The Journal of the Parliamentary and Scientific Committee – All-Party Parliamentary Group

SCIENCE IN PARLIAMENT
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WINTER 2022-23

ARE YOU A DIGITALLY-ACTIVATED ORGANISATION?

ESTABLISH YOUR DIGITAL MATURITY LEVEL

Parliamentary and Scientific Committee

Bringing Science and Parliament together

Established 1939

The Health Crisis of Climate Change: did COP27 Deliver?

Climate change is the greatest risk to human health we face this century. This evening we heard from four expert speakers about the link between climate and health, and the policies needed to reduce harm. Prof. Mike Tipton MBE, Professor of Human & Applied Physiology at the University of Portsmouth and Chair of the Policy Committee at The Physiological Society, spoke to us about the role of physiology in the climate crisis. Dr Marina Romanello, Research Director of the Lancet Countdown Annual Report on Climate Change and Health, spoke to us about how climate change mitigation policies can be enacted to improve human health. Prof. Madeleine Thomson, Head of Climate Impacts at the Wellcome Trust, spoke to us about what the Wellcome Trust was doing to look into the link between health and climate change, as well as it's participation at COP27. Lastly, Hiten Patel, Head of Net Zero Delivery for the Greener NHS programme for NHS England, spoke to us about how the NHS is responding to climate change. We had an impassioned Q&A session, with many questions revolving round what action the government should take.

The climate crisis is a human health crisis, with an estimated 1-3 billion people living outside survivable climate conditions over the next 50 years. Prof. Tipton discussed how physiology will be crucial in mitigating against the health impacts. For example, better understanding of our thermoregulatory system will enable us to both reduce demand on high energy consuming technology, whilst also adapting buildings and planning to mitigate against increasing temperatures. Prof. Tipton also emphasised the point that health and climate change are interdependent; increasing temperatures leads to increasing strain on the health care system, which in turn increases emissions. Working out how to break this cycle is crucial.

Climate action can improve health. A clear example that Dr Romanello gave was how overconsumption of red meat and dairy led to over 105,000 access deaths in 2019. This produce also counts for 61% of consumption-based agricultural emissions. It's clear how moving to more plant based diets can both reduce emissions and improve health.

The Wellcome Trust was an active player at COP27, participating at the health pavilion. Prof. Thomson found it optimistic that there had been an increased interest in the topic of health, but emphasised that more work needs to be done to support lower and middle income countries. More work needs to be done to make the health impacts of climate change more visible before COP28 also.

As a major health system, the NHS must respond to climate change by both preparing for the impacts and reducing its emissions. Mr Patel discussed many of the ways the NHS aims to reduce emissions, with the goal of reaching net zero direct emissions by 2040 and indirect emissions by 2045. The upfront cost of reducing emissions on a large scale will be high, but it's clear that it will pay-off quickly when the health impacts of climate change are considered.

The health challenges of climate change are a key way to engage the general public and politicians, as all of us have a vested interest. All of the speakers emphasised that COP27 wasn't ambitious enough to restrict emissions to reach the 1.5 degrees warming target, with the aim to reach peak emissions by 2025 removed. Going beyond this target will drastically worsen the health impacts of climate change, adding strain to our health system and our lives. Therefore, the number one action government can take to improve health prospects is ambitious emission reduction targets.

Alfie Hoar

P&SC Discussion Meeting, 'The Health Crisis of Climate Change: did COP27 Deliver?'

28th November 2022

Stephen Metcalfe MP
Chairman, Parliamentary & Scientific Committee (All-Party Parliamentary Group)

A warm welcome to our first edition of 2023.

I am pleased to say that we are now back to normal business in terms of our discussion events at the Palace of Westminster. In October we were delighted to partner with the Institution of Mechanical Engineers, in November with The Physiological Society and at the time of going to press, with UKRI.

My thanks to these valued member organisations for their support and to our wonderful speakers, a number of whom have kindly contributed articles to this edition and others who will be doing so for the Spring journal

We have some excellent speaker meetings planned for the first half of 2023 and you will hear more about these events in the coming weeks from David Youdan.

The Programme Committee, chaired by Carol Monaghan MP, is meeting this month to determine the shape of the Autumn and Winter programme.

I should like to thank all members who have fed in interesting suggestions for the discussions to David. We are certainly not short of them!

This Autumn I was delighted to be elected as a member of the House of Commons Science and Technology Select Committee. As a member, and Chair of the Committee, in previous Parliaments, it was a happy return.

The Committee's current Inquiries include the governance of AI and the antimicrobial potential of bacteriophages.

I very much welcome the recent appointment of George Freeman MP as Minister of State for Science, Research and Innovation.

George, of course, brings a wealth of experience to his role and we look forward to seeing him at our events. I am also delighted that he has agreed to write for the next edition of *Science in Parliament*.

As always I am looking forward to hosting STEM for BRITAIN 2023, our annual competition for Early Career Researchers, which takes place on Monday 6th March, and can report that we have received a very high standard of applications which are now being shortlisted by our excellent judging panels.

Finally, it is with sadness that I report the recent passing of Arthur Butler, who served as a distinguished Executive Secretary of P&SC in previous decades. Our thoughts are with Arthur's family.

My thanks to all our members, fellow officers and the P&SC team for their support and my best wishes for a Happy and Healthy New Year.

SCIENCE IN PARLIAMENT
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The Journal of the Parliamentary and Scientific Committee (All-Party Parliamentary Group).

Science in Parliament has two main objectives:

1. to inform the scientific and industrial communities of activities within Parliament of a scientific nature and of the progress of relevant legislation;
2. to keep Members of Parliament abreast of scientific affairs.

THE ROYAL SOCIETY OF BIOLOGY HOSTS ANNUAL PARLIAMENTARY RECEPTION IN PORTCULLIS HOUSE

The Society held its Annual Reception in celebration of Biology Week in the Autumn

Stephen Metcalfe MP, chair of the Parliamentary and Scientific Committee

Stephen Metcalfe MP, chair of the Parliamentary and Scientific Committee and Susie Rabin MRSB, Associate Director of Parliamentary and Public Affairs

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The Journal of the Parliamentary and Scientific Committee (All-Party Parliamentary Group).

ARE YOU A DIGITALLY ACTIVATED ORGANISATION?

Professor Sa'ad Sam Medhat
PhD MPhil CEng FIET FCIM FCMI
FRSA FIKE FIoD
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Institute of Innovation & Knowledge Exchange
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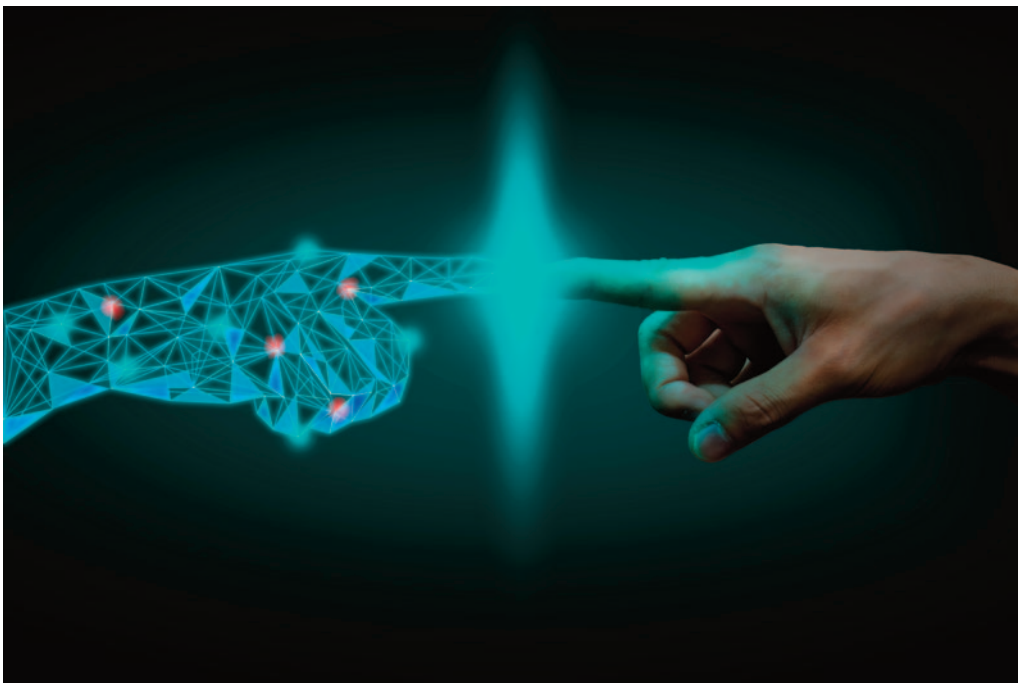
It is a fundamental question all organisations, whatever sector they operate in, need to answer. With statistics like 12.5 trillion hours having been spent online since beginning of January 2021 (with an average of 6 hours and 58 minutes a day online); more than two thirds of the world using mobile phones, and 4.95 billion people globally engaging on internet on a daily basis, (Simon Kemp – Digital 2022 Report, 2022) – digital is force that is only growing in power and reach.

The world is changing fast and digital is at the centre of every change happening. Digital transformation is on the lips of everyone in business, government, and academia. But digital transformation needs to be handled correctly, for as George Westerman, of MIT said famously *"When digital transformation is done right, it's like a caterpillar turning into a butterfly, but when done wrong, all you have is a really fast caterpillar."* A sobering thought for those starting their digital transformation activities.

For the past decade, digital has been experiencing a surge in growth, but in the last few years since the pandemic, digital has gone through a steep acceleration in being actively used more in peoples' lives. From not batting an eyelid at making a video call, or holding interactive meetings and collaborations live online, more organisations have changed the way they work. Business models have been reinvented to adapt to the new environment and deliver new digital propositions and offerings, and internal and external processes have been digitalized for speed and efficiency. Innovation ecosystems have been extended to include digital partners, not just IT suppliers, but stakeholders who are invested in the digital reinvention of an organisation.

A Digitally-Activated organisation demonstrates a number of characteristics including having a coherent and integrated Digital Strategy that aligns with the organisation's overall business objectives and direction. The Digital Strategy provides for strategic goals, operating principles, an



acknowledgement of barriers, with a plan on how to overcome them and an overall risk appetite towards Digital Transformation.

A critical aspect in Digital Transformation is provision for Transparency within a Digital Plan. Transparency ensure that the organisation meets compliancy and regulatory requirements in the sharing of data responsibly for the greater good. Most Digitally-Activated organisations have a focus that is customer-centric, driving their business model through a platform that is intermediated with other sources and channels via Application Protocol Interface (API) management. A key element of success, and something that sets a Digitally-Activated organisation apart from one that is still in digital development is the design, management, and usage of a digital ecosystem. Such an ecosystem supports the creation and co-creation of products, processes, and services with internal and external actors, enabling expertise to be exchanged and leveraged to create value for the organisation, and its end-users.

The tech spotlight for a Digitally-Activated organisation is on web application programming interfaces to create, publish, share, and present data in accordance with privacy and usage policies, thereby, controlling API access, collecting, and analysing usage data and reporting on performance. In driving the organisation to meet these capabilities, those undertaking a Digital Transformation need to make an investment in Training and Development. If the technical competencies aren't available in-house, upskilling, and reskilling needs to take place in technical areas such as data science, data analytics and data architecture, alongside of technical project management skills in Agile and Lean. If organic development can't be undertaken, organisations need to acquire the skills through selection and recruitment. Without such skills, an organisation will not be able to secure the value from Digital Transformation.

It is important, when starting Digital Transformation, senior leadership in the organisation should commission a review of internal processes and evaluate where redesign of process data flows will be necessary to avoid inefficiencies and wastage being baked into newly digitalized processes. A prioritisation by leaders of such process change is critical to deliver expected value-driven KPIs.

IKE Institute recognized through evidential research, that organisations fall into different levels of maturity, and as a result have developed the Digital Maturity Framework, comprising of six assurance categories: Digital Strategy and Alignment, Digital Organisational Readiness, Digital Enablement, Digital Trends and Competitive Intelligence, Digital Interaction Channels and Digital Maturity Impact and Value. The Digital Maturity Assessment (DMA) validates and assures an organisation at four levels of digital maturity, namely:

- Digitally Ad-Hoc – an organisation at the early stages of exploring tactical approaches to Digital;
- Digitally-Activated – an organisation that goes Digital through largely the use and adaption of existing business models;
- Digitally-Mature – an organisation that defines and applies Digital strategically;
- Digitally-Optimized – an organisation that embeds Digital into every part of its DNA.

Across business, government, and academia, assessing Digital Maturity has been given priority. The Institute enables organisations to pursue in parallel, both its Digital Maturity Assured Standard and its Investor in Innovations Standard aligned to ISO56002, as the Institute knows from extensive experience, innovation underpins digital transformation. Innovation is often the catalyst that ensures digital transformation is implemented correctly to gain full effect.

Education and training is key to digital transformation, and thus, it's recognised that academic institutions need to position themselves as digital leaders, equipped with the knowledge, skills and capabilities to support organisations in the private and public sector, that form their customer base.

City of Glasgow College, a leader in digital innovation transformation, and home of Scottish IKE Institute, together with IKE Institute HQ in London, and European partners from Noorderpoort and ROC A12 in the Netherlands; Gradia in Finland, and Miguel Altuna from the Basque Country have formed an exciting collaboration to discover, engage and support digital maturity within the tertiary education sector across Europe. Assessing Digital Maturity in Colleges (ADMiC) is a 24-month project, funded by Erasmus Plus that will help institutions assess their digital maturity. Using the IKE Institute's own Digital Maturity Framework, institutions will be assessed, and guidance in the form of online tools, techniques and resources will be provided close technological gaps, as identified by the (ADMiC) assessment report, thus, supplying institutions with the knowledge to help them accelerate towards digital readiness.

Dr Paul Little, Principal and Chief Executive at City of Glasgow College, said:

"Having made a significant investment in a new virtual learning environment and, as the first college in Scotland to host a visual learning laboratory, I am delighted that we are leading on this vital digital transformation project. The pandemic has greatly increased awareness of the advantages of technology and our own blended learning model offers a richer experience for our students."

Digital transformation offers huge opportunities for institutions; from IT modernisation to digital optimisation, and the design and implementation of new digital business models. But digital transformation in academic institutions is more than just teaching and learning, it focuses on the enterprise architecture, to not only redesign and improve internal processes but also, enhance the way in which the institution interacts across its value chain using technology.

Whether in business, industry, government or education, digital transformation is the primary objective leaders should strive to achieve, to reduce complexity and uncertainty, through balancing people, process, and technology, and aligning data and analytics activities to leverage and optimise their organisation's value. ■

BATTERIES – THE DEVIL OR THE DETAIL

Stephen Shaw

BATTERY STORAGE

Battery storage is considered essential if we want to achieve net zero or at least cut our carbon emissions by creating a system that is low carbon, relatively affordable and which, importantly, offers enhanced security.

In addition to actually storing power generated by renewable sources, batteries improve the resilience of the electricity system by storing energy, usually from renewable sources, which can then be utilized when it's required most. The electricity system operates more efficiently, reducing the risk of outages.

RENEWABLE GENERATION

Wind turbine output varies depending on the wind velocity and solar output varies depending on conditions such as cloud cover and time of year and does not work at night. Batteries help to manage these variations from renewable generation, storing surplus electricity when wind and solar power are generating, and releasing it when there is a gap.

BALANCING POWER SUPPLY AND DEMAND

To keep power supplies flowing effectively, supply and demand must be equal or, to use the common term, balanced. This is far from easy, due to the volatility of renewable power generation and the problems in managing variations of supply.

Batteries are one way of ironing out the differences, and will store and discharge as necessary. Batteries can also manage sudden changes in supply or demand and therefore keep the energy system in balance, ensuring a more resilient and stable system.

HOW MUCH CO_2 IS EMITTED FROM MANUFACTURING BATTERIES?

This question is dependent on many things, including where they are made and what they are made from. What they are used for also makes a difference.

Modern clean technologies where batteries are used in conjunction with renewable power generation are better than a system with no batteries.

Lithium-ion batteries are the preferred choice due to their ability to store large amounts of energy in a small spatial envelope, and to remain effective even after thousands of charge and discharge cycles.

Lithium–ion batteries are best known for their use in cars, where they displace IC engines, thereby saving many tonnes of CO_2 emissions. However they also lend themselves to energy storage for green energy sources, and can take energy from, and release it to, the grid.

The manufacturing and disposal of the batteries does create CO_2, and there are concerns over the effects which mining for lithium and other heavy metals such as cobalt and nickel has on the environment.[1]

[1] Professor Yang Shao-Horn of the Department of Mechanical Engineering and Materials Science and Engineering at the Massachusetts Institute of Technology (MIT), estimates that due to the use of fossil fuels in the mining process, 15 tonnes of CO_2 can be emitted into the atmosphere for every tonne of

lithium produced. The process also uses huge amounts of water: the extraction of one tonne of lithium requires around 1.5 million litres of water.

Professor Shao-Horn also explains that temperatures of between 800 and 1000 degrees Celsius are required and if fossil fuels are used, that will add to the level of CO_2 emissions. Of course such emissions would be drastically reduced by the use of net zero or low carbon power.

So the amount of CO_2 that a battery produces during the manufacturing process varies considerably. For example, a Tesla Model 3 car battery can produce anywhere between 2.4 tonnes and 16 tonnes of CO_2 depending on where it is made and what materials it contains.

[2]The Swedish IVL (Environmental Research Institute) released a report stating that CO_2 emissions from battery manufacture have been halved in recent years and range from 59 to 119 kg CO_2 per kWh of battery capacity. The higher value is where batteries are manufactured solely with the use of fossil fuels and is a worst case scenario. Many organizations consider the mean of 89 kg CO_2 per kWh as a realistic value for calculating the CO_2 emissions.

A study of the whole battery life cycle was carried out by [3]Robert Rapier, and his methodology was set out in his article for Forbes magazine. He used the largest battery storage facility in the world – the Hornsdale Power Reserve in Australia, which was built by Tesla for his investigation.

CALCULATION

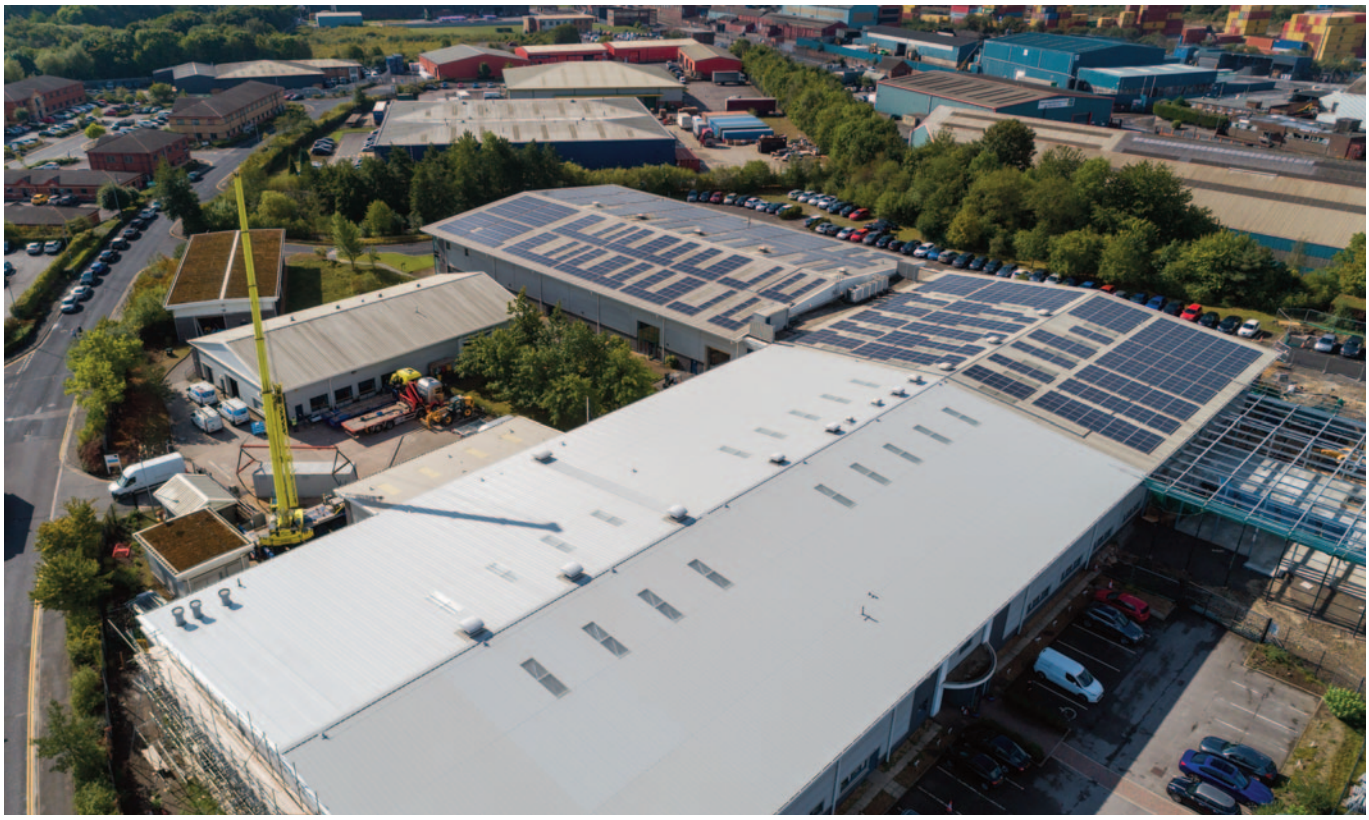
Robert Rapier used the data from the Product Environmental Footprint Category Rules (PEFCR), which indicates, for Li-ion batteries, an energy efficiency of 96% (as 4% energy is lost during charging and discharging), and a lifetime of approximately 400 charge cycles. After 400 cycles, the battery capacity drops below an acceptable limit of 60%. For these calculations, we consider an average value of the battery capacity which is 80% of the initial value.

The value of 400 charge cycles is significantly underestimated. These calculations are based on the value from batteries that guarantee 1,500 cycles. The Australian battery is used to store power from the 100 megawatts (MW) Hornsdale Wind Power Station with 129 megawatt-hours (MWh) of energy storage, meaning:

129 MWh x 0.8 (80%) x 1500 (cycles) = 154,800 MWh.

The received value is the amount of energy from the battery and represents 96% of the energy used for charging it. During the battery's life cycle, we would, therefore, need 161,250 MWh of energy to charge it. According to IPCC, the carbon footprint for wind energy is 11 g CO_2 per kWh, or 11 kg CO_2 per MWh:

11 x 161,250 = 1,773,750 kg CO_2.



To this result, add the carbon footprint of the battery, which is 89 kg CO_2 per kWh. With an energy storage capacity of 129 MWh, this is 11,481,000 kg of CO_2, which together gives us 13,254,750 kg of CO_2. However, to get a value comparable to the carbon footprints of other energy sources, divide this result by 161,250 MWh of electricity (as all of the produced wind energy is used to charge the battery).

RESULTS

The carbon footprint of the energy produced by the wind power plant and stored in the battery is 82.2 g CO_2 per kWh. For solar panels, this would be around 116 g CO_2 per kWh. Both are still significantly lower than emissions from coal and gas power sources with carbon capture technology (220 and 170 g CO_2 per kWh, respectively).

CASE STUDY

AESSEAL fitted 2,300 solar panels and a 1.25 MW BESS (Battery Energy Storage System).

For the full 936 kilowatt peak array (solar energy generated from 2,300 solar panels) AESSEAL expects annual generation to be around 748,800 kWh. At £0.85/kWh this delivers annual savings of approximately £636,500.

The carbon footprint associated with BESS can be calculated as 112 (89kg per kWh x 1,250 kWh = 111,250 kg or 11.25 tonnes of CO_2 in year 1), or, using the whole system approach defined by Robert Rapier, significantly less.

The savings based on greenhouse gas reporting: conversion factors from Department for Business, Energy and Industrial Strategy give a conversion factor of 0.2314 kg CO_2 saved for each kWh produced from a carbon free source. The value is accurately CO_2 eq per kWh and results in savings of 175 tonnes CO_2 annually.

Over a 10 year period that gives a CO_2 benefit of 2,513 (112 against 2,625) tonnes CO_2.

FUTURE

Total installed capacity of utility scale energy storage in the UK is approaching 1.7 GW across more than 100 sites[4].

This capacity is due to increase significantly, and in 2021 two pre-applications were submitted for 500 MW stand-alone sites in Scotland.

Intelligent battery systems can also offer power reliance in the form of UPS to safeguard against outages. They can also charge at cheaper times, for example at night, avoiding the high prices which would be incurred during peak hours. Charging batteries at night and using during daytime can significantly lower CO_2 emissions.

RECYCLING

It can be cheaper to mine lithium than to recycle it from batteries. As lithium-ion batteries become more widespread, especially in cars, some companies claim to be able to retrieve pure lithium from batteries. However, there is a cost. If batteries are key to the viability of a sustainable grid then disposal, recycling and secondary uses for recovered materials will be extremely important. There is no doubt that at the moment batteries are being produced and the problem of their disposal is 10 to 30 years in the future. The issue is not one of technology, but rather one of infrastructure and scale, and is the same problem which has been faced by the renewable energy sector from the outset.

References

1 How much CO_2 is emitted by manufacturing batteries? | MIT Climate Portal

2 New report on climate impact of electric car batteries - IVL.se

3 Robert Rapier is a chemical engineer in the energy industry. Robert has 25 years of international engineering experience in the chemicals, oil and gas, and renewable energy industries, and holds several patents related to his work.

4 Solar Media Ltd, 2022 – UK battery Storage Project Database report, March 2022

GEOLOGICAL DISPOSAL OF RADIOACTIVE WASTE

A programme like no other

Professor Neil Hyatt
Chief Scientific Adviser,
Radioactive Waste Management

BRITAIN'S ATOMIC AGE AND LEGACY

The first nuclear reactor in Western Europe was brought into operation on 15 August 1947, the Graphite Low Energy Experimental Pile, GLEEP (Figure 1) [1], based in Harwell, Oxfordshire. This marked the birth of the UK civil nuclear power programme which has now spanned over 75 years. GLEEP ran for 43 years. Today, GLEEP and its housing, a repurposed World War II RAF hangar on the Harwell site, have been decommissioned, dismantled, and demolished [2]. Almost no trace remains.

GLEEP was a forerunner for the lifecycle of the UK civil nuclear industry. Many of the first and second generation nuclear power stations and facilities have reached, or are reaching, the end of their working lifetime. Earlier this year the Government announced new commitments to provide the country with clean, and affordable British energy for the long term, through the delivery of new and advanced nuclear power generation. The resulting waste will need to be suitably manged and disposed of.

The Nuclear Decommissioning Authority is responsible for the clean-up of the UK's historic nuclear legacy leaving the 17 nuclear sites ready for their next use. Decommissioning will take more than 100 years and will produce around 4,500,000 m^3 of radioactive waste [3,4]. Most of that waste can, and is, already being disposed of; but, around 775,000 m^3 of the most hazardous higher activity waste needs to be stored until a suitable disposal facility is available. Storage is a safe interim measure, but not a permanent solution: stores will need to be rebuilt, and wastes repackaged, every 50-100 years.

Continuing to store higher activity radioactive waste in surface storage would commit future generations to incur the resulting expense and broader risks. It requires continuity of institutional controls to assure

Figure 1: The Graphite Low Energy Experimental pile, the first nuclear reactor operational in western Europe in 1947.

safety and security, yet societal and climatic changes take place on a frequency much shorter than the timescale of the radioactive hazard. The current war in Ukraine has put the Zaporizhzhia nuclear power stations on the front line of conflict. The last glacial period in the UK peaked only 22,000 years ago. By contrast, the time required for radioactivity of higher activity waste to decay to a safe level is around a few hundred thousand years. We need to look deeper to find a permanent solution.

GEOLOGICAL DISPOSAL OF RADIOACTIVE WASTES

Geological systems change relatively slowly in comparison to social and climate systems, typically evolving over millions of years. Disposal of radioactive wastes within a stable geology, at a depth of 200 – 1000 m underground, provides sufficient isolation and containment while the radioactivity naturally decays to a level which is no longer harmful (Figure 2)[5,6]. Crucially, no human intervention is required post closure: a Geological Disposal Facility, or GDF, is designed to be passively safe. Three generic rock types are best suited to house a GDF: evaporites (such as simple rock salt); lower strength sedimentary rocks (such as clay or mudstones); and higher strength rocks (such as granites). These rocks typically show almost no, slow or low rates of groundwater movement, which would be the primary pathway for release of radioactivity from the disposal facility. In the UK, all three rock types are abundant beneath land or seabed (within territorial waters) and could support a GDF in principle. Potential sites must be characterised and understood, by seismic surveys and site investigations such as invasive borehole drilling and geological assessments, to ensure and demonstrate safety during construction, operation and after closure.

Science and engineering are at the heart of GDF implementation and development. The GDF comprises engineered underground infrastructure designed to work with the geological environment[7]. Packages of waste will be placed in tunnels or vaults, according to the need to manage the resulting heat from radioactive decay (Figure 2). Packages of high level vitrified waste, will need to be adequately spaced to allow the heat to dissipate. These waste packages will comprise low solubility waste forms in corrosion resistant containers, which will likely be surrounded by a clay buffer material in a lower strength sedimentary rock (Figure 3). This clay will swell, and once groundwater eventually re-infiltrates the facility after closure, will form a protective seal around the package. This system of multiple engineered and geological barriers will deliver isolation and containment of the radioactivity until it has sufficiently decayed and poses a minimal threat.

A WILLING COMMUNITY AND SUITABLE SITE

Securing a willing host community, through a consent-based siting process is essential to delivering a GDF in the UK. Nuclear Waste Services, the GDF developer, must foster and maintain awareness, understanding and trust in the project. It will do that through engagement with potential host communities in a process that safeguards community right of withdrawal up to the point of a test of public support[5]. When sufficient confidence and understanding of the site and community has accrued, a positive test of public support will be required before development can proceed, subject to government approvals, licensing and permitting. The siting process enables potential host communities to define a future vision, in which GDF development could contribute

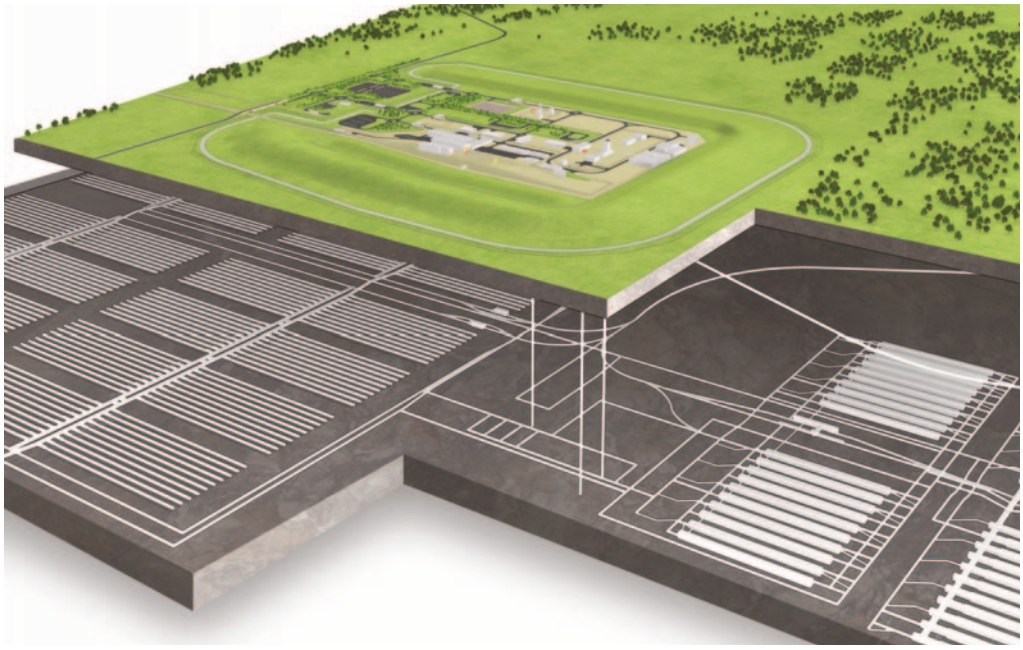


Figure 2: Illustrative representation of a geological disposal facility, showing surface site linked by shaft and drift, to underground disposal area; on the left, tunnel system for disposal heat generating wastes, on the right, vaults for disposal of low heat generating waste.

Figure 3: Illustration of spent fuel disposal system, using a carbon steel container surrounded by a clay buffer, in a lower strength sedimentary rock, at the Mont Terri underground laboratory in Switzerland.

more than 4,000 jobs over the first 25 years, at a range of skill levels, and a package of transformative local development and investment[8]. In parallel with initial desk-based assessments and non-invasive surveys, participating communities will be able to access up to £1 million of immediate community investment per year, increasing to £2.5 million at the point of intrusive borehole investigation[9]. At present, the siting process involves four communities, one around Theddlethorpe on the Lincolnshire coast, and three on the northwest coast in Cumbria - South Copeland, Mid Copeland and Allerdale. In each case, the current focus is on the potential for development of a GDF in the deep geology beyond the coast, accessed from a surface site on land. The cost range for development of a GDF in the UK is £20 – £53 billion, for the full legacy inventory and waste from up to 16 GWe of new build[9]. This is a wide ranging estimate which includes risk, optimism bias, and uncertainty, covering the whole 150 year lifecycle of design, construction, operation, and closure.

SAFETY FIRST AND FOREMOST

An environmental permit and nuclear site licence is required in order to develop a GDF. Nuclear Waste Services will need to demonstrate that the facility will be developed and evolve safely after closure[10]. This requires adequate knowledge and understanding of the fundamental mechanisms of waste package and barrier evolution, of potential groundwater and gas migration pathways in the geosphere, and radionuclide migration, through coupled thermo-hydro-mechanical-chemical processes. More than 50 years of research has already been devoted to meeting this requirement both in the UK and in the international community.

Around the world, substantial progress has been made in GDF construction and site selection in recent decades. Finland is completing the first phase of GDF construction in a granite geology, with operations expected to commence in 2025. Sweden is taking a similar path and the Swedish government recently approved its construction licence application for GDF development at Forsmark. France and Switzerland have also now identified their preferred sites for GDF construction.

The success of these GDF programmes, and that of the UK, depends critically on trust between experts, the public and their elected representatives. Not just up to the ground-breaking ceremony for GDF construction, but enduring for the century long community engagement, operational and closure mission beyond. We should have confidence in the scientific and engineering foundation that we will be successful, the rest is up to us.

SAFETY IN FOCUS

More than 50 years of research has already been devoted to underpinning the safety of geological disposal, both in the UK and in the international community. From investigating the migration of radioactivity to full scale tests of clay barriers using heated dummy waste packages. Natural analogue systems perform a vital role in validating these experiments. For example, the 1.3 billion year old Cigar Lake uranium ore deposit is a proxy for the very long term stability of spent nuclear fuel in an anoxic clay geology. This safety narrative, which sets out our claims, arguments, and evidence, supports the case for long term safety of a GDF after closure. Probabilistic modelling will be used to estimate the potential dose risk to future populations, under conservative assumptions. We aim to ensure that the mean radiological risk from the GDF to a person representative of those at greatest risk should be at least two orders of magnitude lower than the risk from natural background radiation – this is a very cautious safety standard.

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CLIMATE CHANGE, HUMAN PHYSIOLOGY AND THE CHALLENGE OF INTEGRATION

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That humans are most comfortable when naked and at rest in 28 °C air, with an average skin temperature around 33 °C [1], helps explain why thousands travel to "warm" places every year [2]. Our ancient ancestors are responsible for this thermal preference; these are the conditions of the African homeland in which we evolved. As we moved to cooler climates around 300,000 years ago, we did not adapt much physiologically or morphologically, but instead used our intellect to recreate a "tropical climate" next to the skin. The Australopithecus hominid made a windbreak in Tanzania 3.25 million years ago, Homo erectus was building huts from stones, branches and furs more than 1 million years ago, and clothing might have been used by humans 120,000 years ago [2].

This intellectual/technological approach also applied to tools, water and food supply, and has underpinned a planetary population explosion: there were one billion humans on the planet in 1804, two billion in 1927, three billion in 1960 - and we've added another billion every 12–14 years since, reaching 8 billion in November 2022 [3].

The problem isn't just that our numbers have increased eight-fold in 200 years, and doubled in less than 50, it is that we are consuming the planet's resources at a rate which takes us beyond the planetary boundaries we depend on for our survival [3]. This is reflected in our energy use. In 2020, global energy consumption was greater than 580 terajoules/year, equivalent to slightly less than 60 kWh per person per day (equivalent to 8 billion people each boiling a kettle 575 times daily). More than 80% of this energy comes from fossil fuel combustion, meaning that in the span of just 50 years, atmospheric carbon dioxide (CO_2) emissions have reached their highest concentrations in more than 4 million years. This thickening blanket of greenhouse gases traps the energy equivalent of around five, 15 kilotons nuclear bombs every second. This energy gain raises surface temperatures (by 1.1°C already) and that of the ocean (93% of the energy gain has been absorbed by the seas), and causes increasingly frequent and severe extreme weather events.

The consequences are with us now (Figure 1): rising sea levels (approaching 1 cm every 2 years); ever more common and severe droughts, heat waves, floods and fires; crop failure and famine [3]. Things are set to get worse: 20% of the CO_2 we emit today will be warming our planet in 33,000 years' time, and 7% in 100,000 years. Worse, we have already triggered at least eight positive feedbacks, where warming drives warming, including the release of the powerful greenhouse gas methane from carbonate rocks, melting tundra and fermenting wetlands; CO_2 release from fires; carbon monoxide release from fires, which lengthens the atmospheric half-life of methane; loss of the 'albedo' effect (white snow and ice reflecting light back into space) which has doubled the rate of Earth's energy gain in the last 14 years; and warming of the rainforest which, with their destruction by fire, makes them now net *emitters* of CO_2. Catastrophic change may no longer be gradual: sudden changes in ocean and air currents are likely, which will suddenly 'flip' the Earth's weather, while accelerated polar warming (already at 3x the global average rate) may suddenly increase sea levels.

Global heating will harm health through changes in zoonotic, vector-borne and foodborne disease, and malnutrition: more than half of the known human diseases may be aggravated by climate change [4]. But loss of habitation, livelihoods and food will drive societal disruption and

conflict over remaining resources and through climate-driven mass migration. It is no longer just our health, but our very survival which is threatened: the existential threat that has been warned about for so long is becoming a reality[5].

100th birthday[6]. In contrast, the "healthspan" (years of good health) has remained stable since 2019, meaning that the number of years lived in poor health is increasing; those born in 2019 are forecast to spend up to a quarter of their lives in need

homeostatic mechanisms that promote resilience to, for example, fluctuations in climatic temperatures, go unchallenged and undeveloped[8]. Car driving pollutes (even electric vehicles release particulates from road, tyre and brake wear), and lack of

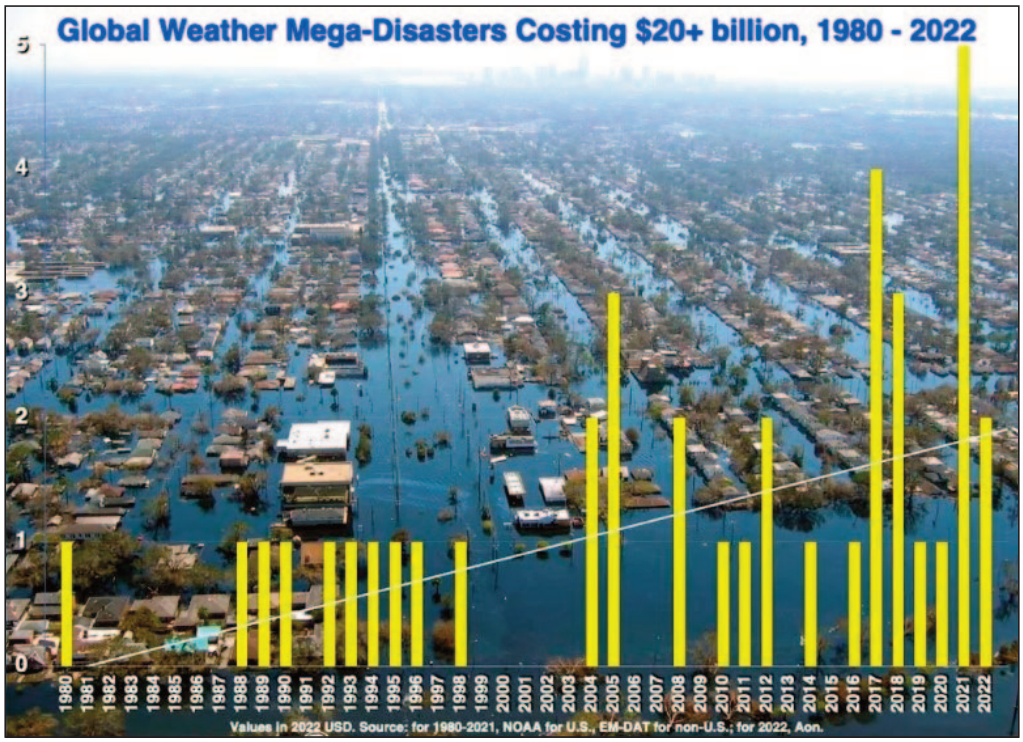

Figure 1. Increasing trend for weather-related disasters costing at least $20 billion (adjusted to 2022 dollars). Data from 2020 flooding in China ($41 billion) and 2003 European heat wave/drought ($26 billion) are not included. Data source: a. From US - National Oceanic & Atmospheric Administration b. Rest of the world up to 2021 - International disaster database EM-DAT c. From 2022 - Aon insurance. Originally published in Masters J (2022) "World rocked by 29 billion-dollar weather disasters in 2022". Yale Climate Connections. With permission. https://yaleclimateconnections.org/2022/10/world-rocked-by-29-billion-dollar-weather-disasters-in-2022/.

A recurrent theme of the recent COP27 World Health Organisation "Health Pavilion" presentations was recognition of the interdependence of climate and health-related issues, and the need for collaborative action and coherent policies. Certainly, the health-related consequences of climate change should be considered in the context of other societal issues, and of the causes of climate change itself. For example, life expectancy is rising, and will likely average over 70 years across the globe by 2050. In the absence of climate change impacts on survival, one in three born in the UK in 2016 could live to celebrate their

of health service support. Much of this physical, and consequent psychological, ill-health, including asthma, allergies, cardiorespiratory disease, infectious disease, maternal ill-health and depression, is related to fossil fuel use. These costs are not factored into the overall costs of fossil fuel industries, which received a net subsidy of $400bn in 2019, with national allocations often exceeding healthcare budgets.

People in industrialised countries spend around 90% of their time indoors[7], with attendant energy costs and related pollution. At the same time their physiological

exercise is harmful to health; combined with poor diet it fuels our epidemic of obesity which is currently costing the NHS 6 billion pounds per annum, rising to 9.7 billion by 2050[9]. By 2034, 70% of adults in the UK are expected to be overweight or obese, which increases the risk of hypertension, heart disease, stroke, cancers, musculoskeletal disease, dementia, depression, kidney disease and anxiety. Worldwide, it is the major modifiable risk factor for type 2 diabetes, and was responsible for healthcare costs of at least $727 billion in 2017 (12 % of adult healthcare spend[10]).

Thus, lifestyles which drive climate change also harm health directly. But the resulting healthcare requirements drive more climate change. NHS England uses £500 million worth of energy each year, with a carbon footprint equivalent to around 20 million tonnes of CO_2. USA healthcare facilities account for 10.3% of total energy consumption in the commercial sector, and the number of these facilities has increased by 22% since 2003 with an associated 21% increase in energy consumption[11].

An understanding of human physiology can help us address these threats, by for example, establishing the degree to which substitution of plant-based protein for animal protein is viable in reducing greenhouse gas emissions and improving health. It can reduce building energy use: 30% of the primary energy supply is used for building heating, ventilation and air-conditioning, and there has been a gradual increase in the thermostat setting, and reduction in clothes worn, in UK homes[12]. Reversing this trend would save energy, money and emissions[13], but the acceptability of doing so requires an understanding of the physiological basis of thermal comfort i.e. the contributions of solar load, air movement, humidity, clothing and physical activity to it, and of the dominant impact of maintenance of peripheral blood flow and warm, stable extremity temperatures on the overall perception of thermal comfort[14]. Physiology can help us understand the extent to which humans can acclimatise to heat, as well as determine the body temperature limits for those having to work in warmer environments, or wear protective clothing.

For these reasons, physiologists have recently joined clinicians in advocating for healthier, more

active and happier lives[15]. Low-carbon living (e.g. clean air from the absence of fossil fuel combustion, active transport and a local seasonal vegetable-based diet) offers one means to maintain and promote individual health while preserving planetary health. However, longer more active lives may drive increased resource consumption - this conundrum has yet to be addressed.

increase, even if emissions cease. A rise of 1.5°C will be more dangerous still, but to stay beneath this requires that global emissions are nearly halved in 7 years. Yet the recent COP27 meeting removed a target to peak in 2025, and also removed any mention of the need to reduce fossil fuel use. Such inertia may soon be fatal. As the 2022 Intergovernmental Panel on Climate Change warned, lack

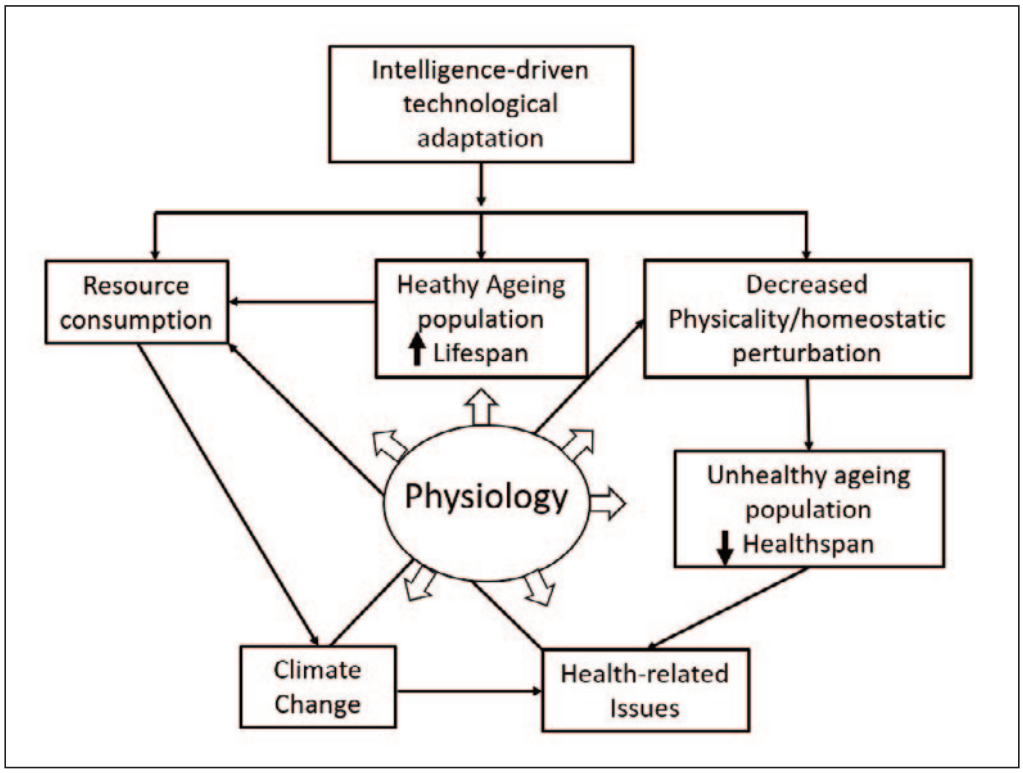

Figure 2. Integrated aspect of climate change and health-related issues. The role of physiology.

The path to comprehensive solutions requires collaborative, integrated action by politicians, policy makers, epidemiologists, engineers, architects, climate change scientists, behavioural psychologists, healthcare professionals, botanists and, physiologists - to provide a fundamental understanding of what humans can tolerate and what needs to be achieved (Figure 2). But we need far more than words, and the time left for action is short. The rise in Earth's surface temperature of 1.1°C above preindustrial levels is already proving dangerous, and this danger will continue to

of immediate action at pace and scale means that we may soon miss our last opportunity to "secure a livable future ".

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ANTI-MICROBIAL RESISTANCE – A POST-MODERN DILEMMA

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In 2016, O'Neill predicted that the death toll associated with anti-microbial resistance (AMR) development would reach a staggering 10 million people by 2050[1] and become the most significant cause of death worldwide. This prediction was corroborated by a real-world review, which showed that in 2019 there were 4.95 million deaths associated with AMR, including 1.27 million deaths directly attributable to AMR[2].

AMR is the development of resistance to antimicrobial agents by bacteria, fungi, viruses and parasites. The most significant of these are multi-resistant bacteria (superbugs) whose global spread has been the subject of considerable concern by the UN, the WHO and the G7. In May 2022 the G7 Health Ministers stated: "We therefore highlight the importance of accelerating the early and late-stage development of urgently needed new antimicrobial drugs, vaccines, alternative therapeutics and diagnostics"[3]. The WHO continue to highlight AMR globally and have launched several initiatives including the Global Antimicrobial Resistance and Use Surveillance System (GLASS) and Global Antibiotic Research and Development Partnership (GARDP). WHO and the Pew Charitable Trust (USA) maintain the most up-to-date databases of antimicrobials in development[4,5].

National action is required to develop incentives for the development and use of new antimicrobials[6]. The UK continues to lead the way in the global challenge against AMR, championed by Dame Sally Davies, the UK's Special Envoy on AMR and the world-leading NICE project on developing models for the reimbursement of antibiotics[7].

In addition to being a scientific challenge (no new classes of antibiotics have been introduced into the market since the 1980s), the development of new treatments also faces economic barriers. The development of new antibiotics is expensive and the drugs themselves do not command a premium price. In addition, because of the development of resistance and limits on prescribing new antimicrobial drugs, lower sales lead to a return on investment for pharma which is less than for other drugs and development is left to SMEs. The inevitability of the development of resistance and the economic realities of drug development means that novel science and innovative ways of paying for the development of new antimicrobials is essential. It is no exaggeration to say that failure to develop strategies against pathogens will have consequences that will dwarf the impact of the Covid pandemic. Each drug-resistant microbe is, in effect, a new organism against which previous strategies will not work. Humanity is playing evolutionary Russian roulette against an enemy that is able, in the short or longer term, to overcome any obstacles we erect.

THE SCIENCE OF ANTIMICROBIAL RESISTANCE

The use of natural compounds as anti-microbial agents was practise by the Egyptians, Greeks, and Chinese. However, it was the development of improved sanitation and vaccination that first led to the reduction in deaths due to enteric diseases and viral infections by the early 20th century. The first chemically synthesised antibiotic, arsphenamine (Salvarsan) was introduced by Ehrlich in 1910. Ehrlich also popularised the phrase 'magic bullet' (derived from German folk tales) to describe an agent that specifically destroyed a harmful entity while leaving the host unaffected[8,9].

The discovery of penicillin by Fleming in the 1920s and its purification and large-scale production by Florey and Chain in the 1930 initiated the age of antibiotics. This was followed by the discovery of streptomycin in 1944, the first effective antibiotic against tuberculosis[8].

The possibility of the development of resistance to penicillin was noted by Fleming in his Nobel Prize-winning address in 1945: "It is not difficult to make microbes

resistant to penicillin in the laboratory by exposing them to concentrations not sufficient to kill them". This proved to be the case. Throughout the 1950s and 60s – indeed until the 1980s – drug discovery kept pace with the development of resistance by bacteria. However, the last new class of antibiotics was introduced in the 80s and the pipeline has, since then, been empty. This has had the consequence that a range of pathogens, particularly *Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa* and *Enterobacter spp*. (the so-called ESKAPE pathogens) have developed resistance to all commonly used antibiotics and are only in part susceptible to the last line of defence.

It is inevitable that microbes will develop resistance to antimicrobials. This is not just a problem for bacterial infections. The increasingly widespread use of anti-viral medication has led to an increase in the development of resistant viral strains. As noted by Fleming, administration of insufficient doses of an anti-microbial can exacerbate the development of resistant strains. While the aim of anti-viral research is to optimise the 'magic bullet' concept of Ehrlich, the therapeutic window for some drugs, including anti-viral medication, is narrow [10]. While vaccination has been seen as a first line of defence against viruses, the experiences of the Covid pandemic (and the need for annual influenza vaccination) suggests that reliance on vaccination alone is a flawed strategy. Indeed, a recent UK government report on anti-viral resistance (NERVTAG) noted that "The emergence of new SARS-CoV-2 variants such as Omicron (B.1.1.529) with the potential to (partially or fully) evade protection from vaccines and monoclonal antibodies increases the potential clinical and public health importance of small molecule directly acting antivirals (DAAs)" [11].

The same message applies to anti-fungal therapies, with the additional factor that there are relatively few anti-fungal drugs available. Several resistant strains of Aspergillus and Candida have been found [12] with the added complication that the use of anti-fungals in agriculture may exacerbate the spread of resistance.

ALTERNATIVE SCIENTIFIC STRATEGIES OR NON-TRADITIONAL ANTIBIOTICS

While the development of new chemical entities has continued, the diminishing return on investment had encouraged the investigation of alternative routes to produce new antimicrobial entities with novel modes of action.

The presence of Gram-negative bacteria in the ranks of human pathogens has encouraged the development of therapies aimed at the molecules used by bacteria to communicate (quorum sensing (QS) molecules). Inhibition of QS has been identified as an approach to understand and reduce pathogens' ability to produce virulence [13] of which there were 24 known examples in pre-clinical and clinical development in 2021 [4]. Many of the Gram-negative QS molecules belong to the chemical class of homoserine lactones. The main strategies for QS inhibition are to use the analogues of various QS signals to block downstream signal transducers thereby blocking the effect of the homoserine lactones [14,15] or using lactonase to break down the lactone ring [16].

Further non-traditional approaches include a) the destruction of alginates produced by Pseudomonas which it uses to protect its biofilms, co-developed in Cardiff, and b) the disruption of biofilms on urinary catheters by reducing the concentration of non-QS, intracellular signalling molecules, being co-developed by a UK-based SME.

The use of bacteriophages (specific bacterial viruses) and the development of novel approaches to enhance existing therapeutics, for example, enhancement of drugs such as amoxycillin where resistance is known throughout diverse bacterial populations [17] are approaches that appear to have promise.

THE ECONOMICS OF ANTIBIOTIC RESISTANCE

In addition to the scientific issues, the development of antimicrobial therapy also faces significant economic challenges. The business model for antibiotic research and development is like that of the rest of pharma – it is predicated by a need for companies to deliver a return on investment to shareholders. In addition to the tendency for doctors to prescribe older (and cheaper) antibiotics, medical professionals typically use new antibiotics only sparingly to prevent microbes to developing antibiotic resistance. This reduces the potential profit for producers and suppresses the development of novel drugs. There is a perfect storm of limiting the use of new drugs to prevent the build-up of antimicrobial resistance, the escalating cost of drug development and the low economic status of those societies where antibiotics are most needed.

ALTERNATIVE ECONOMIC STRATEGIES

Two approaches (termed 'push' and 'pull') have been developed to try to change the economic models associated with the development of new antibiotics. The 'push' incentives have focused on the development of and increasing the speed to market of new bioactives. They include CARB-X (Combating Antibiotic Resistant Bacteria Biopharmaceutical Accelerator), the Innovative Medicines Initiative's ND4BB (New Drugs for Bad Bugs) and others [18]. 'Pull' incentives are designed to provide financial incentives for the introduction of new antimicrobials. These are often couched in terms of some sort of Market Entry Reward (MER) system or a payment for companies linked to early-stage research (pre-clinical and early phase clinical development), aiming to de-risk the drug discovery process and build more robust pipelines [19]. The first real world evaluation of this approach is being performed by NICE [7].

CONCLUSION

AMR is an existing and growing problem for individual countries and the global community. In addition to the human cost in terms of lives lost, it has been estimated that, depending on which model is used, the cumulative global GDP loss due to AMR will range between $2.1 trillion and $124.5 trillion by 2050 [20]. Despite a clear recognition of the problem and an awareness that action must be taken, the national and global response remains weak and poorly coordinated. The consequences of this are clear and urgent action is required. The need for cross-disciplinary and cross-national expertise is recognised. Biophys Ltd and ACTA are developing networks that will be able to respond to

the challenges of AMR and develop novel and effective solutions.

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THE LONG-TERM STORAGE OF CARBON DIOXIDE

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Decarbonisation of the energy system represents a major industrial revolution. Transitioning from fossil fuels to renewables will require a large-scale transformation of many elements of global energy infrastructure. However, there are still many parts of the energy system which are very hard to decarbonise, including fundamental industrial processes such as cement production and iron and steel manufacture. One solution for the decarbonisation of these industries involves carbon capture and storage (CCS) where CO_2 emitted from the flue gas of these industries is captured at source and then stored deep underground in geological storage systems.

The IPCC and the International Energy Agency Net Zero plans suggest that globally we will need to store about a quarter of annual CO_2 emissions every year from 2050 through to the end of the century to meet our climate targets. Alongside this, the IPCC suggest that we will need an enormous scale up of direct capture of CO_2 from the air to achieve the climate target. Together, all the approaches to carbon capture and storage must become a cornerstone of the global response to climate change.

This represents an enormous challenge, and the Royal Society has produced a briefing "Locked

Away – Geological Carbon Storage" to look in more detail at a critical aspect, the storing of large quantities of CO_2 safely for thousands of years. The briefing was produced by representatives from industry and academia, and, in reporting on the scientific and engineering challenges of carbon storage, they drew on evidence from both geological analogues and recent industrial carbon storage projects to produce an overview of where CCS is today, and the opportunities and challenges involved in enabling scale-up of the industry.

There are three existing storage projects, the Sleipnir project in Norway, where over 25 million tonnes of CO_2 has been stored, the In Salah project in Algeria and the Gorgon project in Australia. A large body of knowledge has been built up over the past 20 years relating to the characterisation of potential geological sites for carbon storage, especially below the North Sea waters offshore of the UK.

Several experimental, theoretical and numerical modelling studies have led to an accurate characterisation of the processes crucial to safely and effectively injecting and trapping CO_2 in rocks between 1.5 to 2.5km below the Earth's surface. Of particular note is the important interplay between the subsurface geological formations and the injection and migration of CO_2 through the formations (see figure). Understanding this interplay is essential to ensuring CO_2 can remain safely stored in the target geological formation for tens of thousands of years.

There is also the potential to enhance the efficiency of CO_2 storage, enabling more CO_2 to be trapped in a larger fraction of the available pore space in geological formations. There is a need to develop further research to enable the application of these solutions in the future.

Monitoring is essential for the safe injection and efficient storage of CO_2, and technologies are being developed for monitoring the movement of the CO_2 plume both during and following the injection phase in the subsurface. Such monitoring provides assurance as to the integrity of the storage system and demonstrates how the CO_2 migrates and evolves in the subsurface so that models of the processes can be continually tested and updated. This can then be used to inform management strategies and better understand subsurface CO_2 behaviour to apply to future projects.

One of the key technologies is seismic monitoring, whereby the CO_2 plume is located by sending and receiving sound waves from the surface to the storage reservoir: as the plume advances, the strength of the reflected signal changes, enabling the location and shape of the CO_2 plume to be identified. However, there are also a number of new, lower cost technologies whose development will be key going forward.

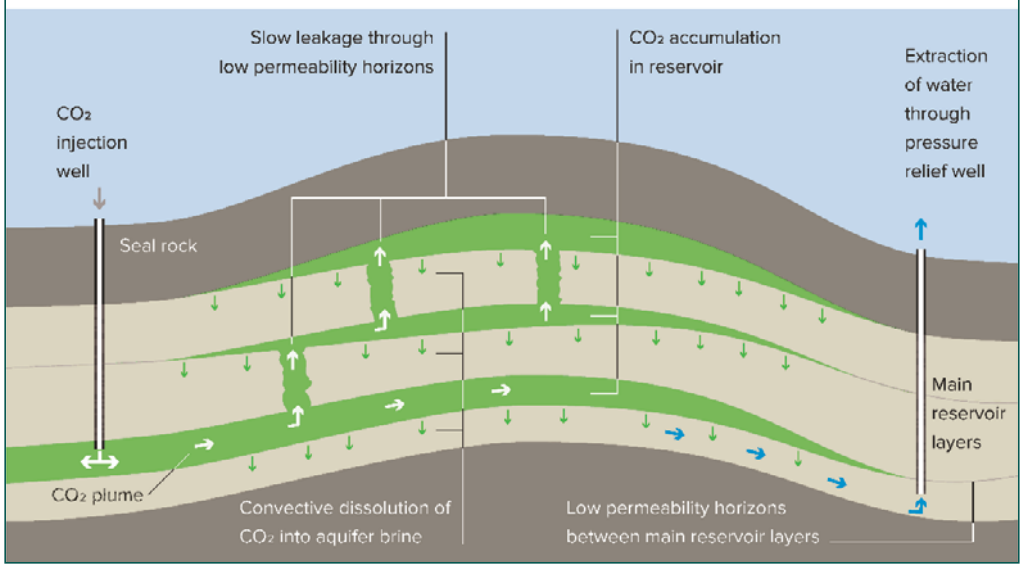
Monitoring for CO_2 leaks must also underpin the management of storage sites. Although the risk of a failure of a CO_2 reservoir is very low, especially when the engineering processes are carefully managed, early detection of leaks is essential if they are to be rapidly addressed. Technologies are being developed to identify and trace submarine plumes of CO_2 which might develop if a leak of CO_2 occurred, leading to a release of CO_2 on the seafloor. Such identification approaches are essential to rapidly resolve leaks and safeguard marine ecosystems.

It is evident that the CCS industry needs to grow very rapidly if it is to meet the IPCC targets. In the UK, there are plans to develop the Endurance field as a CO_2 storage system for the Net Zero Teeside project, and there are plans that the CO_2 collected from the Hynet project in the North-West of England will be stored offshore below the Irish Sea. However, a rapid upscaling of CCS is now needed if we are to achieve our climate obligations. To reach the UK targets for CO_2 storage as proposed in the UK Government's Net Zero 2050 plans, the North Sea Transition Authority envisage that we will require 75-175 Mt storage per year by 2050. This will require the development of about one further storage system, each comparable to the scale of the present Endurance project, every year until 2050. Globally, about 7000-8000 new Sleipnir type CO_2 injection wells will be needed in order to meet the IPCC targets by 2050, which requires about 300 new wells to be developed every year until 2050, a very steep target. Achieving such rapid growth in carbon storage must be underpinned by a robust and enabling regulatory and policy environment.

The briefing is one of a suite of Royal Society briefings on important net zero topics and can be read at https://royalsociety.org/topics-policy/projects/low-carbon-energy-programme/geological-carbon-storage

Prof AW Woods FRS Chaired the briefing working group and is Head of the Institute for Energy and Environmental Flows at the University of Cambridge. He has worked on problems relating to CO_2 flow in porous rocks over the past 20 years and has published widely on the subject. He also collaborates with industry in developing strategies for CO_2 injection and in understanding the dynamics of potential leaks of CO_2 in sub marine environments. ■

Illustration showing what happens to CO_2 when injected underground.
A typical 'anticline' reservoir for CO_2 with multiple layers of porous rock separated by thin layers of mudstone.



POWERING THE FUTURE

Professor Henry Snaith
Credit: Oxford PV.

Professor David Howey
Credit: Ian Wallman

Dr Nick Hawker
Credit: First Light Fusion

Author Dr Caroline Wood is a Communications Manager for Research and Innovation at Oxford University.

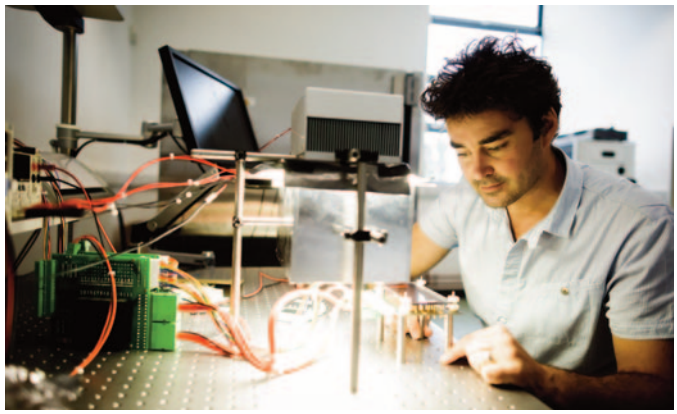
The energy crisis has never been such a critical issue, and the need to break our reliance on fossil fuels is more urgent than ever. Achieving this will require a radical overhaul of our energy systems and cutting-edge research to both improve existing green technologies and develop new ones. Thanks to the talent and leadership of its researchers and an incredible innovation ecosystem, Oxford University is leading the way to develop the energy technologies of the future.

MAKING SOLAR GO FURTHER

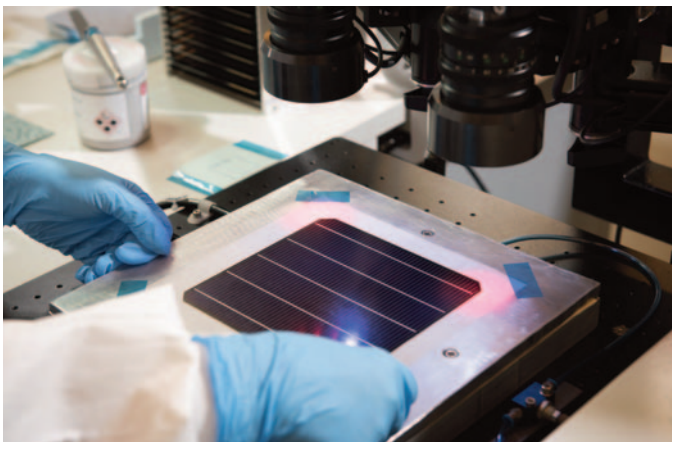
Due to economies of scale and more efficient manufacturing, the average cost of power generated by solar photovoltaic panels has fallen by over 80% since 2010 [1] – but there is still a long way to go if these are to truly replace fossil fuels in the near future. With silicon being costly and energy-intensive to produce in its pure crystalline form, it is likely we have reached the limit for panels made from this material. Since 2010, Henry Snaith, Professor of Renewable Energy at Oxford University, has been leading cutting-edge work to break through this barrier using a transparent material called perovskite. With excellent semiconductor properties, perovskite can be applied as a thin film layer in tandem with an active silicon cell to significantly boost power output.

In 2010, Professor Snaith co-founded the spin-out company Oxford PV [2] to apply this research into delivering low-cost, high-efficiency photovoltaic technology. This is now the largest team globally to be exclusively focused on developing and commercialising perovskite-based solar cell technology. The company has raised over £150M in venture funding, with research and development activities north of Oxford, and industrial manufacturing capabilities in Germany now up and running. Their aim is to become the first company to sell these next-generation solar cells to the public in 2023.

'Our tandem system is designed to be built into standard photovoltaic solar panels to generate more power' said Professor Snaith. 'Typical silicon solar cells convert around 20-22% of the available solar energy into electricity, but the addition of perovskite can boost this to reach efficiency levels in excess of 30%.' In the future, perovskite could become even more efficient, as it can be 'tuned' to different parts of the solar spectrum. Furthermore, the constituent materials in perovskite are abundant, cheap and simple to produce. 'With their improved efficiency and lower cost, we foresee that perovskite solar cells will soon

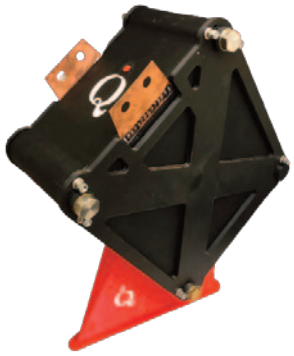


Professor Henry Snaith in the lab. Image credit: Oxford PV.



Oxford PV puts a thin layer of its perovskite material on the top of standard silicon solar cells to convert significantly more of the sun's energy into electricity. Image credit: Oxford PV.

be a viable alternative energy source to fossil fuels, which will be a critical step for delivering more affordable clean energy for all.'



A Qdot battery module prototype, containing 12 Li-Ion pouch cells. Qdot's innovative tab-based thermal management technology extended the discharge time by 27% and the current output of the module by 50% while minimising weight.
Image credit: Qdot Technology Ltd.

BUILDING BETTER BATTERIES

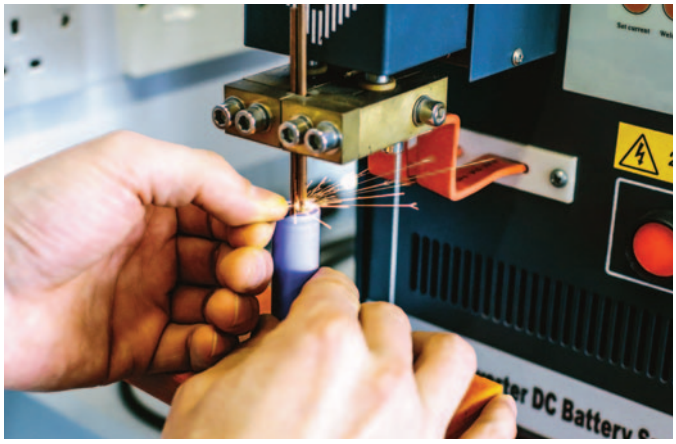
Moving from fossil fuels to a fully electrified system will require significantly better batteries than we have at present. One significant challenge for researchers is to develop batteries capable of charging rapidly (for instance in electric cars) without heating up too much. Qdot[3], a spin-out company from Oxford University's Thermofluids Institute based at Harwell, has developed an innovative battery heat transfer technology based on the Institute's research on cooling systems for fusion energy devices, where heat loads can be in excess of 10 MW (over 100,000 midday suns) per square metre. Qdot's technology enables large amounts of thermal energy to be removed extremely quickly.

'Our aim is to increase the recharging rate for electric vehicles from 6 miles per minute to over 15 miles per minute, making 10 minute recharges a real possibility' said Qdot co-founder and Head of the Oxford Thermofluids Institute Professor Peter Ireland. 'Ultimately, we hope to expand this technology to enable carbon-free, electric flight. This will require battery packs with high-power density for take-off and landing and that can be charged quickly between flights.'

LONGER LIFETIMES

Another focus for researchers is maximising battery lifetimes. 'Lithium-ion cells are made with valuable and limited materials, but we are currently a long way from using all of these to their fullest potential' said Professor David Howey, of Oxford University's Battery Intelligence Lab. 'This is because standard designs group the battery cells together so that the packs are limited by the weakest cells which lose capacity at the fastest rate, wasting the capability of the other cells that remain fully functional.'

To combat this, Professor Howey co-founded Brill Power[4] in 2016 to develop a new generation of intelligent battery management systems. Using novel, patented control technology developed at Oxford University, these systems combine hardware and software with monitoring and diagnostic algorithms that distribute cell currents in proportion to cell health. This maximises energy storage capacity, power capability, lifetime, and safety of the battery system. 'Our hardware can be integrated with any type and format of lithium-ion battery cell and is suitable for any multi-cell battery application, from energy storage modules to electric vehicles' Professor Howey said. 'Our current versions can increase lithium-ion battery system lifetimes by up to 60%, enable up to 20% more energy generation, and facilitate 129% increased storage capacity.'

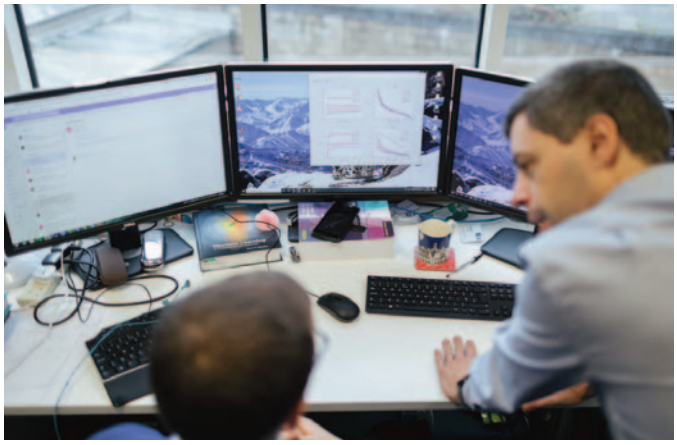


Characterising battery behaviour is a key research area at Oxford.
Image credit: Ian Wallman.

FIRST LIGHT FUSION

But improving existing green energy technologies may not be enough, particularly as global electricity demand is expected to more than triple by 2050[5]. So Oxford researchers are also leading the way in investigating a potentially game-changing technology that could provide virtually limitless safe, clean energy.

Nuclear fusion, where two light atomic nuclei combine to form a single heavier one, is the process that powers the stars. This releases massive amounts of energy: up to four times as much as nuclear fission reactions, but without producing dangerous, long-lived radioactive waste. Replicating this on earth, however, typically requires extremely high temperatures (over ten million degrees Celsius) and pressure. But First Light Fusion[6], an Oxford University spinout founded in 2011, is investigating an alternative approach: projectile-based fusion. This forces atomic nuclei together by compressing a fuel inside a target using a projectile travelling at tremendous speed. In April this year, the company celebrated a world-first by achieving nuclear fusion with its projectile approach, using a 22-metre gas gun to fire a 100g projectile at 20 times the speed of sound. First Light Fusion are now working to develop a demonstration plant to show 'energy gain', the next critical step towards realising commercial fusion. The energy generated will ultimately heat water to generate steam for driving a turbine. The company envisages that each target in the plant would release enough energy to power an average UK home for over 2 years.



Oxford is leader in modelling and simulation of battery performance.
Image credit: Ian Wallman.

Dr Nick Hawker, Co-Founder and CEO of First Light Fusion, said: 'We believe projectile-based fusion offers the fastest, simplest and most scalable path to commercial fusion power. This has the potential to provide near limitless clean energy, helping to provide a clean baseload power

source to deliver net zero for 2050. As it requires only widely available materials, it also offers massive benefits for energy security. But to maintain the UK's world-leading position in fusion, it is imperative that we invest in development and commercialisation now.'

DELIVERING DATA

But developing new energy technologies will only be the first part of the process. Decarbonising our complex energy infrastructures will be a major challenge, particularly aligning the differing demands of the transport, domestic, and industrial sectors. Having real-world data will be a key factor in determining whether all these will be successfully integrated into a seamless, much expanded electric system. But we currently have very little information on how patterns of energy usage and demands are likely to change, particularly as green technologies such as electric vehicles and heat pumps become more widespread. This will make it difficult to ensure that energy systems have enough capacity to meet peak energy demands.

To address this, Oxford University recently launched an International Community for Local Smart Grids[7] as a forum for community energy groups and electricity networks to actively share key learnings from innovation projects around the globe. 'Smart grids play an essential role in bridging the gap between international targets and local ambition, whilst maintaining network resilience' said Dr Andy Gilchrist, an Energy & Zero Carbon Economy Lead at Oxford University. 'Working with a range of partners across sectors, we aim to identify smart grid challenges and opportunities, share knowledge and findings through online resources and inform policymaking and industry best-practice.'

In addition, Oxford University together with University College London will be leading a £8.7 million research project to establish a national Energy Demand Observatory and Laboratory (EDOL)[8]. Launching in January 2023, this will create an 'Observatory' of 2000 representative UK homes to generate high-resolution data that will improve our understanding of how, in real time, domestic activity impacts energy demand and associated carbon emissions. Alongside the Observatory, 'Field laboratories' of 100-200 selected households will serve as test beds for trying out new energy policies, technologies, business models, and other interventions. Project co-lead Professor Philip Grünewald (Department of Engineering Science, Oxford University), said: 'The UK has led the world in access to high-quality energy data and its analytics. The EDOL programme will build on this by providing a high-resolution data resource to inform new technologies, policies, and business models to help achieve net-zero carbon emissions.'

LOOKING FORWARD

According to Professor Chas Bountra, Pro-Vice Chancellor for Innovation at Oxford University, these examples show how Oxford University is making huge strides towards finding solutions to the enormous challenges around energy systems, supply, and sustainability. But keeping up this momentum will require continued financial support from Governments, research councils, and investors until these technologies really bear fruit. He said: 'The UK can be a science superpower but more must be done to encourage and facilitate investment in innovation coming from our great universities, to accelerate research and scale companies, which not only make such a positive impact on people and planet but also play a key role in generating economic growth and investment in the UK.'

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6 https://firstlightfusion.com/

7 https://communitysmartgrids.org/

8 https://www.edol.uk/ ■

First Light Fusion's Proposed Reactor. Image credit: First Light Fusion

A HEALTH-CENTRED RESPONSE TO CONVERGING CRISES: SECURING A FUTURE IN WHICH POPULATIONS CAN NOT ONLY SURVIVE, BUT THRIVE.

Marina Romanello, PhD[1]
Executive Director of the Lancet Countdown, Institute for Global Health, University College London, London W1T 4TJ, UK.
m.romanello@ucl.ac.uk

In 1992, world nations signed the United Nations Framework Convention on Climate Change, agreeing to avoiding dangerous anthropogenic climate change. Thirty years on, global greenhouse gas (GHG) emissions continue to rise unabated. At 1.1°C of heating, anthropogenic climate change is already affecting the mental and physical health of populations worldwide, and the world is getting dangerously close to tipping points which would dramatically alter the environment our lives depend on.[1] Despite these threats, countries are not acting fast enough to curb emissions, and the 2030 climate change mitigation targets laid out in countries' Nationally Determined Contributions under the 2015 Paris Agreement set the world on track to 2.4°C heating by the end of the century. As a result, the threats we now face are not only to our health – but to our very survival.

The Lancet Countdown on Health and Climate Change is an international research collaboration monitoring the changing health profile of a heating world. Its 2022 global report found that every dimension of health monitored is being affected by climate change, with impacts now compounding those of the current food, energy, and cost of living crises (Figure 1).[2] Its data shows that vulnerable age groups are increasingly exposed to life-threatening extremes of heat, and that the rising temperatures are limiting labour capacity, affecting livelihoods, and adding further strain on families grappling with the economic impacts of the COVID-19 pandemic and the cost-of-living crisis. Extreme weather events are being made more likely or more intense due to climate change, causing devastation in every continent. Meanwhile, the changing climate is making conditions increasingly suitable for the transmission of many infectious, and affecting global food systems. Indeed, the rising temperatures and the higher incidence of drought and other extreme events are increasingly affecting crop yields and disrupting supply chains, impacts that now compound with those of the COVID-19 pandemic, the war in Ukraine, and the cost-of-living crisis, to pose acute threats to global food secuity.[2]

Figure 1: The 2022 Report of the Lancet Countdown.
Image credit: The Lancet

Many of these health impacts are already occurring in the UK, often at a faster pace than models predict, with the most vulnerable populations disproportionately affected. Local populations were exposed in 2021 to average summer temperatures 0.79 °C higher than in 1986–2005, surpassing the average global human exposure to heating (0.6 °C),[2] and temperatures in the UK exceeded 40 °C for the first time

in 2022, a threshold that was considered extremely unlikely just two years before, and which pushed the UK Meteorological Office to issue the first ever red extreme heat warning. With an aging population, high incidence of non-communicable diseases (NDCs), an unprepared built environment, and populations unaccostumed to high temperatures, the UK is highly vulnerable to the health impacts of extreme heat. Indeed, excess deaths of people over 65 years of age during the 2022 heatwaves in England, rose to 2,803 – the highest toll since the introduction of the Heatwave plan in 2004.[3] Partly driven by the high temperatures, record-breaking droughts were declared across the UK and much of Europe in 2022, threatening crops, water security, and affecting energy production.[4] In parallel, human exposure to days of very-high fire danger increased over tenfold from 2001–04 to 2018–21, putting populations at risk of direct injury, health harms from wildfire smoke, and indirect impacts from the loss of physical assets and service disruption. Indeed, the hot and dry weather in 2022 resulted in an unprecedented number of wildfires, with 745 registered by August that year – a 200% increase from the total in 2021.

Of particular concern in the UK is the rising sea level, which in a high-emission scenario could reach up 0.8m by the end of the century, or even up to 2.3m in case of ice sheet collapse.[5] The risk of floods and permanent inundation, coastal and riverbank erosion, spread of infectious diseases, and contamination of soil and water resources, threatens the 1.65 million people currently settled within 1 m of current sea levels;[2] and he increased pressures on the current "hold-the-line" policy of the coastal management plan could make 120,000-160,000 households uninhabitable by 2050 in England alone.[6] As the planet heats, urgent adaptation interventions are needed to protect or relocate those coastal populations.

THE HEALTH HARMS OF A DELAYED ZERO-CARBON TRANSITION

Fossil fuels are the main single contributors to anthropogenic climate change, and are responsible for over three quarters of the UK's current emissions.[7] But in addition to fuelling climate change-related health harms, the overdependence on fossil fuels also affects health directly.

With a slow adoption of renewable energies, people in the UK remain vulnerable to volatile fossil fuel markets. Following the restrictions to Russian gas in 2022, the spike in international fossil fuel prices caused local energy prices to soar, leaving millions exposed to energy poverty. As people struggle to afford to heat their homes, the health impacts of cold, damp houses – estimated to cost the NHS at least £2.5 billion annually – are expected rise further, exacerbating respiratory disease, cardiovascular illness, and mental ill-health.[8] Facing energy poverty, many are turning to biomass burning, which in 2020 was responsible for 8200 deaths from outdoor $PM_{2.5}$ particulate air pollution (Figure 2).[2] This adds to the impacts of fossil fuels on air quality, which contributed to 31% of the 27,000 deaths attributable to PM2.5 in 2020, and disproportionately affected the most deprived communities.[2] Adding onto these harms, the cost-of-living crisis, partly driven by soaring energy prices, is deteriorating the socioeconomic conditions that good health depends on. In September 2022, 18% of UK households experienced food insecurity as prices spiked, up from 7.3% in July 2021, with households with children worst affected.[9] The effects of the energy, food and cost-of living crisis will be long-lasting, and felt through years to come.[8]

But despite their health harms, fossil fuels still dominate the global energy system, the carbon intensity of which decreased by less than 1% since the year the UNFCCC was signed.[2] Concerningly, out of 86 countries analysed by the Lancet Countdown, 80% still allocated net subsidies to fossil fuels in 2019, for a collective net total of US$400 billion. The UK allocated US$12.3 billion to net subsidies, making it the European country that most funds allocated to this purpose, and the third European country with the lowest net carbon price.[2]

As a result of the persistent overdependence on fossil fuels, the window of opportunity to keep global temperature rise below 1.5°C and avoid rapidly increasing health harms, is rapidly closing.

A RENEWED OPPORTUNITY FOR A THRIVING FUTURE

Despite their health harms, the response to the converging climate, energy, cost-of-living, and food crises offers a renewed opportunity.

As countries strive to gain independence from international fuel markets, many are accelerating their shift to zero-carbon energy, and the total growth in renewable energy capacity is expected to double within five years. Accelerating this transition would not only maximise the chances of averting the worst health impacts of climate change, but would

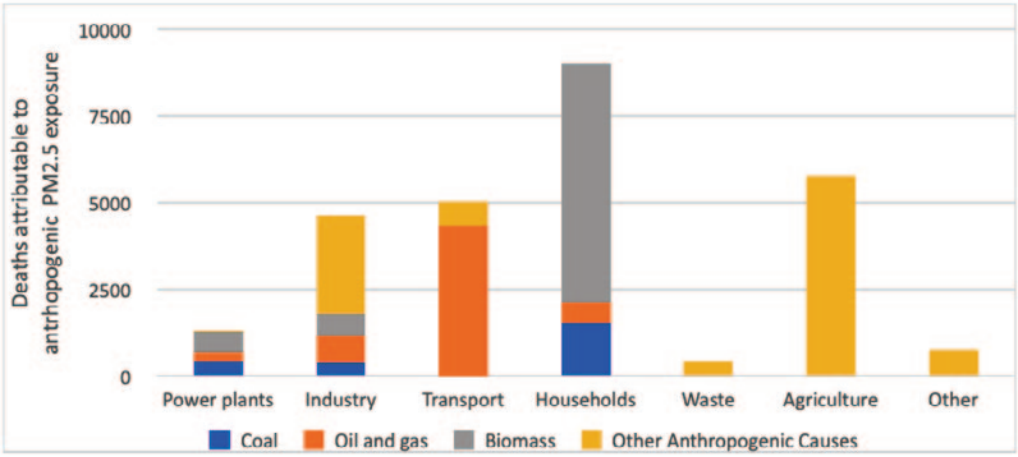

Figure 2: Deaths attributable to anthropogenic PM2.5 exposure in 2020 in the UK, by source contribution and sector

also deliver immediate health gains by diversifying energy grids, increasing access to universal and affordable clean energy, and reducing the health harms of energy poverty. By prioritising policies that deliver health gains, up to 16,500 deaths attributable to ambient $PM_{2.5}$ from dirty fuels (fossil fuels and biomass) could be saved annually, while road travel decarbonisation in favour of public and active travel modes could save up to 4,300 $PM_{2.5}$-related deaths each year, and avert up to 38,000 deaths annually thanks to the adoption of more active lifestyles.[2] To realise the health benefits of the UK's Net Zero ambition fossil fuel subsidies must be swiftly eliminated in alignment with the recommendations of the Climate Change Committee.[10] Redirecting funds to supporting those that could be affected by rising energy and living costs, and to activities that improve overall health and wellbeing, would additionally reduce health inequities in the UK and enable a just transition. Furthermore, by avoiding the worst health impacts of climate change, and delivering healthier environments and lifestyles, the above transition would substantially alleviate the burden on the NHS, thus improving the quality of care for all.

The UK today faces the opportunity of delivering a health-centred, aligned response to the energy, cost-of-living, and climate crises. In doing so, it will not only prevent the worst health impacts of climate change, but also deliver immediate health gains to local populations, securing a future in which they can thrive. This opportunity cannot be missed.

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NEW APPOINTMENTS AT THE GEOLOGICAL SOCIETY

Simon Thompson was appointed Chief Executive of the Geological Society, on 1st November 2022, following the retirement of Executive Secretary, Richard Hughes.

Simon was previously the Chief Executive of the British Institute of Radiology. Prior to that he held senior private-sector roles in publishing and online information. He joins a Society already making excellent progress on the strategic plan agreed in 2020 and implementing the mission, vision, and values identified in 2021.

Simon said "*I am honoured to be joining the team at such an important time. Geoscience is as crucial as ever in addressing the challenges and opportunities of our changing world. I look forward to putting the Society's strategy into action and supporting the geoscience community to thrive and succeed.*"

Appointment of new Director of Science and Engagement

Dr Natasha Stephen will become the Society's next Director of Science & Engagement from January 2023.

Dr Stephen was formerly at the University of Plymouth as a Lecturer and as Director of the Plymouth Electron Microscopy Centre. She will join the Society as Director of Science and Engagement on 3 January.

At the Geological Society, Natasha will be the senior staff member responsible for a broad range of outputs including the science programme, conferences, library services, policy, and engagement – which includes public activities and relationships with the media, government, industry and external partners. Natasha will also oversee the Geological Society's projects to inspire involvement of young people with geoscience, and to ensure that the Society and the field become increasingly diverse and inclusive.

A planetary geoscientist, Dr Stephen's research into the geology of volcanoes on Mars was carried out mostly from the Natural History Museum, gaining her a PhD from Imperial College. She is active within the Royal Astronomical Society and the Royal Microscopical Society. She is an experienced public communicator, and among other things has delivered a TEDx Talk entitled Adventures of an earth-bound astronaut.

Geological Society Chief Executive Simon Thompson said "*We are excited about Natasha's arrival and look forward to benefitting from her very obvious talent and insight. Natasha is deeply interested in the science, and also passionate about engaging new people and helping to involve people who might otherwise be excluded. She is exactly the right person for the opportunities ahead.*"

THE EVOLUTION CHANGES IN THE FARMING AND AGRICULTURAL INDUSTRY

Roger Brown, CEO and MD
CGS Group

Cioux has under-gone research into the changes of the agriculture industry and what role has technology taken up and what are the affects of the future for the industry. The information has been collected from reports such as the research paper from Deloitte & SCiO. This covers the role that agriculture plays in human development. From providing basic sustenance to employing thousands of farmers in the UK, agriculture is a fundamental part of almost all societies and economies. Yet, agricultural systems must adapt, even transform, to meet a growing number of challenges and constraints worldwide. This transformation is crucial for achieving many of the challenges post covid.

Dan Hough, Business Development
Director, CiOUX Group

Steve Collier, Business Operations
Director, CiOUX Group

TRADITIONAL FARMING SERVICES IN THE UK

British farming declined during the period 1870 to 1939 and the countryside was largely neglected and uncared for. During and after the Second World War, there was a need for the UK to become more self-sufficient in food stuffs. Efforts were made to increase the amount of land under production and to improve crop yields.

Since the 1940s, the use of machinery on farms has increased enormously. Farm machinery is now bigger and much more effective. Fewer people are now needed to farm the land, because much of the work is done by machines. Mechanization has also changed the layout of farms. Farm tracks have been improved so that large, combined harvesters and other machinery can use them. Hedges have been removed to enlarge fields so that they can be farmed more efficiently.

In 1973, the UK joined the EU (European Union). The idea was for European countries to work together to achieve economic development. All EU members are subject to the Common Agricultural Policy (CAP), which regulates farming in the EU. Having left the EU, the UK is now free to design its own agricultural policy to replace the EU's Common Agricultural Policy (CAP), although key elements of the CAP-based system currently remain in place. In 2018, UK farmers received around £3.5 billion per year in CAP payments.

The growth of supermarkets has had a major influence on British farmers. Did you know… Farmers are going bust in record numbers – 11 go out of business every day. Fifty years ago, farmers used to receive about half of every £1 that shoppers spent on food in the shops, now they're getting less than 8p in the £1. UK food sales and exports are worth about £130 billion a year. In 2001, the profits of just two supermarkets equaled the total annual incomes of all the farmers in the UK.

Five supermarkets control over 80% of all grocery sales in the UK. Tesco, the biggest, on its own holds nearly 25% of the market.

Supermarkets also buy products from across the world, so UK farmers now have much greater competition.

Diversification means branching out into activities, other than just growing crops and rearing animals. One reason for diversification is the Common Agricultural Policy. The CAP pays farmers to 'set aside' land – they are not allowed to use this land for agriculture, but they can use it for other activities such as tourism. Another reason is that recent food scares have shown that it is dangerous to rely on only one product. The BSE scare in the 1990s bankrupted many beef farmers. The foot and mouth outbreak in 2001 also hit farmers badly. Ref board wicks Ltd whitepaper

FARM SHOPS AND REMOTE BUYING

Retailers and food service providers should embrace the

new technologies to reduce waste by 25%-50% and meet consumers' current needs. AI-bin Winnow is the first AI-based bin to support the hospitality industry, aiming at reducing food waste. Smart scales and smart meters are programmed to identify food wasted. Usage of technology can secure transparency by allowing traceability and verification of the origin of a product, as well as its attributes.

NEW FARMING SERVICES

New farming services used by there farm shops will be using technologies such as:

- Smart Lockers Click & Collect
- Kiosk for faster service
- Electric charging in their car parks
- Out of hours services
- Online digital services

PRESENT FARMING SERVICES

The present services and operations are evolving into a hybrid operation with more farmers starting to embrace the new technology and services with a new operation model. A few farmers are leading the way with others slowly starting to follow in their footsteps.

INCREASING USE OF TECHNOLOGY

Agricultural technology already plays a critical role in modern production settings, especially for large corporations. Robotics, sensors, cloud computing and blockchain are core technologies that act as a catalyst to the AI revolution in agriculture.

ROBOTICS & DRONES

Advancements in navigation and recognition as well as cost reduction have allowed use of robots for relatively complex tasks like spraying and weeding, fruit picking, nut harvesting and crop monitoring. Robots become cheaper and easier to use, thus facilitating their introduction in a wide range of farms.

CLOUD COMPUTING

Reduction in costs of accessing powerful data centers through the Internet has allowed producers to collect, store, and analyze massive amounts of data without the need for building and maintaining costly mainframes. These are further reinforced through the interconnection of various machines.

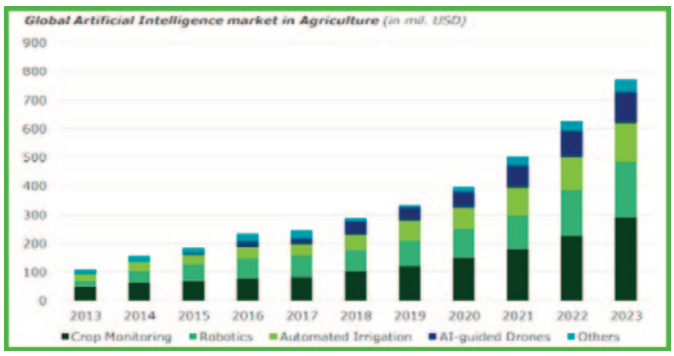
SENSORS

Coverage and sophistication of sensing equipment for agriculture is continuously increasing, with a simultaneous reduction of hardware, installation, and maintenance costs. Factors like moisture levels, sunlight, wind speed and others are already routinely measured.

NEW SOLUTION

One of Cioux's Partners, SCAD Software and SFG Technologies, has recently launched a solution that manufactures a vegetable growing box supported by an educational App that helps companies and government departments improve many of their Sustainable Development Goals (SDG) targets.

AI FUTURE EVOLUTION



The global market for AI in Agriculture is valued at 240 million USD in 2017 and is expected to reach 790 million USD by the end of 2023, growing at a CAGR of 21.8%. The market for crop monitoring accounted for more than 35% of the global revenue in 2016 and during the forecast period AI-guided drone is expected to be the fastest growing solution. These technologies allow for an extensive collection of data which through precision agriculture allows farmers to maximize yields using minimal resources while reducing the overall impact to the environment.

FUTURE DEVELOPMENT OF USING MORE TECHNOLOGY TO REDUCE COSTS

The future of farming could well involve innovative vertical farms like Unit 84, offering an alternative to the lack of extra farmland. Sited in an industrial warehouse in Beckton, East London, 6,000 square feet of LED-lit growing space can produce more than 20,000 kilograms of salads and herbs a year, alongside a clever aquaculture solution that can produce 4,000 kilograms of fish.

Companies like John Deere have started placing sensors, GPS, and radars on their machineries, coupled with machine learning algorithms to distinguish between complex tasks, in-order to develop fully autonomous tractors. This technology could fill the gap of inadequate supply of skilled labor during planting and harvesting, allowing for continuous work, which as a result could dramatically increase output and reduce staff costs.

CIOUX TECHNOLOGY INNOVATION

Like other companies in the sector Cioux brings new technologies for the agricultural market, designing smart technologies with heated and chilled lockers to smooth out the process of buying in a farmer shop. With smart Kiosk to allow payment processing quickly with no queues. Allows the farmers to

embrace the new technologies and adapt much more quickly. We also, see industrial vehicle charging systems that allows a pay as you go system. This will

allow farmers to bring in more revenue by offering other services to assist the consumer.

LAST BUT BY NO MEANS LEAST – WHERE IS IT GOING TO:

Technology will be a large inspiration for farmers to reduce their costs and find more ways to increase their services to their customers. It will be a positive step forward for them to understand how they can improve or adapt their operation for the future.

THE GROWTH OF – THE FARMING INDUSTRY

The future of food systems will primarily depend on the evolution of two key dimensions, market connectivity and consumption patterns. The adoption of digital technologies may contribute significantly to shaping a more sustainable, resource efficient world.

The introduction of technology in agriculture has led to a massive increase in food productivity as well as removing any concerns relating to a scarcity of food in the future. Advancements in technology such as crop sensors, irrigation systems and fertilizers have all helped crop yields meet their maximum potential, and variable rate technologies have also ensured that fields obtain the required amount of input that will as a result lead to huge increases in production.

This was prepared by Cioux Technology services a part of the Cioux Group

Contact - enquiries@ciouxgroup.com ■

NET ZERO AND THE ROLE OF ENGINEERING

Achieving net zero is one of our greatest challenges over the next decades. This evening we heard from three expert speakers about how engineering can help achieve a low emissions society. Stephen Shaw, Global Engineering Director at AESSEAL plc. and IMechE Yorkshire Region Hon. Treasurer, discussed the role of engineers in the context of net zero and how they can benefit businesses. Paul Jordon, Business Leader of Innovator Support & International at Energy Systems Catapult, discussed how engineers are needed to update our power grid and heating systems, which will be crucial if we wish to reach out net zero targets. Lastly, Dr Gbemi Oluleye, assistant Professor at the Centre for Environmental Policy at Imperial College London, discussed hard to abate sectors in society, where additional support will be needed to reduce emissions. The Q&A sessions at the end of talk was varied, but many questions focused on the policies needed to make the transition to net zero as smooth as possible.

The skillset of engineers will be absolutely vital for us achieving a lower emissions society. Mr Shaw explained how engineers can either lower or offset emissions in a given process. Breaking down emissions into three categories: we have scope 1 which are direct emissions from a company; scope 2 which are indirect emissions, such as emissions from electricity produced for the company; and scope 3 which are indirect emissions that stem from the supply chain. Engineers have roles to play in the reduction and offsetting of all of these emission types. For example, Mr Shaw gave the example of replacing a pumping system with a more efficient model, thus reducing a companies scope 1 emissions. Offsetting is often used to compensate scope 2 emissions, but Mr Shaw explains how planting trees isn't a very efficient way of gaining carbon credits. He emphasised that further development is needed to improve carbon capture technology, an area where engineers will play a vital role.

Reducing our energy and heating systems' emissions will be crucial for net zero. Mr Jordan outlined the three components that must be considered here; electricity generation, hydrogen, and district heating. For all of these, Catapult has compared the clockwork path, the path taken if we follow the government's plan, with a patchwork path, an estimation of what's necessary as the energy system changes over the coming decades.

For example, the clockwork path for electricity generation is predicting 550TWh by 2050 for UK energy consumption produced by nuclear and renewables. The patchwork path predicts 700TWh by 2050 mostly produced by renewables. Engineers modelling these systems and working on the necessary technology will be vital for net zero.

Not all sectors can easily transition to low emissions. These hard to abate sectors includes the aviation industry. Dr Oluleye explained how government policy is necessary to push these sectors towards low emissions, as currently there isn't a great enough demand for the market to pull the transition. Dr Oluleye outlined a case study from the UK Chemical Industry, where the subsidising of electric boilers in pushing the industry to adopt this lower emissions options over gas boilers. It's predicted that penalty charges and carbon taxes should then be implemented by around 2030 to further push for this adoption.

Achieving net zero will be difficult, and the speakers emphasised how the development of better carbon capture technology and energy storage is crucial. Such work will be one part of the large role engineers have to play in lowering emissions.

Alfie Hoar
P&SC Discussion Meeting, 'Net Zero and the Role of Engineering'
31st October 2022

HOUSE OF COMMONS SELECT COMMITTEES

BUSINESS, ENERGY AND INDUSTRIAL STRATEGY COMMITTEE

The Business, Energy and Industrial Strategy Committee scrutinises the policy, spending and administration of the Department for Business, Energy and Industrial Strategy and its public bodies, including Ofgem, the Financial Reporting Council and the Committee on Climate Change.

The Committee regularly holds accountability evidence hearings with Government Ministers and with bodies such as the Financial Reporting Council, the Committee on Climate Change and Ofgem. The BEIS Committee also hears from a range of stakeholders in the course of its work, receiving evidence from academics, business groups, NGOs and charities to its inquiries.

Membership:

Darren Jones MP, Labour, Chair
Bif Aflolami MP, Conservative
Alan Brown MP, Scottish National Party
Ruth Edwards MP, Conservative
Jane Hunt MP, Conservative
Mark Jenkinson MP, Conservative
Ian Lavery MP, Labour
Andy McDonald MP, Labour
Charlotte Nichols MP, Labour
Mark Pawsey MP, Conservative
Alexander Stafford MP, Conservative

Current Inquiries:

- Post-pandemic economic growth: State Aid and Post Brexit Competition Policy. Opened 23rd September 2021
- Energy National Policy Statements – Opened 3rd November 2021. Published 25th February 2022.
- Energy Pricing and the future of the Energy Market – Opened 8th December 2021. Written evidence. Deadline 31st January 2022. Published 26th July 2022.
- Decarbonisation of the power sector. Opened 20th May. Deadline 30th June 2022
- The semiconductor industry in the UK. Opened 25th May 2022. Published 28th November 2022.
- Post-pandemic economic growth: UK labour markets. Opened 27th May 2022.
- The work of the Investment Security Unit. Opened 15th June 2022.

For further details: Tel: 020 7219 5777
Email: beiscom@parliament.uk

ENVIRONMENTAL AUDIT COMMITTEE

The remit of the Environmental Audit Committee is to consider the extent to which the policies and programmes of government departments and non-departmental public bodies contribute to environmental protection and sustainable development, and to audit their performance against sustainable development and environmental protection targets.

Unlike most select committees, the Committee's remit cuts across government rather than focuses on the work of a particular department.

From its beginning in 1997, in carrying out its environmental 'audit' role the Committee has had extensive support from the National Audit Office, providing seconded staff and research and briefing papers.

Membership:

Rt Hon Philip Dunne MP, Conservative, Chair
Duncan Baker MP, Conservative
Sir Christopher Chope MP, Conservative
Barry Gardiner MP, Labour
James Gray MP, Conservative
Helen Hayes MP, Labour
Ian Levy MP, Conservative
Clive Lewis MP, Labour
Caroline Lucas MP, Green Party
Cherilyn Mackrory, Conservative
Jerome Mayhew MP, Conservative
Anna McMorrin MP, Labour
John McNally MP, Scottish National Party
Dr Matthew Offord MP, Conservative
Rt Hon Chris Skidmore MP, Conservative
Claudia Webbe MP, Independent

Current Inquiries

- Biodiversity and Ecosystems. Opened 13th July 2020. Report published 30th September 2021.
- Fixing Fashion follow up. Opened 6th October 2020
- Water Quality in Rivers. Opened 8th December 2020. Published 13th January 2022.
- Sustainability of the built environment. Opened 25th March 2021. Published 26th May 2022.
- Mapping the path to net zero: Opened 25th June 2021.
- Net zero aviation and shipping: Opened 20th July 2021.
- Carbon border adjustment mechanism: Opened 24th September 2021. Published 4th April 2022.
- Technological Innovations and Climate Change: Negative emissions and Technologies. Opened 28th September 2021.
- Aligning the UK's economic goals with environmental sustainability. Opened 29th November 2021.
- Technological Innovations and Climate Change: Green Steel. Opened 3rd February 2021.
- Accelerating the transition from fossil fuels and securing energy supplies. Opened 31st March 2022.
- The financial sector and the UK's net zero transition. Opened 30th May 2022. Deadline 30th June 2022.

- Technological innovations and Climate Change: Geothermal Technologies. Opened 16th June 2022. Deadline 21st July 2022.
- Sustainable timber and deforestation. Opened 25th July 2022. Closed 8th September 2022.
- Technological Innovations and climate change: onshore solar energy. Opened 3rd November 2022.
- Environmental Change and Food Security. Opened 10th November 2022.

For further details: Tel: 020 7219 5776
Email: eacom@parliament.uk

SCIENCE AND TECHNOLOGY COMMITTEE

For further details: Tel: 020 7219 2793

Email: scitechcom@parliament.uk

The work of many Government departments makes use of — or has implications for — science, engineering, technology and research. The Science and Technology Committee exists to ensure that Government policies and decision-making are based on solid scientific evidence and advice. It is chaired by Greg Clark MP.

The Committee has a similarly broad remit and can examine the activities of government departments that make use of science, engineering, technology and research (otherwise known as science for policy). In addition, the Committee scrutinises policies that affect the science and technology sectors, such as research funding and skills (often referred to policy for science).

Membership:

Rt. Hon Greg Clark MP, Conservative, Chair
Aaron Bell MP, Conservative
Dawn Butler MP, Labour
Chris Clarkson MP, Conservative
Tracey Crouch MP, Conservative
Dehenna Davison MP, Conservative
Rebecca Long-Bailey MP, Labour
Stephen Metcalfe MP, Conservative
Carol Monaghan MP, Scottish National Party
Iain Stewart MP, Conservative
Graham Stringer MP, Labour
Christian Wakeford MP, Conservative

Current Inquiries

- The role of technology, research and innovation in the COVID-19 recovery. Opened 24th July 2020.
- Coronavirus – Lessons Learnt. Opened 6th October 2020. Report published 12th October 2021.
- The Role of Hydrogen in Achieving Net Zero. Opened 4th December 2020.
- UK space strategy and UK satellite infrastructure. Opened 23rd April 2021. Report published 4th November 2022.
- Reproducibility and research integrity. Opened 22nd July 2021. Closed 30th September 2021.
- Diversity and inclusion in STEM. Opened 22nd November 2021.
- The right to privacy: digital data. Opened 16th December 2021.
- My science inquiry. Opened 12th July 2022.
- Delivering Nuclear Power. Opened 19th July 2022. Deadline 30th September 2022.
- Governance of articficial intelligence (AI). Opened 20th October 2022.
- The antimicrobial potential of bacteriophages. Opened 9th November. Deadline 20th January 2023.

HEALTH AND SOCIAL CARE COMMITTEE

The Committee scrutinises government and in particular the work of the Department of Health and Social Care. It is chaired by Steve Brine MP.

The Committee also scrutinises the work of public bodies in the health system in England, such as NHS England and Improvement, Public Health England and the Care Quality Commission, and professional regulators such as the General Medical Council and the Nursing and Midwifery Council. They do so by holding inquiries on specific topics and accountability hearings with the Secretary of State, and Chief Executives of relevant public bodies.

Membership:

Steve Brine MP, Conservative, Chair
Lucy Allan MP, Conservative
Paul Blomfield MP, Labour
Paul Bristow MP, Conservative
Martyn Day MP, Scottish National Party
Chris Green MP, Conservative
Paulette Hamilton MP, Labour
Dr Caroline Johnson MP, Conservative
Rachael Maskell MP, Labour
James Morris MP, Conservative
Taiwo Owatemi MP, Labour

Current Inquiries

- Coronavirus – Lessons Learnt. Opened 6th October 2020. Report published 12th October 2021.
- NHS litigation reform: Opened 22nd September 2021. Report published 28th April 2022.
- The future of general practice. Opened 16th November 2021.
- Workforce: recruitment, training and retention in health and social care. Opened 23rd November 2021. Report 25th July 2022.
- The impact of body image on physical and mental health. Opened 1st December 2021. Report published 2nd August 2022.
- Digital transformation in the NHS. Opened 13th May 2022.
- Integrated Care Systems: autonomy and accountability. Opened 6th July 2022.
- IMMDS Review follow-up one off session. Opened 1st September 2022.
- Assisted dying/assisted suicide. Opened 5th December 2022. Deadline 20th January 2023.
- NHS Dentistry. Opened 7th December 2022. Deadline 25th January 2023.
- Ambulance delays and strikes. Opened 15th December 2022.

For further details: Tel: 020 7219 6182
Email: hsccom@parliament.uk ■

HOUSE OF LORDS SELECT COMMITTEES

SCIENCE AND TECHNOLOGY COMMITTEE

The Science and Technology Committee has a broad remit "to consider science and technology". It is chaired by Baroness Brown of Cambridge

The Committee scrutinises Government policy by undertaking cross-departmental inquiries into a range of different activities. These include:

- public policy areas which ought to be informed by scientific research (for example, health effects of air travel),
- technological challenges and opportunities (for example, genomic medicine) and
- public policy towards science itself (for example, setting priorities for publicly funded research).

In addition, the Committee undertakes from time to time shorter inquiries, either taking evidence from Ministers and officials on topical issues, or following up previous work.

Members:

The Baroness Brown of Cambridge DBE FREng FRS, Crossbench, Chair
The Baroness Blackwood of North Oxford, Conservative
Viscount Hanworth, Labour
The Lord Holmes of Richmond MBE
The Lord Krebs, Crossbench
The Baroness Manningham-Buller LG DCB, Crossbench
The Lord Mitchell, Labour
The Lord Rees of Ludlow OM
The Baroness Rock, Conservative
The Baroness Sheehan, Liberal Democrat
The Baroness Walmsley, Liberal Democrat
The Baroness Warwick of Undercliff, Labour
The Lord Wei, Conservative
The Lord Winston, Labour

Current Inquiries

Nature-based solutions for climate change. Report published 27th January 2022. Government response, 21st April 2022.
Delivering a UK science and technology strategy. Report published 4th August 2022. Government response due since 25th October 2022.
People and skills in UK science, technology, engineering and mathematics. Opened 20th July 2022.
Clinical academics in the NHS. Opened 18th November 2022.

For further details: Tel: 020 7219 5750
Email: hlscience@parliament.uk ■

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY (POST)

A REVIEW OF 2022

As readers of SiP will know, the Parliamentary Office of Science and Technology (POST) works to bring the best available research evidence to bear on the legislative process and scrutiny of Government.

This has been an exciting year of POST, with a huge range of activities taken forward as the team returned to business as usual following the pandemic. This year we:

- published 35 major research synthesis briefings across the full range of sciences;
- provided advice to select committees over 150 times, for example about witnesses, technical aspects of inquiries and lines of questioning;
- arranged for ~40 PhD students to spend three months working in Parliament on research projects;
- conducted training for parliamentary staff on the use of social science methods for supporting select committee inquiries; and
- contributed to over 250 meetings, presentations and events to support the provision of research for Parliament.

The value that Parliament places on this work was demonstrated by the significant funding increase received by the POST this year. This has enabled the expansion of the team to include an additional social scientist, two knowledge exchange professionals and an information and librarianship expert.

A Chief Scientific Advisor Network for Parliament

In addition to our business as usual activities, POST is continuing to support innovation in Parliament.

One of our key schemes, Parliamentary Academic Fellowships, facilitates work on distinct projects to improve Parliament's access to academic research. These include: Dr Vicky Ward (St Andrews) and Dr Mark Monaghan (Loughborough), who have mapped parliamentary knowledge exchange mechanisms around the world and are working to identify best practice; Dr Nicky Buckley (Cambridge), who is supporting committees to develop Areas of Research Interest; Jonathan Breckon, who is developing methods for

researchers to generate rapid evidence syntheses for parliamentary audiences; and Rajiv Prabhakar, who is evaluating the Parliamentary Academic Fellowship Scheme to identify ways to improve it for academics and Parliament alike.

Our work with such academics, and the value they bring to Parliament, led us to pose a question – could there role for academics in Parliament similar to the role played by Chief Scientific Advisors in Government?

To help answer this, POST's Knowledge Exchange Unit has been collaborating with the Economic and Social Research Council to deliver an ambitious pilot in 2023. POST and ESRC has recruited three mid-career academics to take up positions as inaugural Thematic Research Leads. The three postholders (shown in photo) will each join new thematic policy hubs which will bring together staff from POST, the House of Commons Library and Select Committee teams, ensuring greater co-ordination and a better flow of research information through Parliament.

The Thematic Research Leads will strengthen links to the research community bringing topical, policy-focused research to the desks of MPs, Lords and those working in Parliament, ensuring a strong evidence base for debate and legislation.

Parliament's new Thematic Research Leads: Dr Kristen A. Harkness, Senior Lecturer and the Director of the Institute for the Study of War and Strategy in the School of International Relations at the University of St. Andrews; Dr Rick Whitaker, Associate Professor in Politics at the University of Leicester; and Dr Tamsin Edwards, Reader in Climate Change, King's College London.

Recent published work

POST research is published on our website. POSTnotes produced since September 2022 were:

- 687: Nuclear Energy in the UK
- 686: Diet-related Health Inequalities
- 685: Mental Health Act Reform – Children and Young People
- 684: States' use of Cyber Operations
- 683: Performance, Inclusion and Elite Sports – Transgender Athletes
- 682: Performance, Inclusion and Elite Sports – Athletes with Differences in Sex Development
- 681: Automation in Military Operations
- 680: Climate Change and Security
- 679: Climate Adaption for Nature
- 678: The Habitat Restoration Target

POSTbriefs are responsive policy briefings based on mini-literature reviews and peer reviews. Those produced since September 2022 were:

- 50: Genome edited animals
- 49: The impact of remote and hybrid work on workers and organisations
- 48: Restoration and creation of semi-natural habitats
- 47: Assisted dying
- 46: Geothermal energy

POST has also produced an online article on COVID-19 Immunity.

Ongoing and future projects approved by the POST Board

Over coming months, POST will work on a range of projects, including:

- Hormone Treatments for Children with Gender Dysphoria
- Low-carbon hydrogen use
- GB Plant biosecurity
- Biomass energy
- Long duration energy storage
- Urban Outdoor Air quality
- Electricity Market Reform
- Hypersonic missiles
- Digital Technology and the Future of Freight
- Online Advertising Technologies
- Invisible disabilities

THE POST BOARD

The POST Board oversees POST's objectives, outputs and future work programme. It meets quarterly.

Officers

Chair: Adam Afriyie MP
Vice-Chair: Professor the Lord Winston, FMedSci, FRSA, FRCP, FRCOG, FREng

House of Commons

Rt Hon Greg Clark MP
Katherine Fletcher MP
Stephen Metcalfe MP
Maria Miller MP
Carol Monaghan MP
Dr Ben Spencer MP
Alan Whitehead MP

House of Lords

Baroness Brown of Cambridge

Lord Haskel

Lord Ravensdale

Non-parliamentary

Professor Elizabeth Fisher, FMedSci

Paul Martynenko, FBCS

Professor Sir Bernard Silverman, FRS, FAcSS

Professor Dame Sarah Whatmore, FBA

Ex-officio

Oliver Bennett MBE, Head of the Parliamentary Office of Science and Technology

Grant Hill-Cawthorn, House of Commons Librarian and Managing Director of Research & Information

Ariella Huff, Select Committee Team, House of Commons

Xameerah Malik, Head of Science and Environment Section, House of Commons Library

Nicolas Besly, Clerk of Select Committees, House of Lords

Head of POST

Oliver Bennett MBE

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY

Houses of Parliament
Westminster
London SW1A 0AA

HOUSE OF COMMONS LIBRARY

The House of Commons Library is an impartial research and information service for Members of Parliament of all parties and their staff.

The Library provides confidential, impartial and bespoke briefing to Members of the House of Commons and their offices supporting the full range of parliamentary work, from policy development to constituency issues.

The Library also publishes a range of products including topical research briefings, shorter insight articles and briefings for non-legislative debates, all of which are available online for MPs and the public. These briefings include analysis of all major pieces of legislation. You can find publications on the Commons Library website (https://commonslibrary.parliament.uk) where you can also sign up for alerts.

The Science and Environment Section (SES) is one of eight teams in the Research Service in the House of Commons Library. In recent months they have published and updated briefings on issues including:

Self-Disconnection of pre-payment meters
Published 14 December 2022, CDP 2022/0237

A Commons Library debate pack published ahead of a debate nominated by the Backbench Business Committee on 15 December 2022. Contains background on the issues to be raised as well as recent Parliamentary material, news items and sources of help for those affected.

Sustainability of burning trees for energy generation in the UK
Published 2 December 2022, CDP 2022/0220

A Commons Library debate pack published ahead of a Westminster Hall debate nominated by the Backbench Business Committee on 6 December 2022. Contains background on bioenergy, its sustainability and policy on bioenergy as well as recent Parliamentary and news items.

Debate on Covid-19 vaccines and the Vaccine Damage Payment Scheme
Published 5 September 2022, CDP 2022/0154

A Commons Library debate pack published ahead of a Westminster Hall debate on 6 September 2022. This debate pack contains information about the vaccine damage payment scheme, including eligibility, responsibility for administering the scheme, and processing claims, as well as recent news and Parliamentary material.

Avian influenza
Published 29 November 2022, CBP 9688

In 2021-22, the UK has seen its worst ever outbreak of avian influenza or 'bird flu' spread rapidly through many species of wild birds and kept birds. The most serious type of avian influenza can cause sudden death in birds. Poultry flocks where disease is confirmed must be culled. This briefing explains the scale of the problem and Government policies to tackle it.

Animal Welfare (Kept Animals) Bill
Published 29 November 2022, CBP 9299

This briefing provides an overview of the proposed measures in the Animal Welfare (Kept Animals) Bill, along with background on the issues it aims to address.

Hunting Trophies (Import Prohibition) Bill 2022-23
Published 24 November 2022, CBP 9684

This briefing provides background on the Hunting Trophies (Import Prohibition) Bill, a Private Member's Bill introduced by Henry Smith MP. The Bill has Government support and will ban the import of hunting trophies from species of conservation concern.

Energy Prices Bill 2022-23
Published 14 October 2022, CBP 9642

This briefing provides analysis of the Energy Prices Bill which

includes provisions to reduce energy costs for consumers by capping energy bills and reducing wholesale electricity prices.

Post-Brexit fisheries management
Published 11 October 2022, CDP 2022/0166

A Commons Library debate pack published ahead of a Westminster Hall debate nominated by the Backbench Business Committee. This pack contains background on post-Brexit fisheries policy and challenges for the industry, as well as recent news and Parliamentary material.

The Smokefree 2030 ambition for England
Published 1 November 2022, CBP 9655

In 2019, the government set out an ambition for England to become "smokefree" by 2030 but the 2022 Khan review said England may miss this target. This briefing provides further information.

Huntington's disease
Published 8 November 2022, CDP 2022/0191

A Commons Library debate pack published ahead of a Westminster Hall debate on 9 November 2022. This pack contains background on Huntington's disease, its treatment and clinical research and NHS services connected with it, as well as recent Parliamentary and press material.

World Menopause Day
Published 26 October 2022, CDP 0180

A Commons Library debate pack published ahead of a debate on 27 October 2022. This pack contains background on policy, treatment and support during the menopause, as well as recent Parliamentary and press material.

Detection of poliovirus in London sewage samples
Published 7 September 2022, CBP 9618

Between February and June 2022, multiple vaccine-like-type-2 poliovirus isolates were collected from the London Beckton Sewage Treatment Works. This briefing paper sets out information about polio disease and the response of the UK Government and the UK Health Security Agency.

Government support for marine renewables
Published 5 December 2022, CDP 2022/0224

A Commons Library debate pack published ahead of a Westminster Hall debate on 7 December 2022. This pack gives background on the use of marine renewables in the UK and Government policy, incentives and support for their use as well as recent Parliamentary and news items.

COP27: The 2022 United Nations Climate Change Conference
Published 10 November 2022, CBP 9654

The United Nations Climate Change Conference (COP27) was held from 6 to 18 November 2022 in Sharm El Sheikh. This briefing covers the main themes of COP27 and some of the geo-political issues surrounding the build-up to the conference.

The National Food Strategy and food security
Published 21 October 2021, CDP 2022/0179

A Commons Library debate pack published ahead of a debate on 27 October 2022. This pack contains background on the National Food Strategy and food security issues, as well as recent Parliamentary and news items.

Energy costs in Wales
Published 6 October 2022, CBP 2022/0158

A Commons Library debate pack published ahead of a Westmister Hall debate on 11 October 2022. This briefing looks at the impacts of rising energy prices in Wales for homes, businesses and industries. It also includes recent Parliamentary and news material.

Q&A: Storm overflows discharge reduction plan
Published 6 October 2022, CBP 9617

This briefing paper provides background information and statistics on storm overflows, outlines the main elements in the plan and provides answers to some frequently asked questions on the subject.

Building broadband and mobile infrastructure
Published 7 December 2022, CBP 9156

This briefing paper explains the rules for building telecommunications infrastructure such as 5G mobile masts, including planning rules and the Electronic Communications Code.

Mobile and broadband: affordability and consumer protection
Published 28 November 2022, CBP 9245

This House of Commons Library briefing examines how the UK telecommunications market (broadband, mobile, and landline services) serves consumers and how it is regulated. It discusses recent concerns expressed on behalf of consumers in telecoms markets and looks at reforms aimed at improving customer fairness and protection.

Genetic Technology (Precision Breeding) Bill 2022-23
Published 15 November 2022, CBP 9557

A briefing on the Genetic Technology (Precision Breeding) Bill 2022-23

Powers and protections for trees and hedges in the community
Published 30 September 2022, CBP 8844

A briefing on powers to deal with issues caused by trees and hedges in the community and measures to protect them

Debate on supporting local food infrastructure
Published 6 September 2022, CDP 2022/0155

A Commons Library debate pack published ahead of a debate on 8 September 2022 nominated by the Backbench Business Committee. This pack includes information on local food systems, infrastructure and production and on procurement policy and food poverty, as well as recent relevant Parliamentary material.

Local consent for fracking
Published 10 November 2022, CDP 2022/0201

A Commons Library debate pack published ahead of a Westminster Hall debate nominated by the Backbench Business Committee on 15 November 2022. This pack contains background on the permission process for fracking, the fracking moratorium and local consent as well as recent Parliamentary and news items.

Green Belt
Published 7 October 2022, SN00934

This briefing examines Green Belt planning policy and some of the recent discussions around the Green Belt. It applies only to England.

Debate on an e-petition to include abortion rights in the Bill of Rights

Published 28 November 2022, CDP 2022/0203

A Commons Library debate pack with background on the petition, the law and commentary on abortion as well as recent Parliamentary and news items.

Early medical abortion at home during and after the pandemic

Published 30 November 2022, CBP 9496

This briefing looks at how access to early medical abortion has changed during the pandemic.

Coronavirus: Covid-19 booster vaccines frequently asked questions

Published 6 December 2022, CBP 9332

This Commons Library briefing addresses commonly asked questions about the roll-out of the Covid-19 booster vaccine.

The infected blood inquiry and compensation framework

Published 21 November 2022, CDP 2022/0212

A Commons Library debate pack published ahead of a Westminster Hall debate on 24 November 2022 nominated by the Backbench Business Committee. This debate pack provides further information on the Government's infected blood support schemes, the development of a framework for compensation and the interim compensation payments recently made to those infected, and to bereaved partners, currently registered on UK infected blood support schemes.

Air quality: policies, proposals and concerns

Published 6 September 2022, CBP 9600

A House of Commons Library Briefing Paper on air quality in the UK, including current law and policy, trends in air pollutants and information on the UK Government and devolved Governments' plans and ambitions to improve air quality.

Environmental impact of disposable vapes

Published 28 November 2022, CDP 2022/0216

A Commons Library debate pack published ahead of a Westminster Hall debate on 29 November 2022. This debate pack provides further information about the concerns about the environmental impact of disposable vapes, the regulations in place, along with various calls for change. A separate Commons Library briefing, The regulation of e-cigarettes, provides further information on the health and product safety aspects of vapes.

Permit variation processes for waste incineration facilities

Published 30 November 2022, CDP 2022/0223

A Commons Library debate pack published ahead of a Westminster Hall debate on 1 December 2021 nominated by the Backbench Business Committee. This pack contains background on incineration and issues around its regulation and the permission regime for it as well as recent Parliamentary and news items. ■

UK Research and Innovation

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Tel: 02073952280 | 07706000363
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Website: www.ukri.org

Big challenges demand big thinkers - those who can unlock the answers and further our understanding of the important issues of our time. Our work encompasses everything from the physical, biological and social sciences, to innovation, engineering, medicine, the environment and the cultural impact of the arts and humanities. In all of these areas, our role is to bring together the people who can innovate and change the world for the better. We work with the government to invest over £7 billion a year in research and innovation by partnering with academia and industry to make the impossible, possible. Through the UK's nine leading academic and industrial funding councils, we create knowledge with impact.

Arts and Humanities Research Council

Website: www.ahrc.ukri.org

AHRC funds outstanding original research across the whole range of the arts and humanities. This research provides economic, social and cultural benefits to the UK, and contributes to the culture and welfare of societies around the globe.

Biotechnology and Biological Sciences Research Council

Website: www.bbsrc.ukri.org

BBSRC invests in world-class bioscience research and training. This research is helping society to meet major challenges, including food security, green energy and healthier, longer lives and underpinning important UK economic sectors, such as farming, food, industrial biotechnology and pharmaceuticals.

Economic and Social Research Council

Website: www.esrc.ukri.org

ESRC is the UK's largest funder of research on the social and economic questions facing us today. This research shapes public policy and contributes to making the economy more competitive, as well as giving people a better understanding of 21st century society.

Engineering and Physical Sciences Research Council

Website: www.epsrc.ukri.org

EPSRC invests in world-leading research and postgraduate training across the engineering and physical sciences. This research builds the knowledge and skills base needed to address scientific and technological challenges and provides a platform for future UK prosperity by contributing to a healthy, connected, resilient, productive nation.

Innovate UK

Website: www.gov.uk/government/organisations/innovate-uk

Innovate UK drives productivity and economic growth by supporting businesses to develop and realise the potential of new ideas, including those from the UK's world-class research base. They connect businesses to the partners, customers and investors that can help them turn these ideas into commercially successful products and services, and business growth.

Medical Research Council

Website: www.mrc.ukri.org

MRC is at the forefront of scientific discovery to improve human health. Its scientists tackle some of the greatest health problems facing humanity in the 21st century, from the rising tide of chronic diseases associated with ageing to the threats posed by rapidly mutating micro-organisms.

Natural Environment Research Council

Website: www.nerc.ukri.org

NERC is the driving force of investment in environmental science. Its leading research, skills and infrastructure help solve major issues and bring benefits to the UK, such as affordable clean energy, air pollution, and resilience of our infrastructure.

Research England

Website: www.re.ukri.org

Research England creates and sustains the conditions for a healthy and dynamic research and knowledge exchange system in English universities. Working to understand their strategies, capabilities and capacity; supporting and challenging universities to create new knowledge, strengthen the economy, and enrich society.

Science and Technology Facilities Council

Website: www.stfc.ukri.org

STFC is a world-leading multi-disciplinary science organisation. Its research seeks to understand the Universe from the largest astronomical scales to the tiniest constituents of matter, and creates impact on a very tangible, human scale.

SCIENCE DIRECTORY

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AIRTO, the Association of Innovation, Research and Technology Organisations, comprises approximately sixty principal organisations operating in the UK's Innovation, Research and Technology (IRT) sector. The IRT sector has a combined turnover of £6.9Bn, employs over 57,000 people and contributes £34Bn to UK GVA. AIRTO's members work at the interface between academia and industry, for both private and public sector clients. Members include independent Research and Technology Organisations, Catapult Centres, Public Sector Research Establishments, National Laboratories, some university Technology Transfer Offices and some privately held innovation companies.

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Website: www.amps-tradeunion.com

We are a Trades Union for Management and Professional Staff working in the pharmaceutical, chemical and allied industries.

We have produced a training programme funded by the EU on diversity and helping women managers remain in the workplace after a career break. This training programme is aimed at both men and women and is intended to address the shortfall in qualified personnel in the chemical and allied industries.

We are experts in performance based and field related issues and are affiliated to our counterparts in EU Professional Management Unions.

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AWE plays a crucial role in our nation's defence by providing and maintaining warheads for the UK's nuclear deterrent and delivers advice and guidance on a 24/7 basis to UK government in the area of national security.

We are a centre of scientific, engineering and technological excellence, with some of the most advanced research, design and production facilities in the world. AWE is contracted to the Ministry of Defence (MOD) through a Government-owned-contractor-operated (GOCO) arrangement. While our sites and facilities remain in government ownership, their management, day-to-day operations and maintenance of Britain's nuclear stockpile is contracted to a private company: AWE Management Limited (AWE ML). AWE ML is a consortium comprising three partners: Jacobs Engineering Group, the Lockheed Martin Corporation and Serco Group plc.

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The Biochemical Society works to promote the molecular biosciences; facilitating the sharing of expertise, supporting the advancement of biochemistry and molecular biology and raising awareness of their importance in addressing societal grand challenges. We achieve our mission by :

- bringing together molecular bioscientists;
- supporting the next generation of biochemists;
- promoting and sharing knowledge and
- promoting the importance of our discipline.

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The British Ecological Society is an independent, authoritative learned society, and the voice of the UK's ecological community. Working with our members we gather and communicate the best available ecological evidence to inform decision making. We offer a source of unbiased, objective ecological knowledge, and promote an evidence-informed approach to finding the right solutions to environmental questions.

British In Vitro Diagnostics Association (BIVDA)

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BIVDA is the UK industry association representing companies who manufacture and/or distribute the diagnostics tests and equipment to diagnose, monitor and manage disease largely through the NHS pathology services. Increasingly diagnostics are used outside the laboratory in community settings and also to identify those patients who would benefit from specific drug treatment particularly for cancer.

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The British Pharmacological Society is a charity with a mission to promote and advance the whole spectrum of pharmacology. It is the primary UK learned society concerned with drugs and the way they work, and leads the way in the research and application of pharmacology around the world.

Founded in 1931, the Society champions pharmacology in all its forms, across academia, industry, regulatory agencies and the health service. With over 3,500 members from over 60 countries worldwide, the Society is a friendly and collaborative community. Enquiries about the discovery, development and application of drugs are welcome.

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BSAC is a learned society whose members are among the world's leading infectious disease physicians, pharmacists, microbiologists, and nurses.

With more than 45 years of leadership in antibiotic research and education, BSAC is dedicated to saving lives by fighting infection. It does this by supporting a global network of experts via workshops, conferences, evidence-based guidelines, e-learning courses, and its own high-impact international journal.

BSAC also provides national surveillance and susceptibility testing programmes, an outpatient parenteral antimicrobial therapy (OPAT) initiative, research and development grants, and the secretariat for the All-Party Parliamentary Group on Antibiotics.

BSAC has members in 40 nations and active learners in more than 135 countries.

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The British Society for Immunology's mission is to promote excellence in immunological research, scholarship and clinical practice in order to improve human and animal health. We are the leading UK membership organisation working with scientists and clinicians from academia and industry to forward immunology research and application around the world. Our friendly, accessible community of over 3,500 immunologists gives us a powerful voice to advocate for immunological science and health for the benefit of society.

SCIENCE DIRECTORY

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The British Society of Animal Science (BSAS), the principal body for animal science in the UK, was established in 1944. We work globally with members and partners to shape the future of animal science, supporting the advancement of responsible, environmentally and economically sustainable animal production, addressing issues such as the role of animal science in resolving the world's food crisis. BSAS disseminates research findings to ensure practical and beneficial application of positive outcomes to include livestock, animal health and welfare, the care of equine, companion, and zoo animals.

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The British Society of Soil Science (BSSS) was founded in 1947 and is an established international membership organisation and charity committed to the study of soil in its widest aspects. The society brings together those working within academia, practitioners implementing soil science in industry and all those working with, or with an interest in soils.

We promote research and education, both academically and in practice, and build collaborative partnerships to help safeguard our soil for the future. This includes hosting the World Congress of Soil Science 2022 in Glasgow, where those with an interest in soil science can meet to discuss the critical global issues relating to soil.

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Brunel University London is an international research active university with 3 leading research institutes:

Institute of Energy Futures: Led by Professor Savvas Tassou, the main themes of the Institute are *Advanced Engines and Biofuels, Energy Efficient and Sustainable Technologies, Smart Power Networks*, and *Resource Efficient Future Cities*.

Institute of Materials and Manufacturing: The main themes of research are *Design for Sustainable Manufacturing, Liquid Metal Engineering, Materials Characterisation and Processing, Micro-Nano Manufacturing*, and *Structural Integrity*. The Institute is led by Professor Luiz Wrobel.

Institute of Environment, Health and Societies: Professor Susan Jobling leads this pioneering research institute whose themes are *Health and Environment, Healthy Ageing, Health Economics Synthetic Biology, Biomedical Engineering and Healthcare Technologies*, and *Social Sciences and Health*.

Brunel University London offers a wide range of expertise and knowledge, and prides itself on having academic excellence at the core of its offer, and was ranked in the recent REF as 33rd in the UK for Research Power (average quality rating by number of submissions) and described by The Times Higher Education as one of the real winners of the REF 2014.

Cavendish Laboratory

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The Cavendish Laboratory houses the Department of Physics of the University of Cambridge.

The research programme covers the breadth of contemporary physics

Extreme Universe: Astrophysics, cosmology and high energy physics

Quantum Universe: Cold atoms, condensed matter theory, scientific computing, quantum matter and semiconductor physics

Materials Universe: Optoelectronics, nanophotonics, detector physics, thin film magnetism, surface physics and the Winton programme for the physics of sustainability

Biological Universe: Physics of medicine, biological systems and soft matter

The Laboratory has world-wide collaborations with other universities and industry

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Our vision is integrated design to improve life, wellbeing and performance through science, engineering, technology and psychology. The Institute is one of the largest in the world representing the discipline and profession of Human Factors and Ergonomics. We have sector groups in most industries from defence to aviation and pharmaceuticals that provide expert advice to industry and government. We accredit university courses and consultancy practices and work closely with allied learned societies.

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CTPA is the UK trade association representing manufacturers of cosmetic products and suppliers to the cosmetic products industry. 'Cosmetic products' are legally defined and subject to stringent EU safety laws. CTPA is the authoritative public voice of a vibrant and responsible UK industry trusted to act for the consumer; ensuring the science behind cosmetics is fully understood.

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We bring school students and their teachers

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Clifton Scientific Trust Ltd is registered charity in England and Wales 1086933

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The Council for the Mathematical Sciences is an authoritative and objective body that works to develop, influence and respond to UK policy issues affecting mathematical sciences in higher education and research, and therefore the UK economy and society by:

- providing expert advice;
- engaging with government, funding agencies and other decision makers;
- raising public awareness; and
- facilitating communication between the mathematical sciences community and other stakeholders

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The Francis Crick Institute is a biomedical research institute carrying out world-class discovery research to understand how living things work and to drive benefits for human health. Our discoveries will enhance our understanding of the fundamental processes of life, and have the potential to transform the prevention, diagnosis and treatment of human disease.

The Crick was formed in 2015, commencing full operations in 2017 in a brand new state-of-the-art building in central London which brings together more than 2,000 scientists, staff and students working collaboratively across disciplines.

SCIENCE DIRECTORY

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Founded in 1992 in memory of the UK's first female Professor of Physics, the Trust is the UK's leading charity dedicated to realising the potential of scientists and engineers returning to research after career breaks for family, caring and health reasons. Recently, we have expanded our remit to incorporate the social sciences and arts & humanities. Our Fellowship programme, working in partnership with universities, UKRI, charities, learned societies and industry, enables individuals to undertake part-time research in universities and research institutes. Fellowships comprise a research project alongside an individually tailored retraining programme, with additional mentoring and support, enabling recipients to re-establish their research credentials, update skills and redevelop confidence, in a suitably supportive environment.

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EngineeringUK is an independent organisation that promotes the vital role of engineers, engineering and technology in our society. EngineeringUK partners business and industry, Government and the wider science and technology community: producing evidence on the state of engineering; sharing knowledge within engineering, and inspiring young people to choose a career in engineering, matching employers' demand for skills.

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Fera provides expert analytical and professional services to governments, agrichemical companies, food retailers, manufacturers and farmers to facilitate safety, productivity and quality across the agrifood supply chain in a sustainable and environmentally compatible way.

Fera uses its world leading scientific expertise to provide robust evidence, rigorous analysis and professional advice to governments, international bodies and companies worldwide. Our food integrity, plant health, agri-tech and agri-informatics services ensure that our customers have access to leading edge science, technology and expertise.

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GAMBICA is the voice of the laboratory technology, instrumentation, control and automation industries, providing influence, knowledge and community. We offer members a common platform for voicing their opinions and representing their common interests to a range of stakeholders. GAMBICA seeks to spread best-practice and be thought leaders in our sectors.

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The Geological Society
serving science, profession & society

The Geological Society is the national learned and professional body for Earth sciences, with 12,000 Fellows (members) worldwide. The Fellowship encompasses those working in industry, academia and government, with a wide range of perspectives and views on policy-relevant science, and the Society is a leading communicator of this science to government bodies and other non-technical audiences.

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Advancing knowledge and setting standards in biomedical science

With over 20,000 members in 61 countries, the Institute of Biomedical Science (IBMS) is the leading professional body for scientists, support staff and students in the field of biomedical science.

Since 1912 we have been dedicated to the promotion, development and delivery of excellence in biomedical science within all aspects of healthcare, and to providing the highest standards of service to patients and the public.

By supporting our members in their practice, we set quality standards for the profession through training, education, assessments, examinations and continuous professional development.

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We are the UK's leading professional body for those involved in all aspects of food science and technology. We are an internationally respected independent membership body, supporting food professionals through knowledge sharing and professional recognition.

Our core aim is the advancement of food science and technology based on impartial science and knowledge sharing.

Our membership comprises individuals from a wide range of backgrounds, from students to experts, working across a wide range of disciplines within the sector.

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IKE is the UK's professional body for innovators. It accredits and certificates innovation practices. We influence the inter-relationship between education, business, and government through research and collaborative networks. Our Innovation Manifesto highlights our commitment to support the development of innovative people and organisations. IKE runs think-tanks, conducts research, develops new business models and tools and supports organisations to benchmark their innovation capabilities.

Institute of Marine Engineering, Science and Technology (IMarEST)

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Established in London in 1889, the IMarEST is a leading international membership body and learned society for marine professionals, with over 15,000 members worldwide. The IMarEST has an extensive marine network of 50 international branches, affiliations with major marine societies around the world, representation on the key marine technical committees and non-governmental status at the International Maritime Organization (IMO) as well as other intergovernmental organisations.

SCIENCE DIRECTORY

Institute of Measurement and Control

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The Institute of Measurement and Control is a professional engineering institution and learned society dedicated to the science and application of measurement and control technology for the public benefit. The InstMC has a comprehensive range of membership grades for individuals engaged in both technical and non-technical occupations. Also, it is licensed by the Engineering Council to assess and register individuals as Chartered Engineers (CEng), Incorporated Engineers (IEng) and Engineering Technicians (EngTech).

The InstMC works to develop the knowledge and skills of individual engineers, fostering communication and advancing the science and practices within the industry.

IOP Institute of Physics

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The Institute of Physics (IOP) is the professional body and learned society for physics in the UK and Ireland. The IOP's mission is to raise public awareness and understanding of physics, inspire people to develop their knowledge, understanding and enjoyment of physics and support the development of a diverse and inclusive physics community. As a charity, the IOP seeks to ensure that physics delivers on its exceptional potential to benefit society.

IPEM

Institute of Physics and Engineering in Medicine

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IPEM is a registered, incorporated charity committed to our Mission of Improving Health through Physics and Engineering in Medicine. Our vision is one in which professionalism drives improvements in diagnosis, treatment and care, transforming the lives of patients. Our members, the professional community of medical physicists, biomedical engineers and clinical technologists working in hospitals, academia and industry around the world are the people who deliver our mission and vision. We work to support them through professional development, community and leadership initiatives, including training and CPD, events, campaigns, publications and scientific meetings. IPEM is licensed by the Science Council to award CSci, RSci and RSciTech, and by the Engineering Council to award CEng, IEng and EngTech.

IChemE ADVANCING CHEMICAL ENGINEERING WORLDWIDE

The Institution of Chemical Engineers

The Institution of Chemical Engineers (IChemE) advances chemical engineering's contribution worldwide for the benefit of society. We support the development of chemical engineering professionals and provide connections to a powerful network of around 35,000 members in 100 countries.

We support our members in applying their expertise and experience to make an influential contribution to solving major global challenges, and are the only organisation to award Chartered Chemical Engineer status and Professional Process Safety Engineer registration.

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Kuala Lumpur | London | Melbourne | Rugby | Singapore | Wellington

IET The Institution of Engineering and Technology

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The IET is a world leading professional organisation, sharing and advancing knowledge to promote science, engineering and technology across the world. Dating back to 1871, the IET has over 163,000 members in 127 countries with offices in Europe, North America, and Asia-Pacific.

LGC

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LGC is a global leader in the life sciences tools sector, including human healthcare and applied markets (food, agbio and the environment). LGC provides a comprehensive range of measurement tools, proficiency testing schemes, supply chain assurance standards and specialty genomics tools (oligos, PCR tools, NGS reagents), underpinned by leading analytical and measurement science capabilities. Under the Government Chemist function, LGC fulfils specific statutory duties as the referee analyst and provides advice for Government and the wider analytical community on the implications of analytical measurement for matters of policy, standards and regulation. LGC is also the UK's National Measurement Laboratory for chemical and bio-measurement.

With headquarters in Teddington, South West London, LGC has laboratories and sites across Europe, the US, China, Brazil, India, and South Africa.

L'ORÉAL UK AND IRELAND

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L'Oréal employs more than 3,800 researchers world-wide and dedicates over €877 million each year to research and innovation in the field of healthy skin and hair. The company supports women in science research through the L'Oréal UNESCO For Women In Science Programme and engages young people with science through the L'Oréal Young Scientist Centre at the Royal Institution. L'Oréal also collaborates with a vast number of institutions in the UK and globally.

The LINNEAN SOCIETY of London

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As the world's oldest active biological society, the Linnean Society is an essential forum and meeting point for those interested in the natural world. The Society holds regular public lectures and events, publishes three peer-reviewed journals, and promotes the study of the natural world with several educational initiatives. The Society is home to a world famous library and collection of natural history specimens. The Society's Fellows have a considerable range of biological expertise that can be harnessed to inform and advise on scientific and public policy issues.

A Forum for Natural History

Marine Biological Association

THE MARINE BIOLOGICAL ASSOCIATION Est. 1884 Incorporated by Royal Charter 2013

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Since 1884 the Marine Biological Association has been delivering its mission *'to promote scientific research into all aspects of life in the sea, including the environment on which it depends, and to disseminate to the public the knowledge gained.'* The MBA represents its members in providing a clear independent voice to government on behalf of the marine biological community. It also has an extensive research programme and a long history as an expert provider of advice for the benefit of policy makers and wider society.

SCIENCE DIRECTORY

Institution of MECHANICAL ENGINEERS

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The Institution provides politicians and civil servants with information, expertise and advice on a diverse range of subjects, focusing on manufacturing, energy, environment, transport and education policy. We regularly publish policy statements and host political briefings and policy events to establish a working relationship between the engineering profession and parliament.

Met Office

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The Met Office doesn't just forecast the weather on television. Our forecasts and warnings protect UK communities and infrastructure from severe weather and environmental hazards every day – they save lives and money. Our Climate Programme delivers evidence to underpin Government policy through the Met Office Hadley Centre. Our Mobile Meteorological Unit supports the Armed Forces around the world. We build capacity overseas in support of international development. All of this built on world-class environmental science.

MICROBIOLOGY SOCIETY

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The Microbiology Society is a membership charity for scientists interested in microbes, their effects and their practical uses. It is one of the largest microbiology societies in Europe with a worldwide membership based in universities, industry, hospitals, research institutes and schools.

Our principal goal is to develop, expand and strengthen the networks available to our members so that they can generate new knowledge about microbes and ensure that it is shared with other communities. The impacts from this will drive us towards a world in which the science of microbiology provides maximum benefit to society.

NPL National Physical Laboratory

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The National Physical Laboratory (NPL) is the United Kingdom's national measurement institute, an internationally respected and independent centre of excellence in research, development and knowledge transfer in measurement and materials science. For more than a century, NPL has developed and maintained the nation's primary measurement standards - the heart of an infrastructure designed to ensure accuracy, consistency and innovation in physical measurement.

NATURAL HISTORY MUSEUM
Advancing the science of nature

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We challenge the way people think about the natural world – its past, present and future

We use our unique collection and unrivalled expertise to tackle the biggest challenges facing the world today.

We are leaders in the scientific understanding of the origin of our planet, life on it and can predict the impact of future change.

We study the diversity of life and the delicate balance of ecosystems to ensure the survival of our planet.

We help enable food security, eradicate disease and manage resource scarcity.

We inspire people to engage with science to solve major societal challenges.

University of Northampton

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The University of Northampton is an institution committed to science education through initial teacher training, a STEM Ambassador network which works within the community and teaching and research to doctoral level. We are an Ashoka U 'Changemaker Campus' status university recognising our commitment to social innovation and entrepreneurship.

The University of Nottingham
UNITED KINGDOM • CHINA • MALAYSIA

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With 43,000 students and campuses in Nottingham, China and Malaysia, The University of Nottingham is 'the nearest Britain has to a truly global university'. With more than 97 per cent of research at the University recognised internationally according to the Research Excellence Framework 2014, the University is ranked in the top 1% of the world's universities by the QS World University Rankings.

THE NUTRITION SOCIETY
Advancing Nutritional Science

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The Nutrition Society is a not for profit, membership organisation which is dedicated to delivering its mission of advancing the scientific study of nutrition and its application to the maintenance of human and animal health. Highly regarded by the scientific community, the Society is one of the largest learned societies for nutrition in the world and anyone with a genuine interest in the science of human or animal nutrition can become a member.

The Physiological Society

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As the largest network of physiologists in Europe, with academic journals of global reach, we continue our 140-year tradition of being at the forefront of the life sciences.

We bring together scientists from over 60 countries, and our Members have included numerous Nobel Prize winners from Ivan Pavlov to John O'Keefe.

SCIENCE DIRECTORY

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Prospect is an independent, thriving and forward-looking trade union with over 120,000 members across the private and public sectors and a diverse range of occupations. We represent scientists, technologists and other professions in the civil service, research councils and private sector.

Prospect's collective voice champions the interests of the engineering and scientific community to key opinion-formers and policy makers. With negotiating rights with over 300 employers, we seek to secure a better life at work by putting members' pay, conditions and careers first.

QUADRAM INSTITUTE

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The £75m Quadram Institute opened in 2019 and is focused on fundamental and translational research into the interfaces between the gut microbiome, food, and human health. The Quadram Institute combines leading-edge bioscience capabilities with NHS endoscopy, clinical trials and biobank facilities. The Quadram Institute is a partnership between the Norfolk and Norwich University Hospital, University of East Anglia, Quadram Institute Bioscience and BBSRC.

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As the UK's national academy for engineering, we bring together the most successful and talented engineers for a shared purpose: to advance and promote excellence in engineering. We have four strategic challenges: drive faster and more balanced economic growth; foster better education and skills; lead the profession; and promote engineering at the heart of society.

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RBG Kew is a centre of global scientific expertise in plant and fungal diversity, conservation, and sustainable use, housed in two world-class gardens. Our scientific vision is to document and understand global plant and fungal diversity and its uses, bringing authoritative expertise to bear on the critical challenges facing humanity today.

Kew's strategic priorities for science are:

1. To document and conduct research into global plant and fungal diversity and its uses for humanity.
2. To curate and provide data-rich evidence from Kew's unrivalled collections as a global asset for scientific research.
3. To disseminate our scientific knowledge of plants and fungi, maximising its impact in science, education, conservation policy and management.

These priorities enable us to curate, use, enhance, explore and share Kew's global resource, providing robust data and a strong evidence base for our UK and global stakeholders. Kew is a non-departmental government body with exempt charitable status, partially funded by Defra.

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The Royal Society is the academy of science in the UK and the Commonwealth comprising 1400 outstanding individuals representing the sciences, engineering and medicine. The Society has played a part in some of the most fundamental, significant and life-changing discoveries in scientific history and Royal Society scientists continue to make outstanding contributions to science across the wide breadth of research areas. Through its Fellowship and permanent staff, it seeks to ensure that its contribution to shaping the future of science in the UK and beyond has a deep and enduring impact, supporting excellence in science and encouraging the development and use of science for the benefit of humanity.

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The Royal Society of Biology is a single unified voice, representing a diverse membership of individuals, learned societies and other organisations. We are committed to ensuring that we provide Government and other policy makers – including funders of biological education and research – with a distinct point of access to authoritative, independent, and evidence-based opinion, representative of the widest range of bioscience disciplines. Our vision is of a world that understands the true value of biology and how it can contribute to improving life for all.

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The Royal Society of Chemistry is the world's leading chemistry community, advancing excellence in the chemical sciences. With over 50,000 members and a knowledge business that spans the globe, we are the UK's professional body for chemical scientists; a not-for-profit organisation with 170 years of history and an international vision of the future. We promote, support and celebrate chemistry. We work to shape the future of the chemical sciences – for the benefit of science and humanity.

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*Sf*AM utilises the expertise of its international membership to advance, for the benefit of the public, the application of microbiology to the environment, human and animal health, agriculture, and industry. Our values include equality, diversity and inclusivity; collaboration to amplify impact; scientific integrity; evidence-based decision-making and political neutrality. With Wiley-Blackwell, *Sf*AM publishes five internationally acclaimed journals.

Society for Underwater Technology

Society for Underwater Technology
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The SUT is a multidisciplinary learned society that brings together individuals and organisations with a common interest in underwater technology, ocean science, and offshore/subsea engineering. The society was founded in 1966 and has members from over 40 countries, including engineers, scientists, other professionals and students working in these areas.

SCIENCE DIRECTORY

Society of Chemical Industry

SCI: where science meets business

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Established by Royal Charter in 1881, SCI is a unique multi-disciplinary community. Set up by a prominent group of forward thinking scientists, inventors and entrepreneurs, SCI continues to be a multi-science and industry network based around chemistry and related sciences. Our charitable objective is to promote links between science and industry for the benefit of society. Our passion is invention and creation.

We deliver our charitable objective by:

- Supporting the commercial application of science into industry
- Tackling global challenges across Agrifood, Energy, Environment, Health and Materials

Society of Cosmetic Scientists

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Advancing the science of cosmetics is the primary objective of the SCS. Cosmetic science covers a wide range of disciplines from organic and physical chemistry to biology and photo-biology, dermatology, microbiology, physical sciences and psychology.

Members are scientists and the SCS helps them progress their careers and the science of cosmetics ethically and responsibly. Services include publications, educational courses and scientific meetings.

SMI
Society of Maritime Industries · UK

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The Society of Maritime Industries (SMI) is the voice and champion of the UK maritime engineering, marine science & technology and business service sectors.

THE SOCIETY FOR RADIOLOGICAL PROTECTION

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The Society for Radiological Protection is the principal independent professional body for radiation protection in the UK. Its members operate in the fields of medicine, the nuclear power cycle and other industries, research, and teaching. We offer a profession-wide view to regulators and are involved in training and educational outreach. We ensure that professional standards are maintained at the highest levels.

UK INNOVATION & SCIENCE SEED FUND

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The **UK Innovation & Science Seed Fund** is a leading patient capital investor with more than £330 million private investment leveraged to date. The Fund works to build technology companies from the earliest stage by working closely with its partners led by STFC, BBSRC, NERC and Dstl, with the National Research and Innovation Campuses they support, and with entrepreneurial science-led teams. UK Innovation & Science Seed Fund is also closely aligned with the Catapults and InnovateUK, helping to commercialise key technological advances in industrial biotech, agricultural technology, healthcare, medicine, clean energy, materials, artificial intelligence, software and space.

Understanding ANIMAL RESEARCH

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Understanding Animal Research is a not-for-profit organisation that explains why animals are used in medical, veterinary, environmental and other scientific research. We aim to achieve a broad understanding of the humane use of animals in medical, veterinary, scientific and environmental research in the UK. We work closely with policymakers to ensure regulation is effective and are a trusted source of information for the national and international media. We are funded by our members who include universities, professional societies, trade unions, industry and charities.

University of Essex

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Established in 1964, the University of Essex is ranked as one of the Top 20 universities in the Research Excellence Framework and is awarded Gold in the Teaching Excellence Framework. It is home to world-leading expertise in analytics and data science, with research peaks spanning the social sciences, sciences, and humanities. Pioneers of quantitative methods and artificial intelligence techniques, Essex is also in the UK top 10 for Knowledge Transfer Partnerships, and works with businesses to embed innovation into operations, through KTPs, knowledge exchange and contract research.

Universities Federation for Animal Welfare

UFAW Established 1926

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Website: www.ufaw.org.uk
Registered in England Charity No: 207996

UFAW, the international animal welfare science society, is an independent scientific and educational charity. It works to improve animal lives by:

- supporting animal welfare research
- educating and raising awareness of welfare issues in the UK and overseas
- producing the quarterly scientific journal Animal Welfare and other high-quality publications on animal care and welfare
- providing advice to government departments and other concerned bodies.

The Welding Institute

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The Welding Institute is the leading institution providing engineering solutions and knowledge transfer in all aspects of manufacturing, fabrication and whole-life integrity management.

Industrial membership provides access to innovative problem-solving from one of the world's foremost independent research and technology organisations.

Non-Corporate services include membership and registration, education, training and certification for internationally recognised professional development and personnel competence assurance.

TWI provides Members and stakeholders with authoritative and impartial expert advice, knowhow and safety assurance through engineering, materials and joining technologies.

SCIENCE DIARY

PARLIAMENTARY AND SCIENTIFIC COMMITTEE – ALL-PARTY PARLIAMENTARY GROUP

Email: office@scienceinparliament.org.uk
www.scienceinparliament.org.uk
follow us on Twitter @ParlSciCom

FORTHCOMING DISCUSSION AND OTHER MEETINGS

Tuesday 7th February
Discussion Meeting on Digital Skills
In partnership with the Institute of Engineering and Technology
5.30pm to 7.00pm, Palace of Westminster

Tuesday 21st February
Discussion Meeting on Synthetic Biology: The opportunity for the UK to be a leader in synbio for human health
In partnership with bit.bio
5.30pm to 7.00pm, Palace of Westminster

Monday 6th March
STEM for BRITAIN
Attlee Suite, Portcullis House, House of Commons
12 Noon to 6.00pm

Tuesday 7th March
Annual General Meeting
Palace of Westminster

Monday 24th April
Discussion Meeting on Measurement of Time
In partnership with the National Physical Laboratory
5.30pm to 7.00pm, ONLINE meeting

ROYAL SOCIETY OF BIOLOGY

For further details please contact
Karen Patel: events@rsb.org

ROYAL SOCIETY OF CHEMISTRY

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ROYAL SOCIETY

Details of all events can be found on the events calendar at events@royalsociety.org
For scientific meetings queries:
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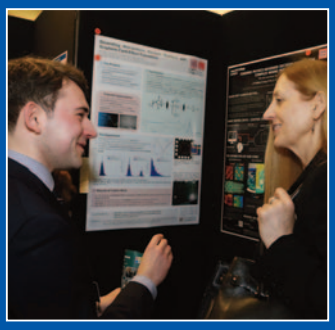
The Parliamentary & Scientific Committee's STEM for BRITAIN 2023 takes place on Monday 6th March, in the Attlee Suite, Portcullis House, House of Commons, during British Science Week



Applications from early-career research scientists, engineers, technologists and mathematicians who wish to exhibit posters closed on 2nd December. The categories are as follows:

- Biological and Biomedical Sciences
- Chemistry
- Engineering
- Mathematics
- Physics

A wide range of important scientific, engineering and mathematics institutions and organisations are lending their support to this event, including the Institute of Physics, The Physiological Society, the Nutrition Society, the Royal Society of Chemistry, the Royal Academy of Engineering, the Council for the Mathematical Sciences, the Royal Society of Biology, Dyson Ltd, Warwick Manufacturing Group, AWE, the Institute of Biomedical Science, the Clay Mathematics Institute, British In Vitro Diagnostics Association, the Heilbronn Institute, United Kingdom Research and Innovation, the Biochemical Society, and the Society of Chemical Industry.

This reflects the importance we all attach to the encouragement of researchers at this stage in their careers.

Prizes will be awarded for the posters presented in each discipline which best communicates high level science, engineering or mathematics to a lay audience.

The Westminster Medal, sponsored by SCI will be awarded at a separate event in Parliament in memory of the late Dr Eric Wharton, who did so much to establish SET for Britain as a regular event in the Parliamentary calendar.

For further information, please go to www.stemforbritain.org.uk

Finalists will be invited to display their posters on the website two weeks before the event.