

Evidence sources used to inform our research strategies

Algebra

1. [Research Excellence Framework \(REF\) exercise](#), (2014).
2. REF 2014, [Impact Case Studies](#), (2014).
3. [EPSRC, Pure Mathematics Evidence and Engagement Workshop Report](#), (2016).
4. EPSRC Mathematical Sciences Regional Workshops 2016.
5. EPSRC, [Algebra Community Overview Document](#), (2016).
6. Council for the Mathematical Sciences (CMS), [Mathematical Sciences Driving the UK Economy Forward](#).
7. [European Research Council](#).
8. CMS, [The Mathematical Sciences People Pipeline](#), (2015).
9. [Deloitte, Measuring the Economic Benefits of Mathematical Science Research in the UK](#), (2012).

Analytical science

1. [Healthcare Technologies Impact and Translation Toolkit](#).
2. [EPSRC, Analytical Science Review](#), (2015).
3. [EPSRC, Roadmap Exercise in Raman and IR Spectroscopic Capability in the UK](#), (2016).
4. [EPSRC, Roadmap to Provide Internationally Leading NMR Infrastructure for UK Physical Sciences](#), (2013).
5. [EPSRC, Terahertz Science and Technology Roadmap](#), (2016).
6. [Government Office for Science, Forensic Science and Beyond: Authenticity, Provenance and Assurance](#), (2015).
7. [Government Office for Science and Department for Environment, Food & Rural Affairs \(Defra\), Animal and Plant Health in the UK: Building Our Science Capability](#), (2014).
8. [EPSRC, The Importance of Engineering and Physical Sciences Research to Health and Life Sciences \('the Maxwell review'\)](#), (2014).
9. [Stanford University, T-Sensors Summit for Trillion Sensor Roadmap](#), (2013).
10. [National Measurement Office and Department for Business, Innovation & Skills \(BIS\), The National Measurement System: Strategy Document 2011-2015](#), (2011).
11. [Association of the British Pharmaceutical Industry \(ABPI\), Bridging the Skills Gap in the Biopharmaceutical Industry: Maintaining the UK's Leading Position in Life Sciences](#), (2015).

Antihydrogen

1. [ALPHA webpage](#).
2. [CERN webpage](#).
3. [CERN, The Future of Antihydrogen Physics](#), (2014).
4. STFC, [STFC Delivery Plan 2016-2020 \(PDF\)](#), (2016).
5. Institute of Physics, [Antimatter: A Review of its Role in the Universe and its Applications \(PDF\)](#), (2013).

Architectures and operating systems

1. Community and user engagement (individual input, group feedback, team visits/events and evidence-gathering activities).
2. Input from the ICT Strategic Advisory Team, the UK Computing Research Committee (UKCRC) Executive Committee and Research Excellence Framework (REF) 2014 panellists.
3. M. Duranton et al., [HiPEAC Vision 2015](#), (2015).
4. [National Audit Office \(NAO\), The UK Cyber Security Strategy: Landscape Review. \(2013\)](#).
5. Analysis of EPSRC data (grant data, application statistics, portfolio funding landscape).

Artificial intelligence technologies

1. [Commons Select Committee, Robotics and Artificial Intelligence Inquiry - Written and Oral Submissions](#), (2016).
2. EPSRC, Analysis of Research Excellence Framework (REF) 2014 data and EPSRC Knowledge Maps, (2014).
3. Community and user engagement (individual input and group feedback).
4. [EPSRC, Future Intelligent Technologies \(FIT\) Workshop](#), (2015).
5. Robotics and Autonomous Systems Special Interest Group (RAS SIG), Strategy and Landscape Documents, (2016).
6. [The Royal Society, Machine Learning Conference Report \(PDF\)](#) and ongoing policy project, (2015).
7. [Nesta, Machines that Learn in the Wild \(PDF\)](#), (2015).
8. [IT Jobs Watch, Tracking the IT Job Market](#), (2016).
9. EPSRC, Output from the EPSRC Speech Technologies exceptions process (2015).
10. BEIS, [Industrial Strategy White paper – building a Britain Fit for the Future](#) (2017)
11. [Growing the artificial intelligence industry in the UK](#), (2017)
12. BEIS, [Artificial Intelligence Sector Deal](#), (2018)
13. Lords Select Committee on Artificial Intelligence – [evidence and report](#), (2018)

Assistive technology, rehabilitation and musculoskeletal biomechanics

1. EPSRC, [The Importance of Engineering and Physical Sciences Research to Health and Life Sciences \('the Maxwell review'\)](#), (2014).
2. Institution of Mechanical Engineering (IMechE), [Biomedical Engineering: Advancing UK Healthcare](#), (2014).
3. Department for Business, Innovation and Skills (BIS), [Strength and Opportunity 2014](#), (2014).
4. Department of Health, [Research and Development Work Relating to Assistive Technology 2014 to 2015](#), (2015).
5. Department of Health, [Research and Development Work Relating to Assistive Technology 2015 to 2016](#), (2016).

Other sources:

- Portfolio visits, Healthcare Technologies Grand Challenge strategy development discussions and workshops (2014-15), theme visits and discussions with key research leaders.

Bioenergy

1. Royal Academy of Engineering, [A Critical Time for UK Energy Policy: What Must Be Done Now to Deliver the UK's Future Energy System](#), (2015).
2. Energy Technologies Institute (ETI), [Bioenergy: Delivering Greenhouse Gas Emission Savings through UK Bioenergy Value Chains \(PDF\)](#), (2015).
3. ETI, [Application of Sustainable Biomass and Waste Resources for Flexible and Affordable Low Carbon Energy \(PDF\)](#), (2015).
4. ETI, [Bioenergy: Enabling UK Biomass \(PDF\)](#), (2015).
5. Supergen Programme Review, (2016).
6. UKERC, The costs and impacts of intermittency – 2016 update, (2017)
7. Royal Society and Royal Academy of Engineering, Greenhouse Gas Removal, (2017)
8. BEIS, The Clean Growth Strategy, (2018).
9. BEIS, Industrial Strategy, (2018).
10. Committee on Climate Change, Biomass in a low-carbon economy, (2018)
11. Committee on Climate Change, Net Zero: UK's contribution to stopping global warming, (2019).
12. BEIS, Energy Needs Innovation Assessment, (2019).

Biological informatics

1. Cross-Research Council [statement](#).
2. [Synthetic Biology Roadmap \(PDF\)](#).
3. Input from the ICT Strategic Advisory Team.
4. Community and user engagement (individual input and group feedback).
5. Innovate UK, [UK Bioinformatics \(PDF\)](#) Landscape, (2015).

6. Office of Life Sciences, [Genomics in the UK \(PDF\)](#), (2015).

Biomaterials and tissue engineering

1. AMLC, [Materials for Healing](#), (2016).
2. EPSRC, [Healthcare Technologies Impact and Translation Toolkit \(PDF\)](#).
3. EPSRC, [The Importance of Engineering and Physical Sciences Research to Health and Life Sciences](#) ('the Maxwell review'), (2014).
4. Institute of Materials, Minerals and Mining, [Biomaterials and Tissue Engineering in the UK](#), (2013).
5. Horizon 2020, [Biomaterials for Health - A Strategic Roadmap for Research and Innovation \(PDF\)](#).
6. Department for Business, Innovation and Skills (BIS), [Eight Great Technologies - Regenerative Medicine and Advanced Materials](#), (2013).
7. BIS and Department of Health, [Taking Stock of Regenerative Medicine in the United Kingdom \(PDF\)](#), (2011).
8. NC3R, [A Non-Animal Technologies Roadmap for the UK: Advancing Predictive Biology \(PDF\)](#), (2015).
9. Life Science Exchange - Regenerative Medicine Focus Group.
10. Regenerative Medicine Expert Group, [Building on Our Own Potential: A UK Pathway for Regenerative Medicine \(PDF\)](#), (2015).
11. UKRMP, [A Strategy for UK Regenerative Medicine \(PDF\)](#), (2012).
12. House of Lords, [Regenerative Medicine Report \(PDF\)](#), (2013).
13. UKRMP, [Regenerative Medicine Forward Look \(PDF\)](#), (2011).
14. World Technology Evaluation Center (WTEC), [Global Assessment of Biological Engineering & Manufacturing \(PDF\)](#), (2014).
15. Cell and Gene Therapy Catapult, [Cell Therapy GMP Manufacturing in the UK \(PDF\)](#), (2014).

Other Sources:

- M. Viceconti, [In Silico Clinical Trials Roadmap](#), (2016).
- [Medical Engineering Initiative, Opportunities and Challenges: Advancing and Translating Knowledge and Technology \(PDF\)](#), (2016)
- IMechE, [Biomedical Engineering: Advancing UK Healthcare \(PDF\)](#), (2014).

Biophysics and soft matter physics

1. Physics of Life Network, [From Molecules to Systems: Towards an Integrated Heuristic for Understanding the Physics of Life \(PDF\)](#), (2015).
2. EPSRC, [The Importance of Engineering and Physical Sciences Research to Health and Life Sciences \(PDF\)](#) ('the Maxwell review'), (2014).
3. British Biophysical Society, [New Horizons for British Biophysics \(PDF\)](#), (2016).
4. Chemistry Growth Strategy Group, Chemistry at Work: Strategy for Delivering Chemistry-Fuelled Growth of the UK Economy (PDF), (2013).

5. Innovate UK Formulation Special Interest Group, [Realising the Potential for Formulation in the UK \(PDF\)](#), (2013).

Built environment

1. HM Government, [Construction 2025 \(PDF\)](#), (2013).
2. Government Office for Science, [Future of Cities: The Science of Cities and Future Research Priorities](#), (2016) (and related reports on the theme).
3. Royal Academy of Engineering, [Built for Living](#), (2015).
4. KPMG, [UK Government Construction Pipeline \(PDF\)](#), (2016).
5. REF 2014, [Main Panel C Report](#), (2015).
6. [UKCRIC website](#), (2016).

Carbon capture and storage

1. The Energy Technologies Institute (ETI), [Carbon Capture and Storage: Building the UK Carbon Capture and Storage Sector by 2030 - Scenarios and Actions \(PDF\)](#), (2015).
2. Committee on Climate Change (CCC), [Meeting Carbon Budgets: 2016 Progress Report to Parliament \(PDF\)](#), (2016).
3. Energy Research Partnership (ERP), [Managing Flexibility Whilst Decarbonising the GB Electricity System \(PDF\)](#), (2015).
4. HM Treasury, [Sustainability in the Spending Review \(PDF\)](#), (2016).
5. Parliamentary Advisory Group on Carbon Capture and Storage (CCS) - [Lowest Cost Decarbonisation for the UK: The Critical Role of CCS](#), (2016).
6. UKERC, The costs and impacts of intermittency – 2016 update, (2017)
7. Royal Society and Royal Academy of Engineering, Greenhouse Gas Removal, (2017)
8. BEIS, The Clean Growth Strategy, (2018).
9. BEIS, Industrial Strategy, (2018).
10. BEIS, The UK carbon capture usage and storage deployment pathway: an action plan, 2018
11. BEIS, Accelerating CCS Technologies, (2018)
12. Committee on Climate Change, Net Zero: UK's contribution to stopping global warming, (2019).
13. BEIS, Energy Needs Innovation Assessment, (2019)

Catalysis

1. Dutch Ministry of Economic Affairs, Netherlands Institute for Catalysis Research and Industrial Advisory Board of NIOK, [Catalysis - Key to a Sustainable Future: Science and Technology Roadmap for Catalysis in the Netherlands \(PDF\)](#), (2015).

2. [Chemistry Growth Strategy Group, Strategy for Delivering Chemistry-fuelled Growth of the UK Economy \(PDF\)](#), (2013).
3. International Energy Agency (IEA), International Council of Chemical Associations and DECHEMA, [Technology Roadmap: Energy and GHG Reductions in the Chemical Industry via Catalytic Processes \(PDF\)](#), (2013).
4. [House of Lords Science and Technology Select Committee, Waste or Resource? Stimulating a Bioeconomy \(PDF\)](#), (2014).
5. [European Technology Platform for Sustainable Chemistry \(SusChem\), Strategic Innovation and Research Agenda \(PDF\)](#), (2015).
6. [Chemical Sciences and Society Symposium \(CS3\), Chemistry and Water: Challenges and Solutions in a Changing World \(PDF\)](#), (2015).
7. [Dial-a-Molecule Grand Challenge Network, Transforming Synthesis, Enabling Science \(PDF\)](#), (2013).
8. [Directed Assembly Grand Challenge Network, Beyond the Molecule: A Roadmap to Innovation \(PDF\)](#), (2012).
9. [European Cluster on Catalysis, Science and Technology, Roadmap on Catalysis for Europe \(PDF\)](#), (2016).
10. National Research Council, [Industrialization of Biology](#), (2015).
11. Research Excellence Framework (REF) 2014, [Overview Report by Main Panel B and Sub-panels 7 to 15 \(PDF\)](#), (2015).
12. Research Councils UK (RCUK), [Large Facilities Project: Science Requirements Document \(PDF\)](#), (2014).

Chemical biology and biological chemistry

1. EPSRC, (2016), Focus group in Chemical Biology
2. Research Excellence Framework, [Chemistry Sub-Panel \(UOA8\)](#), (2014)
3. Professor Patrick H Maxwell FMedSci, The Maxwell Report '[The importance of engineering and physical sciences research to health and life sciences](#)' (PDF), (2014)
4. HM Government, Report '[Life science competitiveness indicators \(PDF\)](#)', (2015)
5. BBSRC, [Vulnerable skills and capabilities report](#), (2015)
6. Chemical Industries Association UK, Chemical and pharmaceutical industry facts and figures (PDF), (2015)

Chemical reaction dynamics and mechanisms

1. CWTS, Leiden Ranking Citation Analysis, (2015).
2. Research Excellence Framework (REF) 2014, [Main Panel B Overview Report \(PDF\)](#), (2014).
3. EPSRC community engagement, (2016).
4. EPSRC, Sovereign capability report, (2015).
5. EPSRC REF panel workshop, (2016).

Other source:

- Dial-a-Molecule Grand Challenge Network, [Transforming Synthesis, Enabling Science: Roadmap for Synthesis in the 21st Century \(PDF\)](#), (2012).

Chemical structure

1. EPSRC, [EPSRC Analytical Science Review \(PDF\)](#), (2015).
2. EPSRC, [Nuclear Magnetic Resonance \(NMR\) Spectroscopy Roadmap \(PDF\)](#), (2013).
3. [Association of the British Pharmaceutical Industry \(ABPI\), Bridging the Skills Gap in the Biopharmaceutical Industry: Maintaining the UK's Leading Position in Life Sciences \(PDF\)](#), (2015).
4. [Institut Laue-Langevin, Annual Report](#), (2015).
5. [European Cluster on Catalysis, Science and Technology Roadmap on Catalysis for Europe \(PDF\)](#), (2016).
6. US Department for Energy:
 - [Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science \(PDF\)](#)
 - [Carbon Capture: Beyond 2020 \(PDF\)](#), (2010).

Clinical technologies (excluding imaging)

1. EPSRC, [Healthcare Technologies Impact and Translation Toolkit \(PDF\)](#).
2. MedTech Europe, [The European Medical Technology Industry in Figures](#), (2019).
3. Ernst and Young Global Ltd, [Pulse: Medical Technology Report \(PDF\)](#), (2016).
4. Yole Development, [BioMEMS: Microsystems for Healthcare Applications](#), (2016).
5. Institution of Mechanical Engineers (IMechE), [Biomedical Engineering: Advancing UK Healthcare \(PDF\)](#), (2014).
6. EPSRC, [The Importance of Engineering and Physical Sciences Research to Health and Life Sciences \(PDF\)](#) ('The Maxwell review'), (2014).
7. [Biosensors Market by Application](#) (Point of Care, Home Diagnostics, Research Labs, Biodefense, Environmental Monitoring, Food Industry), (2019).
8. Optoelectronics Industry and Technology Development Association (OITDA), [Annual Technical Report 2014 \(PDF\)](#), (2017).
9. Policy Exchange, [Eight Great Technologies \(PDF\)](#), (2013).
10. McKinsey and Company, [Disruptive Technologies: Advances that Will Transform Life, Business, and the Global Economy](#), (2013).
11. HM Government, [Strategy for UK Life Sciences: One Year On \(PDF\)](#), (2012).
12. NHS, [NHS Long Term Plan](#), (2019).
13. Avicenna, [In Silico Clinical Trials Roadmap \(PDF\)](#), (2016).
14. [VPH-FET Research Roadmap \(PDF\)](#), (2011).
15. HM Government, [Leading-edge healthcare: Industrial Strategy Challenge Fund](#), (2018).

Other sources:

- IMechE, [21st Century Engineering for an Ageing Population \(PDF\)](#), (2014).
- National Science and Technology Council, [National Nanotechnology Initiative Strategic Plan \(PDF\)](#), (2014).
- Department of Health, [Action Plan on Hearing Loss \(PDF\)](#), (2015).

Coastal and waterway engineering

1. EPSRC Workshop on the Future of Water Research, (February 2016).
2. [The UK Water Partnership, Future Visions for Water and Cities: A Thought Piece \(PDF\)](#), (2016).
3. Sayers for the Adaptation Sub-Committee, [Projections of Future Flood Risk in the UK](#), (2015).
4. [HM Government, National Flood Resilience Review](#), (2017).
5. [E.C. Penning-Roswell, \(2014\), A Realistic Assessment of Fluvial and Coastal Flood Risk in England and Wales, Transactions of the Institute of British Geographers, \(1\), 44-61.](#)
6. [Arup, Global Water Research Review 2014-2015](#), (2016).
7. [Environment Agency, Joint Flood and Coastal Erosion Risk Management Research and Development Programme: Programme Definition Document, \(2015\).](#)

Cold atoms and molecules

EPSRC, Cold Atoms and Molecules Monitoring Portfolio Evolution Report, (2015).

1. European Commission, [Quantum Technologies: Implications for European Policy \(PDF\)](#), (2016).
2. European Commission, [Quantum Technologies: Opportunities for European Industry](#), (2015).
3. National Physical Laboratory, Metrology for the 2020s (PDF), (2013).
4. National Physical Laboratory, Confidence in the UK 2016-2021: A National Approach to Measurement, Preparing for the 2020s (PDF), (2015).
5. UKNQ, [National Strategy for Quantum Technologies: A New Era for the UK](#), (2015).

Combustion Engineering

1. Society of Motor Manufacturers and Traders (SMMT), [Internal Combustion Engine: Capability Report \(PDF\)](#), (2012)
2. Innovate UK, [Automotive Technologies: The UK's Current Capabilities \(PDF\)](#), (2010)
3. Aerospace Technology Institute, [Propulsion Strategy](#), (2016)

4. Advanced Propulsion Centre, [Internal Combustion Engines Roadmap](#). (2013)
5. Automotive Council UK, [Low Carbon Automotive Propulsion Technologies](#), (2016)
6. HM Government, [Driving the Future Today: A Strategy for Ultra Low Emission Vehicles in the UK \(Word\)](#), (2013)
7. European Commission, [Flightpath 2050: Europe's Vision for Aviation \(PDF\)](#), (2011)
8. HM Government, [Government Boost for Jet Engines with £10 million Investment for Next Generation Technology \(press release\)](#), (2016)
9. [UK Turbulent Reacting Flows Consortium](#) (UKCTRF)

Complex fluids and rheology

1. Association of the British Pharmaceutical Industry (ABPI), [Bridging the Skills Gap in the Biopharmaceutical Industry \(PDF\)](#), (2015).
2. EPSRC portfolio data: size, investments, student numbers.
3. [Innovate UK, A Strategy for Innovation in the UK Chemistry-using Industries](#), (2013).
4. [Innovate UK, Realising the Potential for Formulation in the UK](#), (2013).
5. [Innovate UK, A Pre-competitive Vision for the Food & Drink Industries \(PDF\)](#), (2013).

Other sources:

- Learned Society Balancing Capability Workshop, (February 2016).
- Chemical Engineering Heads of Department meeting, (July 2016).
- Community engagement with stakeholders and researchers in this research area.

Complexity science

1. EPSRC, [Mathematical Sciences Community Overview Documents \(PDF\)](#), (2016)
2. Analysis of EPSRC student, fellowship and grant data
3. Research Excellence Framework (REF) 2014: [Overview Report by Main Panel B and Sub-panels 7-15 \(PDF\)](#), (2014)
4. EPSRC, [International Review of Mathematics \(PDF\)](#), (2011)

Other sources:

- EPSRC, [Engineering Grand Challenges: Reports on Outcomes of a Retreat](#), (2014)
- Deloitte, [Measuring the Economic Benefits of Mathematical Science Research in the UK](#), (2012)

Computational and theoretical chemistry

1. Research Excellence Framework (REF) 2014.
2. Nobel Prize in Chemistry, (2013).
3. Department for Business, Innovation & Skills (BIS), [International Comparative Performance of the UK Research Base \(PDF\)](#), (2013).
4. HEC, Annual Report, (2016).
5. EPSRC, [Hector Impact Report](#), (2014).
6. ARCHER science case (EPSRC internal).
7. EPSRC, CCPs mid-term review, (2013).

Condensed matter: electronic structure

1. [Research Excellence Framework \(REF\) 2014, Overview Report by Main Panel B and Sub-panels 7 to 15 \(PDF\)](#), (2014)
2. [European Research Council \(ERC\), Statistics](#)
3. EPSRC ARCHER Resource Allocation Panels, January 2014 to March 2015.
4. Innovate UK, [Solar Energy Systems Value Chain](#), (2015)
5. [University of Maryland, Advancing Caloric Materials for Efficient Cooling \(PDF\)](#), (2015)
6. [MIT Technology Review, Microsoft's Quantum Mechanics](#), (2014)

Condensed matter: magnetism and magnetic materials

1. [REF 2014, Overview Report by Main Panel B and Sub-panels 7 to 15 \(PDF\)](#), (2014).
2. [ERC, Statistics](#).
3. [The 2014 Magnetism Roadmap \(PDF\)](#), (2014).
4. [International Technology Roadmap for Semiconductors](#) (ITRS), (2015).
5. [European Rare Earths Competency Network](#) (ERECON).

Continuum mechanics

1. EPSRC, [Applied Mathematics Evidence and Engagement Workshop Report \(PDF\)](#), (2016)
2. EPSRC, [Continuum Mechanics Community Overview Document \(PDF\)](#), (2016)
3. [International Review of Mathematical Sciences \(PDF\)](#), (2010)
4. EPSRC, [Industrial Mathematics Community Overview Document \(PDF\)](#), (2016)
5. Deloitte, [Measuring the Economic Benefits of Mathematical Science Research in the UK \(PDF\)](#), (2012)
6. [Research Excellence Framework \(REF\) exercise](#), (2014)

Control engineering

1. [Automotive Council UK, Driving Success: A Strategy for Growth and Sustainability in the UK Automotive Sector \(PDF\)](#), (2013)
2. [Network Rail, Technical Strategy: A Future Driven by Innovation](#), (2013)
3. [Department of Energy and Climate Change \(DECC\), Smart Grid Vision and Routemap \(PDF\)](#), (2014)
4. [EPSRC, Future Intelligent Technologies \(FIT\) Workshop \(PDF\)](#), (2015)
5. [Transport Systems Catapult, Traveller Needs and UK Capability Study \(PDF\)](#), (2015)
6. [Aerospace Technology Institute, Technology Strategy and Portfolio Update](#), (2016)
7. Defense Advanced Research Projects Agency (DARPA), [Biological Control](#), (2016)
8. [National Infrastructure Commission, Smart Power \(PDF\)](#), (2016)

Databases

1. Community engagement (individual input, group feedback and team visits) and input from the ICT Strategic Advisory Team, the UK Computing Research Council (UKCRC) Executive Committee and Research Excellence Framework (REF) 2014 panellists (sub-panel 11)
2. Analysis of EPSRC application and student data
3. EPSRC, [ICT Perspectives on Big Data Analytics Workshop \(PDF\)](#), (2015)
4. ACM, [The Beckman Report on Database Research](#), (2016)
5. The Alan Turing Institute, [Shaping our Strategy \(PDF\)](#), (2016)

Digital signal processing

1. Mid-term review of the UDRC (September 2015), which commented on the international standing of UK research in signal processing.
2. Information and Communication Technologies (ICT) workshops with Network and Programme Grant Directors.
3. Discussions with the community.
4. ICT Strategic Advisory Team.

At the time of producing this rationale, there were no published reports dealing explicitly with this research area.

Displays

1. Analysis of EPSRC data

2. Community engagement (individual input, group feedback and team visits)
3. Input from the EPSRC Information and Communication Technologies (ICT) Theme Strategic Advisory Team (SAT) and Research Excellence Framework (REF) 2014 panellists
4. Photonics Leadership Group
5. [Photonics21, Photonics Landscape Europe](#)
6. [A. Hamacker and G. Jordan, Photonics Revolutionising our World](#), (2014)
7. Roadmap: UK III-V Community Engagement with Industry

Electrical motors and drives / electromagnetics

1. [Automotive Council UK, Driving Success: A Strategy for Growth and Sustainability in the UK Automotive Sector \(PDF\)](#), (2013)
2. Automotive Council UK, Electric Machines and Power Electronics: UK Opportunities (PDF), (2013)
3. Advanced Propulsion Centre, Low Carbon Automotive Propulsion Technologies (PDF), (2016)
4. [Aerospace Technology Institute, Technology Strategy and Portfolio Update](#), (2016)
5. [Department for Business, Innovation & Skills \(BIS\), Power Electronics: A Strategy for Success \(PDF\)](#), (2011)
6. [National Infrastructure Commission, Smart Power \(PDF\)](#), (2016)

Electrochemical sciences

1. Research Excellence Framework (REF) 2014, [Main Panel B Overview Report \(PDF\)](#), (2014)
2. J. Skea, Electrochemical Energy Technologies and Energy Storage: Energy Strategy Fellowship - Energy Research and Training Prospectus Report 6, (2014)
3. NACE International, [International Measures of Prevention, Application, and Economics of Corrosion Technologies \(IMPACT\) Study \(PDF\)](#), (2016)
4. EPSRC, Sovereign Capability Report, (2015)
5. CWTS, Leiden Ranking Citation Analysis, (2015)
6. EPSRC REF panel workshop, (2016)

End Use Energy Demand (Energy Efficiency)

1. Low Carbon Innovation Coordination Group (LCICG), [Industrial Sector Technology Innovation Needs Assessment](#), (2016).
2. Low Carbon Innovation Coordination Group (LCICG), [Domestic Buildings Technology Innovation Needs Assessment](#), (2016)

3. Low Carbon Innovation Coordination Group (LCICG), [Non-Domestic Buildings Technology Innovation Needs Assessment, \(2016\)](#).
4. Low Carbon Innovation Coordination Group (LCICG), [Heat Technology Innovation Needs Assessment, \(2016\)](#).
5. UKERC, The costs and impacts of intermittency – 2016 update, (2017)
6. BEIS, The Clean Growth Strategy, (2018).
7. BEIS, Industrial Strategy, (2018).
8. Net Zero: UK's contribution to stopping global warming, (2019)

Energy networks

1. National Infrastructure Commission, [Smart Power \(PDF\)](#), (2016)
2. Department of Energy & Climate Change (DECC), [Towards a Smart Energy System \(PDF\)](#), (2015)
3. Energy Research Partnership, [Managing Flexibility Whilst Decarbonising the GB Electricity System \(PDF\)](#), (2015)
4. Low Carbon Innovation Coordination Group (LCICG), [Technology Innovation Needs Assessment \(TINA\): Electricity Networks & Storage \(EN&S\), \(PDF\)](#), (2012)
5. Research Councils UK (RCUK), [Review of Energy 2010 \(PDF\)](#), (2010)
6. RCUK, [Research Councils UK Energy Programme Strategy Fellowship \(PDF\)](#), (2012)
7. Supergen HubNet, [Position Papers](#), (2012-2016)
8. National Grid, [Future Energy Scenarios](#), (2016)
9. Energy Technologies Institute (ETI), [Smart Systems and Heat: Decarbonising Heat for UK Homes \(PDF\)](#), (2015)
10. International Energy Agency (IEA), [Global Electric Vehicles Outlook 2016 \(PDF\)](#), (2016)

Energy storage

1. Supergen reviews, event attendance and conversations with relevant bodies
2. HM Government (Automotive Council UK), [Driving Success: A Strategy for Growth and Sustainability in the UK Automotive Sector \(PDF\)](#), (2013)
3. Aerospace Technology Institute, [Technology Strategy and Portfolio Update \(PDF\)](#), (2016)
4. Royal Academy of Engineering, [A Critical Time for UK Energy Policy: What Must Be Done Now to Deliver the UK's Future Energy System](#), (2015)
5. HM Government, [2050 Pathways Analysis \(PDF\)](#), (2010)
6. Institution of Engineering and Technology (IET), [Britain's Power System: The Case for a System Architect](#), (2014)
7. Committee on Climate Change, [Fifth Carbon Budget \(PDF\)](#), (2015)
8. Industrial Strategy White Paper (2017)
9. Clean Growth Strategy (2017)

10. Road to Zero (2018)

Engineering design

1. EPSRC, [Engineering Design Action Plan](#)
2. Sir George Cox, [Cox Review of Creativity in Business: Building on the UK's Strengths \(PDF\)](#), (2005)
3. ATI, [Technology Strategy & Portfolio Update](#), (2016).
4. Design Council, [Leading Business by Design: High Value Manufacturing \(PDF\)](#), (2015)

Fluid dynamics and aerodynamics

1. [ATI, Strategy Documents](#), (2015)
2. [Clean Sky, Greener Aviation](#), (2016)
3. [Clean Sky, Report to the European Parliament on the Socio-economic Impact of Clean Sky \(PDF\)](#), (2016)

Other sources:

- EPSRC, [Wind Tunnels: Infrastructure Roadmap \(PDF\)](#), (2015)
- EPSRC data, including EPSRC knowledge maps, information on current and past funded research, and the population of PhD students supported through EPSRC (publicly available information on these sources can be found at <https://www.epsrc.ac.uk/research/ourportfolio/vop/> or through [Gateway to Research](#))
- Outcomes of EPSRC-led workshops, including [Applied Mathematics Evidence and Engagement \(PDF\)](#), (2015)

Fossil Fuel power generation

1. Energy Technologies Institute (ETI), [Bioenergy: Enabling UK Biomass \(PDF\)](#), (2015).
2. Energy Research Partnership (ERP), [Managing Flexibility Whilst Decarbonising the GB Electricity System \(PDF\)](#), (2015).
3. HM Government, [The Carbon Plan: Reducing Greenhouse Gas Emissions](#), (2013 - last update).
4. HM Government, [2050 Pathways Analysis \(PDF\)](#), (2010).

Other source:

- Research Councils UK (RCUK), [RCUK Review of Energy 2010](#), (2010).

Fuel cell technology

1. HM Government, [2050 Pathways Analysis \(PDF\)](#), (2010).
2. CRM_Innonet, [Final Roadmap Report \(PDF\)](#), (2015).
3. CS3, [Efficient Utilization of Elements \(PDF\)](#), (2013).
4. Government Office for Science, [Technology and Innovation Futures: UK Growth Opportunities for the 2020s \(PDF\)](#), (2012).
5. HM Government (Automotive Council UK), [Driving Success: A Strategy for Growth and Sustainability in the UK Automotive Sector \(PDF\)](#), (2013).
6. Low Carbon Innovation Coordination Group (LCICG), [Hydrogen for Transport Summary Report \(PDF\)](#), (2014).
7. Research Councils UK (RCUK) Energy Programme, [Energy in the Home and Workplace \(PDF\)](#), (2013).
8. Institution of Chemical Engineers (IChemE), [Chemical Engineering Matters](#), (2016).
9. Committee on Climate Change, [The Fifth Carbon Budget](#), (2015).
10. European Science Foundation, [Materials for Key Enabling Technologies \(PDF\)](#), (2011).
11. International Energy Agency (IEA), [Technology Roadmap Hydrogen and Fuel Cells \(PDF\)](#), (2015).
12. Supergen reviews, event attendance and conversations with relevant bodies.

Other sources:

- New Energy World IG, [Fuel Cell and Hydrogen Technologies in Europe \(PDF\)](#), (2014).
- Carbon Trust, [Strategic Assessment of the Role and Value of Energy Storage Systems in the UK Low Carbon Energy Future \(PDF\)](#), (2012).

Functional ceramics and inorganics

1. EPSRC, [Materially Better: Ensuring the UK is at the Forefront of Materials Science \(PDF\)](#), (2013).
2. European Science Foundation (ESF), [Materials for Key Enabling Technologies \(PDF\)](#), (2011).
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4. EPSRC, [New Materials for RF and Microwave Technologies \(PDF\)](#), (2014).
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- A.T. Kearney, [Chemical Industry Vision 2030: A European Perspective \(PDF\)](#), (2012).
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9. National Audit Office ([NAO](#)), [The UK Cyber Security Strategy: Landscape Review \(PDF\)](#), (2013).

Quantum devices components and systems

Main sources of input for this rationale:

1. Quantum Technologies Strategic Advisory Board, '[National Strategy for Quantum Technologies \(PDF\)](#)', (2015).
2. Quantum Technologies Strategic Advisory Board, '[A Roadmap for Quantum Technologies in the UK \(PDF\)](#)', (2015).
3. Defence Science and Technology Laboratory, 'UK Quantum Technology Landscape 2016', (2016).
4. Government Office of Science, '[The Quantum Age: Technological Opportunities \(PDF\)](#)', (2016).
5. Institute of Physics, '[The Age of the Qubit](#)', (2011)

Quantum fluids and solids

By the end of the Delivery plan we aim to have:

- Consolidation of experimental capacity at sites with existing necessary infrastructure, taking advantage of the geographical proximity of some of the key groups to combine expertise and to focus research in collaborative, strategic and ambitious programmes
- Encouraged upgrades and full utilisation of existing capital, in preference to large additional investments. For the current generation of experiments, we expect that current, existing equipment will be sufficient, based on previous investments through the UK National Quantum Technologies Programme (UKNQTP), critical-mass grants and industry

- Continuation of training and early-career development, without intervention, through research centres where established research leaders, capital or theoretical expertise are present

We will strongly encourage collaboration and knowledge transfer across disciplines, to accelerate advances through to application and maximise links with other research areas (e.g. Condensed Matter Physics - Electronic Structure, Condensed Matter Physics - Magnetism and Magnetic Materials, Superconductivity, Cold Atoms and Molecules, and Fluid Dynamics).

While this research is fundamental in nature, many of the resultant techniques and outputs have strong applications in the cryogenic industry, with significant crossover with the low and ultralow-temperature physics and technology community. We will encourage strengthening of interdisciplinary interactions, with pathways to application identified through appropriate industries and translational activities (e.g. the UKNQTP).

Quantum optics and information

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3. European Commission, [European Strategy for a Circular Economy](#), (2015).
4. All-Party Parliamentary Sustainable Resource Group, [Driving Resource Efficiency across Supply Chains](#), (2016).
5. High Value Manufacturing Catapult, [Strategy on Resource Efficient and Sustainable Manufacturing](#), (2015).

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5. Government Office for Science, [The Internet of Things: Making the Most of the Second Digital Revolution \(PDF\)](#), (2014).
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5. [European Telecommunications Standards Institute, Maturity and Field Proven Experience of Millimetre Wave Transmission \(PDF\)](#), (2015).
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2. [A Roadmap for US Robotics: From Internet to Robotics \(PDF\)](#), (2013).
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12. UK-RAS Network, [Manufacturing Robotics: The Next Robotic Industrial Revolution](#), (2016).
13. UK-RAS Network, [Surgical Robotics: The Next 25 Years - Successes, Challenges, and the Road Ahead \(PDF\)](#), (2016).

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Sensors and instrumentation

1. McKinsey Global Institute, [Internet of Things: Mapping the Value Beyond the Hype](#), (2015).
2. Electronics, Sensors and Photonics Knowledge Transfer Network, [UK Sensor Community Mapping \(PDF\)](#), (2015).

Other sources:

- Input from Sensors and Instrumentation Leadership Council; questionnaire led by EPSRC (2015).
- EPSRC data (spend, number of universities supported, number of Principal Investigators).

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2. Net Zero: UK's contribution to stopping global warming, (2019).
3. International Technology Roadmap for Photovoltaics, Ninth Edition (2018)
4. BEIS, Industrial Strategy, (2018).
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6. UKERC, The costs and impacts of intermittency – 2016 update, (2017).
7. Supergen Programme Review (2016).
8. Supergen SuperSolar Hub reports, (2016).
9. Low Carbon Innovation Coordination Group (LCICG), Solar Photovoltaic and Thermal Technology Innovation Needs Assessment (TINA), (2016).
10. Energy System Modelling Environment (ESME), (2016).
11. Climate Change Committee, The Fifth Carbon Budget, (2016).

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3. [CITIA, CITIA Roadmap](#), (2016).
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2. [ISIS Neutron and Muon Source, Annual Review 2015 \(PDF\)](#), (2015).
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Other source:

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2. Synthetic Biology Leadership Council, [BioDesign for the Bioeconomy \(PDF\)](#), (2016).
3. HM Government, [Eight Great Technologies](#), (2013).
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4. EPSRC, [The Importance of Engineering and Physical Sciences Research to Health and Life Sciences \(PDF\)](#) ('the Maxwell review'), (2014).

Other source:

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3. [Chemical Sciences and Society Summit \(CS3\), Organic Electronics for a Better Tomorrow: Innovation, Accessibility, Sustainability \(PDF\)](#), (2012).
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5. [Directed Assembly Grand Challenge Network, Beyond the Molecule: A Roadmap to Innovation \(PDF\)](#), (2012).
6. [Research Councils UK \(RCUK\), Large Facilities Project: Science Requirements Document \(PDF\)](#), (2014).
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4. McKinsey & Company, [Disruptive Technologies: Advances That Will Transform Life, Business, and the Global Economy](#), (2013).
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4. [EPSRC, Healthcare Technologies Grand Challenges Report \(PDF\)](#), (2014).
5. Analysis of EPSRC data (grant data, application statistics, portfolio funding landscape).
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UK Magnetic Fusion Research Programme

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Verification and correctness

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Vision, hearing and other senses

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- Review on Antimicrobial Resistance, [Tackling Drug-resistant Infections Globally: Final Report and Recommendations \(PDF\)](#), (2016).
- [UK Water Industry Research \(WIR\), Research and Innovation Mapping Study for the UK Water Research and Innovation Framework \(PDF\)](#), (2011).
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4. EPSRC/Energy Systems Catapult workshop, (2016).
5. Committee on Climate Change, [The Fifth Carbon Budget](#), (2015).
6. [Energy Systems Catapult, Five-year Plan \(PDF\)](#), (2016).
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9. Energy Technologies Institute (ETI), [UK Scenarios for a Low Carbon Energy System Transition \(PDF\)](#), (2015).
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12. Royal Academy of Engineering, [A Critical Time for UK Energy Policy and What Must Be Done Now to Deliver the UK's Future Energy System](#), (2015).
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Key theme evidence sources

In addition to evidence sources that have informed individual research area strategies, there are a number of key evidence sources that EPSRC themes used to inform research area strategies more widely. These key evidence sources included:

Digital Economy

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- [GO Science report: Distributed Ledger Technology: beyond block chain](#)
- [DE PAB Meeting Note \(2015\)](#)
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- [ICT SAT & DE PAB Meeting Note \(2016\)](#)
- [Digital Economy Impact Review \(2012\)](#)
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- [Celebrating Success in the Digital Economy \(2015\)](#)
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Energy

- [Technology Innovation Needs Assessments](#)
- [Insights from the Energy Technologies Institute](#)
- [Analysis reports from the Energy Research Partnership](#)
- [Committee on Climate Change reports](#)
- [Energy Prospectus](#)
- [NIRAB UK Nuclear Innovation and Research Programme Recommendations](#)

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- EPSRC and RAEng, [Assessing the economic returns of engineering research and postgraduate training in the UK](#), 2015
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- Government Office for Science, [Future of cities: the science of cities and future research priorities](#), 2016
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- Sir Henry Royce Institute, Business Case, 2016
- Aerospace Technology Institute, [ATI Strategy](#), 2016
- Advanced Propulsion Centre, [Propulsion Roadmaps](#), 2013
- EPSRC Commissioned Report, [The importance of engineering and the physical sciences to the health and life sciences](#), 2014

Healthcare Technologies

- [“The importance of engineering and physical sciences research to health and life sciences”](#)
The Maxwell Review, April 2014
- [“Biomedical engineering: Advancing UK Healthcare”](#) Institute of Mechanical Engineering, July 2014
- [“Opportunities and Challenges: Advancing and Translating Knowledge and Technology”](#) Medical Engineering Initiative, February 2016
- [“21st Century Engineering for an Ageing Population”](#) Institution of Mechanical Engineers, May 2015
- [“Regenerative Medicine Report”](#) House of Lords, July 2013
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- [EEF report ‘Manufacturing, Britain’s Future’](#)
- [Foresight \(2013\) ‘The Future of Manufacturing’](#)
- [House of Commons Briefing Paper: Manufacturing statistics and policy](#)
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- [EEF – The Manufacturers’ Organisation](#)
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- [UK Manufacturing Review 15-16](#)

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- WHO, [Meeting global health challenges through operational research and management science 2011 World Health Organization bulletin](#) (2011)
- OR Society, [Making an impact in OR](#), (2012)

- Deloitte, [Measuring the Economic Benefits of Mathematical Science Research in the UK](#), (2012)
- Committee on the Mathematical Sciences in 2025, [Mathematical Sciences in 2025](#) (2013)
- Pierre Audoin Consultants, [Competitive analysis of the UK cyber security sector](#) (2013)
- Council for Science and Technology, [The Age of Algorithms](#), (2013)
- Research Excellence Framework 2014 exercise: [Overview report by Main Panel B and Sub-panels 7 – 15](#), (2014)
- EPSRC, [Engineering Grand Challenges: Outcomes of a Retreat Report](#), (2014)
- NHS, [Five Year Forward View](#), (2014)
- Smith Institute, [Data Science: Exploring the Mathematical Foundations](#), (2014)
- BBSRC, MRC, [Review of Vulnerable Skills and Capabilities](#), (2014)
- Institute of Physics, [Mathematical Physics: What is it & why do we need it?](#) (2014)
- CMS, [The Mathematical Sciences People Pipeline](#), (2015)
- Cabinet Office, [UK Cyber Security Strategy 2011–2016, Annual Report](#), (2016)
- EPSRC, [Statistics & Applied Probability Landscape Event](#), (2016)
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- Elsevier for HM Government (BIS), [International comparative performance of the UK research base](#), (2013)
- EPSRC, [The Importance of engineering and physical science research to health and life sciences](#), (2014)
- Science-Matrix for IOP, EPSRC and STFC, [The UK's performance in physics research: National and international perspectives](#), (2014)
- EPSRC, [Materially Better: Ensuring the UK is at the Forefront of Materials Science](#), (2013)
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- Chemical Industries Association, Strategy for delivering chemistry-fuelled growth of the UK economy, (2013)
- Royal Society of Chemistry, [Chemistry for tomorrow's world; A roadmap for the chemical sciences](#), (2009)

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