R&D CHALLENGES: HYBRIDS AND FUELS 2020+

FORECAST ON TECHNOLOGY DEVELOPMENT AND RESEARCH DEMAND

In the near future as well as in the long-term - beyond 2050, **hybrid powertrains** with optimized internal combustion engines (ICE) fueled **with climate-neutral fuels** will be very well suited and very preferred powertrains for on- and off-road vehicles (2-/3-wheelers, passenger cars, commercial vehicles incl. heavy/long-distance traffic and off-road applications) as well as in rail-, marine-, aeronautic- and stationary-applications.

Therefore, research has to focus on further **increase of engine and vehicle efficiency** while at the same time on **zero-impact limited emissions and neutrality of GHG emissions** (taking LCA aspects into account). Thus, every improvement achieved herein directly contributes to the reduction of CO_2 and pollutant emissions in the short and medium term. Already today, the best chemical energy carriers (fuels) achieve as low GHG emissions as the best electric vehicles with current national carbon intensity of electric power generation. Another important aspect is that such climate-neutral fuels can be used in existing vehicles as part of the existing fuel supply infrastructure and the use of these fuels would immediately have a positive impact on the GHG balance.

Studies by the European technology platform ERTRAC also show further potential for efficiency increases or GHG reductions for hybrid drives with combustion engines - also by means of engine measures (increase in peak efficiency in the range of 50% for cars and 55% for commercial vehicles - without fuel effects). These figures underline the great importance of further research efforts to improve the efficiency of hybrid drives.

At the same time, fuel-side measures have an equally high potential for reducing global greenhouse gas emissions. On the one hand, synthetic fuels in the form of sustainable advanced biofuels can be based on a broader biological raw material basis and, unlike sugar, starch, oils and fats, are not in competition with food and feedstock production. Residues from agriculture and forestry, industrial residues and waste can be considered as raw materials. However, the corresponding production technologies still have to be developed to market maturity through appropriate R&D activities. In addition, these fuel paths open up new regional value creation potential. On the other hand, synthetic fuels in the form of e-fuels from renewable (climate-neutral) electricity and renewable carbon sources can also be made available as high-quality and almost climate-neutral energy carriers for engines. Whereas these technologies are already quite developed, they are currently not economically produced.

In summary, the following specific research needs can be stated for the years 2020+:

1) Efficiency improvement of the powertrain system by hybridization, on-demand driven and predictive thermal management, waste heat utilization (e.g. on-board fuel reforming from waste heat recovery) and loss reduction through electrification of auxiliary units.
2) Further development of synthetic fuels and their manufacturing processes to reduce greenhouse gas emissions and improve combustion properties to reduce local pollutant emissions.
3) Technology development for transmissions and hybrid transmissions with the aim of operating the ICE in the optimal efficiency range.
4) Improvement of the thermodynamics and optimal adaptation of the internal combustion engine to hybrid drives and future fuels including exhaust gas aftertreatment to increase the overall efficiency and to achieve zero impact pollutant emissions

ESSENTIAL LEGAL FRAMEWORK

- Creation of an EU-wide legislative framework and directives for rapid implementation of an efficient and climate neutral mobility allowing EU-industry the introduction of new technologies resulting from R&D activities described in this position paper.
- Adapting legislation to allow for higher blending of biofuels.
- Provide incentives to production or supply of advanced renewable fuels
- Adapting the (EU-wide) CO_2-regulation to include well to wheel GHG emission benefits through the use of renewable energy carriers (biofuels) would allow the automotive industry to factor in renewable fuels into their targets and would thus encourage the adaptation of ICEs to higher blends of renewable fuels.

These framework conditions must be long-term and based on the actual GHG reduction potential, without favoring individual technologies. Taking into account the high investment costs and the great uncertainty for industry with regard to regulatory aspects, positive incentives and support are needed for companies that are prepared to invest in innovative long-term solutions.

LIFE CYCLE ASSESSMENT

Key factor in Life Cycle Assessment (LCA) of hybrid vehicle architectures is the change in energy demand and efficiency during operation. While research focuses on increasing system efficiency, the impact of the additional weight of the specific components of hybrid vehicles on energy demand also depends on real world driving. LCA of drop-in biofuels and so-called e-fuels based on carbon capture and utilization involves a wide range of supply chains of different types of biomass, biomass conversion processes, electricity and hydrogen production and CO_2-sources and separation technologies. LCA-results are also influenced by the degree of process integration and system efficiency, by the allocation of the CO_2-emissions between emitter and receiver and the long-term availability of CO_2-sources.

RESEARCH REQUIREMENTS

1. HYBRID SYSTEM

- New hybrid topologies
  - Increase of efficiency (and thus reduce GHG emission)
  - Solutions at optimal costs
- Electrified and on-demand-driven auxiliary units
  - Efficient air conditioning compressor, coolant / oil pump, power steering pump, components of the charging system
  - Electric machines for electric auxiliary units including control - especially powerful units for commercial vehicle applications
  - Electrified units for 48V electrical systems
- Energy management (including thermal management)
  - Avoiding cold start losses (heat storage, heat encapsulation)
  - Thermal conditioning of the exhaust gas after-treatment system
  - Optimizing electric energy management
  - Thermodynamic recuperation including waste heat recovery (WHR)
  - Electrified exhaust gas turbines
  - Rankine cycle (post-steaming process)
  - Thermo-chemical waste heat recovery (e.g. fuel reforming)
  - Thermo-electric waste heat recovery
- Control of the hybrid system
  - Optimal operating strategy and control of hybrids using connectivity Car2X - X2Car (e.g. hybrid system on navigation system); Monitoring and service optimization
  - Software for component control and system control
  - Fast modeling methods and fast, automated parameterization
  - Combined physical-mathematical / statistical modeling
  - Efficient validation of complex drive systems
  - Automated operating and control strategies including AI-based controllers
  - Development tools & methodologies
  - (e.g. “simulation on molecular level”)

2. FUELS

- Efficient and low carbon fuel production and on-board storage
  - Drop-in fuels for energy supply for existing vehicle technologies (and in the current legacy fleet)
  - Production of synthetic fuels, i.e. biofuels, e-fuels and other non-fossil fuels
    - Production processes of e-fuels (e.g. produced from hydrogen from renewable electricity sources and CO_2 from air or industrial sources)
    - Processes for utilization of regenerative carbon sources from exhaust gases, flue gases, or other fossil sources
    - Gasification technologies and other thermal processes for the production of biofuels (e.g. gasification of biomass followed by synthesis to liquid or gaseous fuels etc.)
  - Efficient energy storage for liquid and gaseous fuels (e.g. CNG / LNG, H2)
  - Measurement and analysis techniques for increased quality requirements as well as for online analysis of the gas constituents for optimal setting of the ICE
- Material technology for advanced / new fuels
  - Tank / pipe / sealing materials and fuel metering materials
  - Fuel sensors (on and off board)

3. HYBRID POWERTRAIN

- Transmission and clutch technology for hybrid vehicles
    - Variable gear systems
    - Transmissions for high-speed e-machines (including noise reduction)
    - Sinter and coating technologies
    - Lightweight Technologies
    - Fast actuators
    - Thermal and abrasion models
    - Transmission for highly efficient hybrid topologies

4. THERMODYNAMICS OF THE INTERNAL COMBUSTION ENGINE INCLUDING EXHAUST GAS TREATMENT

- Combustion technologies for future low-emission / low-carbon / carbon-neutral fuels incl. hydrogen and new legal requirements (RDE, ...)
    - Development and use of "Fully Flexible Direct Injection Systems" for liquid and gaseous fuels
    - New variabilities for efficiency improvements of the engine system
    - Alternative combustion systems (including multi-fuel capability) such as HCCI, long expansion, thermal swing
    - Optimal adaptation of engines to hybrid systems
    - Further NVH reduction of hybrid systems with ICE
- Enhanced exhaust gas aftertreatment for future fuels and future legislative requirements (RDE…)
    - Identification and elimination of other pollutants
    - Elimination of ultra-fine particle emissions
    - Sensors and control systems for RDE exhaust gas monitoring (OBD)
- Material technology for engine improvements
    - Improvement of thermal insulation / adiabatic motor
    - Lightweight construction plus the use of new materials
    - Use of sintered components (also for actuators)
    - Reduction of friction and wear (including new bearing technologies especially for future / gaseous fuels …)
    - Fully recyclable materials

REQUESTED FUNDING INSTRUMENTS

- Low TRL research
- Co-operative industrial research and experimental development
- Flagship projects
- funding of demonstration plants, i.e. for the production of biofuels, e-fuels or other synthetic fuels