II.5.3 'Green Cars (GC)' - Public-Private Partnership –

Cross-thematic cooperation between NMP, ICT, Energy and Transport (including Aeronautics)

The automotive industry is one of Europe's key industrial sectors, whose importance is largely derived from its linkages within the domestic and international economy and its complex value chain. It is estimated to account for close to 8% of total manufacturing value added (ca. EUR 120 billion, 2006) and about 6% of total manufacturing employment (over 2 million employees). The automotive industry also provides an indirect employment to 10-11 million persons and is one of the largest RTD investors in the EU with over EUR 20 billion annually (ca. 5% of its turnover)[42].

The foreseeable shortage in crude oil based energy carriers is driving fears about energy security: 73% of all oil consumed in Europe is used in transport and estimates predict a doubling of passenger cars within the next 20 years. From an environmental and energy point of view there is an urgent need to find alternatives to fossil fuels in order to secure future energy supply, to guarantee the availability of appropriate material recycling technologies, and to reduce greenhouse gas emissions and other potential environmental impacts related to the automotive industry entire life-cycle. It is thus increasingly evident that a particular emphasis should be put on the rapid development of technologies supporting the massive emergence of more efficient and sustainable road transport solutions based on alternative fuels/energy, and on the RTD efforts associated with them.

The *'European Green Cars' PPP Initiative* is a series of measures boosting research and innovation aiming at facilitating the deployment of a new generation of passenger cars, trucks and buses that will spare our environment and lives and ensure jobs, economic activity and competitive advantage to car industries in the global market. A series of different measures are proposed: support to research and innovation through FP7 funding schemes, specific EIB loans to the automotive and other transport industries and its suppliers, in particular for innovative clean road transport, and a series of legislative measures to promote the greening of road transport (circulation and registration taxes, scrapping of old cars, procurement rules, the CARS21 initiative).

Other actions that are very closely related to the 'European Green Cars' Initiative but not formally included in it are being implemented, such as the 'Fuel Cell and Hydrogen' (FCH) Joint Technology Initiative and the road transport projects funded under the FP7 Transport Theme.

The 'European Green Cars' Initiative includes three major research and development avenues within its RTD pillar:

- **Research for heavy duty vehicles based on internal combustion engines (ICE)** (Sustainable Surface Transport (SST) sub-theme): The research will primarily concentrate on advanced ICE with emphasis on new combustion, the use of alternative fuels (e.g. bio-methane), intelligent control systems, 'mild' hybridisation (use of recuperated electricity to power the auxiliary systems) and special tyres for low rolling resistance.

[42] 'European industry – a sectoral overview', 2006 update, EC DG ENTR

- **Research on electric and hybrid vehicles**: This component will be the most essential in this package. To have a real impact on the green economy, research in this field should no longer focus on electric vehicle technologies seen in isolation from the rest of the transport system: a massive introduction of the technology requires the availability of smart electricity grids and intelligent vehicle charging systems tailored to customers' needs.

- **Logistics and co-modality** combined with **intelligent transport system** technologies are essential to optimise the overall system efficiency and sustainability avoiding for example that empty trucks circulate on highways due to sub-optimal logistics. In this respect, smooth and co-operative interactions between the different transport modes will be essential.

The 2013 work programme includes three groups of topics:

- Materials for batteries, implemented through the NMP Theme.
- Development of electric vehicles for road transport and on-road charging, research for heavy duty vehicles for medium and long distance road transport, and logistics and co-modality, implemented through the Sustainable Surface Transport (SST) sub-theme of the Transport Theme.
- Architectures for electronics in the car; and comprehensive energy management systems for its infrastructure integration, implemented through the ICT Theme.

The indicative budget for 'Green Cars (GC)' is EUR 112.45 million in 2013, of which EUR 20 million is from the NMP Theme[43], EUR 40 million from the ICT Theme[44] and EUR 52.45 million from the Transport Theme[45].

The Transport topics of the GC initiative also support the Smart Cities Scheme, whose main call is FP7-SMARTCITIES-2013.[46]

In addition, the topics ENERGY.2013.7.3.1 and ENERGY.2013.7.3.2 under the coordinated call on Smart Cities and Communities between the Energy and ICT Themes will contribute to the objectives of the GC Public-Private Partnership Initiative.

II.5.3.1 'Green Cars (GC)' Topics implemented by the NMP Theme

During the last 30 years, significant measures have been taken to improve the efficiency of vehicle propulsion systems. At the same time, the weight of cars has tended to increase in order to achieve significant improvements in terms of comfort, crashworthiness and occupant safety. Indeed the weight of a typical vehicle has increased by approximately 30% within the same class. Since the mass of the vehicle has a direct impact on the traction force required and thus fuel consumption (increasing by about 0.5l/100 km for each 100 kg of extra weight), a reversal of this trend is paramount to respect a fundamental requirement for all future automobiles to achieve the highest levels of energy efficiency possible.

[43] call FP7-2013-GC-MATERIALS
[44] call FP7-2013-ICT-GC
[45] part of call FP7-SST-2013-RTD-1and call FP7-TRANSPORT-2013-MOVE-1
[46] see Theme 3 (ICT) and Theme 5 (Energy)

Moreover the range of electric vehicles, generally seen as a critical issue regarding the acceptance of such vehicles in practice, is directly related to the several factors: the efficiency of breaking energy recovery, the performance and cost of the energy storage systems, and not least the weight of the vehicle and its battery. The application of lightweight materials offers an important potential in this regard as it helps to partly compensate for some of the battery's high mass.

Correspondingly, in addition to improving recuperation, and to making batteries less expensive, improving their rechargeability and increasing their energy density, every opportunity for getting more kilometres out of the same amount of energy by has to be fully exploited in order to arrive at a product that the customer accepts and chooses to use.

Already a multitude of innovative concepts and materials are available and used in vehicles and transport carriers today; their further market uptake has been hindered to date by the relatively high costs associated with the development and implementation of advanced materials and production technologies. So, further research is needed to improve this situation.

Considering the large scope of potential novel materials applications, this call will focus on the development of innovative materials for batteries.

GC.NMP.2013-1 Improved materials for innovative ageing resistant batteries

Technical content/scope: Electric cars in the form of Battery Electric Vehicles (BEV) or Hybrid Electric Vehicles (HEV) are a key technology for reaching a cleaner and more sustainable society and its development is considered in actual Commission Policies, in particular in the PPP on Green Cars. However, a lot of challenges still have to be faced before being able to introduce electric vehicles that could perform as well as combustion engine powered vehicles, and a main issue is related to battery technology. A main challenge in this respect is to produce batteries that may provide e.g. sufficient power density, energy density and rechargeability while having a low weight and that may be quickly charged or re-charged, yet maintaining the safety that is necessary for the use in electrical vehicles. Furthermore battery production and usage should be sustainable, thereby considering a complete Life Cycle Assessment of the used solution. And finally the production and running cost and battery lifetime are other key factors. A way forward to reach this goal is looking towards new and improved battery materials. In the last years the research on battery materials technology was boosted worldwide, and huge investments were made in the development of new battery materials, going beyond the nickel based and improving the current lithium-ion technology. In order to maintain competitiveness, battery and battery cell and system production technology should be improved in Europe. The Commission reflected this in three consecutive calls related to the PPP on Green Cars, and started activities with the work programme of 2010 fostering the improvement of currently available lithium batteries, passing to its production techniques (WP 2011), and looking towards the next generation of post lithium-ion-technology (WP 2012). Some progress could be made in the last years with respect to energy density and power density, but a main problem that has not been considered thoroughly is the charging modality during practical use. Batteries may be charged slowly, overnight, or quickly in 30 minutes. New electrical grid technologies foresee also bi-directional charging/discharging as well as continuous charging. The depth of discharge (DOD) level thus may vary significantly at every single discharging cycle. Due to this usage, charging behaviour and materials lifetime are strongly affected. In practice the effects lead to a shorter battery lifetime, as after certain charging cycles only a much reduced charging capacity and respective battery power and performance remains. However, the full life-time performance of novel electrical vehicle battery cells and systems, including those based on the current Li-Ion technology, has not thoroughly been studied so far.

Research proposals should focus on the investigation of ageing mechanisms in battery materials, including the current lithium-ion technology, in order to understand the basic physical and chemical phenomena and processes that lead to the deterioration of battery performance (at cell and system level) over time. The active materials should be considered to be already suited for automotive EV/HEV applications.

Improvements in cell chemistry (liquid or solid electrolytes, separators, additives, non electrochemically active materials, surface treatments, innovative architectures in electrode micro or nanostructure) and system (SOC strategy, thermal management) should be developed to improve the minimum residual charging capacity after a suitable amount of charging cycles. Today a life time of 10-15 years and recharging number of 1200 cycles at 80% DOD is envisaged; ideally 3000-5000 charging cycles after 10-15 years of use should be reached (new promising high energy density battery materials actually permit only about 10 charging cycles, depending on the battery technology). The performance of the newly developed aging resistant cells and systems should at least equal the energy density and power density that are reachable with existing materials, taking into account the variety of user profiles and its translation in current regimes, average DOD, external temperature variation and the like. The development of new chemistries and technologies to overcome the aging mechanism should take into account the various types of charging that occur during the lifetime of the battery, overnight charging, fast charging, recharging, grid charging and grid de-charging, charging in different climatic conditions (-20 to +50°C, for instance). In particular the effects of fast charging/discharging and deep discharging that are related to huge temperature gradients should be considered, also with respect to safety issues. The performance, lifetime and reliability of the advanced cells and battery systems should be assessed and tested under typical operational and extreme conditions with respect to durability and intrinsic safety, as well as environmental health and safety and external mechanical, electrical and climatic stress, e.g. safety after short circuit, fire and car accident/crash. Proof of concept in terms of product and/or process should be delivered within the project, excluding commercially usable prototypes (2006/C323/01), but convincingly proving scalability towards industrial needs, while maintaining the safety and the stability of the technology. Test methods and simulation tools that enable a thorough modelling and understanding of the aging and degradation processes at both cell and system levels are of great importance. Dedicated modelling can be developed to allow predicting the lifetime, reliability and residual value of the new electric vehicle battery and the results should be backed up with strong evidence provided by "post-mortem" analysis. A related testing procedure applicable at European level should be developed.

In addition to the above, the following issues have to be taken into account:

- Considering the intensive research efforts occurring in the field so far, and the dynamics of development of new knowledge, it should be thoroughly demonstrated that new developed materials and technologies permit a considerable increase with respect to the state-of-the-art. This should by underpinned by an extensive study and presentation of the existing knowledge at the date of proposals submission;
- The new technologies should permit a sustainable maintenance of the battery at cell and/or system level;
- Standardization and regulatory issues should be addressed;

- The effect of battery materials and cell production processes on the environment should be minimised,
- An appropriate Life-Cycle Analysis of the advanced materials and the respective components and systems, including dismantling and recycling technologies should be carried out;
- The life-cycle cost of the materials and assemblies as well of the production technologies should be considered by carrying out an economic analysis, including material resources availability. A thorough cost analysis should demonstrate the real advantages of the new materials, cells and systems;
- IPR issues and the use of background and foreground should be intensively discussed and the arrangements in the consortium should allow suitable access of the knowledge to all participants of the consortium, while safeguarding industrial competiveness through adequate measures (i.e. through patents, licenses or other agreements)

Funding Scheme: Large-scale integrating collaborative projects.

Expected impact: (i) Understanding and verification of ageing and degradation processes in electrical vehicle batteries; and (ii) Considerable improvement of the battery lifetime while maintaining optimal battery performance: it should be demonstrated that the new materials used in the cells and systems would allow recharging, at system level, of a minimum of 4000 cycles at 80% DOD in typical BEV conditions over 10 to 15 years, while maintaining energy densities of at least 250 Wh/kg over the lifetime and permitting a considerable reduction of the battery "memory effect"; and (iii) Economic viability and technological feasibility of the advanced materials and the related processes with reference to real applications of industrial relevance; and/or (iv) Improvement of European battery production capacities; and/or (v) Options for the use of environmentally friendly and sustainable materials.