HI-WI

Materials and drives for High & Wide efficiency electric powertrains

**Funding:** European (7th RTD Framework Programme)

**Duration:** Dec 2010 - May 2014

**Status:** Complete with results

**Total project cost:** €3,560,887

**EU contribution:** €2,408,673

**Call for proposal:** FP7-SST-2010-RTD-1

CORDIS RCN : 98408

**Background & policy context:**

Presently, drives for Fully Electric Vehicles ("FEV") and Hybrid Electric Vehicles ("HEV") develop their highest efficiency of around 93~95% within a speed range of usually 1/4 to 1/3 of the maximum, and at an ideal torque, whereas in real-life driving cycles the motor operates at a wider range of speeds and at partial load, resulting in much lower efficiency.

**Objectives:**

The HI-WI project objectives were to deliver:

- Innovative approaches to the holistic design and modelling of rotating magnetic machines tailored specifically to the in-use conditions of FEV and HEV drive cycles;
- Breakthrough materials and manufacturing advances based upon a fusion of nano-scale science and high-technology high-speed production techniques;
- The prototyping and demonstration of innovative drive topologies showing high efficiencies over the wide torque/speed range demanded by real-use driving cycles;
- Guidelines and IPR to support a world-leading EU position in the economic mass manufacture of motors to exploit the global uptake of FEV and HEV mobility.

**Methodology:**

The HI-WI project addressed this mismatch by advancing the design and manufacture of drive trains through:

- Holistic design across magnetic, thermal, mechanical and control electronics/algorithms in line with real-life use rather than a single-point 'rating';
- The use of variable flux approaches in which the flux of the motor can be adjusted in real-time according to the load condition to maximise efficiency.

In addition to the above efficiency gains, HI-WI coupled its novel design approach to breakthroughs in materials and manufacturing, winning size, weight, logistical and cost savings through:

- Adopting nano-scale materials advances to create superior field strengths with reduced reliance upon rare earths and their economically-vulnerable strategic supply chains;
- Adopting nano-scale manufacturing advances to create permanent magnets having ideal geometries, reduced size and weight, and improved mechanical and thermal behaviour.

**Parent Programmes:**

FP7-TRANSPORT - Transport (Including Aeronautics) - Horizontal activities for implementation of the transport programme (TPT)

**Institute type:** Public institution
Institute name: The European Commission
Funding type: Public (EU)

Lead Organisation:

The Chancellor Masters And Scholars Of The University Of Cambridge

Address: TRINITY LANE THE OLD SCHOOLS
CAMBRIDGE
CB2 1TN
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Organisation Website: http://www.cam.ac.uk
EU Contribution: €509,159

Partner Organisations:

The University Of Sheffield

Address: Firth Court Western Bank
Sheffield
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United Kingdom

Organisation Website: http://www.sheffield.ac.uk
EU Contribution: €524,628

Centro Ricerche Fiat - Societa Consortile Per Azioni

Address: Strada Torino, 50
10043 ORBASSANO (TO)
Italy

Organisation Website: http://www.crf.it
EU Contribution: €448,989

Cedrat Technologies Sa

Address: CHEMIN DU VIEUX CHENE 59
38240 MEYLAN
France

Organisation Website: http://www.cedrat-technologies.com
EU Contribution: €160,725

Stmicroelectronics Srl

Address: VIA C.OLIVETTI 2
20864 AGRATE BRIANZA
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**Technologies:**

- Computer-aided design and engineering
- Advanced magnetic modelling tools  
  **Development phase:** Research/Invention

- Electric road vehicles  
  Electric drivetrain for full and hybrid EVs  
  **Development phase:** Research/Invention

- Manufacturing processes  
  Laser annealing amorphous powder materials for electric motors  
  **Development phase:** Research/Invention

- Electric road vehicles  
  Amorphous NdFeB powder for permanent magnets  
  **Development phase:** Research/Invention

**Key Results:**

**High-efficiency next-generation powertrains**

EU-funded scientists have succeeded in developing electric motors and drive systems using fewer rare earth materials, yet providing higher efficiency over a wider range of speeds and torques.

At present, fully and hybrid electric vehicle motors develop their highest efficiency — around 95% — within a speed range of typically one fourth to one third of the maximum rotating speed. However, in the plurality of driving cycles, the motor operates at a wider range of speeds and at partial load, resulting in lower overall efficiency.

The EU-funded project ‘Materials and drives for high & wide efficiency electric powertrains’ ([http://www.hiwi-eu.org/](http://www.hiwi-eu.org/)) addressed the mismatch between the high-efficiency region and the wide region of frequent operation with advances in the design and manufacture of drivetrains. The focus was on optimising drivetrain performance over a whole drive cycle rather than a single point.
HI-WI members demonstrated that the total system efficiency can be enhanced by using a distributed power train with dissimilar machine technologies at the front and rear. To achieve high efficiency over a wide operating range, the motors for one of the axles should have high efficiency, while the motors for the other axle should exhibit low idling loss.

Another project achievement was the development of smart power systems to ensure highly integrated, energy-efficient power conversion using technologies that reduce energy losses and potential perturbations that might disturb other electronic components.

In addition to efficiency gains, HI-WI coupled its novel design approach to developments in magnetic materials. Nano-scale manufacturing advances led to creating permanent magnets having ideal geometries, reduced size and weight, as well as improved mechanical and thermal behaviour.

For high-performance magnetic materials design and production, researchers investigated the synthesis of novel magnetic composites as pre-formed bulk components, and modelled their properties and behaviour. Use of such materials minimised reliance on rare earth elements, reduced the dysprosium content by about 80 % and improved motor torque.

Project advancements in magnetic modelling and simulation tools should allow extensive studies into the nano-structured and nanocomposite materials, and computation of machine efficiency, respectively.

HI-WI outputs should contribute to the development of a European standard reference technology platform for electric vehicle design. This will contain architectures, models, methods and tools for real-time embedded system development, verification, validation and testing.

Documents:
- Final Report Summary - HI-WI (Materials and drives for High & Wide efficiency electric powertrains)
- STRIA Roadmaps: Vehicle design and manufacturing
  - Transport mode: Road transport
  - Transport sectors: Passenger transport
  - Transport policies: Environmental/Emissions aspects, Decarbonisation
  - Geo-spatial type: Other