

Sustainable Propulsion

EXECUTIVE SUMMARY

Overview

EUCAR's members, the European automotive manufacturers, strive for a competitive industry whose products meet the needs of society. European collaborative research & innovation (R&I) supports this strategic objective by enabling cooperation between stakeholders and providing co-funding to mitigate part of the risk inherent in automotive research. In the area of Sustainable Propulsion, co-funded research supports the development of technologies which meet customer demands whilst fulfilling ever more stringent regulatory standards.

The EUCAR R&I roadmaps define the strategic recommendations of the manufacturers for collaborative R&I, detailing the necessary topics for R&I projects aligned with the strategic objectives. They are a vital and unique contribution, since they represent the outlook of the manufacturers, who themselves have the ultimate responsibility to innovate in bringing the resulting technologies to market.

In Horizon 2020, the programmes on “Smart, Green and Integrated Transport” and “Leadership in Enabling and Industrial Technologies” are of direct relevance to R&I in Sustainable Propulsion. The roadmaps for Sustainable Propulsion present recommendations for collaborative R&I in two areas: “ICE-based Powertrains” (powertrains based on an internal combustion engine) and “xEV-based Powertrains” (powertrains which have a fully electric drive function). These incorporate the cross-cutting technology domains “Fuels and energy carriers” as well as “Thermal and energy management”.

For ICE-based powertrains, collaborative research should concentrate on affordable design changes which increase efficiency and reduce emissions in engines for light and heavy-duty vehicles, including downsizing, advanced flexible combustion processes and alternative fuels supported by advanced after-treatment and efficient thermal management. Demonstration activities for holistic concepts for heavy-duty vehicles are an additional priority. For xEV-based powertrains, priorities include lithium-ion and post-lithium-ion batteries, fuel-cell systems, hydrogen storage, improved electric drives, charging systems and concept demonstration, as well as electrification for heavy-duty vehicles.

The expected outcome from these activities is a technology readiness for enhanced conventional powertrain technologies and advanced alternative technologies such as electrification of the vehicle as a platform for further development and eventual industrialisation. The final target is to meet customer and regulatory demands for lower fuel consumption and emissions whilst maintaining utility, performance and affordability of passenger and commercial vehicles, supporting a highly innovative and competitive European automotive industry which secures jobs and prosperity.

The Strategic Framework for Automotive Research & Innovation

EUCAR’s members have analysed in depth the strategic motivation for performing research and innovation (R&I) activities and specifically collaborative R&I, in order to set out a future vision for these activities. The following questions need to be answered: “why is collaborative automotive R&I important”, “what should policy makers and stakeholders expect to gain from EUCAR’s roadmaps and this summary, and how is it related to Horizon 2020”. The motivation and the answers to these questions can be considered in terms of three strategic elements at different levels of detail:

- **The main relevant Strategic Trends:** these set the context for long-term strategy and have been identified by EUCAR’s members as the long-term global driving forces and trends which motivate change and require identification of the key automotive R&I themes.
- **Overall Objectives for automotive R&I:** aligned with the European policy perspective (aiming at Sustainable Transport and Competitive Industry) and the constituent programmes of Horizon 2020, these include:
 - i. CO2 emissions regulations for cars, vans and trucks;
 - ii. The Renewable Energy Directive and the Fuel Quality Directive;
 - iii. The 2011 Transport Policy White Paper;
 - iv. The Clean Power for Transport proposal;
 - v. The Strategic Transport Technology Plan;
 - vi. The Horizon 2020 programmes “Smart, Green and Integrated Transport” and “Leadership in Industrial and Enabling Technologies”.
- **Priority R&I Focus Areas:** these represent the key areas of R&I for the automotive sector, identified by the European automotive manufacturers through their collaborative activities in EUCAR.

These three strategic elements are highlighted and represented graphically in the following chart, which represents this strategic outlook in the domain of Sustainable Propulsion:

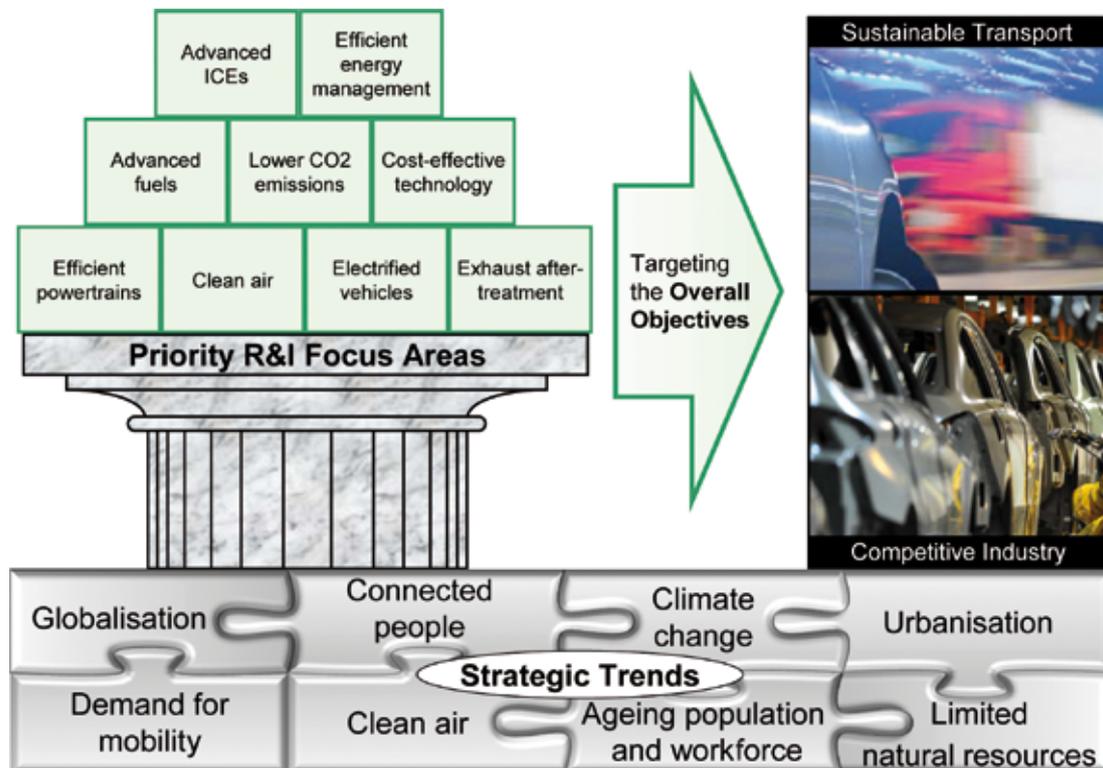


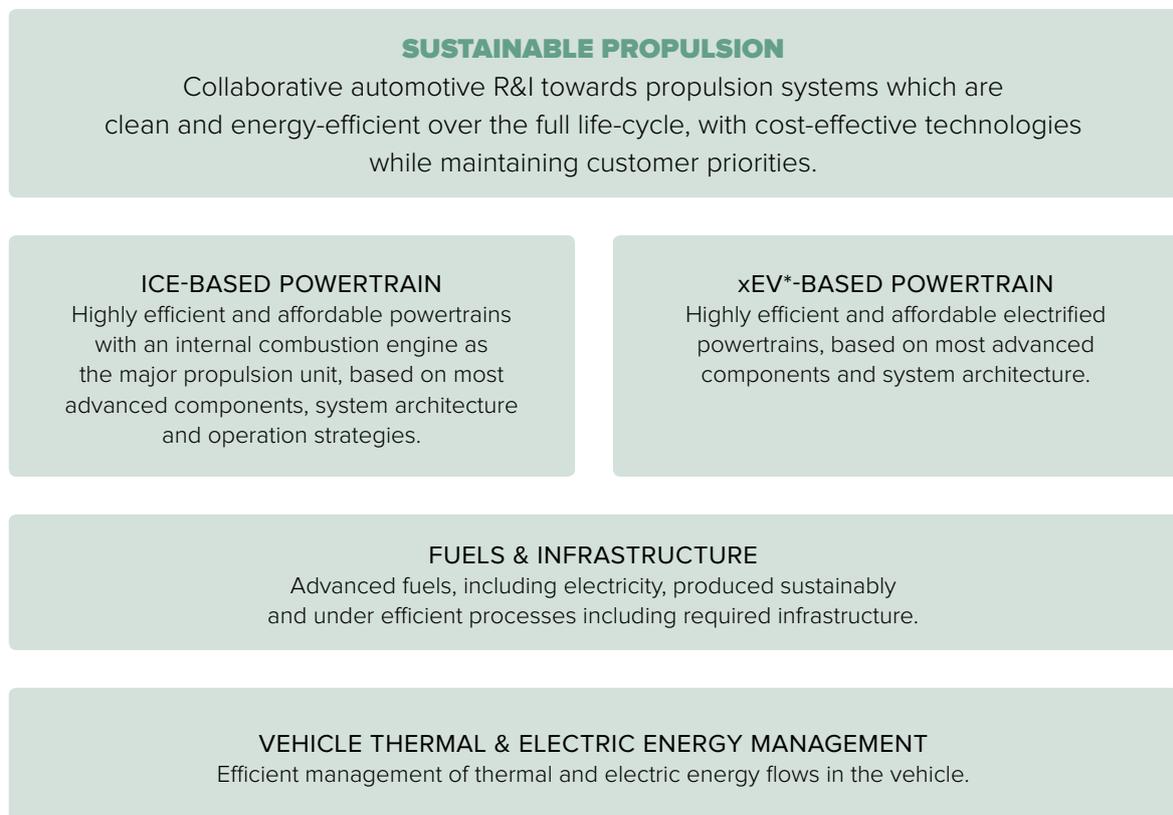
FIGURE 1 Strategic framework for Sustainable Propulsion

A number of key R&I priorities in Sustainable Propulsion derive from the need to meet societal and industrial challenges, within the global strategic framework of prevailing conditions and trends. These priorities relate to the need to reduce all types of exhaust emissions whilst ensuring that technologies are cost effective, through developing advanced conventional and alternative powertrains, with advanced fuels and efficient energy management.

The EUCAR Strategic Vision for Collaborative R&I

Derived from the above strategic framework, the statements presented below represent the strategic vision of the European automotive manufacturers in the domain of Sustainable Propulsion. They are to be considered as an expression of the ambition of the manufacturers for research and innovation in meeting future societal and industrial objectives. They also represent a motivating objective for the definition and performance of research and innovation activities by EUCAR’s members.

The statements include an overall vision statement for Sustainable Propulsion and four statements, each representing the strategic vision for part of the domain. This subdivision indicates the breakdown of the Sustainable Propulsion domain from the automotive manufacturers’ point of view into two vertical themes “ICE-based Powertrain” and “xEV-based Powertrain”. For each of these themes a EUCAR R&I roadmap has been compiled. The two horizontal themes “Fuels & Infrastructure” and “Vehicle Thermal and Electric Energy Management” are key elements of the powertrain domain and elements in each are considered in the two vertical powertrain themes and the corresponding roadmaps.



*xEV includes BEV, FCEV, REEV, PHEV

FIGURE 2 EUCAR Research & Innovation Strategic Vision for the Strategic Pillar “Sustainable Propulsion”

EUCAR Research & Innovation Roadmaps, Milestone Objectives and Correspondence to Horizon 2020

In order to create a productive link between the automotive manufacturers' strategic vision and their priorities for collaborative research and innovation, milestones have been compiled, representing the objectives to be reached by technology at different levels of readiness.

Milestones and R&I priorities are described in EUCAR's roadmaps. In particular, industrialisation milestones have been compiled, representing the objective for the industrialisation of the technology on the market, derived from the Strategic Vision and relevant indicators.

Industrialisation milestones can be considered as a more detailed expression of elements of the strategic vision and are listed below:

For the ICE Powertrain roadmap:

ICE1: "A reduction in per-vehicle CO2 emissions contributing the fulfilment of future regulatory standards" (through reduction in per-vehicle fuel consumption and reduction in carbon content of fuels)

ICE2: "Availability of affordable powertrains which are adapted to operate at optimum efficiency for use with alternative fuels"

For the xEV Powertrain roadmap:

xEV1: "A reduction in per-vehicle CO2 emissions contributing to the fulfilment of future regulatory standards" (through increased market penetration of xEVs and reduction in carbon content of energy)

xEV2: "A significant increase in vehicle range approaching the useful range of conventional vehicles, whilst maintaining vehicle utility (space) and maintaining or reducing cost"

xEV3: "A continuous reduction in per-vehicle energy consumption"

xEV4: "A significant reduction in cost of xEV powertrains whilst maintaining equivalent performance, enabling total cost of ownership to approach that of conventional vehicles"

In the domain of Sustainable Propulsion, roadmaps have been compiled which cover the following areas:

1. Internal Combustion Engine (ICE-based) Powertrain (light-duty and heavy-duty applications)
2. Electric Vehicle (xEV-based) Powertrain

In this domain, the corresponding elements of the proposed Specific Programme Horizon 2020 have been identified, as well as the relevant public-private partnerships:

EUCAR Strategic Pillar	Horizon 2020 Specific Programme	Public-Private Partnerships
Sustainable Propulsion	Smart, Green & Integrated Transport: 4.1 Resource efficient transport that respects the environment 4.3 Global leadership for the European transport industry	European Green Vehicles Initiative (EGVI) Joint Undertaking on Fuel Cell and Hydrogen 2
	Secure, Clean & Efficient Energy 3.3 Alternative fuels and mobile energy sources	Joint Undertaking on Electronic Components and Systems for European Leadership (ECSEL)
	Leadership in Enabling & Industrial Technologies 1.1 Information and Communication Technologies	

FIGURE 3 Potential correspondence to the Specific Programme Horizon 2020 and Public-Private Partnerships

Research and Innovation Roadmaps

The Research and Innovation roadmaps for Sustainable Propulsion have been published in parallel to this executive summary. They set out the collaborative technological research and pilot/demonstrator topics and their timing, which are priorities for the automotive manufacturers during the course of Horizon 2020 and beyond, in order to meet the defined strategy and milestones.

The following research and innovation areas are the priorities identified for the two Sustainable Propulsion powertrain roadmaps as well as for holistic sustainable propulsion concepts for heavy-duty vehicles:

ICE-BASED POWERTRAIN – LIGHT DUTY

1. Spark-ignition engine technology:

- A. Flexible injection and valvetrain
- B. Downsizing / downspeeding
- C. Aftertreatment & emissions control
- D. Combustion process

2. Diesel engine technology

- A. Fully flexible injection
- B. Aftertreatment
- C. Alternative fuels

3. Alternative fuels

- A. Spark-ignition engine technology
- B. Engines for gaseous fuels
- C. Non-precious metal aftertreatment systems

4. Transversal technologies and methodologies

- A. Lightweight engine solutions
- B. Waste heat recovery & advanced cooling
- C. Advanced control systems

5. Alternative propulsions and transmissions

- A. Hybridisation
- B. Advanced transmissions

ICE-BASED POWERTRAIN – HEAVY-DUTY

6. Efficient heavy-duty vehicles

- A. Hybridisation
- B. Driveline control systems
- C. Combustion improvements
- D. Waste heat recovery
- E. Statistics

7. Diesel engine technology

- A. Concepts for high octane fuel combustion
- B. Di-methyl ester concepts

Roadmap: ICE-based Powertrain

XEV-BASED POWERTRAIN

1. Fuel-cell systems

- A. Next generation fuel-cell components
- B. Materials and manufacturing technologies
- C. Advanced fuel-cell systems
- D. Standardised components
- E. Fuel-cell range-extender

2. Hydrogen storage systems

- A. Compressed Storage Systems
- B. Hybrid Storage Solutions
- C. Components optimization

3. Electrochemical storage systems

- A. Lithium batteries ageing
- B. Lithium-Ion applications in x-EV's
- C. Safety evaluation of Lithium-based batteries
- D. Second Use and Recycling
- E. Post Li-ion batteries

5. Electric drives

- A. Electric motors
- B. Power electronics
- C. Traction powertrains

6. Electric vehicles

- A. Renewable Electricity for Electric Vehicles in cities
- B. Assessment of advanced Infrastructures for "charge-while-driving"
- C. New vehicle architectures for electric powertrain systems

7. Technology demonstration

HEAVY-DUTY VEHICLES

8. Heavy-duty electrification (fully electric and fuel-cell bus, fully electric truck)

Roadmap: xEV-based Powertrain