European Commission

This fiche is part of the wider roadmap for cross-cutting KETs activities

'Cross-cutting KETs' activities bring together and integrate different KETs and reflect the interdisciplinary nature of technological development. They have the potential to lead to unforeseen advances and new markets, and are important contributors to new technological components or products.

The complete roadmap for cross-cutting KETs activities can be downloaded from:

http://ec.europa.eu/growth/industry/key-enabling-technologies/eu-actions/ro-ckets

Potential areas of industrial interest relevant for cross-cutting KETs in the Transport and Mobility domain

This innovation field is part of the wider roadmap for cross-cutting KETs activities developed within the framework of the RO-cKETs study. The roadmap for cross-cutting KETs activities identifies the potential innovation fields of industrial interest relevant for cross-cutting KETs in a broad range of industrial sectors relevant for the European economy.

The roadmap has been developed starting from actual market needs and industrial challenges in a broad range of industrial sectors relevant for the European economy. The roadmapping activity has focused on exploring potential innovation areas in terms of products, processes or services with respect to which the cross-fertilization between KETs can provide an added value, taking into account the main market drivers for each of those innovation areas as well as the societal and economic context in which they locate.

Taking the demand side as a starting point, cross-cutting KETs activities will in general include activities closer to market and applications. The study focused on identifying potential innovation areas of industrial interest implying Technology Readiness Levels of between 4 and 8.

T.2.1: Low emissions (and noise) vehicle powertrain

Scope:

To develop combustion powertrains taking into account fuel feeding and real operational conditions so as to reduce energy consumption and pollutants emissions, taking advantage of advanced simulation means to optimize combustion conditions, engine architecture and control loops, powertrain subsidiary components, lubrication and power transmission, vibration and noise energy losses.

Demand-side requirements (stemming from Societal Challenges) addressed:

- Tackle the “Smart, green and integrated transport” societal challenge
- Contribute to the achievement of the 10% minimum Member States target for the share of biofuels in liquid fuel consumption in transport in 2020, to be introduced in a cost-effective way (Renewable Energy Directive (2009/28/EC))
- Contribute to the achievement of the EU Transport 2050 strategy (COM/2011/0144 final) objectives of no more conventionally-fuelled cars in cities, 60% reduction of CO_2 emissions from transports, 40% use of sustainable low carbon fuels in aviation and at least 40% cut in shipping emissions
- Reduce emissions of soot, particles, NOx and other harmful residues of combustion
- Reduce individual vehicle noise emission levels as well as traffic noise and vibration footprints around transport axis (highways, airport climb and descent paths, railways, etc.) and transport nodes (airports, harbours, stations, freight loading/unloading facilities, etc.)

Demand-side requirements (stemming from market needs) addressed:

- Reduce dependency on hydrocarbon-based propulsion, subject to a long-term price increase tendency, and related operational costs
- Enable short-term transport greening without waiting for full scale mature and financeable revolutionary propulsion means, making best use of retrofit and improvement capabilities of existing fleets of vehicles and vehicle production capabilities
- Lower local constraints and resistances on infrastructure operation or new construction projects

Specific technical/industrial challenges (mainly resulting from gaps in technological capacities):

- Development of holistic approaches of vehicle powertrain design, optimizing altogether powertrain architecture, all individual components and fuel/propellant and lubricant formulation (including bio-fuels), so as to reduce fuel consumption, pollutant emissions (CO_2, NO_x, SO_x, particles, soot, volatiles, etc.), use of chemicals falling under REACH constraints (as hydrazine or xenon for space thrust), needs for maintenance and production costs.
- Development of high thermodynamic efficiency combustion engines (diesel/gasoline for road or sea transport, jet aircraft engines, rocket upper stage re-ignitable cryogenic propulsion, etc.), taking advantage of active architectures, advanced combustion management, extreme condition/constraint materials and coatings, advanced supercharging, etc.
- Development of and improve flex-fuel engines and enable mass-production and efficient distribution of best alternative fuels
- Optimization of engine combustion conditions, pressure and feed flows
- Development of non-intrusive (in-operation) measurement techniques, including optical techniques for pollutant characterization in combustion chamber
- Development of small volume engine architectures, enabling “downsizing”, i.e. weight and volume reduction of powertrains including packaging structures as nacelles, car hood, etc.
- Enable weight reduction of engine parts based on materials and/or manufacturing improvements
- Optimization of post-combustion gas treatment and exhaust thermal energy recovery, so as to optimize the catalytic reduction of metals and other pollutants and increase the overall powertrain efficiency, while using less precious catalytic metals
- Development of high power density, low vibration and low roller resistance gearboxes, transmission and associated lubrication
- Development/optimization of different concepts of compact, modular, lightweight and reasonable production cost hybrid powertrain solutions that optimize on board energy management and reduce

overall energy consumption, including electrical power boost on core engine for transient and emergency operations

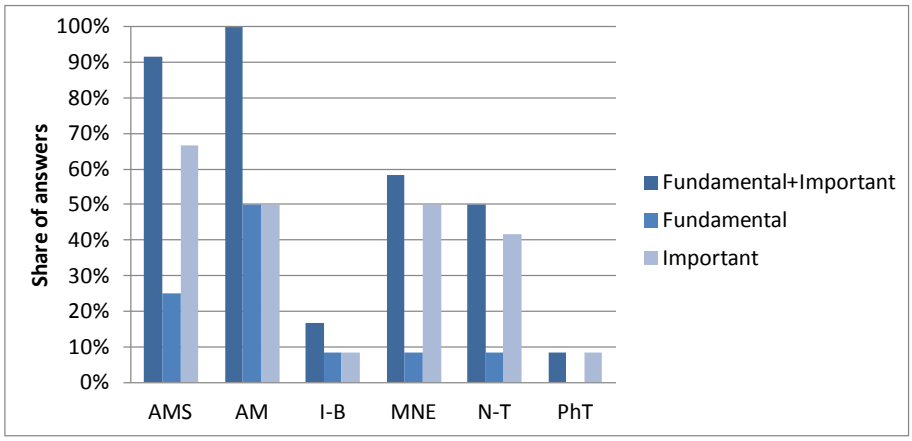
- Optimization of tyre and brake design so as to optimize safety while minimizing roller resistance and particle-emitting wear (including through co-improvements of asphalt surfaces and tyres)
- Continue maturing modelling and prediction tools (Computational Fluid Dynamics, evaporative emissions, fuel permeation, tribologic simulation, air/water cooling and heat exchange, aeroacoustics, combustion, rig testing, engine emission and fuel properties prediction and modelling tools, etc.)
- Development of active and advanced noise controls (including 3D nozzles, simulation based exhaust pipe design, noise dampers, optimized fans, morphing structures, liners, etc.)
- Enable energy recovery (waste heat, braking energy, etc.) and optimal reuse
- Design of engine intake, bypass and exhaust to reduce energy lost in noise

Contribution by cross-cutting Key Enabling Technologies:

In respect to this Innovation Field, the integration of KETs could contribute to the development of more advanced vehicle powertrain designs, benefitting of solutions such as high thermodynamic efficiency or flex-fuel combustion engines, taking advantage of active architectures, non-intrusive (in-operation) measurement techniques, advanced combustion management, extreme condition/constraint materials and coatings, advanced supercharging, and innovative post-combustion gas treatment and exhaust thermal energy recovery.

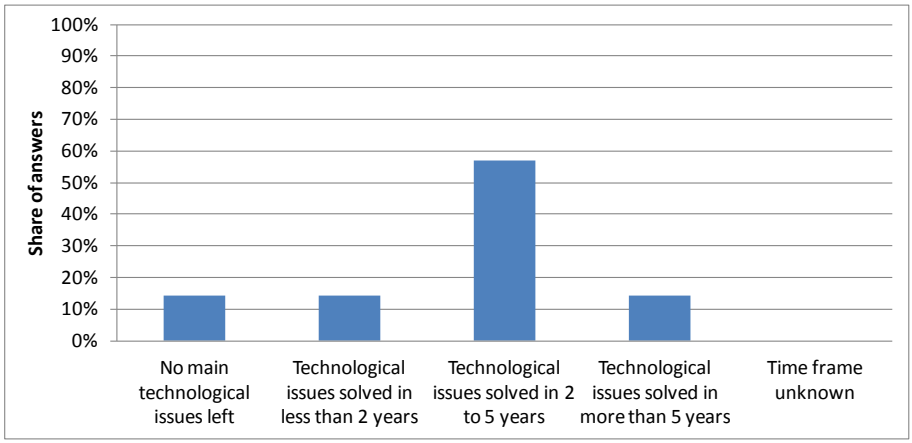
To this aim, the combination of KETs experts' opinions collected through the dedicated survey (whose result is depicted in the below bar chart), the examination of KETs-related patenting activity in respect to this Innovation Field, and desk research activities, have allowed identifying a rather strong interaction of KETs with respect to this Innovation Field, with either fundamental or important contribution mainly by the following KETs:

- Advanced Manufacturing Systems (AMS)
- Advanced Materials (AM)
- Micro- and Nano-Electronics (MNE)
- Nanotechnologies (N-T)



Timing for implementation:

According to the majority of KETs experts' opinions (whose result is depicted in the below bar chart), desk research, and in line with the KETs-related patenting activity in this field, it is considered that the main technological issues holding back the achievement of cross-cutting KETs based products related to this Innovation Field could be solved in a time frame of 2 to 5 years:



Hence, depending on the specific technical and/or industrial challenges holding back the achievement of cross-cutting KETs based products related to this Innovation Field, the provision of support in the short term should be taken into consideration within this framework.

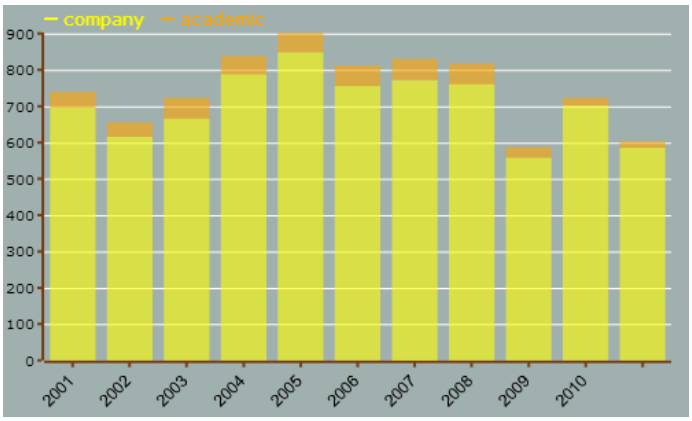
Additional information according to results of assessment:

- ***Impact assessment:***
  - Considering the size of vehicle series in the automotive sector, or the quantity of Jet A1 fuel burnt by an aircraft over its campaign life, a few % gained in fuel consumption can have already a dramatic impact on pollution and operational cost reductions. This requires however that the new powertrain technology is effectively adopted, which in this highly structures and constrained sector may be a challenge. The pilot line here really makes sense.
  - The need to consider this innovation field with a holistic approach is true also as regards interaction with green fuels, with cross-fertilization to be expected from progress in powertrain depending on best management of the combustion, fuel circulation in engines and surface effects at the points of contact of the fuel and engine internal surfaces.
  - A specific aspect relates to waterborne transport, since the historical distribution of petroleum cuts attributed the heaviest fuel oils, rich in sulphur and other dirty elements, to ship propulsion.
  - Progress in mastering engine combustion is not always straightforward and reducing CO_2 emissions may in some cases increase NOx or particles emissions, calling for a balance between objectives and/or regulations.
  - As regards noise, the best-known issues are the ones concerning immediate surroundings of railways or aircraft take-off and landing at airports, but the concern about urban ambient noise is growing and a smart individual or public urban transport is also a silent one.

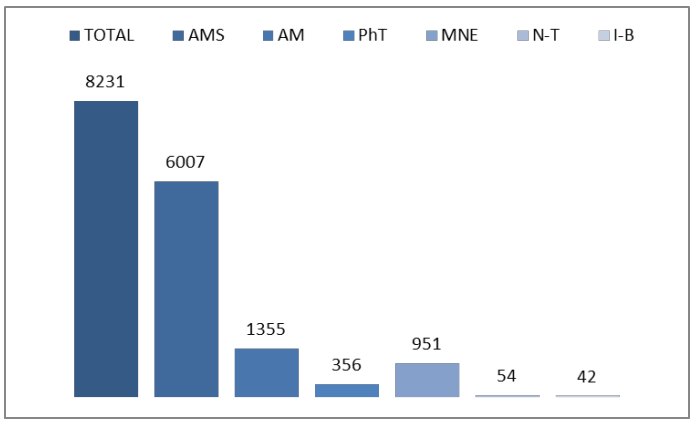
- ***Results of patents scenario analysis:***

Many KETs-related patents apply to this innovation field (8231, 2% of all KETs-related patents identified in the period 2001-2011)

- Stable trend curve (number of patents per year), maybe slowly declining in most recent years
- Highest share of industrial applicants, with Applicants in the top 30 being first German, then American, Japanese or French engine manufacturers or first tier subcontractors, and half of the total 8231 patents being from European players, highlighting a strong and active European position in this field:



- The split of patents by KETs reveal a major interest for modernizing the production of vehicle powertrains.
- Patents by KET(s):

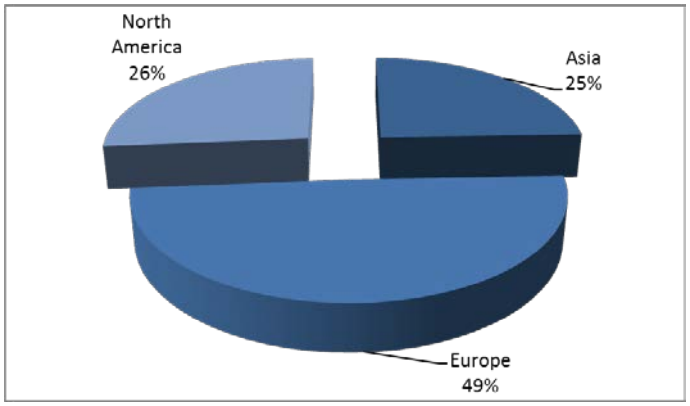


- Patents by KET(s) and relevant combinations of KETs:

KET(s)	*Number of patents*
AM	1355
AM / IBT	1
AM / MNE	38
AM / MNE / N-T	1
AM / MNE / PhT	2
AM / N-T	33
AM / N-T / PhT	1
AM / PhT	7
AMS	6007
AMS / AM	178
AMS / AM / MNE	1
AMS / IBT	1
AMS / MNE	95
AMS / MNE / N-T	2
AMS / MNE / PhT	24
AMS / N-T	4
AMS / PhT	79
IBT	42

KET(s)	*Number of patents*
IBT / MNE	1
IBT / MNE / PhT	1
IBT / PhT	1
MNE	951
MNE / N-T	11
MNE / PhT	116
N-T	54
N-T / PhT	1
PhT	356

- Patent distribution by (Applicant) organization geographical zone:



- Patent distribution by geographical zone of priority protection: