Innovate UK

# Results of Competition: Faraday Battery Challenge: Innovation R&D Studies Round 3

## Competition Code: 1809_CRD_MMM_ISCF_FARADAY_R3

Total available funding is £23 million

Note: These proposals have succeeded in the assessment stage of this competition. All are subject to grant offer and conditions being met.

| Participant organisation names | Project title | Proposed project costs | Proposed project grant |
|---|---|---|---|
| JAGUAR LAND ROVER LIMITED | LIBRIS (Lithium Ion Battery Research In Safety) | £1,532,937 | £766,468 |
| 3M UNITED KINGDOM PUBLIC LIMITED COMPANY | | £117,352 | £58,676 |
| DENCHI POWER LIMITED | | £1,378,779 | £965,145 |
| Health and Safety Executive | | £1,205,215 | £1,205,215 |
| LIFELINE FIRE AND SAFETY SYSTEMS LIMITED | | £399,325 | £279,528 |
| POTENZA TECHNOLOGY LIMITED | | £328,191 | £229,734 |
| TRI-WALL EUROPE LIMITED | | £1,181,499 | £708,899 |
| University of Warwick | | £645,051 | £645,051 |

Note: you can see all Innovate UK-funded projects here: https://www.gov.uk/government/publications/innovate-uk-funded-projects
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Funders Panel Date: 18/02/2019

| Project description - provided by applicants |
| --- |
| The Government's Faraday programme is supporting an important new research project to improve the safety of batteries for use in electric vehicles and as stationary power sources. Businesses Jaguar Land Rover, Denchi Power, 3M, Potenza, Lifeline and Tri-Wall are pooling resources with academics and experts at the University of Warwick and the Health and Safety Executive to ensure public safety in the age of electric motoring.<br><br>Electrically-powered vehicles and battery storage installations thankfully have a good safety record in the UK, but engineers and academics involved in battery design are taking no chances. Lithium-Ion battery cells have the potential to catch fire aggressively, and with consumers demanding that batteries give them further range and faster charging, there is an urgent need to develop an understanding of how such "thermal runaway" (TR) events may be triggered, suppressed and contained. The use of improved prevention materials, methods and mechanisms and a focus on identifying and detecting all early signs of risks, will ensure that fires can be prevented, or if necessary isolated and suppressed before they spread.<br><br>Project LIBRIS seeks to improve understanding of the range of potential causes of TR in individual battery cells and through scaling up tests and scientific understanding, develop better computational models for assessing the spread of TR within battery packs. The team will use real vehicle and stationary Lithium-Ion battery designs and applications to model theoretical work and will take forward the most effective innovations into newly designed packs which will be tested to make sure that the inventions actually work. The group will then use this experience to develop standard tests for assessing the effectiveness of any future battery fire prevention mechanisms, thus assisting the next generation of work on this vital issue.<br><br>The project will lead to better battery pack design and control software, better fire sensing equipment, more use of innovative flame-retardant materials and better packaging for batteries in transport and during storage. It will create business opportunities and investment in the UK, whilst also contributing to public safety. It will also build UK public sector capability to influence future international safety standards and regulations, so that safety remains paramount, but is science-based and not used as an artificial excuse for trade barriers. |

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|---|---|---|---|
| HEATH SCIENTIFIC COMPANY LTD | Developing the Isothermal Control Platform (ICP) as the Basis of New Proposed Standards for the Testing of Lithium Batteries for Use in Electric Vehicles. | £396,625 | £277,638 |
| Cranfield University | | £82,205 | £82,205 |
| Imperial College London | | £87,777 | £87,777 |

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| Project description - provided by applicants |
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| The characterisation of batteries is critical in the development of lithium battery chemistries and in their safe and efficient implementation in every-day devices. This is of particular importance when considering their use within electric vehicles, where the accuracy of data obtained during tests can significantly influence the designs of modules, the associated thermal management systems and greatly affect performance. Consequently, it is fundamental to understanding whether or not particular battery chemistries and constructions are capable of providing enough power in a safe manner to drive a vehicle under both normal and extreme conditions of use. The design of a cooling system which prevents batteries from overheating is a necessary requirement in every electric vehicle and impacts on safety, battery longevity, vehicle range and vehicle performance. So, in essence it can make or break a particular electric vehicle design.<br><br>To address these issues, during the past eight months Thermal Hazard Technology (THT) and Imperial College London (Imperial) have been involved in the development of the Isothermal Control Platform (ICP), as part of a Feasibility Study funded by the Faraday Challenge.<br><br>The ICP is a platform which controls the temperature of a battery precisely by adding or removing heat directly. Each cell is subdivided into a matrix of zones based on its geometry and specific components, and the temperatures of each of these zones is controlled independently. Furthermore, by using a model for predicting internal temperatures it is possible to control the internal temperature of these to a specified depth or layer non-invasively.<br><br>The programme is progressing well and is on track to deliver the expected prototype. The improvements in the accuracy and quality of data obtained during cycling tests, stress tests, etc. which the ICP makes possible, are ultimately translated into significant gains in battery performance, reliability and safety. With such enhancements in the quality of data available there exists a real potential for setting new standards across the whole industry.<br><br>A programme of work is therefore proposed whereby the Imperial team focuses on developing such protocols, and are joined by researchers from Cranfield who will enhance the team's capabilities and give additional momentum to establishing these tests as internationally recognised standards. During the Research phase of the project, THT will concentrate on integrating these prescribed methods into the ICP system, whilst also taking the platform from its current prototype configuration to a pre-commercial system. |

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|---|---|---|---|
| BRILL POWER LIMITED | Hybrid Battery Optimisation | £582,984 | £408,089 |
| ASTON MARTIN LAGONDA LIMITED | | £924,291 | £462,146 |
| DELTA MOTORSPORT LIMITED | | £647,143 | £453,000 |
| Imperial College London | | £555,700 | £555,700 |

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| Project description - provided by applicants |
| --- |
| The Hybrid Battery Optimisation (HBO) project will develop a novel type of high-performance hybrid energy storage system (HESS) with higher power and energy storage capability per weight than existing alternatives. Existing energy storage systems for hybrid electric vehicles (HEV) are typically based on a single type of electrochemical energy storage device (typically lithium ion batteries) which is designed for either high power or high energy but not for both. The HBO project will screen all commercially available high-quality devices, such as lithium-ion batteries and supercapacitors, and select a combination of devices to optimise for both energy and power capability. The result will be a smaller and lighter energy storage system, which will be particularly well suited for high-performance HEVs, such as those developed by Aston Martin, one of the project partners.<br><br>The HESS will be designed through a new method of optimal system design, which involves a wholistic modelling approach -- from cell to vehicle. This modelling approach will be developed in collaboration between Imperial College London, Delta Motorsport and Aston Martin. By simulating the performance of the different energy storage devices, the most suitable devices can be chosen, which avoids additional hardware tests and accelerates the product development process. Once the optimal combination of energy storage devices is chosen, the HESS is designed and built by Delta Motorsport, a specialist provider of high-performance automotive electrical energy storage systems. To combine the different energy storage devices into a single system, a novel battery management system (BMS) will be developed by Brill Power, a spin-out of Oxford University. Brill Power's BMS can combine any type of lithium-ion battery or supercapacitor while maximising performance and cycle life. Two HESS will be built -- one for lab tests in a controlled environment and one for tests in an Aston Martin vehicle. The tests will confirm the compliance of the HESS with the high performance requirements defined by Aston Martin.<br><br>Once the performance of the new HESS is confirmed, the consortium will develop a plan for commercialising the technology. The first target market will be high-performance vehicles, such as those developed by Aston Martin but the technology is expected to find many more applications, including off-highway vehicles, marine and aerospace. |

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|---|---|---|---|
| JOHNSON MATTHEY PLC | Innovative Carbons for Electrodes in Batteries (ICE-Batt) | £384,811 | £192,406 |
| CENTRE FOR PROCESS INNOVATION LIMITED | | £241,063 | £241,063 |
| THOMAS SWAN & CO.LIMITED | | £184,118 | £110,471 |

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| Project description - provided by applicants |
| --- |
| ICE-Batt aims to tackle key challenges on the Automotive Council Electrical Energy Storage Roadmap. For example, optimising existing Li-ion cathode materials; exploring replacements for currently used solvents with more environmentally desirable alternatives; and preparation of cathode chemistries for new chemistries (e.g. Li-S and Li-air)<br><br>The approach that will be undertaken is as follows:<br><br>* Develop a specification for the requirement of battery<br>* Development of nanomaterials (Graphene/CNTs or hybrids) and composite materials that can be formulated to develop the electrode<br>* Formulation and optimisation of the electrode slurry<br>* Testing the performance of the electrodes from coin-cell testing to, ultimately, single layer pouch cell<br><br>The project partners involved, Johnson Matthey (JM), Centre for Process innovation (CPI) and Thomas Swan (TS), bring unique technical skills that, when collaboratively combined, will allow for the accelerated technical development of this project. Outputs from this project will yield, in an optimised battery pack, an EV that will (i) go further, (ii) have a smaller battery, (iii) perform better in low temperatures, (iv) cost less. Further outputs from the project include (i) safeguarding, and generation, of UK jobs, (ii) give UK industry a technical advantage in lithium-ion sector, and (iii) enable access to global markets for UK based SMEs. |

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| Participant organisation names | Project title | Proposed project costs | Proposed project grant |
|---|---|---|---|
| QINETIQ LIMITED | Scalable Ultra-Power Electric-vehicle Batteries (SUPErB) | £478,545 | £239,272 |
| ECHION TECHNOLOGIES LTD | | £815,709 | £570,996 |
| University College London | | £279,999 | £279,999 |
| University of Birmingham | | £279,685 | £279,685 |
| WILLIAM BLYTHE LIMITED | | £60,165 | £30,082 |

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| Project description - provided by applicants |
| --- |
| One of the big challenges for electric vehicles is to meet the peak power requirements in all modes of operation, at all ambient temperatures. The automotive council has set targets for the power density of Li-ion batteries to quadruple by 2035\.<br><br>This project will develop, test and scale-up new ultra-high-power cells for electric vehicle batteries that have very high peak power handling capability, whilst improving on the energy density of competitive high-power energy storage devices, such as supercapacitors. The main application for such cells will be in the improved delivery of peak power handling in EV main traction batteries. The consortium will also seek to exploit the technology in other applications including use in fast charge stations, public transport, UPS and military applications. A project consortium led by QinetiQ and comprising Echion Technologies Ltd, University College London, the University of Birmingham and William Blythe will scale-up and prove the manufacturability of high-performance electrode materials developed on pilot plants at University College London and Echion Technologies Ltd. The project will deliver improved ultra-high-power cells to demonstrate the technology. |

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|---|---|---|---|
| NEXEON LIMITED | SPICE (Silicon Product Improvement via Coating Enhancement) | £2,064,185 | £1,444,930 |
| AGM BATTERIES LIMITED | | £256,767 | £179,737 |
| PHOENIX SCIENTIFIC INDUSTRIES LIMITED | | £715,456 | £500,819 |
| University of Oxford | | £311,695 | £311,695 |

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| Project description - provided by applicants |
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| The project will deliver a continuous, consistent and scalable coating process developed and optimised by PSI for Nexeon's silicon anode materials. Such coatings promote enhanced cell performance and the use of low-cost electrolytes. Confirmation of enhanced cell performance will be validated in 21700 cells at AGM.<br><br>Battery cells typically represent \>60% of the cost of an EV battery pack and almost 100% are currently imported to the UK. Security of supply is a major concern for UK pack builders and vehicle OEMs. AGM is already working with partners to grow the UK supply chain for cell materials and components, alongside its own plans for significant upscaling of its UK cell manufacturing capability. The need for UK based core cell material manufacturers is partly addressed through this project -- secure supply of IP rich, cell performance enhancing materials means that the cells developed in the UK can offer leading edge performance and provide the consortium members the confidence to scale beyond niche and into mass market application. Oxford University's Department of Materials will provide state-of-the-art material characterisation to support the project. |

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|---|---|---|---|
| VANTAGE POWER LIMITED | High-Power and High-Energy Battery Systems with Integrated Structural Thermal Management for Heavy-Duty Applications | £726,165 | £508,316 |
| Brunel University London | | £134,861 | £134,861 |
| FERGUSSON'S ADVANCED COMPOSITE TECHNOLOGY LIMITED | | £290,981 | £203,687 |
| FLINT ENGINEERING LTD | | £189,115 | £132,380 |

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| Project description - provided by applicants |
| --- |
| This project, titled "High-Power and High-Energy Battery Systems with Integrated Structural Thermal Management for Heavy-Duty Applications" will use the latest in integrated structural and thermal innovations to reduce part count, complexity and cost, whilst improving thermal performance of heavy-duty battery packs.<br><br>These innovations include the use of integrated heat pipes, to provide an order of magnitude better heat transfer than solid aluminium, as well as structural adhesives with far superior thermal conductivity than existing thermal interface materials.<br><br>By improving heat transfer from the cells within a battery, packs with higher overall specific energy and power densities can be built, whilst enabling applications that previously required prohibitively costly and complex cooling. |

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|---|---|---|---|
| SYNTHOMER (UK) LIMITED | Synergy | £390,513 | £195,256 |
| AGM BATTERIES LIMITED | | £216,875 | £151,812 |
| CENTRE FOR PROCESS INNOVATION LIMITED | | £328,279 | £328,279 |
| WILLIAM BLYTHE LIMITED | | £170,956 | £85,478 |

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| Project description - provided by applicants |
| --- |
| The Synergy project is focused on developing a step change in performance and environmental friendliness of lithium ion batteries to meet the needs of electric vehicles. It brings together the raw material, formulation, electrochemical knowledge and cell manufacture capabilities of Synthomer Plc (including Synthomer's polymer development team in Harlow and inorganic material team at William Blythe in Accrington) the Centre for Process Innovation and AGM Batteries Ltd.<br><br>The project will lead to manufacturing and performance improvements in the anode system. It will also focus on methods to improve the safety and environmental profile of cathode systems. The combined improvements are expected to reduce the costs of cell manufacture and help to realise the range and power output needed for the next generation of electric vehicles.<br><br>The project is well suited to capture and exploit the value of electrode materials and lithium ion cell manufacture by establishing a robust UK supply chain. |

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|---|---|---|---|
| JAGUAR LAND ROVER LIMITED | Granite - Passenger Car Solid State Battery | £487,177 | £243,588 |
| AGM BATTERIES LIMITED | | £218,886 | £153,220 |
| ILIKA TECHNOLOGIES LTD | | £1,295,757 | £907,030 |
| University of Warwick | | £509,832 | £509,832 |

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| Project description - provided by applicants |
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| The Government's Faraday Battery Challenge program is supporting an exciting research project to bring solid-state batteries much closer to market in future electric vehicles.<br><br>The main advantage of solid state batteries (SSBs) lies in their increased safety, power performance, enhanced cycle life and increased energy density as compared to current Lithium-ion cells. This should translate into electric vehicles which can travel much further between charges, simpler battery pack designs and faster re-charging when it is necessary. This would ease any remaining customer worries about long charging delays or running out of power on long trips and help more people make the switch to electric motoring.<br><br>However, solid state battery technology is still in its infancy and no one has yet worked out how to deploy the science on an industrial scale and at reasonable cost.<br><br>Project Granite will explore the cost-effective routes for scaling up the solid-state technology developed by Ilika, a pioneering leader in this technology, with the support of AGM Batteries, which has industrial experience in manufacturing Lithium-ion cells. The project is led by Jaguar Land Rover, which will develop the new battery pack designs to fit within their future electric vehicles. Warwick Manufacturing Group will supply academic excellence in abuse modelling and cell performance evaluation.<br><br>The consortium's expertise, backed by Government financial support, will allow Britain's best talent to be brought to bear, so that the UK can take the lead in this transformative technology. |

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|---|---|---|---|
| M&I Materials Ltd | I-CoBat : Immersion-Cooled Battery | £266,917 | £160,150 |
| RICARDO UK LIMITED | | £296,467 | £148,234 |
| University of Warwick | | £162,867 | £162,867 |

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| The ability to charge batteries rapidly is one of the main barriers to the wider adoption of battery electric vehicles (BEVs). For longer journeys and for users who do not have the space or equipment to charge at home ultra-fast charging stations are the answer to alleviate range anxiety. However a key limiting factor to the adoption of fast charging is the battery itself and often the rate of charge from a fast charger is limited to prevent overheating of the battery cells.<br><br>This project aims to validate the concept of immersion cooling for vehicle batteries with a novel thermal management system design. The chosen coolant is a new ester-based dielectric liquid which has been developed to meet the needs of battery cooling. This liquid is also environmentally friendly, cost effective and expected to have a long lifetime in service, needing very little maintenance.<br><br>It is intended that this new thermal management method will allow much more rapid charging of vehicle batteries, to alleviate range anxiety and also prolong the lifetime of cells by avoiding high peak temperatures during fast charge. Immersion cooling is envisaged its first application on premium/luxury/high performance vehicle but this project will address the challenges to apply it also for mainstream applications.<br><br>Validation of the new cooling concept and fluid will be achieved through modelling and testing against the current state of the art cold plate cooling method, used widely in the automotive industry. In addition testing will be conducted to evaluate the ability of immersion cooling with ester liquid to prevent thermal runaway within a battery module. |

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| JOHNSON MATTHEY PLC | Enhanced-Lifespan Saggars for Battery Material Production Scale Up (SAGGAR-LIFE) | £877,883 | £438,942 |
| LUCIDEON LIMITED | | £224,741 | £134,845 |
| VULCAN REFRACTORIES LIMITED | | £81,314 | £56,920 |

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| A saggar is a ceramic container to enclose or protect product during the firing process within a furnace. Saggar lifespan is a very important economic factor for the competitiveness and growth of battery material production, not only because durability of the saggar increases the amount of battery material you can make per saggar, but also reduces waste generation, and the costs of logistics and transportation of new and waste saggars.<br><br>Most common commercial saggars are composed of varying ratios of materials such as alumina and silica. Such materials can be susceptible to chemical attack and corrosion from the battery materials they are designed to hold. With a rapidly growing market for battery material production there is an opportunity to develop saggars that have favourable compatibility for battery materials to enhance the saggar lifespan, enabling re-use of the saggars for multiple production cycles of battery material. Increasing the number of saggar cycles significantly reduces the saggar volumes required, thereby reducing operating cost (OpEx), capital costs (for example by reducing warehousing), and the environmental impact of disposing contaminated saggars when they have reached end-of life.<br><br>This project will develop, screen and benchmark commercially competitive saggars with novel compositions and microstructures to substantially increase saggar lifespan, thereby offering a sourcing route for scalable saggars for long-term commercial-scale production of battery materials. Ideal ceramic material properties are high melting point, wear resistance, chemical stability, appropriate thermal conductivity and deformation resistance at elevated temperature. Along with careful consideration of appropriate raw material particle size and porosity to avoid microstructural defects (e.g. microcracks, agglomerates, porosity) which have an impact in the mechanical and chemical resistance of the ceramic materials during the battery material manufacturing process.<br><br>This supply-chain consortium of UK manufacturers brings together Johnson Matthey's scientific expertise in battery material production, Vulcan's excellence in saggar development and manufacture, and Lucideon's longstanding experience in developing testing programmes and standards. It will put the consortium members, and the UK, in a strong competitive position with a cost optimised process, both using and enhancing the respective members' areas of expertise. |

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|---|---|---|---|
| RD GRAPHENE LIMITED | G-Cap Supercapacitor in All-Terrain Vehicles | £1,212,901 | £849,031 |
| AGILE VEHICLE TECHNOLOGIES LIMITED | | £517,579 | £362,305 |
| MEP TECHNOLOGIES LTD | | £369,602 | £258,721 |
| University of Liverpool | | £179,041 | £179,041 |

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| RD graphene Ltd has invented a transformational process for the manufacture of 3D porous graphene with perfect quality for energy storage devices. The development team currently develops supercapacitor cells which demonstrate incredibly high energy and power density. This technology will disrupt the energy storage industry as the patent pending process is the only one in the world which is capable of creating these graphene-based supercapacitors with very few, simple process steps with cycle times in seconds using existing reel-to-reel technology and therefore removing the barrier to commercialisation completely. This project will demonstrate the value proposition of this innovation by building a complete energy storage system ('battery') with a unique Battery Management System in an innovative EV architecture to validate the use of these systems. |

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|---|---|---|---|
| DEREGALLERA LTD | Low-cost, scalable and agile synthesis routes for sodium-ion battery materials | £672,060 | £470,442 |
| London South Bank University | | £129,089 | £129,089 |
| University of Southampton | | £156,466 | £156,466 |

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| Project description - provided by applicants |
| --- |
| The cost of lithium-ion batteries is set to rise substantially in the near future, due to limited availability of lithium and the growing furore over "African blood Cobalt", a key material of automotive LIB. This project establishes a capability to manufacture alternative candidate sodium-ion batteries at Deregallera. It develops low cost, readily scalable unconventional material processes for synthesising electrodes and develops targeted electrolyte formulations to maximise system synergy. |

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