THE FARADAY INSTITUTION

POWERING BRITAIN'S BATTERY REVOLUTION

ANNUAL REPORT 2018/2019

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The trustees and strategic report and the statement of financial activities including the income and expenditure account can be found at www.faraday.ac.uk/2018-19-annual-report

A YEAR OF ACHIEVEMENT

Founded in October 2017, and in under two years, the Faraday Institution has:

Committed £71 million

to energy storage research, training, and analysis

through March 2021

91% of our total budget

Launched

9 major research programmes

Across **22 UK universities**, 3 of which are in the world's top 10*

Driven by the needs and guidance of over **50 industrial partners**

*as cited by the 2019 Times Higher Education Supplement

United and empowered

a community of over 310 researchers

to solve battery challenges

(450 by end of 2019)

9 Principal Investigators

135 Co-investigators

110 Faraday Institution Research Fellows

(with 79 more joining the new projects launching in late 2019)

30 Faraday Institution-funded PhD researchers across 17 universities

And another 30 PhDs researchers affiliated to Faraday Institution projects (with 46 more joining the new projects launching in late 2019)

Published

58 scientific papers

over **80% in top quartile journals**

Funded

4 entrepreneurial fellows

to launch start-ups related to our research programmes

Awarded

£3 million

from the Department for International Development to explore **energy storage solutions for developing countries** and emerging economies

Filed **1 patent**

and made **4 IP disclosures** from our research projects

Authored

4 Faraday Insight briefings

commissioned **4 market studies**, and participated in the publication of the **WEF Global Battery Alliance's** *A Vision for a Sustainable Battery Value Chain in 2030*

Provided **8 weeks**

of hands-on **battery research placements** to 50 Faraday Undergraduate Summer Experience interns

Funded

10 undergraduate students

from backgrounds under-represented in STEM careers with **bursaries to support their education**

Hosted

3 Royal Institution panel discussions

educating **150,000 online viewers** on the increasing role of energy storage to electrify the UK economy

The Faraday Institution is today creating meaningful impacts for the UK where energy storage science, technology, and policy meet in the global race to fully electrify.

STATEMENT FROM THE CHAIR

This has been a significant year of development, transformation and growth for the Faraday Institution. During the year, recruitment of key staff was completed and the team, now headed by CEO Neil Morris, is fully engaged in delivering the mission of the Faraday Institution.

From expanding our research portfolio and growing our network of academic, research and industrial partners to launching a new programme for entrepreneurship, we are maturing our research programmes to yield real-world results. A year ago, we were beginning to see early indicators of success in the research programmes. Today, this is translating into a stream of scientific discoveries evidenced by numerous papers and multiple IP disclosures, and by the progression of four commercial spinouts.

We have boosted our educational programmes to attract the next generations of research talent from school children to undergraduates and PhD researchers, particularly focusing on those from backgrounds under-represented in careers in science, technology, engineering and maths. We have advised government on policymaking through a landmark economic study on electric vehicle (EV) and battery cell production potential for the UK and aim to continue to inform policymakers through a new monthly publication Faraday Insights.

In short, the Faraday Institution is today creating meaningful impacts for the UK where energy storage science, technology, and policy meet in the global race to fully electrify. Over the next few years we will build from this stable foundation, in depth and in range, as the needs for electrochemical storage and conversion grow in the electrifying economy. We will hold to our vision of bringing together four pillars for economic success: research, training, analysis, and translation.

I'm pleased to share this Faraday Institution Annual Report, which outlines the achievements, milestones, and progress made in our research, technology development, and education and skills programmes over the past year, as well as the government support making such achievements possible. This report also presents our financial results for the 2018-2019 fiscal year.

I would like to acknowledge the commitment and dedication of our executive team and staff, our trustees, the Faraday Institution research community, our supporters and advisers in government, and our many new partners and friends as we continue into our next year, in which our programmes will expand further.

Thank you for your ongoing contributions, support, and accomplishments.

Peter B. Littlewood
Chair

The work of the Faraday Institution will contribute to economic prosperity, the lowering of carbon emissions, improvements in air quality, the creation of new industries, and the securing of high-quality jobs.

STATEMENT FROM THE CEO

I am delighted to be introducing the Faraday Institution's Annual Report.

It is our mission to accelerate much-needed scientific breakthroughs in energy storage to benefit the UK and, with our colleagues across the wider Faraday Battery Challenge, to meet the national goals set by the Government's Industrial Strategy. We must leverage the UK's world-class research capabilities to lead the charge to break down the fundamental scientific barriers that hinder the commercial realisation of future battery technologies.

To achieve the ambitious goals we have set, we have assembled a unique community—dedicated university researchers from a multitude of fields, committed industry partners, and a new generation of students—who bring a diversity of perspectives and who are united in their efforts to overcome tough scientific challenges: to reduce battery cost, weight, and volume; improve performance, efficiency, and reliability; develop scalable designs; improve manufacturing abilities; develop whole-life strategies; and accelerate commercialisation. This community is 300-strong and growing, including over 20 academic and 50 industrial partners, and we are building collaborations with world-class international research organisations.

In this report, you will hear much about our extended research portfolio. New projects in four focus areas join our existing research projects that collectively have the dual aims of improving current generation lithium ion batteries as well as longer horizon materials discovery and optimisation projects to support the commercialisation of next-generation batteries.

The Faraday Institution is already having a direct impact on the UK, not only through our research programmes, but also from the ideas of its leaders, the engagement of our team with policymakers, and the network of influential partners we have assembled. This report will lay out our year of progress in research, education and skills, and technological development that will set the stage for future successes yet to come.

While our initial research targets were focused on the automotive sector to meet the Government's Road to Zero commitments, the Faraday Institution must look beyond automotive and help advance battery development for other applications and sectors—such as rail, marine, grid, and aero—to support the UK's emerging electrified economy. We have established a strong foundation from which we can also start to address the challenges in these areas.

Finally, I want to say thank you to our staff, research community, and our partners across the Faraday Battery Challenge and in government for their focus, dedication, and advice throughout this past year. I very much look forward to our work together in the coming year, and beyond, to deliver energy storage breakthroughs for the UK.

Neil Morris
Chief Executive Officer

THE FARADAY INSTITUTION

THE FARADAY INSTITUTION

Battery technology will enable the electrification of the UK, and the world. The Faraday Institution wants to ensure that this future is built in Britain.

Despite recent developments in energy storage, battery technology is still far from reaching its potential. Shortcomings in battery life, power density, and energy efficiency impede the introduction of next-generation batteries to the marketplace. The high cost of raw materials, materials processing, cell and module packaging, and manufacturing also hold us back.

Bringing together expertise from universities and industry, the Faraday Institution is tackling these challenges. Powering Britain's battery revolution, the Faraday Institution is the UK's independent institute for electrochemical energy storage science and technology, supporting research, training, analysis and translation. Our goal is to make the UK the go-to place for the research and development of new electrical storage technologies for both automotive and other industry sectors.

Electrification of the economy will reshape the workforce and we need to predict needs and provide training. The Faraday Institution anticipates these impacts and, by partnering with government and the auto sector, will provide a curriculum roadmap that enables the UK to take full advantage of this moment of transition.

Headquartered at the Harwell Science and Innovation Campus, the Faraday Institution is a registered charity with an independent board of trustees.

ISCF FARADAY BATTERY CHALLENGE

The Faraday Battery Challenge is part of the Industrial Strategy Challenge Fund (ISCF), overseen by the Department for Business, Energy and Industrial Strategy, which is designed to ensure that research and innovation take centre stage in the government's Industrial Strategy.

With an investment of £274 million between 2017-2021, the challenge aims to support a world class scientific, technology development and manufacturing scale-up capability for batteries in the UK. The challenge is focused on developing cost-effective, high-performance, durable, safe and recyclable batteries to capture a growing market.

Research

Funded through the Engineering and Physical Sciences Research Council (EPSRC), part of UK Research & Innovation, the Faraday Institution is a £78 million research institute that will accelerate the fundamental research needed for future battery development.

Innovation

Delivered by Innovate UK, part of UK Research & Innovation, £88 million of funding is available for businesses to lead feasibility studies and collaborative research and development projects in battery technology.

Scale-up

Delivered by the Advanced Propulsion Centre (APC), the £108 million UK Battery Industrialisation Centre (UKBIC) will enable companies of all sizes to develop manufacturing capabilities for battery technologies to get them to market quickly

The eight limitations of automotive battery technology

Initially addressing eight present-day limitations of automotive battery technology, the challenge will allow the UK to realise its commitment to move to full electrification and zero-emissions vehicles. The challenge is expected to translate into other sectors including aerospace and rail.

Cost

2/3 cost reduction

Now	2035
$130/kWh (cell) $280/kWh (pack)	$50/kWh (cell) $100/kWh (pack)

Energy Density

2x energy density

Now	2035
700Wh/l, 250Wh/kg (cell)	1400Wh/l, 500Wh/kg (cell)

Power Density

4x power density

Now	2035
3 kW/kg (pack)	12 kW/kg (pack)

Safety

Battery packs 'inherently safe'

2035
Eliminate thermal runaway at pack level to reduce pack complexity

1st Life

Pack life equivalent to life of the car

Now	2035
8 years (pack)	15 years (pack)

Temperature

50% increase in operating temp. range (°C)

Now	2035
-20° to +60°C (cell)	-40° to +80°C (cell)

Predictability

Full predictive models

2035
Full predictive models for performance and aging of battery

Recyclability

Closed-loop recycling system in place

Now	2035
10-50% (pack)	95% (pack)

FARADAY INSTITUTION BOARD OF TRUSTEES

Our Board of Trustees brings multifaceted perspectives and experiences from academia, industry, and public service to the role of advising the Faraday Institution. Board members serve as ambassadors and advisers in support of the Faraday Institution's aims.

Chair

Professor Peter B. Littlewood
Professor of Physics
The University of Chicago

Vice Chair

Stephen Heidari-Robinson
Co-founder and Managing Director
Quartz Associates

Dr Stefan Berger
Director of Electrification
Jaguar Land Rover

Dr Jeff Chamberlain
CEO
Volta Energy Technologies

Dr Johney Green Jr.
Associate Laboratory Director
US National Renewable
Energy Laboratory (NREL)

Dr Julie Maxton
Executive Director
The Royal Society

Professor Mark Spearing
Vice President, Research
and Enterprise
University of Southampton

Professor Kristina Edström
Director, Ångström Advanced
Battery Centre (ÅABC)
Uppsala University, Sweden

Jorge Pikunic
Managing Director, Distributed
Energy and Power
Centrica

Professor Pam Thomas
Pro Vice Chancellor for Research
University of Warwick

Sir Oliver Letwin
Senior Advisor

For complete biographies, see section 2

FARADAY INSTITUTION EXECUTIVE TEAM

Chief Executive Officer

Neil Morris

Chief Financial Officer

Susan Robertson

Head of Programme Management

Allan Paterson

Head of Engagement and Education

Matthew Howard

Head of Economics and Market Insights

Stephen Gifford

Head of Technology Transfer

Ian Ellerington

Chief Scientist

Peter G. Bruce

For complete biographies, see section 2

1 A YEAR OF DEVELOPMENT, TRANSFORMATION AND GROWTH

GROUNDBREAKING RESEARCH TO IMPROVE BATTERY PERFORMANCE

The Faraday Institution is powering one of the most exciting technological developments of the 21st century—Britain's battery revolution. As the world competes to define the future of energy and automation, the Faraday Institution is accelerating the application-inspired research needed for future battery development to power the transport and energy revolution for the UK.

£42m

Initial application-inspired research to address known technical performance gaps*

£55m

The five new projects announced in September 2019 represent an investment of up to £55 million over their intended four-year duration.

**The Faraday Institution's research portfolio, shown in the figures above, was assembled after consultation with UK academic and industrial stakeholders, with due consideration of the potential UK impact they could make. Project selection involved independent technical review panels.*

THREE RESEARCH STREAMS

The Faraday Institution's research model unites the best battery researchers across the UK from many scientific fields to work collaboratively on real-world battery challenges. Through frequent reviews, and with advice from an external expert panel, the Faraday Institution actively manages its projects to meet the urgent needs demanded by the global race to electrify; it adjusts research directions, reallocating funding to the research that appears the most promising. Because of the UK's need to deliver improvements in energy storage over a range of timescales, the Faraday Institution is pursuing a portfolio of research projects. With the projects announced in September 2019, our research portfolio consists of three project streams.

Optimising current generation lithium-ion based batteries

Five focus areas aiming to optimise current generation lithium-ion based batteries where there are still considerable gains to be made and where research breakthroughs could start to be realised in commercial batteries (delivering benefits to EV owners) within 3-4 years.

Focusing on

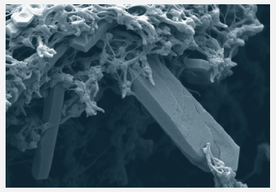
- Extending battery life
- Multi-scale modelling
- Recycling and reuse
- Electrode manufacturing
- Lithium-ion cathode materials

Beyond lithium-ion: a new generation of battery technologies

Three focus areas that are higher risk, higher reward and could facilitate the long-term commercialisation of next-generation battery technology that still require considerable research in the areas of materials discovery and optimisation.

Focusing on

- Solid-state batteries
- Sodium ion batteries
- Lithium sulfur batteries

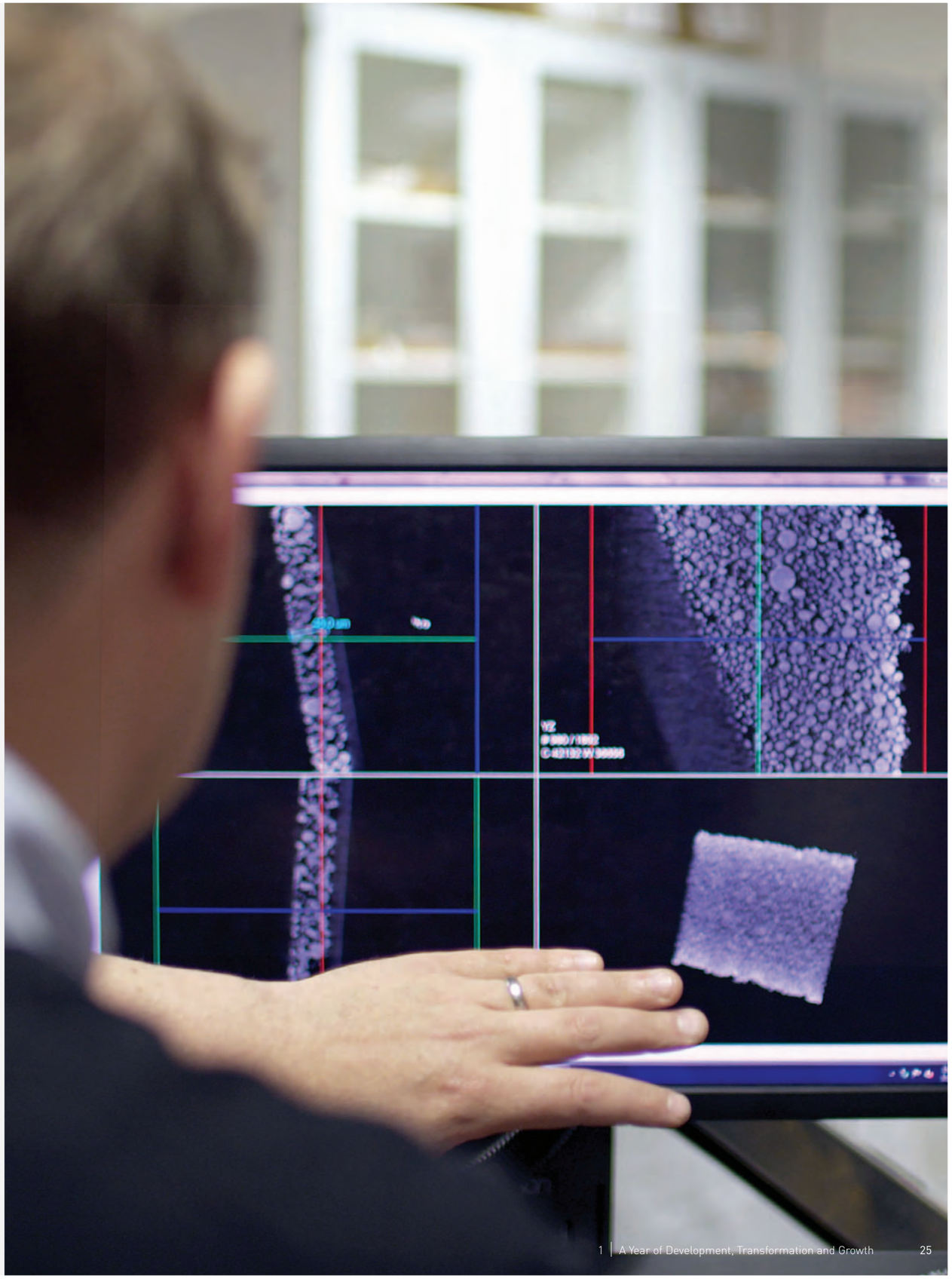


New battery focused characterisation and analytical techniques

Three small projects to develop battery-focused characterisation and analytical techniques (launched in the summer of 2019). These projects will provide UK researchers with world-leading tools to accelerate their understanding of battery materials and their performance.

Focusing on

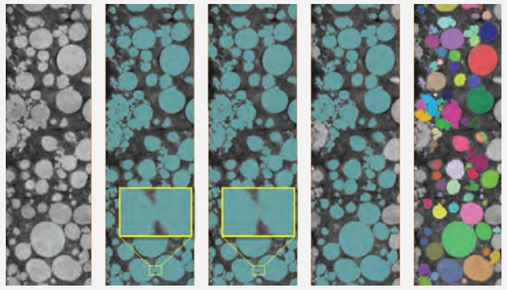
- Imaging dynamic electrochemical interfaces
- The development of high-resolution optical microscopies
- Probing buried interfaces in working batteries



OPTIMISING CURRENT GENERATION LITHIUM-ION BASED BATTERIES

Extending battery life

Project: Degradation



Led by the University of Cambridge with eight other university and seven industry partners, this project is examining how environmental and internal battery stresses (such as high temperatures, charging and discharging rates) damage electric vehicle (EV) batteries over time. Results will include the optimisation of battery materials and cells to extend battery life (and hence EV range), reduce battery costs, and enhance battery safety.

UNIVERSITY OF CAMBRIDGE

Lead institution
University of Cambridge

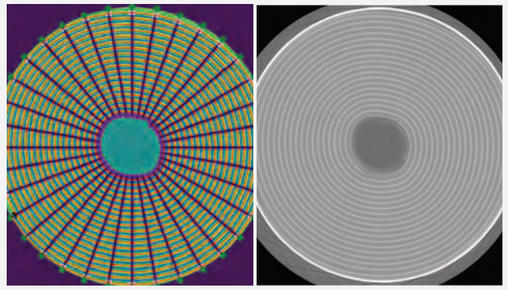
Principal Investigator
Professor Clare Grey

Academic consortia

University College London
Newcastle University
Imperial College London
University of Manchester
University of Sheffield
University of Southampton
University of Liverpool
University of Warwick

Multi-scale modelling

Project: MSM



Imperial College London is leading a consortium of eight other university and 13 industry partners to equip industry and academia with new software tools to understand and predict battery performance, by connecting understanding of battery materials at the atomic level all the way up to an assembled battery pack. The goal is to create accurate models for use by the automotive industry to extend lifetime and performance, especially at low temperatures.

Imperial College London

Lead institution
Imperial College London

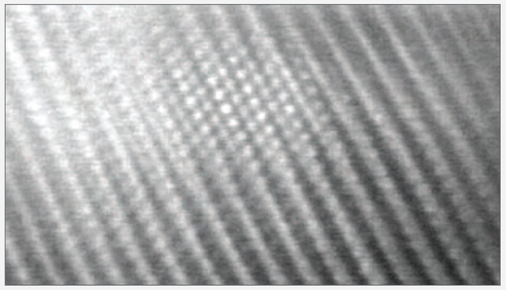
Principal Investigator
Dr Gregory Offer

Academic consortia

University of Southampton
University of Warwick
University of Oxford
Lancaster University
University of Bath
University of Portsmouth
University College London
University of Birmingham

Recycling and reuse

Project: ReLiB



A project led by the University of Birmingham and including seven other academic institutions and 12 industrial partners is determining the ways in which spent lithium-ion batteries can be recycled. With the aim to recycle 100% of the battery, the ReLiB project is looking at how to reuse batteries and their materials to make better use of global resources and ultimately increase the impact of batteries in improving air quality and decarbonisation.

UNIVERSITY OF BIRMINGHAM

Lead institution
University of Birmingham

Principal Investigator
Dr Paul Anderson

Academic consortia

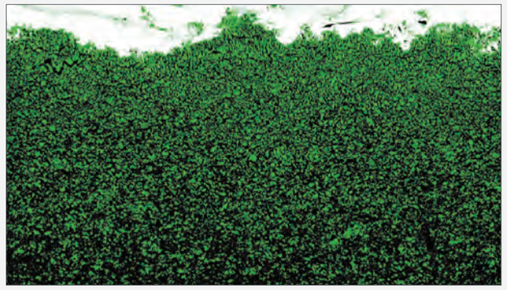
University of Leicester
Newcastle University
Cardiff University
University of Liverpool
Oxford Brookes University
University of Edinburgh
Science and Technology Facilities Council

OPTIMISING CURRENT GENERATION LITHIUM-ION BASED BATTERIES

(CONTINUED)

Electrode manufacturing

Project: Nextrode



Announced September 2019

The University of Oxford is leading a consortium of five other university and six industry partners to revolutionise the way electrodes for Li-ion batteries are manufactured. By understanding how materials assemble as electrodes are cast, and developing new manufacturing tools, the Nextrode consortium aims to usher in a new generation of smart, high performance electrodes, which could enable EVs with a longer range and batteries that are more durable.

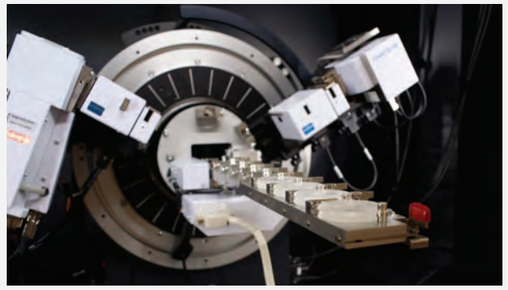
Lead institution
University of Oxford

Principal Investigator
Professor Patrick Grant

Academic consortia
University of Birmingham
University College London
University of Sheffield
University of Southampton
University of Warwick

Lithium-ion cathode materials

Project: FutureCat



Announced September 2019

The FutureCat project is led by the University of Sheffield with five other university and nine industry partners. It has a coordinated approach to cathode chemistry design, development and discovery (including tailored protective coatings and designer interfaces) to deliver cathodes that hold more charge, that are better suited to withstand prolonged cycling and promote ion mobility (increasing battery durability and range and acceleration of the EV) while reducing the dependency of cell manufacturers on cobalt.

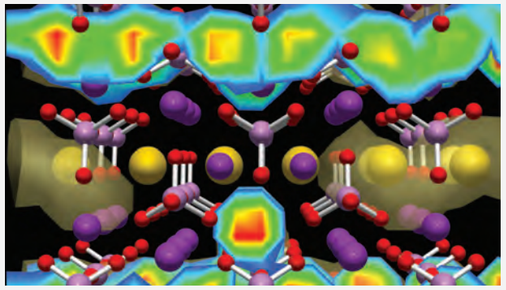
Lead institution
University of Sheffield

Principal Investigator
Professor Serena Corr

Academic consortia
University of Cambridge
University College London
Lancaster University
University of Oxford
Science and Technology Facilities Council

Lithium-ion cathode materials

Project: CATMAT



Announced September 2019

The CATMAT project is led by the University of Bath with six other university and 12 industry partners, this project will place considerable emphasis on understanding the fundamental mechanisms at work within novel cathodes that currently prevent the use of nickel-rich cathode materials (with low or no cobalt) and lithium-rich cathodes. The consortium plans to exploit this new knowledge to inform the discovery of novel cathode materials with enhanced properties. It will scale up the synthesis of the most promising new materials and assimilate them into fully battery cells to demonstrate performance.

Lead institution
University of Bath

Principal Investigator
Professor Saiful Islam

Academic consortia
University of Birmingham
University of Cambridge
University of Liverpool
University of Oxford
University College London
Science and Technology Facilities Council

MEET MICHAEL

THE SUPERCOMPUTER DESIGNED TO BUILD BETTER BATTERIES

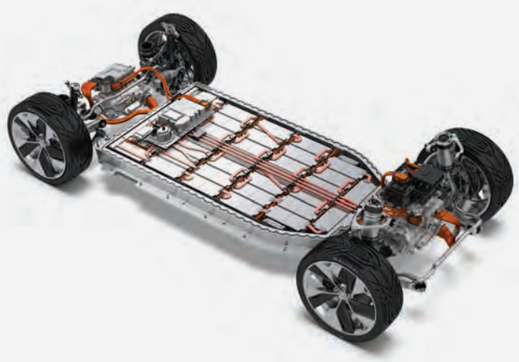
The Faraday Institution funded the build of a new supercomputer designed to speed up research on two of the UK's most important battery research projects by providing dedicated capacity available responsively at short notice.

The supercomputer (named Michael, after the UK's most famous battery scientist, Michael Faraday) is located at University College London and will assist over 110 researchers focused on creating new models for battery systems and researching next-generation, solid-state batteries.

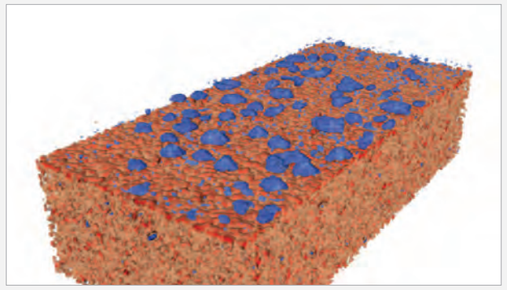
This new supercomputer will be a valuable resource for the UK's battery researchers, providing them with the insight necessary to improve battery performance and lifetime and reduce costs.

Professor Sir Mark Walport
Chief Executive, UK Research and Innovation

BEYOND LITHIUM ION – A NEW GENERATION OF BATTERY TECHNOLOGIES



Solid-state batteries
Project: SOLBAT



The University of Oxford is leading an effort with five other university partners and six industrial partners to break down the barriers that are preventing the progression to market of solid-state batteries that should be lighter and safer and have longer range, meaning potential overall system level cost savings through less reliance on cooling systems. The ambition of the SOLBAT project is to understand the key chemical and fabrication challenges that would be inherent in the integration of batteries with a chemistry beyond Li-ion.

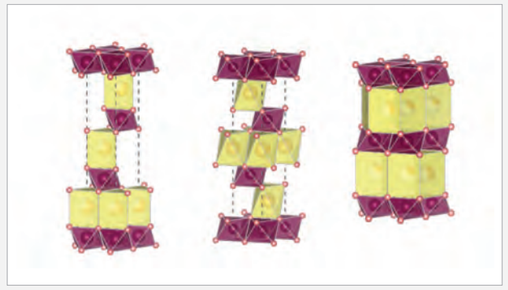
UNIVERSITY OF OXFORD

Lead institution
University of Oxford

Principal Investigator
Professor Peter Bruce

Academic consortia
University of Liverpool
University of Cambridge
University College London
University of Sheffield
University of St. Andrews

Sodium ion batteries
Project: NEXGENNA



Announced September 2019

This project, led by the University of St Andrews, will include five other UK partner laboratories, three industrial partners and collaborations with Diamond Light Source and five leading overseas research institutes. NEXGENNA will accelerate the development of sodium ion battery technology by taking a multi-disciplinary approach incorporating fundamental chemistry right through to scale-up and cell manufacturing. Its aim is to put on the path to commercialisation a safe sodium ion battery with high performance, low cost and a long cycle life. The relatively low cost of sodium ion batteries makes them an attractive next generation technology, particularly for static energy storage applications, low-cost vehicles and 12V lead-acid battery replacement.

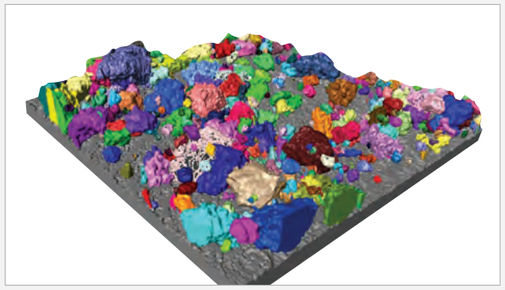
University of St Andrews

Lead institution
University of St Andrews

Principal Investigator
Professor John Irvine

Academic consortia
Lancaster University
University of Cambridge
University College London
University of Sheffield
Science and Technology Facilities Council

Lithium sulfur batteries
Project: LiSTAr



Announced September 2019

University College London (UCL) is leading an effort with six other university partners and seven industrial partners to enable rapid improvements in Li-S technologies by generating new knowledge, materials and engineering solutions, thanks to its dual focus on fundamental research at material and cell level, and an improved approach to system engineering. If the potential of Li-S is realised it would improve lithium chemistry batteries beyond current limitations: Li-S is one of the most attractive alternative technologies available as it would be inherently lighter and in theory less expensive. This project will collaborate directly with the SOLBAT project to leverage advances that enable lithium metal anodes and a route to high energy density.

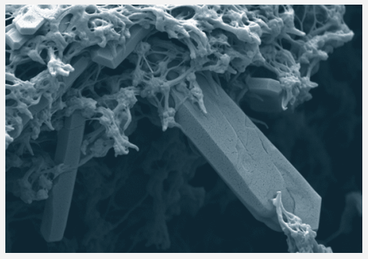
UCL

Lead institution
UCL

Principal Investigator
Professor Paul Shearing

Academic consortia
University of Leicester
Newcastle University
Cardiff University
University of Liverpool
Oxford Brookes University
University of Edinburgh
Science and Technology Facilities Council

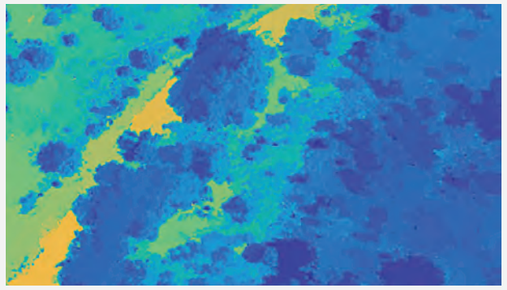
NEW BATTERY FOCUSED CHARACTERISATION AND ANALYTICAL TECHNIQUES



The Faraday Institution awarded a total of £2 million to three UK-based consortia in July 2019 to develop battery-focused characterisation and analytical techniques to provide UK battery researchers with world-leading tools to accelerate the development of their understanding of battery materials and enable scientific breakthroughs that will ultimately improve the performance of electric vehicles (EVs). These projects build upon the recommendations of a study of scientific facilities available in the UK (Identifying Infrastructure and Collaborative Expertise for Electrochemical Energy Storage Application, Nigel D Browning and Laurence J Hardwick).

The new projects target advanced technique development across small, medium and large-scale user facilities to support structural and mechanistic understanding of a wide range of battery chemistries, not limited to those currently being investigated by the Faraday Institution.

Imaging dynamic electrochemical interfaces



Led by the University of Liverpool with five other universities and five additional partners, this project will define a framework that can connect state-of-the-art imaging and analytical methods across the different length and time scales important to battery research in a coherent way to improve understanding of how a battery works. Machine learning will play a key role in the project. Success will provide researchers with a clear view of how altering the structure, shape and chemistry of a battery material leads to a change in battery function and a potential improvement in performance.

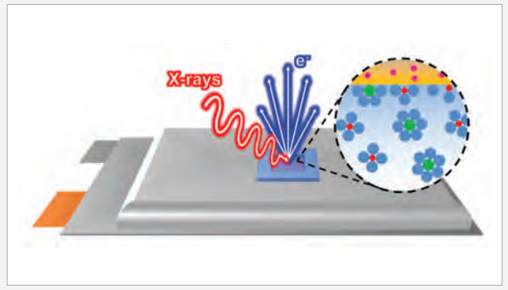
UNIVERSITY OF LIVERPOOL

Lead institution
University of Liverpool

Principal Investigator
Professor Nigel Browning

Academic consortia
University of Manchester
University of Birmingham
University of Warwick
University of Bath
University College London

What lies beneath? Probing buried interfaces in working batteries



This project, led by the University of Oxford with Diamond Light Source and contributions from eight other partners, will develop a novel platform that enables the exploration of changes at interfaces deep within a battery while it is charging and discharging. It will also develop a technique to preserve surfaces after a battery has been disassembled for further research. Technique development will take advantage of newly available experimental capabilities at Diamond Light Source and the Henry Royce Institute. For the first time researchers will be able to examine the same battery sample using three key interface-sensitive characterisation techniques, allowing direct correlation of the complementary information they provide.

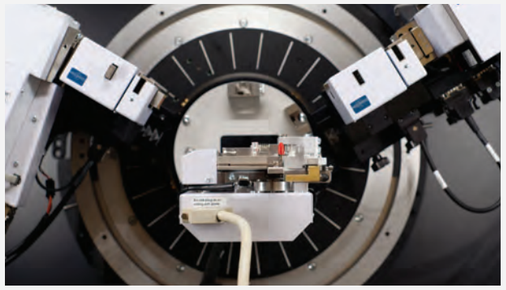
UNIVERSITY OF OXFORD

Lead institution
University of Oxford

Principal Investigator
Professor Robert Weatherup

Academic consortia
Science and Technology Facilities Council
University of Manchester

The development of high resolution optical microscopies



Composed of researchers from three departments at the University of Cambridge, this project will build upon recent breakthroughs in characterisation methods developed for semiconducting materials to provide a greater understanding of how electrode materials function at the single particle level and at shorter timescales than is currently available. Methods developed during this project will tackle crucial questions, such as how fast lithium ions move, how the crystal structure of electrodes change, and what are the obstacles for ion transport at a microscopic scale? These world-leading methods will allow the research community to examine battery materials in order to develop the next generation of high-performance materials.

UNIVERSITY OF CAMBRIDGE

Lead institution
University of Cambridge

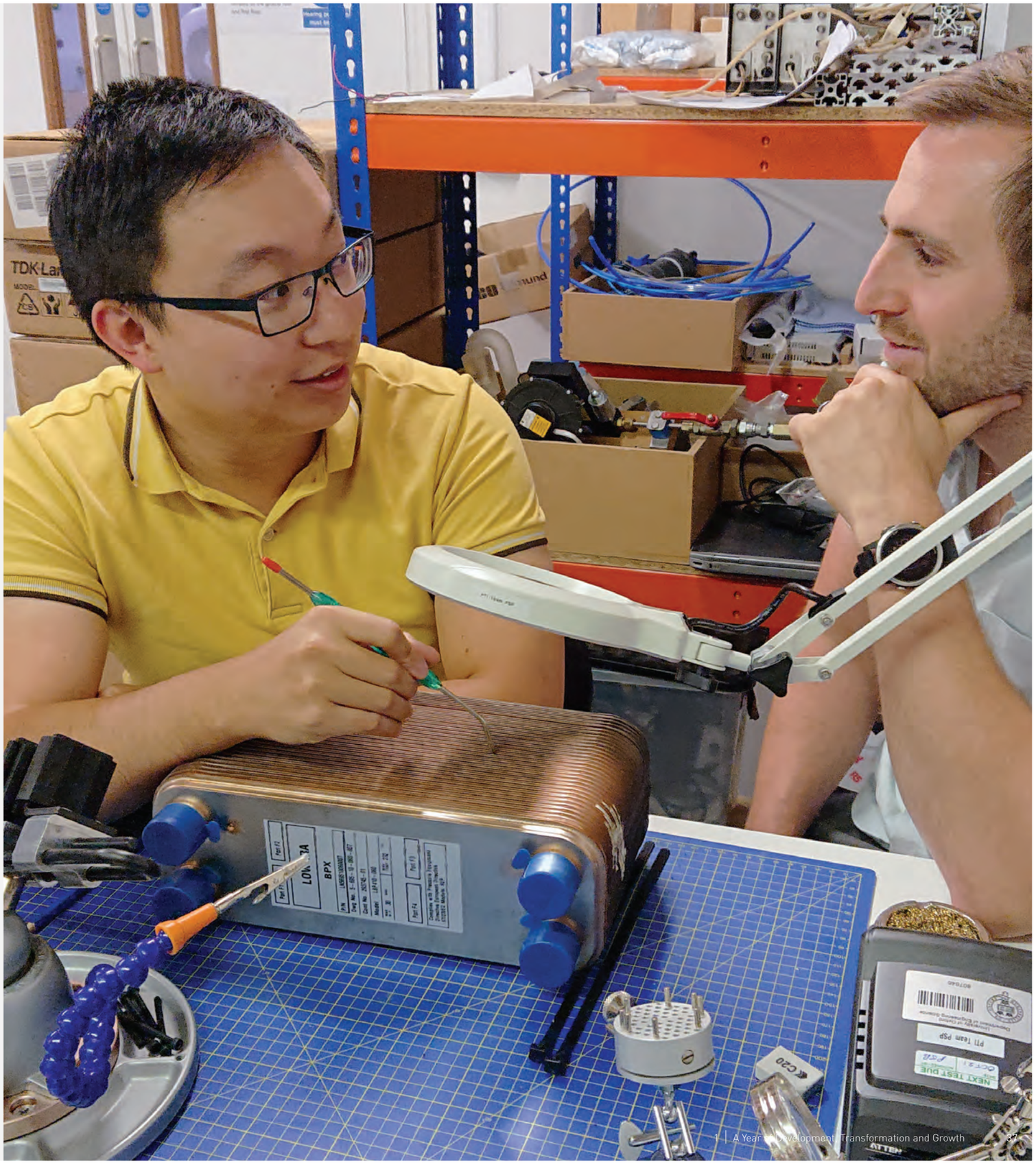
Principal Investigator
Dr Siân Dutton

STRENGTHENING THE CAPABILITIES OF OUR RESEARCH COMMUNITY

Next-generation energy storage technologies will come from the next generation of scientists and engineers. To this end, the Faraday Institution seeks to build a diverse pipeline of talent across different levels—undergraduate, graduate, PhD, PDRA—to create a steady stream of trained battery scientists for the UK.

The Faraday Institution educational programmes, now in their second year, have provided 50 undergraduate interns with real-world laboratory experiences, 30 PhD researchers with structured technical and skills training, and 110 postdoctoral research associates with continuing professional development opportunities. With the first phase of projects, in total, the Faraday Institution is supporting the development of over 310 researchers across 20 universities. This will increase by around 130 researchers with the start of the next round of projects.

Numbers expected by March 2020



UNDERGRADUATE PROGRAMMES

Faraday Institution Scholars Programme (FISP)

Launched in the autumn of 2019 at five of our founding universities, FISP provides an annual bursary for up to 14 students from under-represented groups (ethnic minorities, women, and the socio-economically disadvantaged) to pursue STEM (science, technology, engineering and maths) degrees and careers to diversify the talent pool. University partners provide Faraday Scholars with a mentor and a paid summer internship in an energy storage laboratory in their university or with an appropriate industry partner.

Faraday Undergraduate Summer Experiences (FUSE)

Over the summers of 2018 and 2019 the Faraday Institution has funded 50 undergraduate internships in partner universities. These 8-week, competitive internships give undergraduates access to leading scientists and unique facilities and hands-on research experience. A select number of interns present their research via a poster session at a Faraday Institution research project review meeting. Several graduates of this programme have since gone on to pursue PhDs in energy storage related disciplines; one is now an advanced battery engineer employed by JLR.

The Fully Electric Engagement Programme (FEEP)

In February 2018, 50 undergraduate students on STEM degree programmes attended an event held at the Royal Academy of Engineering in partnership organised by the Faraday Institution and SEO London, a charity that prepares talented students from ethnic minority or low socio-economic backgrounds for career success. The vision is to inspire, attract and retain people from backgrounds historically under-represented in STEM. The first event focussed on London and a second event in Birmingham in October 2019 was attended by 38 students. Students were able to network with battery researchers from a range of our industrial partners including JLR, Siemens, Horiba Mira, Rolls Royce, Johnson Matthey, Williams Advanced Engineering, and Ricardo exposing them to potential battery related careers.

Equality, Diversity and Inclusion Working Group

To be successful in its mission, the Faraday Institution must create and grow a community of researchers and associated teams that can work effectively in a collaborative way, training, recruiting and developing those working within the community and enabling all to maximise their potential. An equality, diversity and inclusion (EDI) working group has been established to support this mission. The working group will identify priorities, recommend and develop policies and actions and act as EDI champions within the Faraday community. Specific areas of responsibility include:

- Monitoring programme against EDI metrics
- Promoting best practice in selection processes within activities
- Ensuring FI events and communications represent the diversity of our community
- Recommend EDI related training

The scope of this work will be those areas directly managed by the Faraday Institution and those that are within the scope of its influence, for example activities funded by Faraday Institution grants.

Faraday Institution PhD Cluster

The Faraday Institution offers a comprehensive PhD training programme. Our PhD cohort has access to networking opportunities, industry visits, mentorship, internships, as well as quality experiences that will further develop knowledge, skills, and aspirations. Their progress is tracked against individual training plans on an app developed by a University of Oxford start-up called InkPath.

The training programme aims to equip students with the in-depth knowledge and skills needed to support their research projects with modules such as the *Battery Safety Course* in Newcastle and *WMG Battery School* in Warwick. An energy-storage themed *Mini-MBA* programme for the second year PhDs is planned to develop wider business and management skills for their future careers, whether in academia or industry.

Early Career Travel Grants

The Faraday Institution provides funds of up to £2000 each to cover travel and subsistence for early career researchers to visit international institutions or large-scale facilities and aims to facilitate collaboration between scientists from a range of disciplines relating to electrochemical energy storage research.

BATTERY RESEARCHER SPOTLIGHT

Watch the videos at tinyurl.com/faradayresearch

PhD researcher
Dana Thompson

Battery Recycling Project
University of Leicester

PhD researcher
Aaron Wade

Multi-scale Modelling Project
University College London

PhD researcher
JJ Marie

Solid State Batteries Project
University of Oxford

PhD researcher
Haydn Francis

Battery Degradation Project
University of Cambridge

GROWING ECONOMIC VALUE FOR UK INDUSTRY

The Faraday Institution's initial research projects have developed strong and significant collaborative links with a wide range of industrial partners. More than 50 companies from the UK and overseas and several international research organisations provide support and direction to the projects. This engagement continues to both grow and deepen.

50+

Companies provide support and direction to our projects

MINI production plant, Oxford

Our industrial partners take an active role in the management of our research programmes working with the Faraday Institution to ensure that the research outcomes are shaped to meet commercial needs. Further, the Faraday Institution has identified potential commercial collaborations and spinouts based on our research engagements.

AGM Batteries
Arcola Energy
BBOXX
Benchmark Mineral Intelligence
BenevolentAI
BMW Group
British Metals Recycling Association
cap hpi
CarTakeBack
Carl Zeiss Microscopy
Circular Energy Storage
Claytex
Continental Automotive
Deregallera
Echion Technologies
Ecobat
Envision AESC
Exawatt
Faradion
Horiba Mira
Huntsman Corporation
Ilika
Imerys Minerals
Intelligens
Jaguar Land Rover
Johnson Matthey
KU Leuven
KUKA Robotics
Lancaster Materials Analysis
LG Chemical
Lianhetech
McGill
McLaren Automotive
Morgan Advanced Materials
Nexeon
Nissan
nVIDIA
Omicron Nano Technology
Oxis Energy
Potenza Technology
PV3 Technologies
QinetiQ
Rolls-Royce
Shell
SHIELD Investment Management
Siemens
Silson
Talga Technologies
Thatcham Research
Thermo Fisher Scientific
Toyota Motor Europe
William Blythe
Williams Advanced Engineering

INDUSTRY SPRINTS

The Faraday Institution builds closer industry relationships where specific short-term research needs have been identified, which lie within the broad scope of our research projects and which are of wider interest to industry.

Cell degradation

A Faraday Institution partner highlighted an issue whereby some battery chemistries have been shown to suffer from increased capacity fade when stored at a specific state of charge. Aligned with both the Degradation and Multi-scale Modelling projects, researchers will be analysing commercial cells after 20, 40 and 60 weeks of temperature-controlled storage, using local and national scale facilities. The outcome of this work will indicate if the issue can be solved by modification to the cell chemistry, or whether battery management system strategies need to be employed to minimise residence time at these conditions.

Timeframe **15 months** Projects Involved **Degradation, Multi-scale Modelling**

Cell abuse, off gas species and detonation behaviour

Under cell failure conditions, the collection of off gases within a pack potentially poses a risk to aerospace applications where venting is undesirable. The aim of this sprint is to characterise the composition of these gases under various failure conditions, and to determine the danger they present across a range of environmental limits. This is expected to be an exploratory study into what is potentially a larger piece of work, where modelling could predict any flammability or detonation limits, and then be used to inform pack design during early development phases.

Timeframe **4 months** Projects Involved **Degradation**

Materials for thermal transfer and module manufacture

Thermal control of a battery pack is vitally important to its performance and longevity. Higher performance thermal materials could usefully improve both, by transferring heat efficiently from the cells to the cooling system, and by isolating cells from their neighbours in cases where an individual cell is going into thermal runaway. This sprint will look into the development of nanomaterials composites, phase change materials and functional scaffold materials to meet these aims, then both model and experimentally validate them.

Timeframe **6 months** Projects Involved **Multi-scale Modelling**

ENTREPRENEURIAL FELLOWS

£100k

funding each to help to support researchers to commercialise battery technologies

The Faraday Institution's entrepreneurial programme offers up to £100k funding each to help to support researchers to commercialise battery technologies. These fellowships have been set up to facilitate the creation of new business opportunities that have emerged from Faraday Institution research programmes or closely related activities. Fellowships provide seed funding, business support and mentoring to maximise the potential of success and accelerate the spin-out process.

ENTREPRENEURIAL FELLOWS SPOTLIGHT

Watch the videos at tinyurl.com/faradayfellows

Dr Ian Campbell
and Dr Yan Zhao

Breathe Battery Technologies

Dr Ola Hekselman

Solveteq

Our goal is to give some of the brightest entrepreneurs in the battery space the best chance of success.

Ian Ellerington
Head of Technology Transfer

Breathe Battery Technologies

Breathe is an independent start-up founded by Drs Yan Zhao and Ian Campbell, who recently completed their PhDs in Dr Gregory Offer's group at Imperial College London. Breathe targets a step reduction in the charging time of batteries by replacing widely used static charging algorithms in existing battery management systems. By adapting the charging process to the unique, evolving health of every battery, the researchers believe they can unlock substantial latent performance. Health-adaptive charging could also potentially increase battery lifetime and decrease battery cost.

The researchers are targeting the consumer electronics market, with its short qualification periods, as a proving ground for its longer-term focus on electric vehicles. This fellowship is allowing the team to refine its business and pricing strategy and make progress along its technical roadmap to develop and demonstrate a product to satisfy early adopters in the consumer electronics market.

Solveteq

Solveteq's co-founder, Dr Ola Hekselman of Imperial College London, is developing a new, low-energy, low-pollution, potentially low-cost chemical alternative to current smelting processes for lead-acid battery recycling. It produces lead oxides, which are commodities that can be directly used in the production of new batteries. Despite the rise of Li-ion batteries, lead acid batteries are still present in hybrid and electric vehicles and with emerging applications such as grid energy storage, no decline in their use is expected in the near future.

Through this entrepreneurial fellowship, Solveteq is aiming to scale up and optimise the process from gram scale to multi-kilogram scale. In the longer term, the same process could be used to tackle the challenge of recycling other types of batteries.

Qdot

Qdot is a University of Oxford spin-out developing cutting edge heat transfer technology to solve some of the world's most challenging thermal engineering problems. The three co-founders of Qdot—Dr Jack Nicholas, Dr Holt Wong and Prof Peter Ireland—are aiming to apply the company's patented heat transfer technology to achieve a step change in the recharge rate of Li-ion batteries. Applied to EVs, Qdot aims to more than double the recharge rate from 6 miles/min to over 15 miles/min.

Qdot's heat transfer technology was originally developed for applications in a nuclear fusion tokamak, where heat loads can be in excess of 10 MW per square metre and the temperatures are over 100 million kelvin. The aim of the twelve-month entrepreneurial fellowship is to develop a prototype thermal management system, based on this technology, to achieve extremely fast charging at the battery cell level. Future research would then look at expanding this to a battery module, and then pack, level. Qdot would initially look to market its technology in the EV sector, particularly in applications that demand high availability.

SHARING FARADAY INSIGHTS

To address UK energy storage policy questions, the Faraday Institution launched "Faraday Insights" briefings to provide independent, evidence-based understanding of battery economics, societal issues, and UK capabilities.

The Faraday Institution has been working to inform policy makers on the energy transition and to do so in direct support of one of the its key directives: 'to seek to influence opinions, regulation, legislation or policies and to seek to ensure that members of the public, public bodies, policy makers and public institutions are well-informed on questions relating to any research or any other activity undertaken.'

Faraday Insights provide an evidence-based assessment of the market, economics, technology and capabilities for energy storage technologies and the transition to a fully electric UK. The insights are concise briefings that aim to help bridge knowledge gaps across industry, academia and government.

The road to electrification – from the internal combustion engine to the battery electric vehicle

All around the world, markets are transitioning from the internal combustion engine to electric vehicles (EVs). The UK is at the forefront of this push for the electrification of road transport. By 2030, the Faraday Institution expects that 64% of new cars bought in the UK will be EVs. Three-quarters of these will be battery EVs and one-quarter plug-in hybrids.

The gigafactory boom: the demand for battery manufacturing in the UK

The transition to electric vehicles will substantially increase the demand for batteries. Across Europe, there is a race to develop battery manufacturing factories to meet this demand. The UK is well-positioned to be a major player in this market. By 2040, the Faraday Institution estimates that eight gigafactories will be needed in the UK and consequently employment in the automotive industry and battery supply chain could increase from 186,000 to 246,000 jobs.

Bringing cheap, clean and reliable energy to developing countries

Over 800 million people worldwide do not have access to electricity and, of those that do, many suffer from an unreliable supply. Diesel and petrol generators commonly used in developing countries bring problems of noise, air quality and climate impacts. Energy storage technologies including batteries have the potential to replace generators and provide cheap, clean and reliable electricity to millions of people.

Electric vehicle and battery safety skills for emergency services, vehicle repair, and auto retailers

Fire, police, ambulance, and service personnel will need new skills to handle EV accidents and repair to ensure the safety of themselves and others The number of those workers who need reskilling is substantial and resources are needed to support sector skills councils and providers for regional delivery of accredited courses.

The UK's electric vehicle and battery production potential to 2040

Further, the Faraday Institution has commissioned deeper studies to generate understanding and inform policy. For example, with McKinsey Energy Insights and the University of Oxford, the Faraday Institution published *The UK's Electric Vehicle and Battery Production Potential to 2040* in 2019. Additional 2019 studies underway include the impact of electrification of auto on skills, battery energy storage needs in developing countries, high energy density materials and markets, and international comparison of battery cell costs.

The potential for UK gigafactories and cost competitiveness of cell manufacturing in the UK

The Faraday Institution has collaborated with the UK Battery Industrialisation Centre, Advanced Propulsion Centre and Innovate UK on the potential for gigafactories to be built in the UK and on building the evidence base to help secure investment from a cell manufacturing company. We have jointly commissioned Element Energy to undertake a study to assess the cost competitiveness of battery cell manufacturing in the UK compared to transporting battery cells manufactured in, for example, Germany or China.

Download the reports at faraday.ac.uk/publications/faraday-insights

CONNECTING THE WORLD TO BECOME FULLY ELECTRIC

The Faraday Institution has joined the World Economic Forum's Global Battery Alliance and the World Bank's Energy Storage Partnership in order to effect global change and allowing communities without connectivity to have reliable access to sustainable energy sources.

Global Battery Alliance

The Faraday Institution with the other partners in the Global Battery Alliance, a public-private partnership led by the World Economic Forum, helped launch a 2019 report entitled *A Vision for a Sustainable Battery Value Chain in 2030*. The report suggests that, with a concerted push to put the right conditions in place, batteries could enable a 30% reduction in carbon emissions in both the transport and power sectors. These two sectors alone collectively account for 40% of all greenhouse gas emissions today. Energy storage technology could become the most significant intervention to keep global warming within the limits set by the Paris Agreement on climate change between now and 2030.

Energy Storage Partnership

This World Bank initiative brings together 28 international partners to prioritise activities through seven working groups for the next 12 to 18 months. The Faraday Institution is directly involved in two working groups: development of testing protocols and validation of performance, and recycling systems and standards. With the National Renewable Energy Laboratory in the US, the Faraday Institution will be investigating discrepancies between specifications of energy storage systems and actual performance in developing countries.

Battery storage in developing and emerging economies

On 7 March 2019 the Department for International Development (DfID) announced £30 million of new funding to the Transforming Energy Access programme to give more people and companies across Africa access to affordable, clean energy.

60% of African businesses say access to reliable power is a constraint on their growth. Power outages cost African countries 1 to 2% of their GDP annually. Currently, 600 million people across the continent have no access to electricity.

£3 million of the new DfID funding will support research into finding new energy storage technologies, such as ways of replacing diesel generators. It will be administered by the Faraday Institution to define the market and technological needs and opportunities for battery and other energy storage technologies in developing countries and emerging economies.

£3m

to support research into finding new energy storage technologies for use in emerging economies

DEVELOPING A STRONG NATIONAL AND INTERNATIONAL REPUTATION

The Faraday Institution has a responsibility to ensure that the public has the best information based on data as the UK transitions to a fully electrified economy. Over the past year, the Faraday Institution have conducted desk briefings with a range of top tier media outlets in the UK to establish itself as a reputable source of information regarding energy storage research and technology and electric vehicles. This has led to repeated top tier media coverage in outlets that include the BBC, CNN Business, Sky News, *The Telegraph*, Bloomberg, *The Guardian*, Reuters, *Financial Times*, and *The Times*.

Further, the Faraday Institution is committed to be a voice in the UK's academic and energy storage related industrial and financial communities. Our CEO, Neil Morris, has presented keynote addresses in a range of forums this year including the Aurora Spring Forum, Oxford; The Battery Show Europe, Stuttgart; and events organised by the Natural Resources Forum, Bessemer Society, and Benchmark Mineral Intelligence.

AN AUTHORITATIVE SOURCE ON ENERGY STORAGE AND ELECTRIC VEHICLE TOPICS

The Faraday Institution works with high reputation partners to leverage its resources through selected activities that can provide maximum impact. The Faraday Institution ran a set of events this year to engage the public in dialogue about the challenges and promises of energy storage.

A Royal Institution discussion series *The Batteries are Coming!*

This included a series of three panel discussions in the lecture theatre of the famous Royal Institution—home to Michael Faraday's laboratory—with the goal of engaging the public around topics of electrification and electric vehicles. Over 150,000 views of the videos have been logged online.

Sandhurst STEM Careers Fair

The purpose of the Sandhurst STEM Careers Fair is to provide secondary school students, 11-16 years old, access to a wide range of careers available in STEM and to inspire future generations of scientists, technicians, engineers and mathematicians. Members of the Faraday Institution research community put their STEM ambassador training to use, meeting with students to inspire them to consider careers in the energy storage and battery technology field.

The Big Bang UK Young Scientists and Engineers Fair

This event is the largest celebration of science, technology, engineering and maths (STEM) for young people (primarily aged 7-19) in the UK with over 80,000 attendees annually. The Fair showcases a combination of exciting shows, interactive workshops, hands-on activities and careers information from STEM professionals. Faraday Institution PhD researchers attend and work to convey their research in a relatable way to a diverse audience with the aim of inspiring the next generation of battery researchers and raising their STEM career aspirations.

Image © Paul Clarke / Ri

EVENT SPOTLIGHT

Watch the videos at tinyurl.com/RI-Faraday

The Battery - Inside Out

Serena Corr
University of Sheffield

Simon Moores
Benchmark Mineral Intelligence

David Greenwood
Warwick Manufacturing Group

Judith Richardson
Jaguar Land Rover

How Will Batteries Change Our World?

Vicky Edmonds
Office of Low Emission Vehicles

Colin Herron
Zero Carbon Futures

Peter Stephens
Nissan

Jo Coleman
Shell

The Future of Mobility

Robert Llewellyn
host of The Fully Charged Show

Christian Bedford
Williams Advanced Engineering

Alison Park
Economic and Social Research Council

Richard Morris
Innovate UK

2 PROFILES

BOARD OF TRUSTEES PROFILES

The Faraday Institution's trustees bring multifaceted perspectives and experiences from academia, industry, and public service to the role of advising the Faraday Institution. Board members serve as ambassadors and advisers in support of the Faraday Institution's aims.

Peter B. Littlewood

Chair

Peter B. Littlewood is Professor of Physics at the University of Chicago. He served as the 13th Director of the US Department of Energy's Argonne National Laboratory, after having served as the associate laboratory director of its Physical Sciences and Engineering directorate. He spent the previous 14 years at the University of Cambridge, where he last served as the head of the Cavendish Laboratory and the Department of Physics. Littlewood is internationally recognised for his research in a number of areas, including superconductivity, semiconductor optics, and magnetic materials. Littlewood holds a bachelor's degree in natural sciences (physics) and a doctorate in physics, both from the University of Cambridge.

Stephen Heidari-Robinson

Vice-Chair

Stephen Heidari-Robinson is co-founder and managing director of Quartz Associates. He served as former UK Prime Minister David Cameron's energy and environment adviser and was one of the architects of the UK's generation strategy and decarbonisation plan. Heidari-Robinson spent nine years as a leader in McKinsey and Company's energy practice and was a vice president of Schlumberger. Heidari-Robinson read history at the University of Oxford, holds an MA in architectural history from the Courtauld Institute, University of London, and studied Farsi at the School of Oriental and African Studies.

Stefan Berger

Dr Stefan Berger joined Jaguar Land Rover (JLR) as Director, Electrification, in October 2017. He plays a vital role in JLR's electrification journey, leading and coordinating both the electrification of the product portfolio and related activities like charging infrastructure development and the creation of new business models around electrification. Stefan holds a PhD in Information Systems from the University of Regensburg, Germany, and a Diploma in Business Administration of the University of Passau, Germany.

BOARD OF TRUSTEES PROFILES

Jeff Chamberlain

Dr Jeff Chamberlain is CEO of Volta Energy Technologies, a company that identifies and invests in battery and energy storage technology after performing deep diligence with the support of unparalleled global research institutions. In service both to its strategic corporate investors and to entrepreneurs, Volta identifies and invests in the most promising energy-storage innovations. Chamberlain holds a PhD in physical chemistry from the Georgia Institute of Technology and a BS in Chemistry from Wake Forest University.

Johney Green Jr

Dr Johney Green Jr. serves as the Associate Laboratory Director for the Mechanical and Thermal Engineering Sciences directorate at the US Department of Energy's National Renewable Energy Laboratory (NREL). Green oversees early-stage and applied research and development in NREL's advanced manufacturing, buildings efficiency, concentrating solar power, geothermal energy, sustainable transportation, water power, and wind energy programs. Green holds a bachelor's degree in mechanical engineering from the University of Memphis and a master's and doctorate in mechanical engineering from the Georgia Institute of Technology.

Julie Maxton

Dr Julie Maxton CBE is the Executive Director of the Royal Society, the first woman in 350 years to hold the post. Before taking up her position at the Royal Society in 2011 Maxton was Registrar at the University of Oxford, the first woman in 550 years in the role. Maxton combined a career as a practising lawyer with that of an academic, holding a number of senior academic positions, including those of Deputy Vice Chancellor, Professor and Dean of the Faculty of Law at the University of Auckland, New Zealand.

Jorge Pikunic

Dr Jorge Pikunic is Managing Director of Centrica's global Distributed Energy & Power business, established to deliver distributed energy solutions for large energy users as part of a more flexible energy landscape. Born in Venezuela, Pikunic is an engineer and holds a MSc and PhD in Chemical Engineering. He was a research fellow at the University of Oxford before joining McKinsey & Company, where he advised a number of institutions in energy and other sectors.

BOARD OF TRUSTEES PROFILES

Mark Spearing

Professor Mark Spearing is the Vice-President, Research and Enterprise at the University of Southampton. Previously he was the Pro Vice-Chancellor (International) and Head of the School of Engineering Sciences, having been appointed as the Professor of Engineering Materials in 2004. He was a faculty member at the Massachusetts Institute of Technology from 1994-2004. His personal research focuses on structural and functional materials. He holds a BA and PhD in Engineering from the University of Cambridge.

Pam Thomas

Professor Pam A. Thomas FInst P, CPhys, is currently the Pro Vice Chancellor for Research at the University of Warwick with responsibility for academic leadership of the research portfolio. In her personal research, she leads the Ferroelectric Crystallography group in the Department of Physics. She was educated at the University of Oxford, where she took a BA (Hons) in Physics and a DPhil on the subject of optical activity in crystals in the Crystallography Group of the Clarendon Laboratory.

Kristina Edström

Professor Edström leads the Ångström Advanced Battery Centre (ÅABC) and she is a professor of Inorganic Chemistry at Uppsala University, Sweden. Her main research interests are lithium-ion batteries for all applications including electric vehicles, 3D microbatteries but beyond lithium batteries (sodium-ion, organic batteries, lithium-sulfur, lithium/sodium-oxygen batteries and solid-state batteries). She also develops photon science and neutron scattering in operando methods for studying dynamic processes in materials and batteries, in addition to having a great interest in teaching and guiding young researchers. She is a member of the Royal Academy of Engineering Sciences.

Sir Oliver Letwin

Senior Advisor

Sir Oliver served as the Member of Parliament for West Dorset from 1997 to 2019. From 2010, he was the Minister for Government Policy in David Cameron's coalition government and coordinated the push to make the UK a world leader in electric vehicles. He continued to serve as Chancellor of the Duchy of Lancaster, Cabinet Minister in overall charge of the Cabinet Office until July 2016. He was educated at the University of Cambridge, Princeton University, and London Business School. In a varied career, Sir Oliver has been a research fellow at the University of Cambridge, a civil servant, and a bank director. He lives in West Dorset and London.

Neil Morris

Chief Executive Officer

Neil has over 33 years of international operations, business and commercial experience in the energy sector.

Neil joined BP plc in 1985 and has led large, globally diverse teams, consistently delivering sustainable performance improvement in a wide range of challenging roles. He has excellent strategic, analytical, leadership, management and communication skills. He has a track record of driving sustainable change through distilling complex issues to establish a clear improvement strategy and engaging teams at all levels in the organisation in delivery. After leaving BP in 2014 Neil was Chief Executive Officer of a privately owned downstream oil company with refining and trading operations in Germany, London and Geneva. He significantly improved performance by driving operational improvements, making changes in the sales strategy and active risk management of exposure to refining margins.

Neil holds a first-class degree in chemical engineering from Loughborough University and an MBA from Edinburgh University. He is a Chartered Engineer and Fellow of the Institute of Chemical Engineers.

Susan Robertson

Chief Financial Officer

Prior to joining the Faraday Institution, Susan was Chief Financial Officer of Velocys, the AIM-listed renewable fuels company, a position she held for 10 years through the company's transformational years from early stage start-up to the point of having a commercial plant in operation. Prior to that, she was at the BOC Group (now Linde Group) where she held various senior-level financial management and business development positions in the UK and in Japan. Susan helped to set up and then, from 2003 to 2006, served as Vice President and CFO of Japan Air Gases (JAG), a joint venture between The BOC Group and Air Liquide.

Susan has an honours degree in economics from the University of Cambridge and is a chartered accountant (FCA) having originally trained with Arthur Andersen in London.

Peter G. Bruce

Chief Scientist

Professor Peter Bruce is a founder and Chief Scientist of the Faraday Institution. He is also leading the research project on solid state batteries. He is the Wolfson Professor of Materials at the University of Oxford.

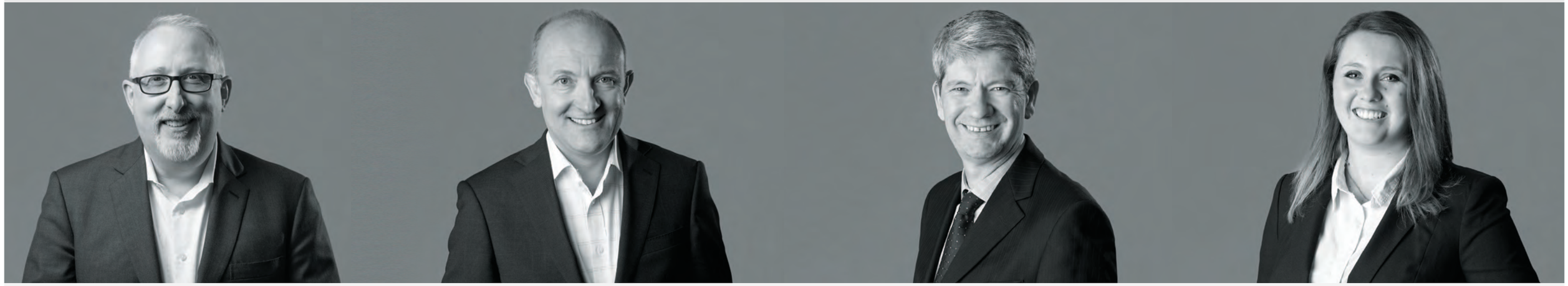
Peter's research interests embrace materials chemistry and electrochemistry, especially lithium and sodium batteries. Recent efforts have focused on the synthesis and understanding of new materials for lithium-ion batteries, on understanding anomalous oxygen redox processes in high capacity Li-ion cathodes, the challenges of the lithium-air battery and the influence of order on the ionic conductivity of polymer electrolytes.

His research has been recognised by a number of awards and fellowships, including from the Royal Society, the Royal Society of Chemistry, the German Chemical Society and The Electrochemical Society. He was elected to the Royal Society (UK Academy of Sciences) in 2007 and the Royal Society of Edinburgh (Scottish Academy of Sciences) in 1994. He has appeared on the Thomson Reuters list of highly cited researchers since 2015.

Allan Paterson

Head of Programme Management

Dr Allan Paterson is the Faraday Institution's Head of Programme Management. Prior to joining, Allan was Chief Electrochemist at both Cummins and Johnson Matthey Battery Systems, where he led a team of electrochemists, managed a range of collaborative R&D projects including investigating new battery technologies and their application in next generation low carbon EVs, plug-in hybrid EVs and hybrid EV applications. Allan has over 19 years' experience in the field of lithium-ion batteries, and over eight years in automotive batteries, including developing novel high energy density materials and next-generation battery technologies. Allan holds a PhD in chemistry from the University of St Andrews on advanced cathode materials for lithium-ion batteries.



Matthew Howard

Head of Engagement and Education

Prior to the Faraday Institution, Matt served as the Chief Communications Officer and director of the communications and public affairs division for the US Department of Energy's Argonne National Laboratory. In this capacity, he was responsible for communications strategy, brand and visual identity, media relations, crisis communications, internal communications, educational programmes and community engagement.

Before joining Argonne in 2007, Matt served as the director of the media initiatives group at the University of Chicago. In the past, Matt has worked as a higher education adviser, as an editorial and communications lead for multiple start-up companies, and as an editor for an academic publisher.

Matt holds an MBA from the University of Chicago Booth School of Business, a master's degree from Miami University, and a bachelor's degree from the University of Rochester.

Ian Ellerington

Head of Technology Transfer

Ian joined the Faraday Institution after six years in central government where he worked on designing and implementing innovation programmes in the energy sector. He was responsible for the government's energy innovation programme in the Department of Energy and Climate Change and continued in the Department of Business, Energy and Industrial Strategy as Head of Disruptive Energy Technologies and Green Finance Innovation.

Ian is an engineer who graduated from University of Cambridge with an M.Eng. in manufacturing engineering in 1993 and is now an experienced technical manager who has worked with small, medium and large corporates, academia and government. His early career was spent working on gas turbine engines with the Ministry of Defence before moving to project management at QinetiQ where he was responsible for research programme management and delivery of large test programmes. He left QinetiQ to join Meggitt Defence Systems that developed and operated new technical products. As UK General Manager Ian set up and ran a new R&D and manufacturing facility.

Stephen Gifford

Head of Economics and Market Insights

Stephen has over 25 years of economics experience, including as the Chief Economist at Grant Thornton, the Director of Economics at the CBI and as a senior economist at KPMG, Oxford Economics and the Prime Minister's Strategy Unit. Prior to joining the Faraday Institution, Stephen was Head of Economic Regulation at the Civil Aviation Authority, where he focused on the regulation of Heathrow and Gatwick airports, and the development of the new runway at Heathrow. Stephen is currently a Commissioner in the National Infrastructure Commission for Wales.

Stephen brings particular skills and expertise in economic policy, transport economics, infrastructure, market assessment and the role of the public sector. He has a first-class degree in economics from the University of Liverpool and a MSc in econometrics and mathematical economics from the London School of Economics.

Alison Green

Financial Analyst

Alison joined the Faraday Institution from Navitas, a leading global education provider where she helped to set up the European shared services centre and ran the general ledger team. Prior to that she held finance roles in an international paints and coatings company.

Alison has a BA (Hons) in accounting and finance from Leeds Metropolitan University and is currently in the process of completing her accountancy qualification with the Chartered Institute of Management Accountants (CIMA).

Louise Gould

Communications Specialist

Louise Gould is a marketing and communications professional who has centred her career around technology-based organisations. She joined the Faraday Institution after 5 years as Marketing Communications Manager at the renewable fuels company Velocys.

Prior to joining Velocys she served as Marketing Manager for an equipment manufacturer serving the print industry. She was also Product Manager for one of Oxford Instruments' range of low temperature sample environments used for spectroscopic techniques that sold into research institutions worldwide. She started her career as a scientific consultant and project manager at AEA Technology, who was also based at Harwell Science and Innovation Campus.

Louise graduated from the University of Cambridge with a BA in Natural Sciences (Chemistry) and holds an MSc in the Chemistry of Advanced Materials from the University of Manchester Institute of Science and Technology (UMIST).

Fran Long

Education and Training Coordinator

Fran Long overseas the operations of the Faraday Institution's undergraduate, PhD, and PDRA educational and training programmes.

Prior to her work at the Faraday Institution, Fran served as a STEM engagement specialist and award-winning primary science teacher who is passionate about promoting science and engineering. In 2017, Fran was honoured to receive a Primary Science Teacher Award (PSTA), endorsed by the Institute of Physics, and is now a Fellow of the Primary Science Teaching Trust (PSTT).

As part of a Post Graduate Certificate for Professional Recognition in Engineering STEM Learning, Fran interviewed 35 engineers in the work place, gaining insight into 'Engineering Habits of Mind' (EHOM) as described by Bill Lucas in 'Thinking Like An Engineer'. She ascertained the inspiration behind STEM career choices and presented findings to industry experts and colleagues.

Craig Chapling

Project Manager

Prior to joining the Faraday Institution as Project Manager, Craig Chapling was responsible for the delivery of components and systems into many vehicle lines at Jaguar Land Rover, including a model year upgrade of the I-Pace battery pack. He was also part of the team developing a hybridised dual clutch transmission at Hofer Powertrain. Responsible for engineering investment budgets of up to £5 million, with annual bill of materials spends measured in the hundreds of millions, his ability to effectively plan and deliver was essential in the automotive industry.

As a student, Craig helped to develop a hybrid vehicle during an exchange at Penn State University in the USA, through the Challenge X programme sponsored by GM, the US DOE and managed by Argonne National Laboratory. He holds a first class Masters degree in Automotive Engineering from the University of Leeds. Outside of work, he enjoys cycling, flying, track driving, and spending time with his young family.

Vicki Harper

Executive Assistant

Vicki has over 25 years' experience working in the administrative, HR and office management fields. Most recently Vicki held the position of Office Manager at Oxford Biotrans, a University of Oxford spin-out company developing and commercialising enzymatic process technologies that yield high-value chemical compounds. Prior to that she was at Velocys plc, an AIM-listed renewable fuels company for 11 years, where she was the Office & HR Manager. Vicki holds an advanced diploma in business studies and also a certificate in Human Resource Management. She is an associate member of the Chartered Institute of Personnel and Development (CIPD).

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THE FARADAY INSTITUTION

UK Research and Innovation

INDUSTRIAL STRATEGY

The Faraday Institution is the UK's independent institute for electrochemical energy storage research and skills development.

We bring together scientists and industry partners on research projects to reduce battery cost, weight, and volume; to improve performance and reliability; and to develop whole-life strategies including recycling and reuse.

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