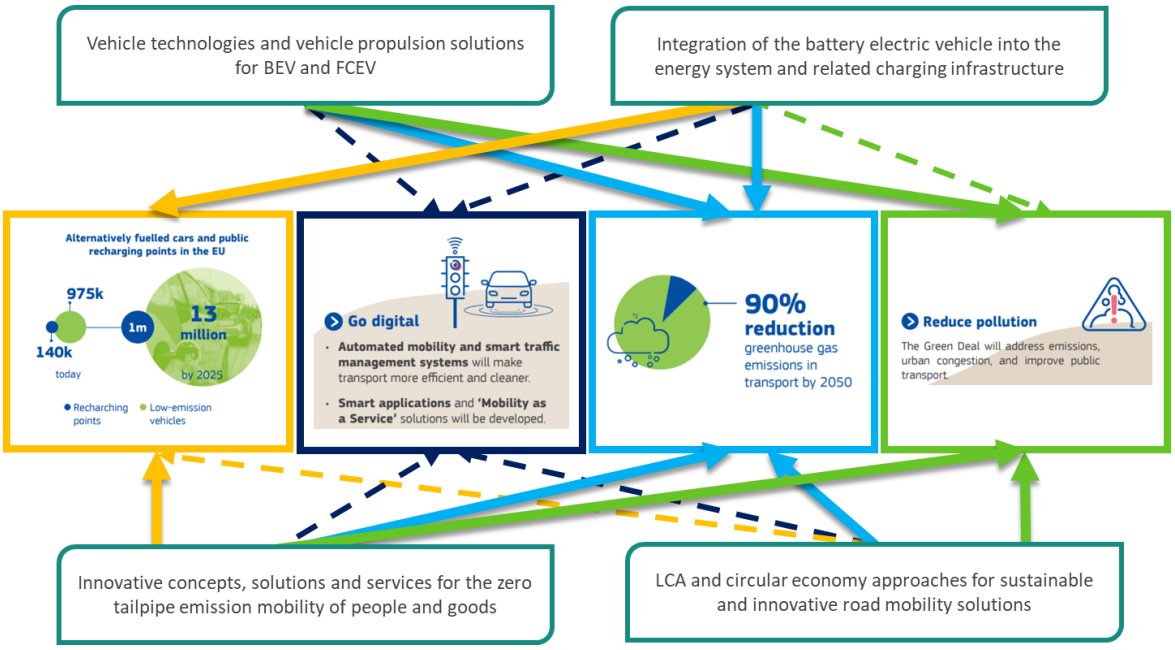


Figure 2 - Contribution of the 2Zero partnership to the Green Deal targets

The 2Zero partnership will address 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 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 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 capitalizing 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 ecosystem.

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

The list of objectives and related KPIs is still under definition – further modifications will be implemented before the final version of the document.

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 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;
- 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 ecosystem;
- 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:

- 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;
- A number of patent applications 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.

The table below aims to present, in a concise way, the outcomes that could reasonably be expected from the 2Zero partnership. As 2Zero will take a system approach, interconnections between the different items 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 …).
SMART objectives will be defined, along with methods for the monitoring of such objectives, that are aligned with the scope and funding of the 2Zero partnership. This exercise will be part of the SRIA preparation (see section on the SRIA preparation below), leading to possible modifications in the table.
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 …).

General Objectives	Specific Objectives	Measurable expected outcomes by 2030
Contribute to Europe having the first carbon-neutral road transport system by 2050	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 technologies and solutions to reduce non-powertrain related emissions and transport related noise Develop affordable, user-friendly charging infrastructure concepts and technologies that include vehicle and grid interaction	CO_2 emissions reduction from road transport Air quality improvement in EU urban areas and a forecast thereof Number of zero tailpipe emission vehicles on the market by 2030 and a longer-term forecast Number of demonstrated zero tailpipe emission heavy-duty vehicles on the road by 2030 and a longer-term forecast of their uptake Number of (public) charging stations available in the EU by 2030 and planning for further deployment
Technology leadership supporting economic growth and job creation all over Europe	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 technologies and solutions to reduce non-powertrain related emissions and road transport related noise Support the development of life-cycle assessment analysis	Share of European zero tailpipe emission and zero emission impact vehicles in the world market by 2030. Number of zero tailpipe emission vehicle models available by 2030, both for passenger cars and for heavy-duty vehicles Improvement of the user acceptance, and affordability of zero tailpipe emission vehicles Number of affordable zero tailpipe vehicles tailored for

	tools and skills for the effective design, assessment and deployment of innovative concepts in products/services in a circular economy context	urban use (focusing on A, B and C segments and below) Reduction of development and production time and cost LCA used as a standard analysis in science and industry (increase of LCA-experts in research centres / companies) Number of new business models (involving all or several of the following stakeholders: aggregators, resellers, car fleet owners, dedicated market operators …
Ensure European competitiveness thanks to solutions for an integrated, carbon-neutral, road transport ecosystem	Develop affordable, user-friendly charging infrastructure concepts and technologies that include vehicle and grid interaction	Number of (public) charging stations available in the EU by 2030, including fast charging stations and low power charging Increase of Renewable Energy Sources (RES) hosting capacity of local distribution thanks to electric mobility Deployment of V2G technologies (% of models being V2G-enabled) Improvement of the integration of EVs into the grid (and related improvement on the load curve management) Demonstration of zero tailpipe emission logistics at a similar cost level to those with conventional solutions
Improve the quality of life of EU citizens and ensure mobility for people and goods	Demonstrate innovative use cases for the integration of zero tailpipe emission vehicles and infrastructure concepts for the road mobility of people and goods Develop technologies and solutions to reduce non-powertrain related emissions and transport related noise	Air quality improvement in EU urban areas Number of cities and regions implementing integrated deployment strategies for boosting e-mobility as project follow-ups Number of cities and regions equipped with decision-making

		tools and stakeholder engagement practices aimed at boosting e-mobility Number of cities and regions implementing and deploying eMaaS solutions Number of (public and private) transport operators implementing new business models

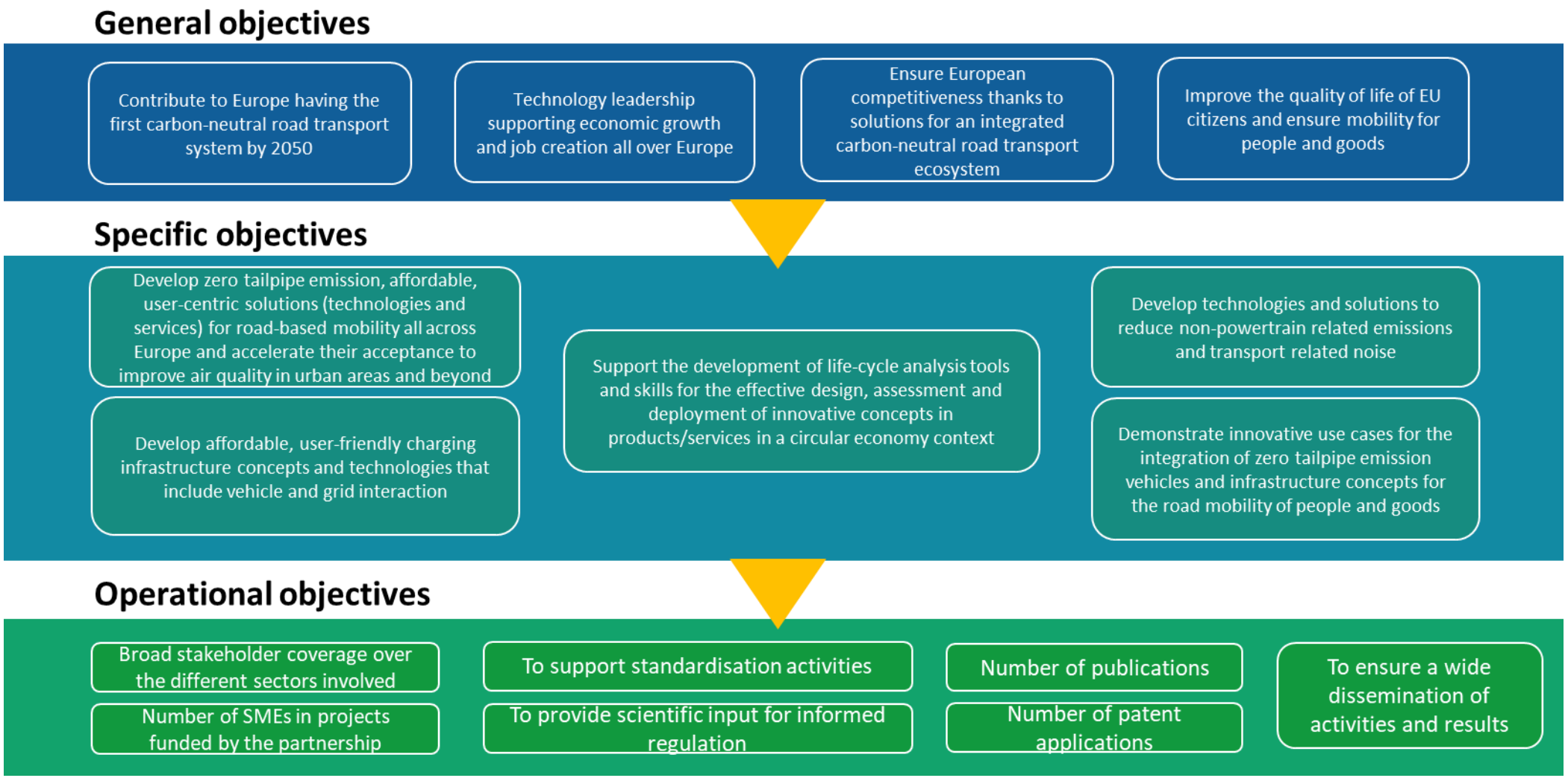


Figure 3 – The hierarchy of objectives of the 2Zero partnership

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 (see Figure 4), 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 /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:

1. **Vehicle technologies and vehicle propulsion solutions for BEV and FCEV;**
2. **Integration of battery electric vehicles into the energy system and related charging infrastructure;**
3. **Innovative concepts, solutions and services for the zero tailpipe emission mobility of people and goods;**
4. **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 …). 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 …), the cost of the proposed solutions is a key parameter and will be addressed all along the process (development, manufacturing …).

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/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 optimization 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

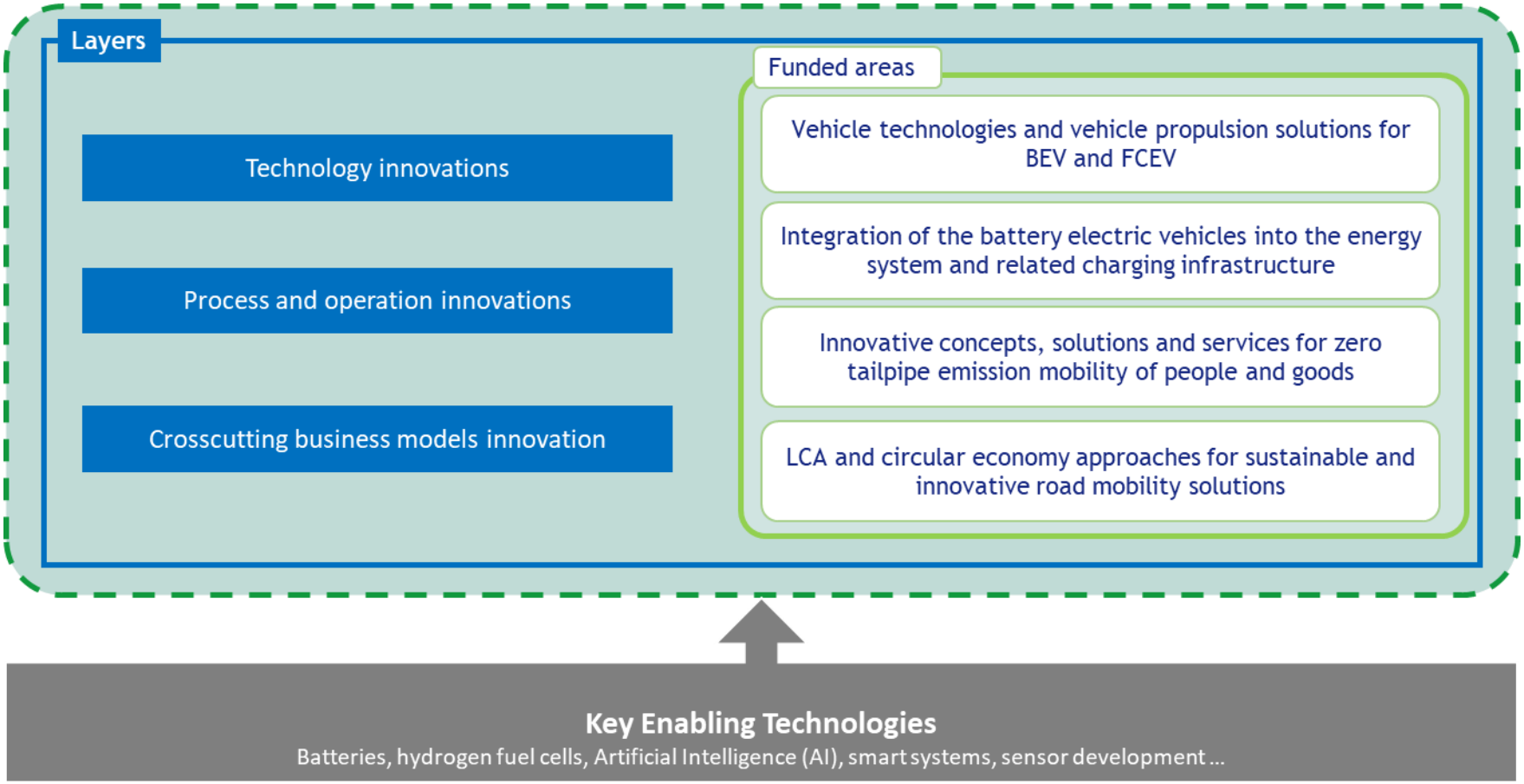


Figure 4 - 2Zero partnership funded activities and their interactions

4.1 Vehicle technologies and vehicle propulsion solutions for BEV and FCEV

R&I funding pillar for vehicle technologies and vehicle propulsion solutions are 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.
The final success of new concepts depends on fulfilling the needs, including TCO, and expectations/preferences (including the perceived preferences) of users and operators. This is a prerequisite to accelerating the uptake of zero tailpipe emission vehicles.
The specific BEV and FCEV technologies envisaged are, by definition, inherently "clean" (no tailpipe emissions). Some minor issues, in comparison to combustion-engined vehicles (thanks to the elimination of clutches and the extensive use of regenerative braking), remain within friction systems (e.g. tyres and brakes) and electromagnetic compatibility (EMC) and noise.

a. Specific challenge 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 optimization 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 vehicle concepts that are both efficient in operation and efficient in the use of resources, and that are acceptable for mainstream users through:
  - Cost parity for comparable user requirements
  - Satisfying user's priority expectations and needs.
- To develop vehicle architectures, powertrain subsystems and components, with optimized requirements hence reduced costs, is the main issue to reach EV initial cost parity with conventional vehicles by 2030.
- 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 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, in order to maximize 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, and especially the future needs of users, whilst considering how new mobility models can

influence these interests and user acceptance.

- To determine how to quantify commonly accepted and robust usability and utilization rates, in order to support decisions on engineering trade-offs that are a vital part of the vehicle development process.
- The system approach entails 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 that 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 that can be up to 30% lower the peak price.

Enhancing reliability and safety

- To satisfy user's needs during the design optimization 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 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 after 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 and low-cost powertrain components, subsystems and systems, capable of slow to ultra fast charging:
    - Battery packs and systems
    - Electric motors and gearboxes
    - Power electronics.
  - Ancillaries, energy management (especially for heating and cooling systems for cabin and components) and connectivity, in cooperation with cooperative, connected automated mobility (CCAM), to access data relevant for optimising systems and their integration (architecture) as well as for maintenance.
  - Technologies for efficient, slow and fast charging whilst maximising battery life.
  - Specific zero tailpipe emission vehicle safety and emissions aspects (tyres, brakes, usage profile optimisation to maximise efficiency and recuperation whilst minimising particle 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 users' and operators' 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 prioritized 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 necessary for vehicle motion optimisation and improved driver support.

- To create and validate tools for accelerated product development
  - Digitalisation of design and production processes, which accelerates the uptake of advanced technologies for zero tailpipe emission vehicles.
  - Enabling modular, flexible and individualised optimal concepts.
  - Virtual verification, validation (testing), comparison and scaling-up of zero tailpipe emission vehicles themselves and 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

- Accelerating the 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 enabled to adapt and adopt new technological innovation twice as fast as current development and industrialization 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 …), as well the diversity of world-wide markets, will lead to much more various user needs and mobility models, so that a pure conversion of ICE-based vehicles becomes no longer economically viable. Instead, a more optimal design will become 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. At the same time, modularity and scalability must be taken into account, based on the already practiced, common parts strategy to reduce costs. 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 innovations are 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 active 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 optimized balance of all demanded targets, will have an impact on vehicle architecture

and vice-versa.
Conceptual vehicle design and advancements in vehicle systems involve both the operational aspects as well as the physical design characteristics (such as vehicle volume, weight, energy-efficient components and user-centric needs). 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 onboard space management ….) in order to optimize the TCO attractiveness for both, private vehicle owners and fleet operators: 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 to low density areas with low availability of charging infrastructure) change and evolve. These result 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, they 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 new 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.

Zero emission Heavy-Duty Vehicle

Priority action

Given that trade and freight development forecasts suggest that global freight demand might triple by the end of 2050, it becomes clear that addressing the road freight transport emissions should be a top priority.
Battery and Hydrogen Fuel Cells (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 mainly for short to medium range mission; and FC (or combined BEV-FC) for long range and where high payloads are required, because of the relatively high energy density of hydrogen (e.g. compressed, liquid or any other storage technologies (metal or complex hydrides)) in comparison with state-of-the-art battery technologies. In addition, the implementation of advanced vehicle network architectures shall enable the development and optimization of powertrain and holistic energy management systems, in terms of performance and efficiency (also including energy consumers such as refrigerated cargo compartments, hotel loads and other ancillaries).
R&I actions shall cover both battery electric and Hydrogen Fuel Cells (FC) electric solutions.

BEV HD vehicles

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

This can support 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 BEV HD. Prioritizing the use of digital twins, as a means to optimise the balance between topology, sizing, and control are needed.
High efficiency BEV HD vehicles shall maximize the driving range between recharging events for the city and regional transport of people and goods, considering opportunity charging and specific cases depending on fleet operations. Synergies with light-duty vehicles, for last mile delivery, and HD service vehicles can be considered.

FCEV HD vehicles

Building on the synergies with the Clean Hydrogen for Europe Partnership (CHE), the FCEV activities in 2Zero will focus on integrating the storage and fuel cell systems, developed in that 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 energy split management and the right sizing of fuel cell systems, energy storage and powertrain components, especially the size of the battery in comparison to the fuel cell stack size, shall be considered. To increase the lifetime, the power, performance and degradation of the FC caused by thermal issues (avoiding "loss of heat rejection") shall be addressed. 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 is to reduce weight; at the same time, the added weight of the battery system is significant and, over the coming years, will not be completely compensated by advances in battery technologies. Correspondingly, a decisive factor will be identifying the best compromise between vehicle range and battery gravimetric and volumetric energy density (and specific power), 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 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, the pressing need to minimise weight together with the opportunity 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, recyclable 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 that do not introduce compromises in terms of safety and performance (including noise and vibration).

Digitalization 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 right from the beginning, to shorten the development time, to bring zero-emission solutions sooner to market, to reduce costs at increased quality, (functional) safety and reliability levels, whilst ensuring a desired vehicle range and, especially, considering diverse user needs, all together increasing the acceptance of zero-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 optimization 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., lightweight potential and to optimize 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, maximizing 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 materials 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 usage towards multi-purpose mission execution with optimized vehicles (possibly combining passengers, goods and professional needs) will have an important impact on vehicle operations, control, energy use and maintenance. Further optimization 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 maximize 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 pattern and driver performance, vehicle control strategies (e.g. predictive eco-routing, eco-driving ….), 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 ….), lightweighting and cost reduction, where modular powertrain platform concepts with lightweight and integrated powertrain components or subsystems could play a key role due to their flexibility, but at the same time tackling the challenge of minimizing "overhead" required for interfacing. 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 and integration concepts for the next generation of 2Zero vehicles. The biggest challenge here is identifying the solutions that can transition rapidly from modular to integrated systems as the market uptake and, accordingly, the pressure to reduce cost for large series applications increases.

To overcome these challenges for the current powertrains, to improve and optimize 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 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 and GaN), and their control systems for the next vehicle powertrain generations (with different voltage levels, e.g. 48V for light vehicles, 400V, 800V and higher), present further integration challenges. They are the right direction towards more energy-efficient powertrains with high performance and reliability.

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 (kWh/l or kWh/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 standardize modular battery modules and systems in the past were not successful because of differing vehicle platform requirements (exclusive battery vehicle platforms vs. ICE-shared platforms). The assessment of the degree of standardization, for the best trade-off between integration versus modularity, is required to achieve cost reduction as well as OEMs acceptance. Minimizing 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 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 optimized 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 optimizing the overall battery system.

Thermal management

Thermal management covers fields from cabin temperature management (heating and cooling) to component thermal effects control (heating and cooling), 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). This is a new 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 to be cooled (e-motor,

power electronics, battery, chargers, fuel cells and components ….) 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, with longer lifetimes, highly compact, integrated and lower cost (less demanding temperature running conditions). This will also contribute to fast charging, enhancing efficiency and the thermal conditions for battery 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.

FCEV will also require dedicated activities. The operating temperature impacts directly the fuel cell performance and state of health, thus needs to be monitored and managed. Currently, thermal management is an issue related to the integration of FC systems into heavy-duty vehicles, as previously mentioned, because of conventional radiator dimensioning, as a result of the low fuel-cell operating temperature and the higher heat rejection in the coolant, which makes dissipation of the heat losses in the tight vehicle space available a huge challenge. Besides re-dimensioning and optimisation of the vehicle cooling system, a possible solution to be implemented, possibly in collaboration with Clean Hydrogen Europe (CHE), is to operate the FC system at higher temperatures (with non-negligible impact on the membrane material selection and overall durability). 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).

For BEVs, the thermal management of the powertrain is inherently included in the challenges, a particular emphasis is given already for cabin climatization 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.

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 exclusive service provider, through soft or hardware at the charging points, linked to the technologies chosen by the vehicle manufacturer, should be avoided, so as to avoid creating distortions in 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. In any way, 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 and 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 by shorter charging stops.
- For contract based charging and related payments, ensure that according 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 like e.g. target state of charge (SoC) at a target time for 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 health innocuousness, 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 vandalism. 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

In general, 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 which needs 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 (HLC) on top of the actual XL category. An HLC tyre of

a given size will, hence, undergo 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, minimizing 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 vaporize 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 optimized 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 full battery, i.e. smart charging on 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. For HDV FCEVs, R&I should focus on the crash safety of the energy storage and supply systems on-board the vehicles, taking into consideration future package and structural integration concepts. Moreover, the use of hydrogen raises subjective safety concerns which are not always fact-based. The extent to which this may be a barrier to societal acceptance needs to be investigated and, if necessary, be addressed by the development of evidence-based communication.

The post-crash safety of electric vehicles has not been an important focus of European research either, R&I is needed on innovative fire extinguishing media, systems and improved extinction procedures for batteries. 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 EU funding

Hydrogen ICE

One of the key challenges for hydrogen ICE 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%; once the challenges are addressed, this technology offers a cost-effective solution for decarbonization of the transport sector, thus being attractive for customers. The scope is to:

- Develop solutions to maximize 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 application, being complementary to other zero tailpipe emission technologies whilst minimizing TCO and enhancing customer experience. Light vehicles, mainly in the heavier segments (e.g. SUVs and LCV), 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 (like NO_x, unburned hydrogen and nanoparticles).
- Develop, in parallel, solutions for retrofitting engines to accelerate decarbonization of existing fleets.
- Get advantages through reusing existing footprints and skills, with positive 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 hybridization/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 the safety.
- A second usage stream would also benefit the deployment of hydrogen refilling infrastructure.

PHEV (also with e-fuels and H_2)

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 ….) to minimize purchase price, make the TCO attractive for customers, optimize the range in pure electric mode, minimize combustion mode usage (hybrid mode) and enhance the customer experience.
- ICE and electrified components should be highly integrated to reduce costs and

maximize 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 the 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)

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 work packages of Horizon Europe, such as:

- Develop new/sustainable materials to replace petrol-based polymers used in tyre composition (to improve CO_2 impact measured by LCA, aligned with the 4th R&I Pillar).
- Understand the emissions impact (particulate matter and noise) and develop solutions (tyres and brakes) to improve/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).

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, paralleling the growth of EV sales, and become a seamless process: easy, available at any time, whilst charging durations should be responsive to the user's needs.
- New technological developments, such as smart charging and vehicle-to-grid (V2G) solutions, will need to be progressively implemented, 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 ecosystem with an open architecture.
- 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 should be ensured.

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) require 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 is addressing 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 to 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 suit best 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 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. 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. Building retrofit in urban areas, including both Multi-Family Houses and Single-Family Houses, can provide charging stations using renewable sources embedded into the built environment.
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[31]. 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 …), whilst at the same time reducing the need for additional energy distribution infrastructures. 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, e-bikes demand at the same time that share energy resources with functioning infrastructures, and commercial and recreational areas.

A special attention should be given to include in the designs of charging infrastructure the special needs of electric L-category vehicles[32] for passenger and goods that are strong candidates for effective widespread of electromobility in cities. The standards and systems for this vehicles 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:

- 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 faced to pollution (optical, noise, electromagnetic fields …).
- Whilst wireless dynamic charging (infrastructure embedded in the road) minimises the visual impact on the surrounding area, there are still relevant issues regarding power transfer or installation costs that prevent a widespread deployment for BEV users. Technologies are already being tried out but extensive research work is still needed to bring them to commercial level whilst ensuring interoperability and 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.

[31] Mckinsey and Company (2014). Electric vehicles in Europe: Gearing up for a new phase?, April 2014 | Report
[32] 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.

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 in to the charging point).

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 enhance BEV penetration and to support the energy transition objectives.

Boosting 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. In consequence, 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.

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[33]:

- improved utilization 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, 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 smart charging adoption 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.

Vehicle-to-grid (V2G) is a technology that enables to push back 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

[33] Smart charging and electricity system, by the French TSO, published in May 2019, https://www.rte-france.com/sites/default/files/electromobilite_synthese_9.pdf

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. Today only Japanese technology CHADEMO offers mature bi-directional charging.
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 and hence the aggregation function is performed either directly by the OEMs, or by parties (aggregators) linked to the OEMs. The role and the costs / benefits for the EV owner need to be better clarified, particularly on his / her 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 and capitalizing 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 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 vehicles is plugged in. A better understanding of different use-cases and the formulation of best-case scenarios is required.

Fast charging

On the technical level, reliable fast charging solutions are available for light vehicles, whilst for some categories of vehicles they are still in the development phase and need more R&I, particularly to increase the maximum charging power, without compromising the BEV equipment and battery lifetime during the charging process.
A 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.
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 fast 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, a 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 picking up and playing its role in the energy transition strategy. End-to-end communication compatibility along the whole service chain is needed to ensure an effective and user-friendly experience.
Information on 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 speeds (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 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 economic level of security of electric mobility for grid failure events (e.g. maintain 50% electric mobility for 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 generate 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, 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. Cybersecurity is a key issue regarding end-to-end communication chain 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 unauthorized 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 utilizing 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), EMSP, explore charging infrastructure schemes that may be procured by the agglomerations/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 operation 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.
- For buildings:
  - Develop private home smart charging stations: optimize and coordinate the BEV charging within different private home facilities, including other type of energy storage system (static battery, heat …). The end-user is protected by electricity supply provisions whilst charging at home, and can choose an aggregator different than the electricity supplier.
  - 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 optimization 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 …).
- 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 ….

- Investigate trading / pricing / 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:
  - 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 …).
  - 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 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 of 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 …) 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 the minimum disruption. R&I should concentrate, as a priority, on delivering solutions that will minimize 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 and services, roadways …

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 BEVs falls within the enabling technologies that can play an active role in balancing, stabilizing 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, extending the family of solutions available that include non-OEMs providers.
- 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/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 vehicles 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 routesand 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 of 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 optimization 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 optimization 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 optimization 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, time of charge and level of charge …) and at the same time supports solutions for higher utilization of the interconnecting 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 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.

Fast high power charging

Smart high-power / fast charging facilities and accurate Artificial Intelligence (AI) forecasting techniques are required to pave the way to the high penetration of passenger BEVs and electric MHDV in the mobility of passengers and goods system. An efficient very high-power / fast charging infrastructure will be required for passenger and MHDV, to minimize 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, utilizing 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 optimization 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 optimization 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 fast and high power charging infrastructure (service centres, depot, logistics hubs and on highways), offering planning options to the developers of the targeted infrastructure.
- Design and propose tests for fast and 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 / fast charging.
- Specifically, for the MHDV category, there is a technical challenge to transition from 150kW to 800kW–1 MW charging systems, to decrease charging time for heavy-duty vehicles from 9h currently to less than 45min. by 2025.

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

It is key to consider the user[34], 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. Hence, this chapter focus on user centric innovative concepts, solutions and services for the zero-tailpipe emission road mobility and logistics. It is essential to complement vehicle concepts, technologies and propulsion systems development (Chapter 4.1) and the integration with the charging infrastructure and the energy system (Chapter 4.2) with user-centric usage models, operations and services that facilitate zero tailpipe emission vehicles adoption. The concepts and solutions developed shall follow a system approach, with the integration of vehicles and infrastructure into operations and services around the user needs.

Zero tailpipe emission vehicles are more and more available in the market, with very competitive TCO[35] and performance. However, their deployment is not uniform across Europe: the 2Zero partnership needs to bring solutions to accelerate the market uptake and allow the transition of the whole continent towards zero-emission mobility in an harmonized way, at scale.

Concerning public transport and shared mobility, zero emission buses are today operating in several cities in each country in Europe, the fleet renewal towards zero emission solution is implemented, even if at different speeds in different European countries. In addition, more importantly, not every operation can be covered today, by the existing solutions, in an affordable way. Regarding shared and on-demand zero emission mobility solutions, some implementations, mostly in the form of tests, are appearing, spreading through European cities.

The situation for freight transport and logistics is specific because of the limited availability of competitive zero tailpipe solutions for some segments (e.g. HDV) and access to proper charging / refuelling facilities to ensure smooth operations. Currently, the TCO[36], the lack of infrastructure, the range and the performance of vehicles (i.e. payload, managing slopes, operational speed …) are preventing a large-scale adoption in many segments since current solutions do not match logistics operational and business models.

Concepts, solutions and services for the future mobility and logistics, involving zero tailpipe emission vehicles and charging / refuelling infrastructure for which performance and socio-economic benefits are demonstrated, need to be formed, analysed and integrated. As zero tailpipe emission vehicles' operational and maintenance costs are lower compared to conventional vehicles (BEV in particular), the TCO is favourable in use cases with an intense usage. Stakeholders co-creation (including users), collaborative and shared approaches to usage

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[34] User refers to both people and commercial vehicles using companies.

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

[36] TCO 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 maximizing 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.

(vehicles and infrastructures), shared mobility, the Physical Internet[37], mixed cargo and passenger concepts, e-mobility hubs, multipurpose modular vehicles / infrastructure / swappable bodies, and shared charging schemes are potential enablers to accelerate the transition to zero tailpipe emission road transport. Additionally, avoiding congestion, broader operating time windows (e.g. off peak / night deliveries for freight or high frequency and capacity 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 (develop, test, define requirements and develop again) is proposed, so the current and future capabilities of zero tailpipe emission vehicles are considered, managing the transition in a flexible and cost-effective way, by developing user-centric future proof solutions for people and goods. This iterative approach includes feedback loops, in terms of user needs and requirements collection towards 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 harmonized solutions that can create impact at scale.

a. Specific challenge 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 the mobility and logistics system. The following different aspects need to be considered:
Zero emission zones started with cities and are expanding to broader areas[38] to answer societal needs (health and environment) but these require substantial adaptation from end users, mobility and logistics operators in order to perform their activities.
The mobility and logistics landscape is big but fragmented due to the large number of different stakeholders involved: a wide range of scenarios / use cases needs to be addressed for people (collective / individual / shared & urban / peri-urban /long haul and rural) and goods (long haul, regional and urban, with different type of flows addressed: waste, construction, services, parcel, retail stores …).
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 in the mobility and logistics system(s):

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

[38] 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

- Achieve a sound prioritization of scenarios / use cases to be addressed. The challenge is to prioritize use cases to accelerate adoption at scale (e.g. focus on feasibility - TRL 6-7 and beyond - and impact).
- Identify and capture actual user needs and use cases, translating them into workable requirements for the development of vehicle concepts and charging infrastructure. The challenge is to apply a user-centric approach for the strategic planning and definition of requirements and usage models, translating them in workable concepts, solutions and services for the vehicle and infrastructure development, as described in Chapters 4.1 and 4.2.
- Adoption of zero tailpipe emission solutions in public and shared passenger mobility is growing but still it does not cover all operations and services. Today the adoption of zero emission solutions in road public transport and shared mobility is growing as the deployment of zero tailpipe emission urban bus technologies is accelerating in European cities. However, their adoption still does not cover all the operations and services that can help cities to reduce emissions and noise pollution to the expected levels.
- Overcome the performance and range trade-offs of zero emissions vehicles for freight applications. The challenge is to develop concepts, solutions and usage models considering current and future capabilities, performance (payload, power to manage slopes, optimal operational speed) and the range of zero tailpipe solutions.
- Lack of operational models and tools to support decision makers, fleet managers and drivers in order to manage the capabilities and constraints of zero tailpipe emission vehicles. The introduction of zero tailpipe emission vehicles, such as electric bus fleets[39], small trucks and vans, cars and L-category vehicles, is gaining momentum. However, there is a lack of managerial tools for decision makers, fleet owners and managers. Additionally, specific skills and user behaviours need to be addressed.

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 need to be addressed, such that zero tailpipe emission vehicles are affordable and usable in a wider range of applications. The objective is to leverage the integrated system approach (i.e. 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) in connected, shared and on-demand mobility and logistics networks.
- Complementary to the above, to demonstrate and validate zero emission fleets in high frequency and high capacity bus lines as well as high demand freight transport corridors.
- Test and learn from use cases in order to identify and overcome adoption barriers: operational (vehicle performance, integration with charging infrastructure ...) 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

[39] Zero Emission Urban Bus System (ZeEUS) project demonstrations have proved to prevent 3.273 tons of CO_2 emissions.

policy recommendations and regulatory frameworks following the innovation principle[40], 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 vehicles suitable to all users' requirements, whilst supporting their uptake and deployment in cities, regions[41] 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 (e.g. re-thinking usage models to get the same results, whilst using less and zero emissions resources). 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[42].
- A broad real-life test and demonstration portfolio use cases, applications and solutions for zero emissions 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.

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

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

[42] 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*

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 ...)
- 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 may be considered in demonstrations.

c.1 – receiving EU funding

Zero tailpipe emission vehicles integration into the road mobility and logistics systems

Action 1 – Road mobility for people & logistics systems: pathways towards zero emission.

This action details the requirements and capacity building to accelerate the integration and adoption of zero tailpipe emission vehicles, including integrated strategies and solutions (technological and non-technological).

A sustainable and future-proof[43] zero emission transport system needs to bring clarity to the different stakeholders involved and build trust for future investments. This will be approached through three main phases, which will be complementary and feed each other: 1. **Identification and direction / priority setting, 2. Development and capacity building** and **3. Integration, evaluation, assessment and recommendations.**

1. Define zero-emission tailpipe emission vehicles adoption and development scenarios, strategies and pathways towards 2030, 2040 and 2050 (direction & priority setting)

The first step will focus on the 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 on-going works, incorporating the 2Zero partnership developments in particular of Actions 4 and 5 explained later on.

The identified concepts need to be assessed and prioritized according to their potential to generate socio-economic benefits (e.g. decarbonization and the reduction of pollutants) that are affordable or even have the 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 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.
- 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 operated with zero tailpipe emission vehicles (use cases and solutions), which are socio-economically and financially viable and

[43] If something is future-proof, it will continue to be useful or successful in future if the situation changes https://www.collinsdictionary.com/dictionary/english/future-proof.

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

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

This action will support the development of the necessary instruments and tools to support the adoption and integration of the innovative concepts, solutions and service developed, at the urban, regional and national dimensions[44].

- 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. These instruments should consider the overall transport situation, including the current more polluting fleets.
  - 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.
- **Capacity-building in the 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 complementary initiatives such as the Mission on Climate Neutral and Smart Cities, the DUT partnership and the EIT-Urban Mobility KIC.
- **Capacity building for commercial fleets 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 for charging. Capacity building and skills development for drivers so that they can extend the range and optimize the usage of energy.
- The analysis and engagement with users in order to develop strategies and understanding that supports **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, in order to continuously improve offers, and institutions to develop the means to support and implement winning policies, these should feed broader initiatives such as the Mission on Climate Neutral and Smart Cities, the DUT partnership and the EIT-Urban Mobility KIC.

[44] 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.

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

This action focusses 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.
- Evaluation, assessment and refinement of the innovative solutions and concepts once they are integrated in the real-life environment, based on the collection of performance indicators, other data and the models used. Also, the models need to be assessed, evaluated and refined to achieve the objectives of the partnership
- 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[45], 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 and shared e-services for people and goods mobility (in collaboration with CCAM)

Mixed mobility / 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).

Additionally, CCAM concepts could have a leverage factor on the adoption of zero tailpipe emission technologies. i.e. CCAM brings the opportunity of the vehicles to be used extensively and zero tailpipe emission concepts brings operational and maintenance cost opportunities (e.g. fully autonomous last mile e-deliveries[46, 47] that could be used and combined with people mobility[48]).

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

- Assess and test highly automated modular and scalable mixed passenger and freight zero tailpipe emission vehicle concepts (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 …), including the modelling of the charging infrastructure roll-out strategies and their lifecycle assessment for different types of vehicles / applications (from L1 to intercity coaches), applications (including MaaS) and traffic environments (urban, peri-urban, rural and interurban).

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

[46] 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/

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

[48] e-Palette Concept: https://global.toyota/en/newsroom/corporate/20546438.html

- Develop accompanying supportive infrastructure strategies (e.g. automatic loading and unloading or recharging), reliable systems (sensors, actuators, identification and autonomous control) to hand over goods at unattended hubs or to the end user.

Action 3 – Define right sized vehicles and infrastructure requirements according to user needs and usage models (people mobility, freight and logistics)

This action aims at the identification and analysis of vehicle requirements for the mobility of people and goods, in terms of use cases, usage models and usage patterns. As a result, specific or combined use cases, usage models and usage patterns can be derived for all type of vehicles within the scope of 2Zero and need to be taken in full consideration for the pathways development in Action 1. This action also aims to provide good input for vehicles and infrastructure developments as part of Chapters 4.1 and 4.2.

Freight and logistics

As background, we need to recognize that on the one hand bigger road vehicles offer the potential to reduce emissions if well utilized, meaning they may be more efficient in terms of traffic and congestion generation (i.e. one full truck substituted by a few vans results in more traffic and congestion). This is shown in Figure 5 below. However, there are other factors (spatial distribution of the demand, reducing size of shipments volumes, safety …) that are promoting the use of smaller vehicles within cities.

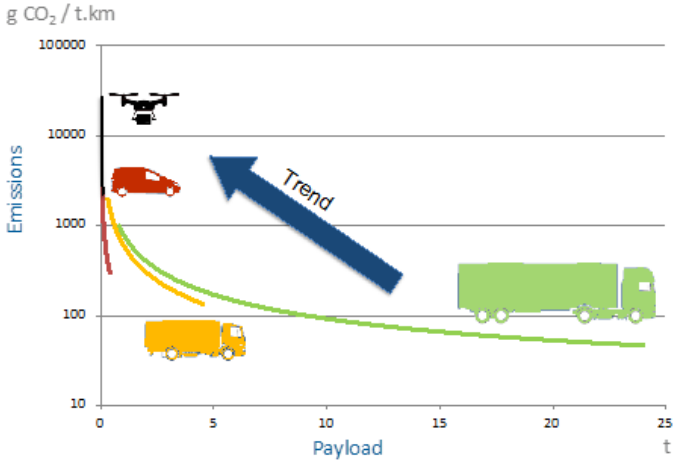


Figure 5 - CO_2 emission per tonne.km according to the payload and vehicle: data sources[49]

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 / vehicle manufacturers, energy providers as well as charging point infrastructure, so that there is 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 infrastructures (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. trucks mostly travel less than 400km and then a stop is required for resting).

[49] Stolaroff JK, Samaras C, O'Neill ER, Lubers A, Mitchell AS, Ceperley D. (2018). Energy use and life cycle greenhouse gas emissions of drones for commercial package delivery. Nature Communications. 9(1):409.
Robert Joumard. (2016) Methods of estimation of atmospheric emissions from transport: European scientist network and scientific state-of-the art: Action COST 319 final report. INRETS. France. pp.158, 1999, Action COST 319 final report. hal-01253787

- 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. FMCG, automotive, textile, retail ...).

People mobility

The development of right-sized transport will aim at meeting the mobility requirements, optimizing public and private vehicle ownership in all sectors and levels of the society. For people's mobility, it will be vital for offering 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, in order 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 the user 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[50], also considering developments in the R&I Pillar 1.

Testing and demonstrating concepts, solutions and services for the zero tailpipe emission people mobility

Action 4 – Innovative zero emission people mobility solutions in urban, peri-urban and rural areas

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

This action will support the identification, development and ultimately the integration of the innovative 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.

This action will:

- **Investigate and define the users' and stakeholders' behaviour, needs and requirements**, ensuring 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 uses cases to test 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

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

as procurement, business models and governance. This covers those mobility areas where, today, zero emission solutions are not available or not tested in full operations:

- Develop and demonstrate new service concepts, both digital and physical, to improve the integration the acceptance zero emission mobility and zero emission vehicles based on innovative technologies (e.g. service robotics or digitalization).
- Develop new business models to ensure the economical attractiveness of ZEVs for people mobility (public and private).
- 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 (e.g. mobility hubs) 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 (e.g. conceptual, digital and physical) 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, 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, therefore not only focusing on improvements in vehicles, 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 a 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 optimize their services and management of fleets, also taking account of, for example, charging requirements.
  - Develop demand management strategies for zero emission solutions[51]. These solutions could consider the mobility demand in relation to mobility generators, such as work, schools, hospitals and places related to care, retail, 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 also be considered, as well as nudging techniques, marketing and social innovations.
  - Develop combined approaches for an integrated traffic and charging management system for the adoption of zero-tailpipe emission vehicles.

[51] 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 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 air-conditioning and heating systems (HVAC). 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, optimized 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 overall optimization of demand and supply.
  - Monitor international relevant initiatives that should be considered as well as identify opportunities for exploiting mobility models worldwide.

Testing and demonstration of concepts, solutions and services for long haul, regional and urban zero tailpipe emission freight transport and logistics

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

Whilst electric van fleets are well demonstrated for parcel delivery solutions, being currently the challenge for the grid infrastructure reaching to the depot, 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, payload or both, whilst FCEV could be a suitable solution for long haul freight transport and high payloads. Additional strategies for zero tailpipe range extenders (combined powertrains) could be explored for certain use cases and also beneficial for operations and time windows in which trucks are not driving (e.g. charging whilst loading / unloading, drivers resting times[52]...). 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 concept and solutions (including fleet management and routing aspects) addressing the user needs for specific use cases (e.g. HDV for full payload in shorter ranges > 350km) for which these new vehicles could match and outperform conventional ones. Innovative freight and logistics concepts, capitalizing on zero emission operational and maintenance costs, need to be envisioned in different segments (urban, regional and long-haul)

[52] https://ec.europa.eu/transport/modes/road/social_provisions/driving_time_en

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 operations in an efficient way.
This action will:

- **Analyse the capabilities and performance characteristics of zero tailpipe emission vehicles and infrastructure, mapping potential near future use cases to be addressed**.
  - Based on requirements and user needs of 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 could 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 44tonne): utilization, energy consumption, charging times, traffic situations …
- **Identify and prioritize 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 ...) and domains (urban / regional / long-haul) overcoming limitations, such as current / future vehicle cost, infrastructure and performance limitations, and constraints with a systemic approach (vehicles, infrastructures and operations).
  - Large testing schemes 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 44tonne 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, construction activities need to be addressed.
    - Fuel Cell Hydrogen trucks test and demonstration for regional and long-haul and payloads up to 44tonne 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 ...) even without these places being open and attended. The TCOs can benefit from extended hours of delivery in city centres.
  - 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 localizations, 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 bike and L-category e-vehicles for last mile logistics concepts. Light Electric Freight Vehicles

(LEFVs) could replace 10-15% of delivery vehicle movements[53], so it is key to demonstrate the new generation of electric L-category vehicles uses for an extended portfolio of freight transport and logistics applications.

- **Develop zero emission shared freight transport and logistics solutions** (e.g. supported by the development and implementation of the physical internet) considering how to benefit from zero tailpipe emission vehicles in order to increase their affordability, by:
  - Developing new concepts and solutions, smartly combining zero-tailpipe-emission vehicles requirements and capabilities (charging, range ...) with other logistics operational aspects, such as loading docks (charging), routing...
  - Making optimal use of the required vehicle "stops" during their working period and develop appropriate management systems for scheduling a daily list of jobs (=trips) considering all vehicles / charging / refuelling conditions and other limitations and peculiar issues.
  - 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 autonomous (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 digitalization) to optimize 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. in combination of trucks and trailers and 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 maximize charging infrastructure utilization without incurring in waiting times and logistics loses (stops for charging should last no more than 45 minutes, aligned with necessary driver breaks).
- **Create a collaborative framework and knowledge base sharing** for testing and demonstration of innovative concepts, services, solutions, use cases and business models in controlled but real-life implementation environments, with the wide participation of stakeholders 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 (urban, regional and long-haul) and for different application flows (payloads, ranges, type of goods: waste, construction, retail, parcels, FMCG, including sectorial needs ...).
  - 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.

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

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 Roadmap[54]. A research roadmap paving the way towards an integrated urban mobility system,
- The ALICE Roadmap towards Zero Emission Logistics 2050[55] includes a variety of solutions to decarbonize 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[56]
- The report on the Truly Integrated Transport System for Sustainable and Efficient Logistics[57] developed in the frame of the EU funded project SETRIS[58] and supported by all transport European Technology Platforms.
- The ALICE Roadmap to the Physical Internet[59] developed in the frame of EU funded project SENSE.

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 an holistic way.

Finally, in close cooperation with the CCAM partnership, the 2Zero partnership will also investigate the effectiveness of the non-technological measures that are being taken to reduce emissions: impact of new ownership models on traffic network, user behaviour and related emissions.

[54] ERTRAC, ALICE, ERRAC (2017) Integrated Urban Mobility Roadmap.
[55] ALICE and LEARN EU project (2019). Roadmap towards Zero Emissions Logistics 2050. https://www.etp-logistics.eu/?p=3152
[56] ERTRAC (2019) Long Distance Freight Transport: A roadmap for System integration of Road Transport;
[57] ACARE, ALICE, ERTRAC, ERRAC and WATERBORNE. (2017) *A truly Integrated Transport System for Sustainable and Efficient Logistics.* http://www.etp-logistics.eu/?p=1298
[58] Strengthening European Transport Research and Innovation Strategies, SETRIS. *H2020 project. Grant agreement ID: 653739*
[59] http://www.etp-logistics.eu/?page_id=292

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 …). 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[60] approach is needed, to expand the existing complexity of an environmental LCA 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. Within this context, research and innovation is needed along two axes: assessment and minimisation of the ecological footprint over the entire life-cycle.
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). 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.

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 LCA is quite large, many

[60] 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/

gaps still exist[61]. The existing databases require a great amount of data from companies related to foreground and background processes[62] (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 ...) 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 accessiblity 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 LCA 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 characterization in data inventory.
Another challenge to be overcome within the 2Zero partnership is to advance and adapt existing methods and tools, to integrate them into the product development and mobility planning tools. The methods and tools must become an integral part of eco-design strategies 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 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 LCA, considering regional, interregional and worldwide material flows, and to maximise the benefit for the EU by helping retain key materials. LCSA and CE approaches considering the full transport system and associated value chain may favour production and recycling within the EU, thus increasing European competitiveness.
Besides developing datasets, methods and tools for circular economy and LCA, 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 ...), social aspects such as the impact on work force 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.

[61] E.g. for some advanced key materials/processes like 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).
[62] 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

Whilst LCA has been practiced for a long time and international standards exist, there is 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 LCA[63] (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,
  - Assumptions, baselines and boundaries can differ significantly not allowing comparison of data and LCA,
  - 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.
- **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 LCA / 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 and definitions** for consistent circular economy approaches (e.g. categories like share of recovered materials, energy efficiency of recycling process …),
- **Knowledge and skills** for LCA and CE are lacking,
- LCA- and circular economy-based solutions are not implemented at a wide scale,
- Communication and acceptance of LCA- and circular economy-based solutions.

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

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 analysis where this is appropriate (e.g. where accounting for 2nd 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)

- Definitions of circular economy criteria at a vehicle and system level (e.g. categories like share of recovered materials, energy efficiency of recycling process …),
- Identifying harmonised factors influencing the defined CE criteria,
- Defining harmonised strategies for consistent circular economy approaches,
- 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 minimizing 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,
- 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[64] 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).

Monitoring of the ecological footprint

Priority: medium (2023 – 2027)

The impact of LCSA methods and tools depends on the accuracy of data as outlined already. Complementing R&I action on methods and tools, methods and tools will have to be derived enabling the access and analysis of real-world performance and emission data over the full life-time of vehicles and fleets in arbitrary mobility scenarios. The access and analysis of such data will not only improve continuously the quality and baseline of required data sets for the assessment, 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.

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. 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

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

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 …) varies over time, the methods and tools must be able to account for changes over time. Furthermore, the methods and 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 (2024 – 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 emphasizing 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: high (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 supporting the design and production of CE-based transport and vehicle systems, not only accounting for materials and associated manufacturing solutions but also considering material flows and the supply chain management (e.g. further building on the PEF[65] Circular Footprint Formula approach). Additionally, mobility concepts and operations must be designed for CE strategies which requires methods as well.

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, to carry out system-wide modelling (particularly for consequential aspects), at the very least at 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

[65] Product Environmental Footprint

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).

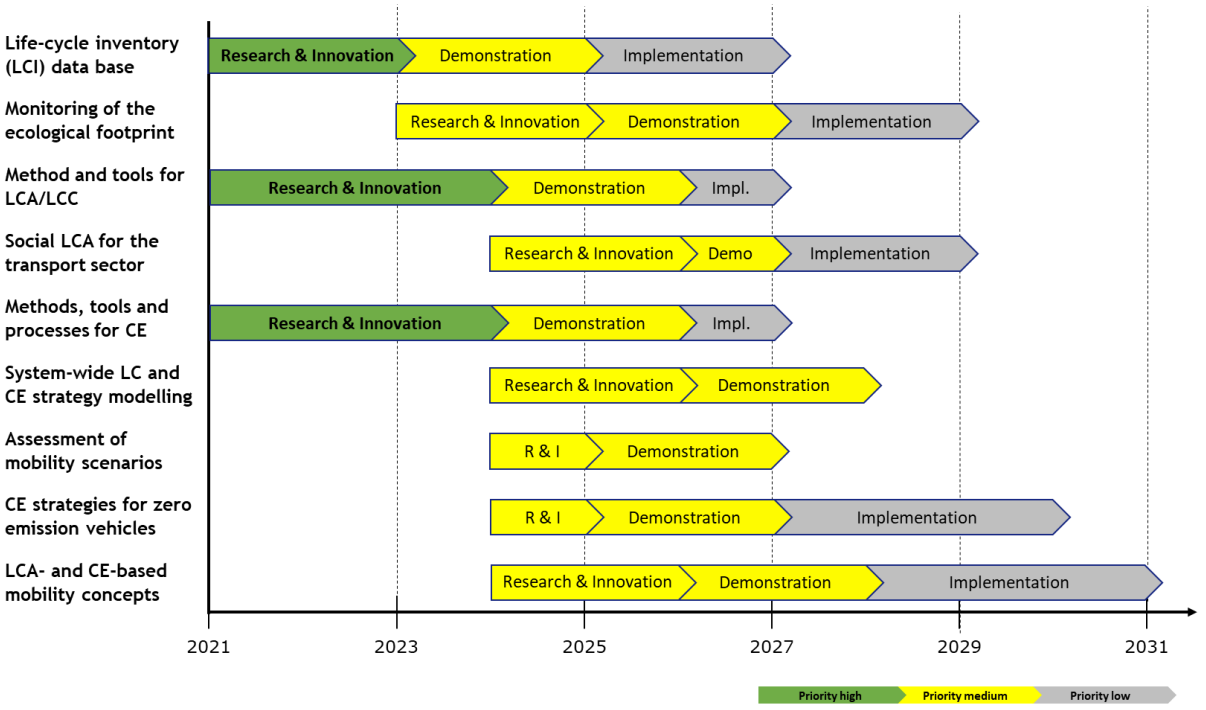
Assessment and demonstration

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 (2024 – 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 mean 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 (2024 – 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.

f. Roadmap


Life-cycle inventory (LCI) data base
Research & Innovation
Demonstration
Implementation
Monitoring of the ecological footprint
Research & Innovation
Demonstration
Implementation
Method and tools for LCA/LCC
Research & Innovation
Demonstration
Impl.
Social LCA for the transport sector
Research & Innovation
Demo
Implementation
Methods, tools and processes for CE
Research & Innovation
Demonstration
Impl.
System-wide LC and CE strategy modelling
Research & Innovation
Demonstration
Assessment of mobility scenarios
R & I
Demonstration
CE strategies for zero emission vehicles
R & I
Demonstration
Implementation
LCA- and CE-based mobility concepts
Research & Innovation
Demonstration
Implementation
2021
2023
2025
2027
2029
2031
Priority high
Priority medium
Priority low

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 the 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.

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 impact from 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 contribution into 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 …)
- 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 …);
- 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[66]. In particular, recent announcements by vehicle

[66] 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

manufacturers are ambitious. Investments are already high, with the automotive sector investing over €50 billion in R&I on a yearly basis[67], 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 beyond), 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 … 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 to 2Zero will be implemented. The coordination will mainly address exchange of information and avoidance of duplication of activities.

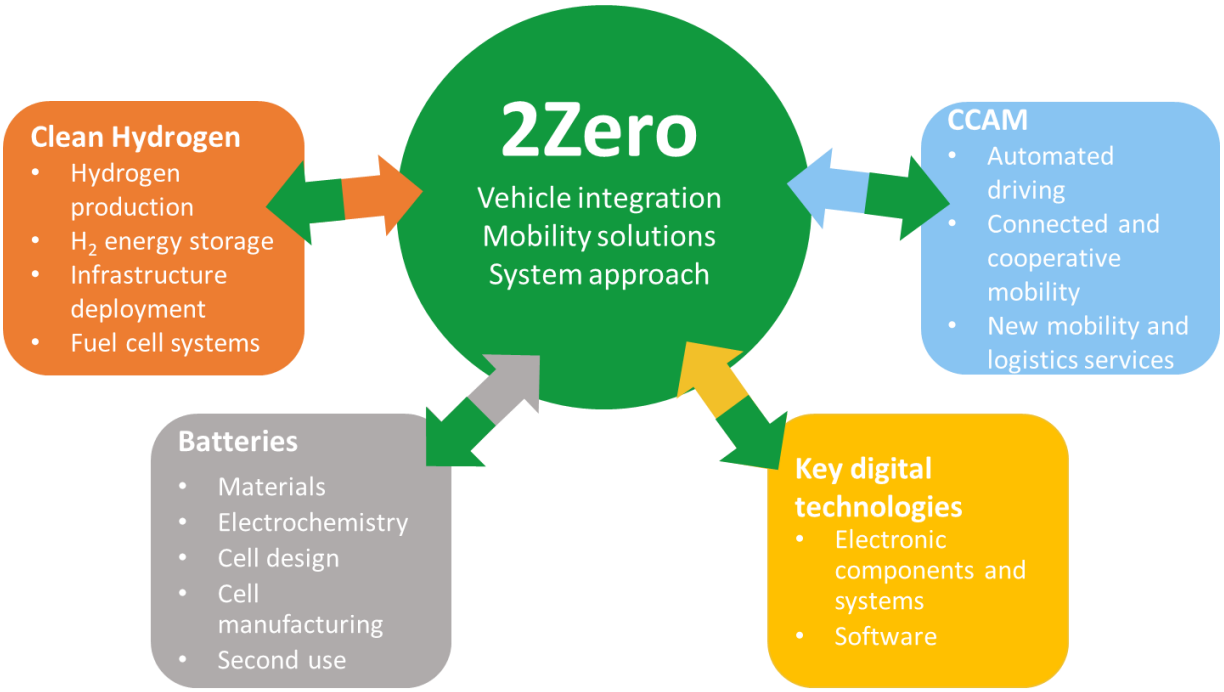


Figure 6 - The interaction of the 2Zero partnership with other key co-programmed and institutional partnerships

[67] https://iri.jrc.ec.europa.eu/scoreboard/2019-eu-industrial-rd-investment-scoreboard

a. Batteries

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 proposed ***Batteries*** partnership will be needed.

As shown in Figure 7 below, the proposed breakdown of activities is in line with the batteries value chain: the batteries 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 Batteries partnership, as an interface with 2Zero. A regular exchange of information will be needed to ensure that 2Zero provides the necessary requirements to the Batteries partnership and that the advancements of the latter are brought to the attention of the 2Zero community for the integration activities.

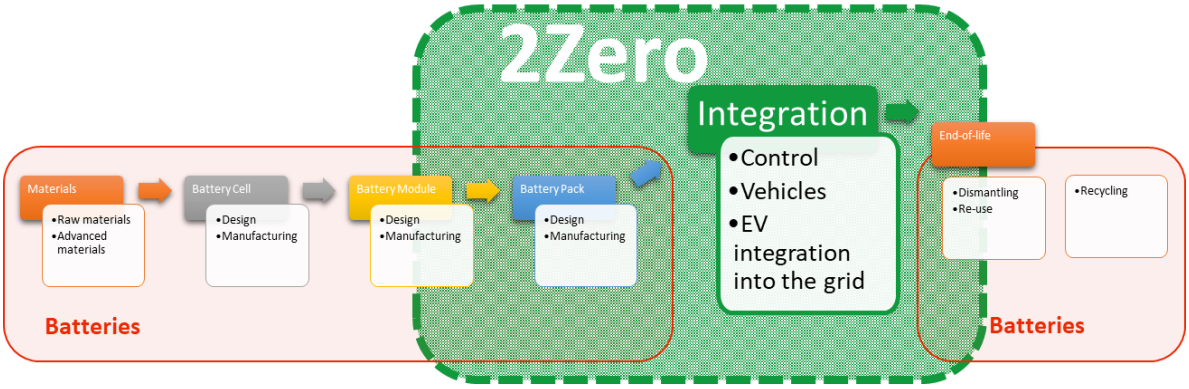


Figure 7 - The interaction of the 2Zero and Batteries partnership

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 …)
  - Responsibilities for the reporting and assessment of the achievements of the selected projects (aligned with the monitoring frameworks set by each partnership).

b. Clean Hydrogen

Existing links (common statement paper published in 2017[68]) with the "***Clean Hydrogen for Europe***" 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 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.

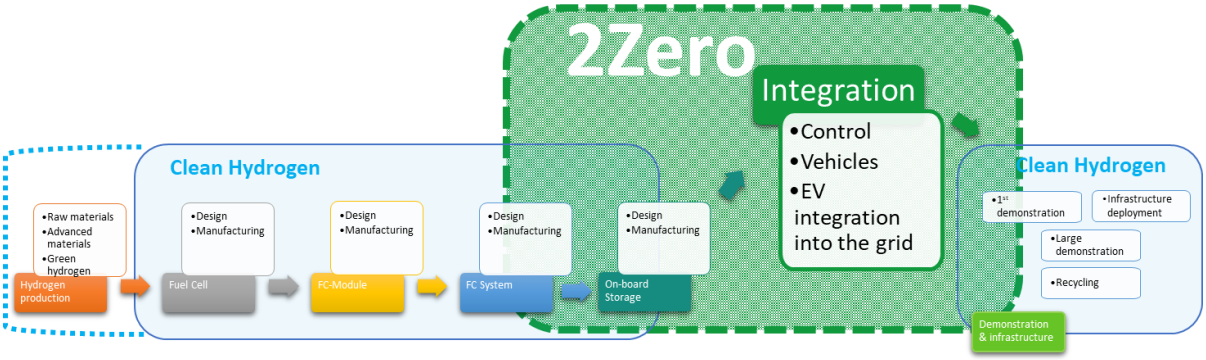


Figure 8 - The interaction of the 2Zero and Clean Hydrogen partnerships

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
Onboard 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 level (non-binding list):

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

- 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. Key Digital Technologies

Links already established with "***Key Digital Technologies***" (former ECSEL-JU) and EGVI will need to be reinforced. A "soft" coordination between EGVIA and the ECSEL-JU is already existing, relying on common members, the support from the European Technology Platform to both partnerships (namely EPoSS), as well as EGVIA 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 KDT community is aware of the specific automotive requirements and that the 2Zero community is kept informed of the latest advancements of the KDT partnership.

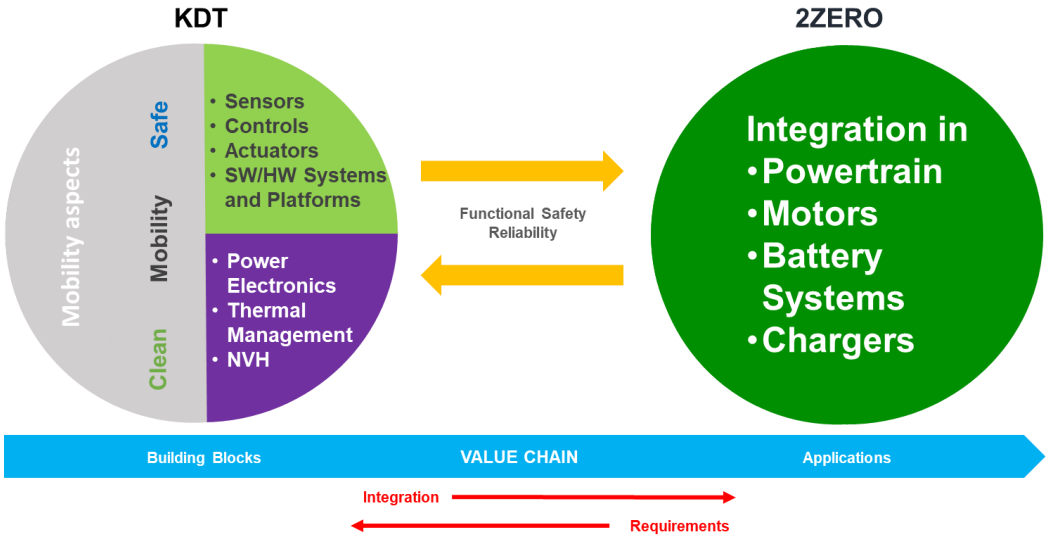


Figure 9 - The interaction of the 2Zero and Key Digital Technologies partnerships

Due to the fact the 2Zero and KDT are two different types of partnership, some coordination activities will be difficult to implement (i.e. joint calls for proposals are not seen 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 partnership 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.
- Appointment of additional 2Zero members to the Mobility.E lighthouse.

d. CCAM

Alongside decarbonisation, another trend is disrupting the road transport: digitalisation, 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. Simply saying, 2Zero will ask for data, CCAM will provide data and 2Zero will use this data in enhanced models / algorithms to meet its optimisation targets. 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 …), the 2Zero Partnership should work closely with the future CCAM partnership to develop solutions to minimise the impact of such potential rebound effects.

Whilst collaboration with Batteries, Clean Hydrogen and KDT 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, experts' selection …),
  - Responsibilities for the reporting and assessment of the achievements of the selected projects (aligned with the monitoring frameworks set by each partnership).

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 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.
- While 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 closed 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.
- A better coordination with the ***Safe and Sustainable Mobility*** (SSM) partnership initiated under the Smart Specialisation Platform for Industrial Modernisation (S3P-Industry) led by DG GROW will also be investigated. Created by several regional authorities, to promote a bottom-up approach to industrial innovation in the automotive sector, the SSM partnership's main objectives are to strengthen the regions' innovation capacity beyond the automotive industry and to facilitate investments based on open innovation infrastructure and new technologies.
- Coordination activities could be organised with other partnership or platforms, depending on the respective needs.

5.3. Cooperation with other EU funding instruments

2Zero will be 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", but 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.

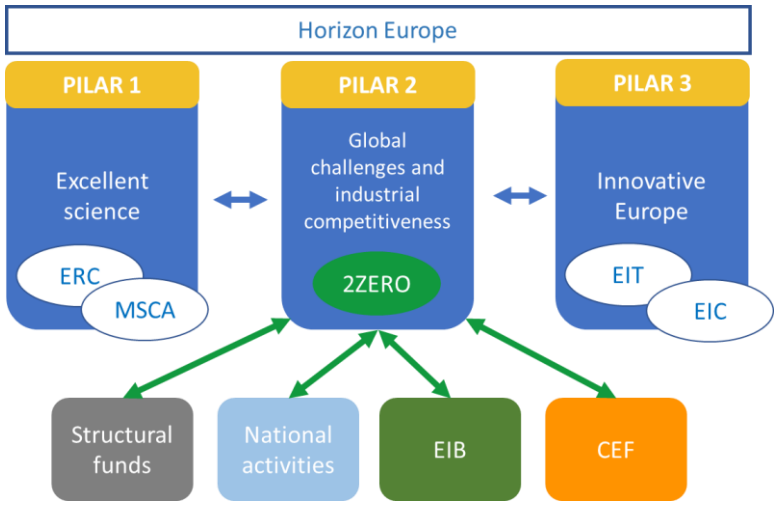


Figure 10 - The possible interaction of the 2Zero partnership with other Horizon Europe tools

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 incentivize 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.
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.
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 Member States Alignment Board 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 which 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 Directive", 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. An Alignment Board gathering representatives of the ministries and / or national agencies will be set-up as a side-body, as shown in Figure 11 below. This Alignment Board 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 infra-structure, contributing to accelerate the uptake of zero tailpipe emission road transport.

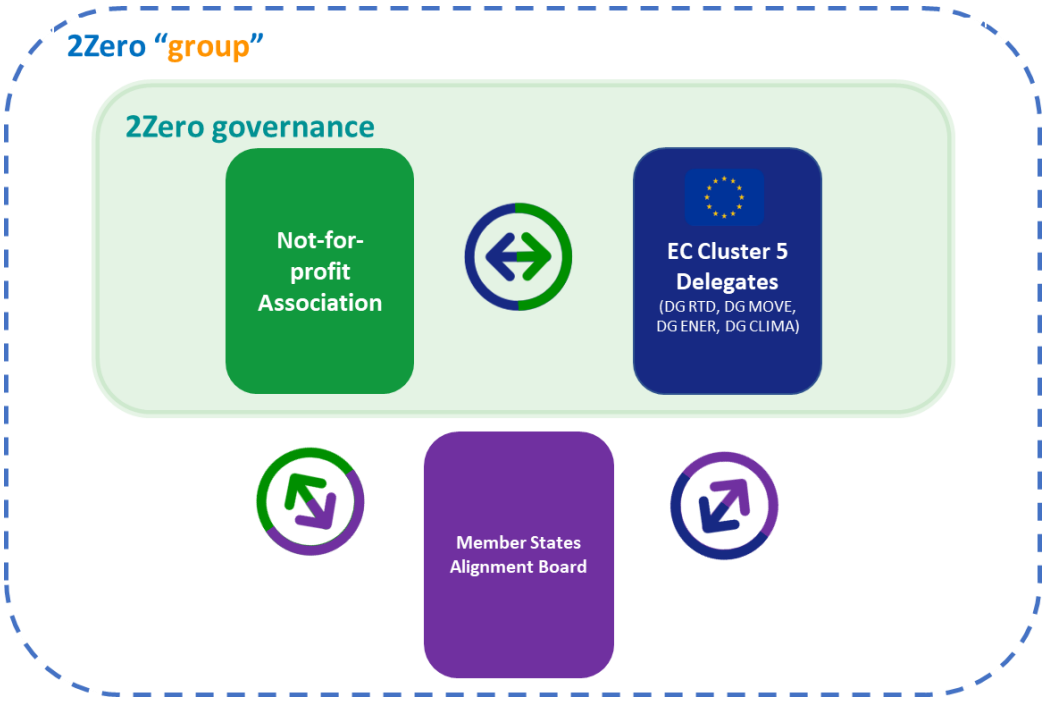


Figure 11 – The integration of Member States in 2Zero

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 Alignment Board. 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 will be similar to that currently applied in EGVI and other co-programmed public private partnerships, ensuring a lean and flexible organisation. Various services of the European Commission will be involved, under the leadership of DG RTD, and the stakeholders representing the counterpart of the EC will be represented by a not-for-profit association, as shown in Figure 12 below

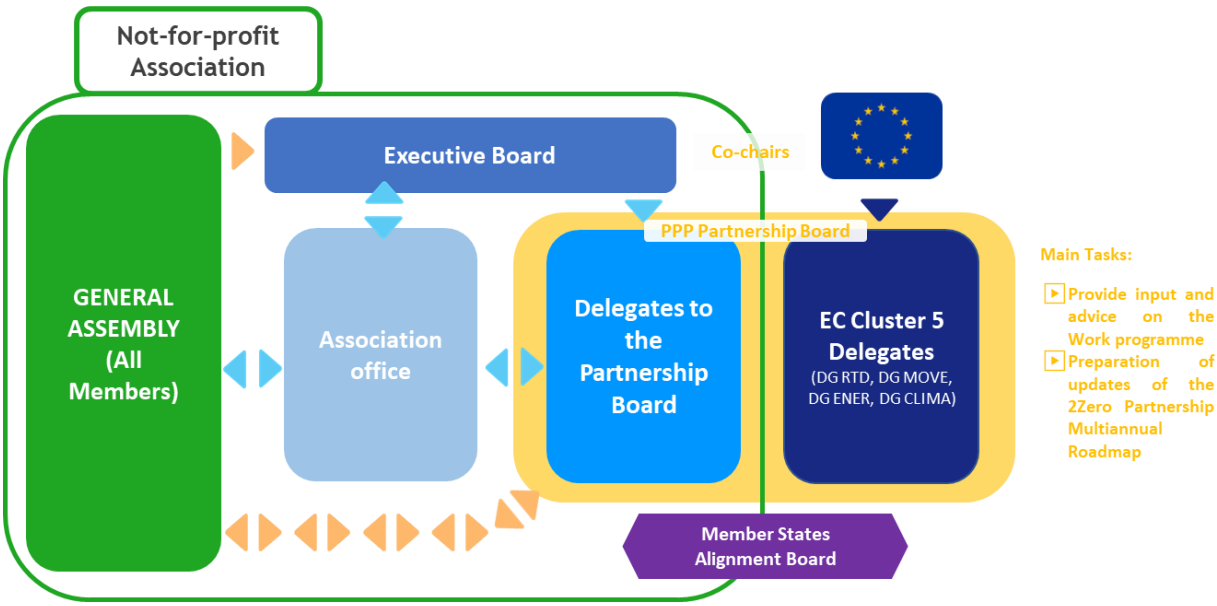


Figure 12 - The 2Zero Governance Structure

a) The not-for-profit association

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

- ***OEMs***: 16 members;
- ***Automotive suppliers***: 22 members;
- ***Smart systems industry***: 2 members;
- ***Smart grids industry***: 2 members;
- ***Research centres***: 14 members;
- ***Universities***: 19 members;
- ***Associate members***: 10 members.

To achieve the objectives, the partnership will build 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 ecosystem including, SMEs and cluster organisations, thus to integrate EU-funded projects into the broader innovation ecosystem. 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 all across 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 will be 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, will be detailed in the association statutes and should guarantee that all members will:

- 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 will be strictly limited to members based in the EU, and in countries associated to Horizon Europe. However, the international dimension should not be been 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 ecosystem, support effectiveness and efficiency, and the openness of the partnership to newcomers.

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

- Gathering all members, the **General Assembly** will be the main decision body of the association, endorsing publication of documents, electing the Executive Board members

as well as members of the Delegation to the Partnership Board. It will approve the general policy of the association on the basis of proposals from the Executive Board.

- The **Executive Board** will be 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 will be supported by the association office in its daily activities.
- **Delegates to the partnership board** will be 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 will be detailed in the statutes of the association. Its role will be to exchange on priorities for the calls for proposals with the European Commission services and contribute to the SRIA updates. In doing so, it will ensure 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 will contribute to the association activities on an equal basis, independently to their size or activity domain. Consultation processes will be 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 will be 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, involvement of EC services, the continuous flow of information and exchange of views has been ensured with the stakeholders involved in the partnership preparation. Hence, 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 (or equivalent body) will be created as the governing body and the official mechanism for dialogue between the European Commission and the not-for-profit association.

Delegates to the Partnership Board from the not-for-profit association side will be elected by the General Assembly and will represent the association as a whole. The delegates from the association will also reflect the different sectors (automotive, energy and logistics) and type of members involved in the association (industry, research and public authorities); the specific breakdown of representatives will be detailed in the statutes of the association. Members in the Delegation to the Partnership Board will be elected for a defined duration (typically two years), to ensure all members have the chance to apply and join this body. The Delegation will be 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 will be responsible for bringing together the stakeholders and the European Commission views on the content of the calls for proposals and SRIA updates. It will be 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 the 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 a good coordination with other EU-funded partnerships. The partnership board will meet on a regular basis (and at least once a year).

d) Alignment Board of Member States

An "Alignment Board" gathering representatives of the ministries and / or national agencies will be set-up as a side-body to avoid any duplication of activities with the Programme Committee. This "Alignment Board" will have two 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 would be organised on a voluntary basis. Several configurations of this "Alignment Board" 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 will focus its activities around research and innovation in all areas involved in the transition towards carbon-neutrality, from low TRL (3-4) up to demonstrations activities in real life environment (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 "Alignment Board of Member States".

As illustrated in Figure 13 below, the 2Zero partnership will:

- Provide 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.
- Deliver 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.

- Monitor the advancements of research and innovation activities performed at a European level in this field and adjust its recommendation according to the latest developments.
- Ensure 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 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 ecosystems conducive to innovation. A particular attention will be paid to turn 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.
- Align 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.
- Ensure good collaboration with other activities performed at European level that will have an impact on the development of zero tailpipe emission mobility in Europe. That will include 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.
- Support projects in putting forward the results from EU-funded projects towards relevant standardisation bodies.
- Build 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.
- Ensure 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 will follow 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 the association engaged with the European Commission in the partnership will not be a pre-requisite for selection for funding. The evaluation of the proposals submitted and projects selected will be organised by the European Commission services and executive agencies, in order to ensure fairness and independence.

The 2Zero partnership is committed to operate on principles of openness and transparency. It shall be 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 will ensure a broad dissemination of results from funded projects; this will be 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 …);
- 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. Multi-annual agenda & planning process

This overall picture will be drafted once the content of R&I areas will be agreed with the EC services.

Acknowledgment

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

- *Ian FAYE, Bosch*
- *Christof SCHERNUS, FEV*
- *Alvaro COUPEAU, Tecnalia*
- *Gereon MEYER, VDI / VDE*

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

- *Venizelos EFTHYMIOU, ETIP-SNET*
- *Stephanie JUMEL, EDF*
- *Villy PORTOULI, ICCS*

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

- *Fernando LIESA, ALICE*
- *Sabina ASANOVA, POLIS*
- *Evangelos BEKIARIS, CERTH*

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

- *Thilo BEIN, Fraunhofer LBF*
- *Carsten WEBER, Ford*
- *Johann BACHLER, AVL*
- *Aldo OFENHEIMER, Virtual Vehicle*

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	
	Clean Hydrogen Europe	
	CCAM	
	Driving Urban Transitions - DUT	
Digital, Industry and Space	Key digital technologies - KDT	
Other clusters	Clean Energy Transition	
	Made in Europe	
	Built4People	

Table 2 - Overview of areas identified

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

Programme	Purpose	Details (form …)
Connecting Europe Facility (CEF)		
ESIF, IPCEI, national or regional programmes		
Structural Funds		
EIB		

Table 3 - Overview of synergies identified