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SPRING 2024

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

A MANIFESTO
COMMERCIALISING GREAT SCIENCE IN THE UK

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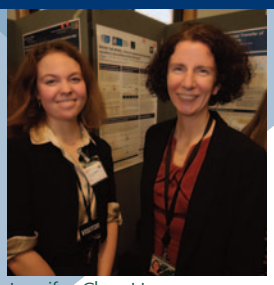
STEM FOR BRITAIN 2024 PHOTO GALLERY

BIOLOGICAL AND BIOMEDICAL SCIENCES



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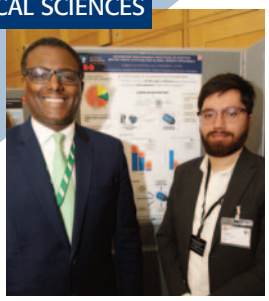

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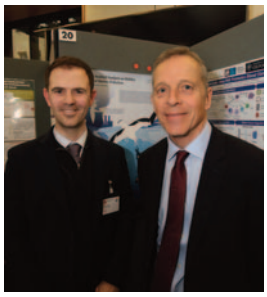

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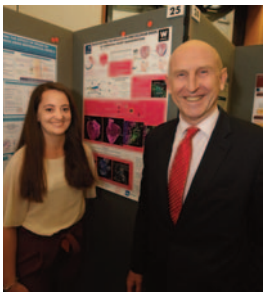
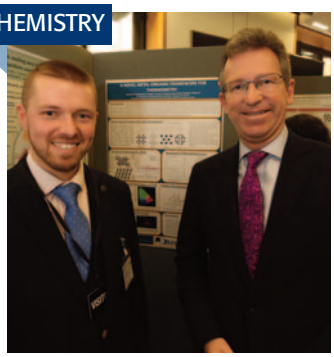


Chloe Tubman University of Oxford) and John Healey MP

Dr Luke Evans MP and Elpida Vounzoulaki (University of Leicester)

CHEMISTRY



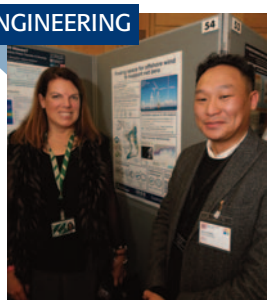
Tom Chamberlain (University of Warwick) and Sir Jeremy Wright MP

Vichawan Sakulsupich (University of Cambridge) and Daniel Zeichner MP

Jonathan Ashworth MP and Patricia Rodriguez Macia (University of Leicester)

Michael Rumbelow (University of Bristol) and Thangam Debbonaire MP

ENGINEERING



Caroline Nokes MP and Hugo Putuhena (University of Southampton)

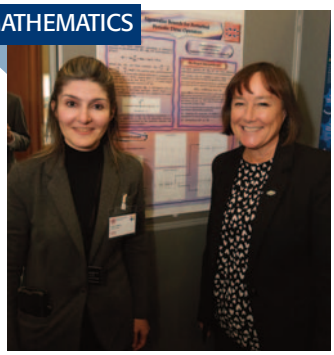
Nicholas Wilson (University of Hull) and Sir David Davis MP

Lord Robert Mair and Lauren Miller (Durham University)

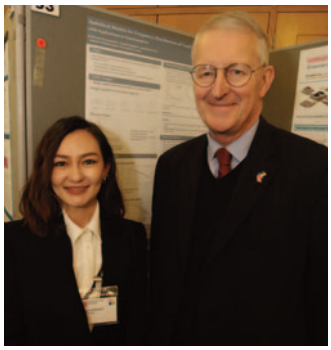
Alison Thewliss MP and Muhammad Iqbal (University of Strathclyde)

Disni Gamaralalage (University of Nottingham) and Lilian Greenwood MP

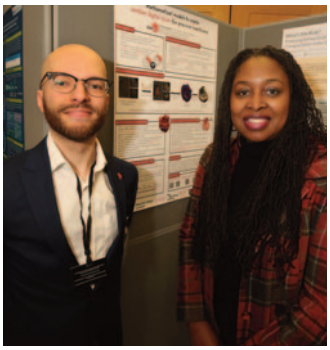
MATHEMATICS



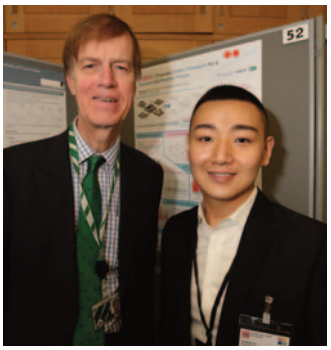
Ghada Shuker (Cardiff University) and Jo Stevens MP



Ruheyan Nuermaimaiti (University of Leeds) and Hilary Benn MP

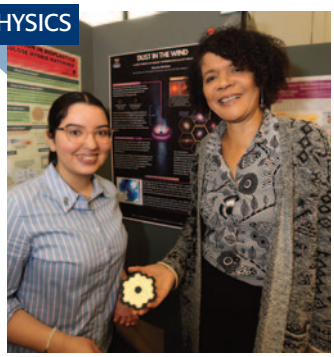


Christobal Rodero (Imperial College London) and Dawn Butler MP

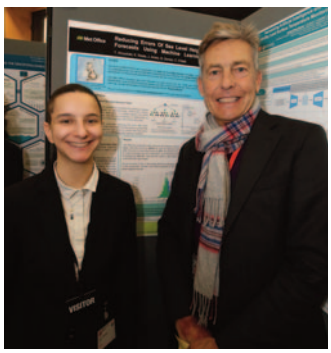


Sir Stephen Timms MP and Songwei Liu (Queen Mary University London)

PHYSICS



Houda Haidar (Newcastle University) and Chi Onwurah MP



Theano Xirouchaki (Met Office) and Sir Ben Bradshaw MP

Hilary Benn MP and James King (Bragg Institute)

Eloise Matthews (University of Cambridge) and Daniel Zeichner MP

Credit: John Deehan Photography

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

Welcome to the Spring journal.

In addition to our usual features, we have 13 excellent articles brought to you by 20 distinguished contributors.

My thanks to them all.

It was a pleasure to host STEM for BRITAIN, our annual competition for Early Career Researchers on 4th March.

My congratulations to the winners and all those who exhibited a poster, and thanks to all involved in organising this P&SC flagship event, not least Dr Isabel Spence, together with the five judging panels. I am also grateful to the core Learned Societies and sponsors, without whose support the day would not have been possible.

Following online presentations from the five Gold medalists, the winner of the Westminster Medal will be announced on 15th April in the Palace of Westminster.

The Programme Committee, chaired by Carol Monaghan MP, supported by Karen Smith and Leigh Jeffes has themed meetings planned until the end of the year. My thanks to our partnering organisations and speakers, including those who presented at the January and February discussion meetings, sponsored by IMechE and Imperial College London respectively.

In February I was delighted to be appointed by the Prime Minister as Government Trade Envoy to Dominican Republic, Panama and Costa Rica.

Trade Envoys support the UK economy by supporting British businesses to take advantage of the opportunities arising from the UK's global trade agenda. They champion Global Britain and promote the UK as a destination of choice for inward investment across all regions of the UK, helping to level up the country.

The Parliamentary & Scientific Committee was pleased to co-host, on the 11th March, an important reception in the House of Commons with STOPAIDS on British health R&D: Innovation that delivers global impact to reach the SDGs by 2030. This was attended by our President, Viscount Stansgate.

On the following day, P&SC participated in the Maths Summit at the Science Museum, when Deputy Chair Chi Onwurah MP represented the Committee as one of the speakers.

I was pleased to take part in the annual Voice of the Future event, organised by the Royal Society of Biology on the 14th March, and be quizzed on science policy, along with Carol Monaghan MP and other Parliamentary colleagues, by a panel of early career scientists drawn from 20 STEM organisations.

Carol and I also attended the Royal Society Pairing Scheme event on the 20th March.

On 21st March I was delighted to meet Space Sector organisations at a Space APPG drop-in session organised by the ADS Group UK, which was supported by UK Space.

I look forward to seeing P&SC members at the Annual General Meeting on Monday 15th April, which precedes the awarding of the Westminster Medal and a discussion meeting kindly sponsored by the Society of Chemical Industry.

I would also encourage as many Parliamentarians as possible to attend the AGM, as under new APPG rules, eight are required to be present in order to constitute a quorum.

Finally, I should like to welcome two new Parliamentary members to P&SC: Lord Lucas and Lord Northbrook, together with the British Specialist Nutrition Association as a scientific and technological member.

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.

CONTENTS

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

PARLIAMENT RALLIES TO GIVE BRITAIN ITS SCIENCE SUPERPOWER BACK

Sharon Todd, CEO of SCI

SCI is a global industrial innovation hub based in London. Formed as the Society of Chemical Industry by Royal Charter in 1881, it connects industry, academia and government to accelerate science out of the laboratory for the benefit of society.

Today, the SCI community is working on the big societal challenges - from developing new forms of low carbon energy and new medicines to advancing the production of healthy and sustainable foods.

In recent months, Parliament has rallied to the calls from SCI to put in place a bold and ambitious plan to drive economic and societal growth for the UK from the strong science base that we have in place.

Recognising that a comprehensive industrial strategy is needed to achieve the Prime Minister's ambition for Britain to be a Science Superpower once more, the call has been taken up by politicians and peers in both Houses. Many have recognised science and innovation as key to the UK's economic growth and manufacturing security.

Science and innovation-based business in the UK will help us to secure food supplies for our families, respond to new diseases and enable us to live a sustainable future. It is vital that this new emerging business develops in Britain, for both our security and our economy.

THE CALL FOR ACTION

The UK's economy has not performed well over the long term, showing a 1.5% average growth in GDP versus a global average of 3.6% over the last 20 years[1]. Key metrics, such as pharmaceutical exports, inward investment and start-ups scaling up are all heading in the wrong direction.

Other countries are taking action, investing heavily in driving inward investment and putting in packages to support growth.

CASE STUDY: US Inflation Reduction Act

The US has created $500bn in tax breaks and spending for clean energy to reduce healthcare costs. R&D will be boosted beyond measure, commercialising state-of-the-art technologies including carbon capture & storage and clean hydrogen.

CASE STUDY: EU Green Deal

The EU is mitigating the competitive threat with its industrial plan worth c. $270bn.

Action is needed to really drive economic and societal value from the UK's incredible science base and we need this to be bold rather than incremental.

There has been a chronic shortage of investment by and for UK companies in the last 20 years. Meanwhile, the rest of the World's economies are forging ahead, developing new medicines, clean tech products and services, and food production techniques.

If we do not act by the start of the next Parliament, it will be too late for the UK to catch up. The UK will lose out on the investment in high quality jobs and regional economies which the science sector has historical brought.

PARLIAMENTARIANS TAKE ACTION

At the end of 2023 the Business and Trade Committee made a call for written evidence as it launched a programme of work to scrutinise the UK Government's approach to industrial policy. The Committee is examining how industrial policy can be used to build on the UK's strengths and competitive advantages, enhance economic security and help the UK reach net-zero by 2050.

In submitting evidence, SCI set out some of the structural weaknesses that the UK is dealing with and how SCI's Manifesto for a Science and Innovation Strategy provides a roadmap for taking the UK back to the leadership position it deserves to be in. We highlighted the UK's great academic research, with 17 of the top 100 universities in the world located in the UK. Despite this great foundation the UK has fallen behind its international competitors in turning that great science base into value, according to research by LEK Consulting commissioned by SCI in 2023.

On the 1st February 2024 a motion brought to the House of Lords by Lord Watson of Wyre Forest debated the case for a 'comprehensive industrial strategy for the United Kingdom.'

'I do not think that we are doing enough to make a decisive difference to the UK's economic prospects, given our sluggish growth, flatlining wages, regional disparities and chronic under investment ... A lack of a proper planned industrial strategy is the UK's Achilles heel,' said Lord Watson of Wyre Forest, opening up the debate.

As a nation we are quite rightly aligned with the leading global players, but commenting on green investment, Earl Russell remarked during the debate: 'The UK is near the bottom of the table in the G7 for investment and the outlook is bleak.'

WE DON'T NEED A 'COUNCIL OF PERFECTION'

The various statistics and data can be debated and argued, but the consistent call is that investment and growth in the UK is not what it should be. This Government and the next Government need to act urgently to implement a comprehensive industrial strategy - with an express focus on growing the economy, driving investment and creating jobs.

The SCI Manifesto, launched in August 2023, was endorsed by three former business secretaries: the Rt Hon the Lord Mandelson, the Rt Hon Sir Vince Cable and the Rt Hon Greg Clark MP. The three were called to give oral evidence on industrial policy at a meeting convened by the House of Commons Business and Trade Committee in February. All three former ministers from across parties were in agreement that an industrial strategy is needed if the UK is to keep up with its economic partners and this should have cross party support to ensure consistency and longevity, something that is critical to underpin industrial investment.

'I would recommend to whoever is Government after the next election that there should be a serious attempt to embed a long-term approach to industrial strategy. It almost does not matter whether you have precisely the right policies,' said Clark. 'If you get eight out of ten right, that is better than a council of perfection that says we cannot have anything unless it is absolutely perfect.' Clark added.

The UK has a deserved reputation for science and for creating spin-out businesses from universities. However, once life science start-up businesses grow to the point of listing on national stock exchanges, all but a handful choose to list in the United States. We need an environment which reverses this so that the UK can reap the many benefits from our brilliant start-ups.

It is in this spirit that SCI's Manifesto sets out four key areas of policy interventions that together would ensure the UK could compete on a more level footing. Most recently, SCI has set out three targets for the UK which may not represent a perfect industrial future but provide a guide that whichever

FTSE 100

Not one top ten FTSE100 company built new manufacturing plant in the UK between 2003 and 2023.

AstraZeneca

The UK-based pharmaceuticals giant chose to invest $360bn in new manufacturing facilities in Ireland in 2023.

UNICORNS

Only 2 of the 10 life science unicorns to list between 2012-2021 listed in the UK.

party is leading this country can get behind. One of those targets is to see five home grown science unicorns (start-up companies valued at over $1 billion) list on the UK Stock Exchange by 2030.

SPRING BUDGET IS STEP IN THE RIGHT DIRECTION

Several inventions have already been welcomed, such as full expensing for business, the ongoing commitment to a strong R&D tax credits scheme, the recent Mansion House Reforms on pension fund investment and the new LIFTS funding scheme announced by the British Business Bank.

The announcement in the Spring Budget of £92 million worth of investment to help encourage innovation and support jobs in life science is also step in the right direction. AstraZeneca's plans to invest £650 million in the UK to boost research, development and manufacturing of vaccines at its sites in Liverpool and Cambridge was encouraging. The comment from Sir Pascal Soriot, AstraZeneca CEO, that the investment demonstrated an 'ongoing confidence in UK life sciences,' is reassuring and demonstrates progress.

However, measures to support business and innovation from Government have been largely piecemeal, short-term and inconsistent. Major investments in the UK by science-based companies, such as that announced by AstraZeneca, should not be unusual or unexpected.

The global markets across life sciences and clean tech alone amount to over $3 trillion and they are growing rapidly, spurred on by scientific inventions, yet the UK is capturing very small shares of this growth. From 1998 to the end of 2022, the UK has created 157 unicorns[2]. Life sciences spin-outs accounted for only 10 of these.

AMBITION AND BOLD MOVES ARE NEEDED

SCI believes that with the right backing it is possible to see five new life science unicorns listing in the UK by 2030. Our great universities are likely to be one of the main conduits for these new companies, as 19 of the UK's current 157 unicorns are university spin-outs. We want to see more of those innovative businesses born in the UK list in the UK. We are missing great opportunities to create value, jobs and real economic growth.

Getting the environment right for growth is an imperative. Revised R&D data confirms that the UK has a strong innovation base. The Government has already acknowledged that while many UK companies are at the forefront of innovation, the development and commercialisation of that innovation is lacking. We need to move on from talking about R&D (research and development) to D&C (development and commercialisation).

INVEST FOR THE LONG-TERM

SCI would like to see more focus on promoting skills and knowledge transfer in innovation growth areas. Indeed two of the 10 actions in the Government's Science and Technology Framework released in March 2023 centred on 'boosting private and public investment in research and development for economic growth and better productivity' and 'ensuring researchers have access to the best physical and digital infrastructure for R&D that attracts talent, investment and discoveries.'

There is also an argument to be made for taking the investment in R&D beyond the 3% of GDP already achieved. R&D expenditure should be used to promote levelling up, equality and societal welfare. There are some big global challenges, not least climate change and progress towards sustainability.

The Government is taking some steps in support of market led investment in R&D, as set out in the Government's Advanced Manufacturing Plan published in November 2023. A UK Battery Strategy document also outlines the need to provide funding for later stage product development and marketing to protect the UK's supply chains.

These are steps in the right direction. But as it stands, investors and innovators have to sift through a mountain of information and knock on several Government department doors just to get to the starting point.

A straightforward strategy that takes innovators and investors on the journey from science laboratory bench to business is needed to propel the UK into the position it deserves to be in, making it a 'Science Superpower' and a great place to do business. If we are to lead the World once more with our industrial science ingenuity and support the UK into a sustainable future, we must secure our core business now, as we head into a new parliamentary term.

References

1 World Bank

2 Scale Up Institute Review 2023

SCI published A Manifesto for an Industrial Science & Innovation Strategy in August 2023. It forms a comprehensive blueprint to support UK science-based business. To read the manifesto visit bit.ly/SCIManifestoPdf or scan the QR code below.

DEVELOPING A UK SUSTAINABLE BATTERY INDUSTRY

Martin Dowson, Chief Engineer Electrification WMG & Electrification Director HVM CATAPULT

Adoption of electrification has been led by the automotive industry, but other sectors are increasingly embracing electrification, from marine and aviation to energy storage. Due to this, the UK government's vision is for the UK to have a globally competitive battery supply chain to support economic prosperity and the net zero transition [1]. UK localisation provides environmental opportunities due to the high environmental standards and low-carbon energy available.

Kit Jones, Lead Engineer WMG

Batteries are a complex balance of techno-economic interactions. It is typically not possible to meet all the requirements with the current technology, therefore trades must be made. Cost reduction dominates the technical agenda, followed by faster charging, degradation and safety.

Recent development has been driven by the automotive industry, which is expected to dominate UK demand at around 80-90GWh out of 100GWh in 2030. The UK has a very long tail of companies that require battery supply to support existing businesses that generate significant GVA and employment.

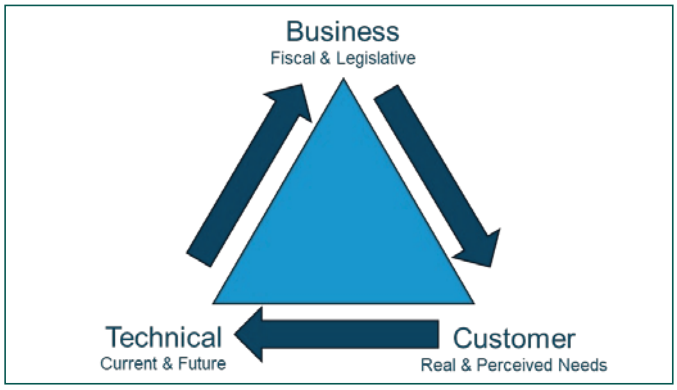

Figure 1 – Techno Economic Modelling Net-Zero & Sustainability Framework

However, there is more forecast demand than planned cell production capacity, this has potential to either result in imports with a potential strategic vulnerability for the UK, or loss of industry. For automotive it is expected that cell manufacture must be located close to vehicle manufacture for viability.

THE RACE TO DEVELOP BATTERY SUPPLY CAPABILITY

The UK is in a global race to develop appropriate battery

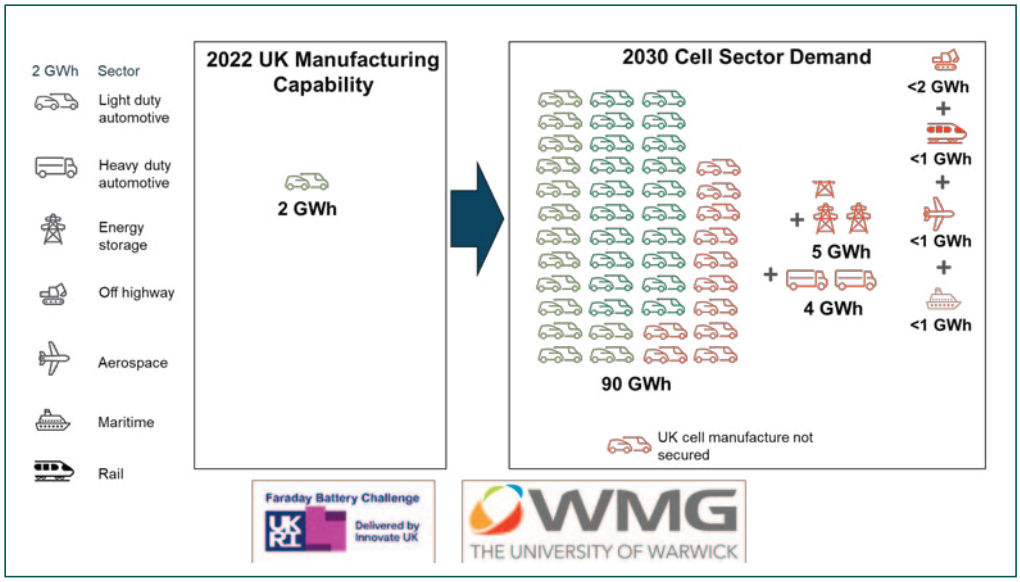

Figure 2 - Projected 2030 UK Battery Demand

supply industry and capability both to support sustainability of existing manufacturers and to benefit from new opportunity. The UK's low-carbon electricity will enable more sustainable production than many other countries, along with high social standards for extraction, processing and manufacturing.

Figure 3 – Simplified Battery Supply Chain

The UK has some established & planned material extraction and processing capability, e.g. production of up to 52,000t/yr lithium carbonate[2,3,4,5] and ~8,000t/yr lithium hydroxide[6] (The UK likely requires ~40% more, assuming 850g/kWh[7]). There is existing and planned lithium processing[8,9], but an expected 48% global shortfall in 2040[9].

The Humber refinery is the only European facility producing anode coke, with production for about 1.3m BEVs/yr[10], giving the UK an advantage over many neighbours. Electrolyte is produced in Tees Valley[11].

China accounts for 78% of global cathode and 91% of global anode production[12], with no volume UK electrode manufacturing[12] . Work is underway at research and pilot scale[13,14,15], with plans to produce at volume[16].

Cells are manufactured in the UK by Envision AESC and AMTE Power. The Agratas (Tata Motors) plant in Somerset is also progressing with expectation to supply approximately 40GWh/yr[17].

With forecast UK demand of 100GWh in 2030, more capacity is required to avoid reliance on imports and a potential strategic vulnerability. Lead times for such large-scale facilities mean that the window to attract investment is limited, e.g. up to a decade for critical minerals mines and chemical plants[18].

The high-volume module and pack applications will likely be covered by cell manufacturers. The UK has many other niche applications and these require support such as standardised modules[19], allowing shared development costs and expertise.

At End-of-Life (EoL) it is expected that batteries will primarily be recycled rather than used for second life. Recycling will be an important future feed of material in the long term, but short-term supply is limited, driven by an average car life of 14 years. EoL supply is likely to only meet demand close to 2050.

Battery supply is about more than just the cell assembly gigafactories, and includes other items such as connectors, current collector foils, thermal management systems and pack enclosures. It is critical that these are considered for the UK supply chain.

Innovation must be proven at each scale of manufacture and needs the ecosystem to support this. This starts at small scale for fundamental research, growing to larger scales as success is demonstrated by the technology.

Gramme Scale - Typically university scale research of hand-made materials for fundamental research and initial half-cell experiments.

Kilogramme Scale - Typically corporate R&D lab or University / Catapult centre, used to demonstrate scalability of materials to full size cell processes and formats.

50kg – tonne Scale -Full scale manufacturing facilities used at low rate. Expensive, inflexible, and often impossible to access except by owner. UKBIC provides bespoke facility for this purpose, used to develop and prove materials, cell design, manufacturing processes and parameters "at-rate".

Kilotonne Scale - Full-scale, high-volume manufacturing plant. Typically, 6-50GWh/year, used to deliver very large volumes of cells with no variation or flexibility to chemistry, format or quality.

SKILLS DEVELOPMENT

Research has found that significant change will impact the existing workforce[20]. Across automotive manufacturing roles related to batteries, power electronics and electric machines, 63% of job roles will be subject to significant change. Examples include 61% of current powertrain jobs and 91% of power electronics quality engineers and technicians will have significant competency gaps requiring training[20].

By 2030, 90,000 automotive technicians will be required to service zero-emissions vehicles, with IMI forecasting a shortfall of 35,700 technicians[21]. Up to 182,000 mechanics across the automotive sector will need reskilling by 2030[20]. National Grid has estimated that 117,000 skilled recruits are required by 2030 to support the energy sector[22].

In manufacturing, the Faraday Institution estimates 100,000 will require reskilling by 2035[23]. For cell manufacturing in 2030 up to 10,000 workers could be needed[23].

Delivering the workforce requires new skills, upskilling and reskilling[22]. Organisations including Faraday Institution, Innovate UK, Faraday Battery Challenge, UKBIC and UK universities are contributing to filling the skills gap.

FUNDING

It is critical that funding be provided to target the technical challenges of delivering batteries with the needed performance profiles for their intended purpose. The existing funding framework is split by TRL, which can be classified as fundamental research, proof of concept, product pre-production and series manufacture.

Figure 4 - UK Funding Framework and Support Mechanisms

This has created a coherent funding ecosystem to support battery development from research to industrialisation however the job isn't finished. We need continued funding aligned to overall strategy to ensure this can meet the demands of industry.

THE RACE IS ON

The EU trade agreement requires a percentage of local content for EV's and batteries, this is driving the race to secure the supply chain to avoid tariffs. The existential risk is that vehicle manufacture will be closely tied to battery manufacturing location, therefore, it is both an opportunity and a risk to existing vehicle manufacturing. Europe is in competition with the US, which has overtaken following the IRA.

Faraday Battery Challenge have created 6 Battery "Big Plays" to focus industry and ensure future UK success:

Secure the supply chain in the UK

1. "Double down" on all efforts to secure competitive, sustainable UK manufacturing of Nickel-rich batteries & associated supply chain.

2. UK supply chain for very high performance, high value, relatively modest volume solutions at cell, module & pack level.

Develop the next generation technologies

3. UK technical capability and physical supply chain for Li metal anode solutions.

4. Low cost / Good enough (for high volume auto) energy density pack level solutions.

Make it all sustainable

5. Total end-to-end life cycle assessment optimisation, use of earth-abundant materials, manufacturing energy reduction, end-to-end cost of ownership optimisation, robustness to first use duty cycles, efficient recovery and recycling.

Leverage digital tech developments

6. The "5 Dimensions of Digital" - Big Data & AI for materials discovery- Digital Design Optimisation Performance Verification- Test and field data analytics- Digitisation of the end-to-end bill of process- Digitisation of "Provenance" and State

KEY TAKE OUTS

- Whole life cost reduction is the key factor driving innovation in electrochemistry, battery design, manufacturing processes and recycling.
- Batteries are critical to UK manufacturing, and a key building block to NetZero and sustainability targets. A heavy reliance on imports creates a potential strategic vulnerability.
- A UK battery supply chain can offer improved environmental sustainability due to the high standards and low-carbon electricity supply available.
- Strategic alignment is required to ensure the development of skills, investment in research and investment in the supply chain happens in a timely manner to meet the needs of industry.
- Without strategic intervention, we will lose the battery race.
- Sustained policy and intervention is required, e.g. financial support, electricity supply, transport infrastructure and tariff-free access to global markets.

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WHEN WILL POLICY MATCH SCIENCE?

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REAPING THE WHIRLWIND

It is now 165 years since John Tyndall warned that 'Greenhouse Gases' could create dangerous atmospheric energy gain. But global anthropogenic CO_2 emissions have risen from 196.75 *million* tonnes in 1850 to 5.93 *billion* tonnes [Gt] in 1950, and 40.9 Gt in 2023 if land use change is included[1], with 20% remaining in our atmosphere for 33,000 years. Atmospheric CO_2 concentrations have thus risen from 280 parts per million (ppm) in 1850 to 424ppm in 2023[2], as have those of other GHGs such as methane (CH_4: 750 parts per billion [ppb] in 1800 to >2000 ppb in 2023)[3]. Earth's atmosphere is thus gaining ever more energy[4]: oceans alone have absorbed 345x10[21] Joules since 1955 alone[2], the energy equivalent of 19 billion Hiroshima Bombs[2]. Ocean heat content to 2km depth, and surface temperature were, in 2023, the highest recorded[5] as was annual-mean global surface temperature (GST). Average land temperatures were 2°C above pre-industrial[2]. We will likely breach a 2°C average 10 year rise (the maximum which the Paris 2010 agreement sought) by 2030[6]. Ice stocks are melting rapidly[7]: from 1997-2021, Antarctica lost 7.5 trillion tonnes[8]; Greenland lost >1 trillion tonnes (5,091 km^2 area) from 1985-2022 and now 66 Gt annually[9]; Swiss glacier volume dropped 10% in 2022/23 alone[10]; 1.73m km^2 of Arctic January ice was lost since 1979; Antarctic sea ice is in decline[11]; and Arctic summer sea ice may have vanished by 2030[12]. With water added from land ice melt, and ocean thermal expansion, sea levels have risen 10cm since 1993[13].

Adding energy is driving increasingly severe and frequent and severe extreme weather events: global climate-related events rose 83% from 1980-1999 to 2000-2019 (3,656 to 6,681), the number of major floods has doubled in 20 years (1,389 to 3,254), and storm incidence has risen from 1,457 to 2,034[14]. In 2013-2022 (vs 1986-2005), the number of heatwave days (2 or more days where both the minimum and maximum temperatures exceeded the 1986–2005 95th percentile) rose 94%[15]. From 2019-2023, annual or seasonal temperature records were broken in every part of the world[16]. Wildfires are more frequent, extensive and intense across the globe[17, 18, 19]. Compared to the 10 years from 2001, the ten years to 2021 saw annual tree cover lost to wildfires rise 93% (2.86m to 5.5m hectares)[20, 21].

IMPACTS ON SOCIETY AND SURVIVAL

The climate stability which allowed human civilization to flourish for 11,700 years is now being lost. Impacts on human health and disease are well documented[15]. But impacts mediated through social and economic change (and resultant migration and war) may soon be catastrophic. The global land area affected by extreme drought annually rose 30% (18% to 47%) from 1951-1960 to 2013-2022[15]. This threatens global food supply, as do many other climate-related factors (reviewed in[22]) such as rising sea levels (loss of agricultural land/saltwater ingress); damaged soil quality, soil desiccation and loss; increased crop respiration/evapo-transpiration reducing water availability; impaired animal productivity/herd survival; crop loss to even short-lived single extreme weather event; changes in weed flora and animal/plant diseases, pests, parasites, and vectors; and inability to work outdoors (in 2022, heat exposure caused the loss of 490 billion potential labour hours, up 42% from the 1990s[15]).

From 1980-2022, climate-related weather extremes caused EUR 650 billion losses to EU member states, and EUR 59.4 billion and 52.3 billion in 2021 and 2022 respectively[23]. Heatwaves alone cut European annual GDP growth by 0.5% (1% in vulnerable regions) in the past decade[24]. The 2022 heatwave cost Italian farming EUR 6.6 billion[25]; Pakistan floods US$ 40 billion[26]; 2023 Florida flooding US$ 9.4 billion[27]; and the 2023 heatwave 0.6% of GDP worldwide- and <1.3% for China[28], with US$ 1.3 trillion losses over the last decade[29]. Losses of US$ 5 trillion are predicted within 5 years, with a 1-in-300 chance of a single event costing over US$17.5 trillion- circa 1/6th of current world GDP[30]. Insurance actuaries warn that "*our economy may not exist at all* if we do not mitigate climate change"[31].

Within 45 years, <3billion people (if surviving intervening climate catastrophe) would face mean annual temperatures >29°C - currently only found in 0.8% of land area (mostly Saharan), and likely incompatible with survival[32]. In 2023, the UN Security Council was warned that accelerating sea level rise could cause a "mass exodus of entire populations on a biblical scale", triggering massive global economic and social disruptions worldwide[33]. War will result[34,35], and climate change is already a "national security threat to Europe"[36].

Finally, human survival depends upon that of the global ecosystem. Vertebrate species' abundance fell 69% between 1970-2018[37]. On top of this, even "moderate" climate change might drive 16% of all species to extinction within 50 years, and fully 1/3rd if emissions continue to rise[38, 39]. Indeed, Earth's five past mass extinctions were associated with global heating of circa 5.2°C: this level over the preindustrial temperatures would today cause a mass extinction event "rivalling those in Earth's past"[40, 41].

WORSE STILL

Impacts may, in fact, occur far faster than this. Earth's energy imbalance is accelerating due to the triggering of multiple (and cross-interacting) positive feedback loops. Heat gain has accelerated as snow/ice loss reflects less back into space (albedo effect), adding an energy gain equivalent of an extra 100ppm CO_2[42]. Rises in atmospheric methane (83x as potent a GHG as is CO_2 over its first 20 years[43] from human activity are augmenting global heating[44], with release from warming permafrost[45, 46], carbonate rocks[47], and wetlands[48]. Increasing wildfires release carbon monoxide (which extends methane's atmospheric lifespan [49]) and more (heating) CO_2: forest fires emitted nearly 33.9 Gt CO_2 in 2021-2022[50] and, in 2023, Canadian fires released 22 Gt[51]. Global wildfire emissions may double within decades[50]. Smoke aerosols create ozone holes[52, 53], short-term accelerated heating detectable < 10km in altitude[54], and significant disruptions to global weather[55]. Soot landing on distant glaciers enhances their melt rate, and thus albedo effect even further[56]. Worsening storms inject water vapour < 19km into the atmosphere, where it acts as a GHG[57], while the ability of rainforests to draw down CO_2, is in decline[58], with some areas becoming net CO_2 emitters[59, 60]. Finally, burning 'dirty' fossil fuels to power shipping releases aerosols which can, paradoxically, help 'shield' the Earth and partially mitigate global heating. As such emissions fall, the full effects of GHG are felt and heating is, consequentially, accelerating[4].

Weather systems may also change abruptly[61]. As polar regions are warming 3-4x faster than the global average, the (moisture-laden) Northern Jet Stream will move progressively northwards- leading to worsening droughts in the Iberian Peninsula, and worsening winter flooding in Northern Europe[62]. Global heating is also driving acceleration in its windspeed, bringing more extreme weather events[63].

Inflow of cold ice meltwater is

disrupting flow of the Atlantic Meridional Overturning Circulation (AMOC, which transports ocean heat)[64], which is now at its weakest in at least 1000 years[65] and which may be at a point of critical transition[66]. Whenever this occurs, it will bring catastrophic disruption to global weather[67]. Likewise, the Antarctic Ocean circulation is slowing[68].

But we may have triggered rapid, severe and sudden Arctic heating, which would accelerate all these impacts[69, 70]. The last three years have seen sudden spikes in Greenland temperature with massive ice melt in days[71, 72, 73]. In 2023, Antarctic sea ice reached record lows, with evidence that the processes underlying polar ice formation have been significantly altered. In Antarctic mid-winter, a large portion of sea ice failed to reform, with 7% (1.25 million square kilometers) less ice than in 2022[74].

THE NEED FOR ACTION

We must save ourselves. As the chair of the intergovernmental Panel on Climate Change stated in 2022, "Any further delay in concerted global action will miss a brief and rapidly closing window to secure a *liveable future*"[75]. The much-trumpeted 'Paris Deal' targeted emissions reductions of 45% by 2030 from a 2010 baseline in order to keep emissions below 1.5°C but, by 2022, emissions had risen by 12.7% [76], '1.5°C' is no longer attainable, and we are likely to breech a 2°C rise by 2030 (above). Independent of party allegiance, politicians must show true leadership and act – whether out of beneficence, moral integrity, concerns for the UK economy or over mass migration, or self-interest for their own survival and that of their children.

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INDOOR AIR QUALITY: SHOULD WE BE WORRIED?

Nicola Carslaw, Professor in Indoor Air Chemistry, Department of Environment and Geography, University of York.

CONTEXT

We spend around 85-90% of our time indoors in developed countries such as the UK, including in our homes, at work and commuting between the two. However, with the exception of occupational settings, regulation around air pollution exposure focuses almost entirely on outdoor air pollution. If we want to understand our overall exposure to air pollution, and then design scientifically rigorous mitigation strategies, we need to consider exposures to both indoor and outdoor air pollution.

INDOOR AIR POLLUTION

Indoor air pollution can derive from numerous sources and materials. Some of the air pollution we are exposed to indoors comes from outdoors, for instance through open windows and doors. If a building is located on a busy road, traffic emissions could be a major source of indoor air pollutants. Indoor sources include activities such as cooking, cleaning, fuel burning on open fires or inefficient/poorly maintained stoves, DIY activities, smoking and the use of personal care products and air fresheners. There are also sources of pollution from furnishings and building materials, as well as bio-effluents (e.g. carbon dioxide and numerous other chemicals) from people. Finally, there can be chemical and physical interactions between air pollutants and/or internal building surfaces, which can produce even more air pollutants indoors.

The indoor air quality in a building will therefore depend on its location, how it is ventilated (naturally or mechanically) and the activities inside it. Unlike for outdoor air quality, the indoor air quality can differ significantly along a street from building-to-building, even in identical houses. Human behaviour plays a large part in the composition of indoor air pollution, making it challenging to generalise between buildings.

UNEXPECTED CONSEQUENCES

The discussion so far has shown that indoor air quality is influenced by a wide range of potential sources, the emissions from which are then modified by physical, chemical and behavioural factors. It is vital that both indoor and outdoor sources of air pollution are considered when trying to understand the overall exposure and consequent health effects of an individual. Otherwise, by trying to avoid one source of pollution, you may inadvertently expose an individual to higher (and potentially more harmful) concentrations of a different pollutant. For instance, shutting the windows of a house to avoid traffic exhaust from cars outside, may lead to higher exposure to cigarette smoke generated by a smoker indoors. In addition, cleaning and cooking indoors can lead to the production of particulate matter, and the use of fragranced products can produce formaldehyde, both of which are associated with adverse health effects.

Our current drive to increase energy efficiency in buildings as

we move towards our net zero aspirations could also have unanticipated consequences if not considered carefully. Energy efficiency in buildings is often achieved through increased insulation, which generally leads to more airtight buildings. However, more airtight buildings mean that species emitted indoors take longer to be diluted and removed. If these species have impacts on health, we may just be replacing one problem with another.

RELEVANCE FOR POLICY MAKERS

There are several issues for policy makers to consider when it comes to indoor air pollution. It would be very difficult to regulate indoor air quality in homes, although there is some general advice that can be shared as summarised at the end of this article. Public buildings would be an easier place to start and a recent European project (INDAIRPOLLNET: Indoor Air Pollution Network) involving 200 scientists led by the University of York, suggested how we might start to put regulations in place using a fairly simple approach[1].

In the meantime, we need to better regulate the products we take into and use in our homes. These include cleaning products, scented candles, and building and furnishing materials, all of which emit chemicals when used[2]. Products need to be tested in realistic indoor environments, rather than the carefully controlled laboratory environments they are tested in at the moment. Such testing environments should encompass the temperature and humidity fluctuations, and mixtures of indoor air pollutants typically found in houses. Clearer labelling would also help consumers to choose lower emission products and materials, maybe using a traffic light system such as that adopted for the sugar and salt content of food. On a related note, our recent research has shown that some products marketed as 'green' or 'natural', often contain more volatile organic compounds and at higher concentrations than regular products[3]. There is an implicit assumption that such products are better for health and/or environment. Such labels are confusing for the consumer and need to be more carefully defined.

There also needs to be regulation around air cleaning devices. These devices often claim to remove bio-pathogens (such as covid) and/or air pollutants such as particulate matter. Whilst some of them are effective, others are less so and some use chemical reactions internally that can cause harmful products to be emitted upon use. As these devices are largely unregulated at the moment, it is important to understand the full impacts of any instrument used in a building, particularly in a school or a healthcare setting. The UK Government's SAGE Environmental Modelling Group recently published a comprehensive report on these air cleaning devices, and particularly their use during the covid pandemic[4].

INGENIOUS

TRANSFORMING INDOOR AIR QUALITY KNOWLEDGE THROUGH UK SCIENCE

At the University of York, we are currently leading 2 projects to better understand the science behind indoor air quality, with the aim of informing policy in this area. The first is called INGENIOUS (Understanding the sources, transformations and fates of indoor air pollutants) and aims to better understand air pollution in our homes[5]. We are focusing on the city of Bradford, which has a multi-ethnic population, high levels of deprivation and some of the highest childhood illness rates in the UK. The Born in Bradford study[6] is involved in this project, which is a long-term health research study involving 30,000 Bradfordians. We are making indoor air pollutant measurements in 300 Bradford homes, whilst tracking resident behaviour through diaries, which should allow us to better understand links between indoor air pollution, behaviour and health.

The second project aims to build a new indoor air quality testing facility called INTERIORS (An Interdisciplinary Facility for Indoor Air Quality and Health Research) on the University of York campus. The facility will comprise two houses with an integrated air pollutant sampling laboratory. One of the houses will be standard build, whilst the other will be built to Passivhaus standard, and thus can be thought of as a proxy for our net zero housing of the future. INTERIORS will be used to quantify the emission rates of speciated pollutants from key indoor products (e.g. cleaning products, air-fresheners, building materials), understand how these emissions and resulting concentrations are affected by ventilation characteristics (standard versus Passivhaus), house design, furnishings, chemical transformations and occupant behaviour, and how emissions from indoor materials vary over time and in realistic environments. Concurrent outdoor measurements of air pollutants will also be made, allowing investigation of the exchange of pollutants between indoors and outdoors.

WHAT CAN WE DO IN THE MEANTIME?

There are several ways to lower exposure to indoor air pollutants in any setting.

- Avoid excessive personal care or cleaning product use and always follow manufacturers instructions
- Always use cream products instead of spray products: the latter form aerosols, which are much easier to breathe in.
- Use a cooker hood (that ventilates outdoors) while cooking and regularly clean the filter. If you don't have a cooker hood, open the window while cooking and for 10 minutes afterwards.

- Use the back rings on a hob, as cooker hoods work more efficiently over the back rings.
- Switch from a gas hob to an electric or induction hob if possible.
- Ventilate regularly with outdoor air if it is relatively clean: if you live near a road, use a window on the other side of the building, or open windows outside of rush hour.

Finally, there is a clear need for a holistic approach to considering how to provide the best possible indoor air quality, through combining the expertise and experiences of building designers, managers, and users. It also requires a more joined up approach across Government, given the cross-cutting nature of the topic and to avoid some of the unintended consequences highlighted above.

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Other resources that provide more information:

The RCPCH and Royal College of Physicians Report 'The inside story: Health effects of indoor air quality on children and young people (2022). https://www.rcpch.ac.uk/resources/inside-story-health-effects-indoor-air-quality-children-young-people

CMO report on air pollution from 2022: https://assets.publishing.service.gov.uk/media/639aeb81e90e0721889bbf2f/chief-medical-officers-annual-report-air-pollution-dec-2022.pdf ■

HOW UKHSA SUPPORTS POLICY ON INDOOR AIR QUALITY AND HEALTH

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Over the last 10 years, there has been an attempt to better understand indoor air quality and its impacts on our health and wellbeing. UKHSA has established a Cleaner Air Programme, as part of its core activities, which aims to reduce people's exposure to air pollution, including poor indoor air quality, and achieve better outcomes for all. The work that UKHSA carries out on indoor air quality and health, for each of the core ambitions of its Cleaner Air Programme, is discussed below.

WHY DOES INDOOR AIR QUALITY MATTER?

The COVID-19 pandemic has led to people spending more time at home due to increased home working. This has raised the importance of indoor air quality (IAQ) and ventilation. People in developed countries spend about 90% of their time indoors, much of which is at home. This is especially the case for vulnerable populations, such as young children and the elderly. Over the last 10 years there has been an attempt to better understand IAQ, the factors affecting it, the health effects associated with exposure to air pollutants indoors and what should be done to improve IAQ and its impacts on our health and wellbeing.

The ingress of outdoor air indoors, housing conditions in terms of building characteristics (such as building form, building fabric, airtightness, infiltration and ventilation systems), indoor sources (from building and construction materials, furnishing and consumer products), as well as occupant activities (e.g., cooking, smoking, wood burning, cleaning, drying clothes indoors) are important modifiers of indoor air quality (Dimitroulopoulou, 2021).

Indoor air pollutants include particulate matter (e.g., $PM_{2.5}$, PM_{10}), volatile organic compounds (VOCs), combustion products (nitrogen dioxide -

NO_2, carbon monoxide - CO), radon and biological contamination. Exposure to indoor air pollutants cause significant adverse health effects; they can trigger or exacerbate asthma, other respiratory or cardiovascular conditions, irritate the upper airway system and may even have carcinogenic effects (NICE, 2020; RCPCH, 2020). Markers of dampness/moisture in buildings such as visible mould, mould odour, or moisture in the walls have been associated with respiratory health outcomes, such as exacerbation of asthma, respiratory infections and allergies. However, we know much less about the health impacts from indoor air pollution compared to outdoor air pollution.

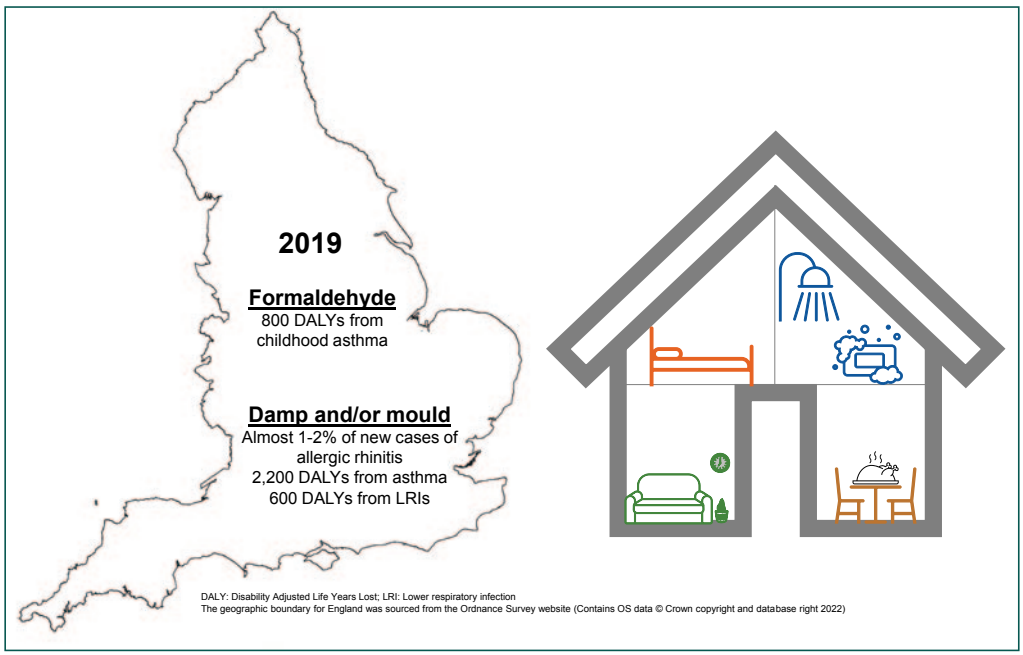
WHAT UKHSA IS DOING TODAY ON IAQ

UKHSA has established a Cleaner Air Programme, as part of its core activities, which aims to reduce people's exposure to air pollution, including poor IAQ, and achieve better outcomes for all – particularly for the most vulnerable groups such as those with pre-existing respiratory and cardiovascular conditions, older people, pregnant women and children, and deliver physical and mental health as well as climate change co-benefits (UKHSA, 2022). The core ambitions of the Programme are reported below together with the work related to IAQ, for each of them.

1. Increasing the evidence base

Damp and mould

To inform the governments' guidance on damp and mould (DHSC/UKHSA/DLUHC, 2023), UKHSA led on the quantification of the respiratory burden of disease in England from exposure to damp and mould in housing. In 2019, the presence of damp and/or mould in English residences (3-4%) was estimated to be associated with approximately 5,000 cases of asthma and 8,500 cases of lower respiratory infections among children and adults and contributed to 1%-2% of new cases of allergic rhinitis. Using alternative data sources, primarily from self-reporting, that suggests that the percentage of dwellings affected by damp and/or mould may be even higher, the total number of cases could be 3-8 times greater (Clark et al., 2023).



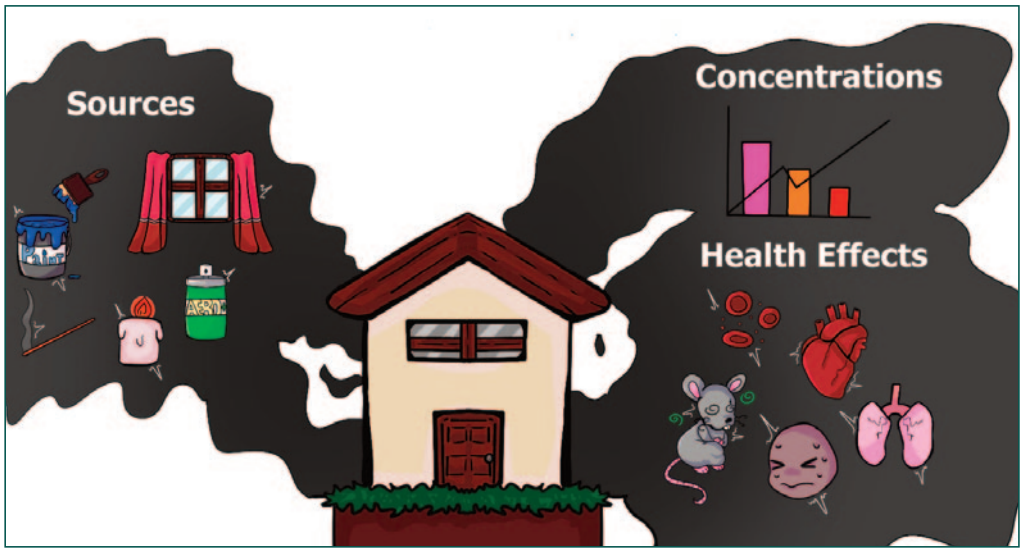
Respiratory burden of disease from exposure to damp and mould and formaldehyde in UK homes (from Clark et al., 2023)

Indoor sources

A systematic literature review has been carried out on concentrations, emissions from indoor sources, and health effects of volatile organic compounds (VOCs) measured in European and UK homes (Halios et al., 2022). 65 individual VOCs were identified, and 17 of them, most frequently occurring in homes, have a relevance to health. Widely used building and construction materials (e.g. composite boards, paints and coatings) are sources for 11 VOCs: benzene, ethylbenzene, xylenes, styrene, toluene, acetone, acetaldehyde, formaldehyde, trimethylbenzene, naphthalene, α- pinene and limonene. UKHSA is leading on the development of a modelling tool to assess exposure to chemicals in homes. Health effects from exposure to these chemicals and emission rates from construction materials and consumer products found in the literature review will provide a valuable input for modelling tools.

Indoor air quality guidelines – Ventilation standards

Until recently, in the UK, there were no IAQ guidelines for



Chemicals in homes (from Halios et al., 2022)

individual VOCs. UKHSA carried out a comprehensive literature review of existing assessment values proposed by health organisations around the world, we selected the most appropriate existing health-based guidance values for inhalation and proposed them as health-based IAQ guidelines for 11 individual VOCs in the UK (Shrubsole et al., 2019; PHE, 2019). These are recommended as performance criteria for ventilation in the revised building regulations (Approved Doc. F for ventilation).

UKHSA carried out a literature review (Lowther et al., 2021) to identify if carbon dioxide (CO_2) is a pollutant with known health effects at low levels (below 5000 ppm) measured in indoor environments. Looking at the individual designs of human studies, we concluded that any health impacts can be indicative of reduced ventilation, emissions of human bio-effluents and presence of indoor air pollutants, so CO_2 is only an indicator for ventilation at these levels. Reviewing international ventilation standards concluded that the current consensus that CO_2 concentrations below 1000 ppm represent good IAQ, in the range of 1000–1500 ppm represent moderate IAQ and above 1500 ppm represent poor AQ, seems to be appropriate.

UKHSA is working with ISIAQ (International Society on Indoor Air Quality and Climate) on the development of an open database on international indoor environmental quality (IEQ) guidelines (Toyinbo et al., 2022; Dimitroulopoulou et al., 2023a). The database aims to be actively used by researchers, practitioners, and policymakers across the world.

Climate Change

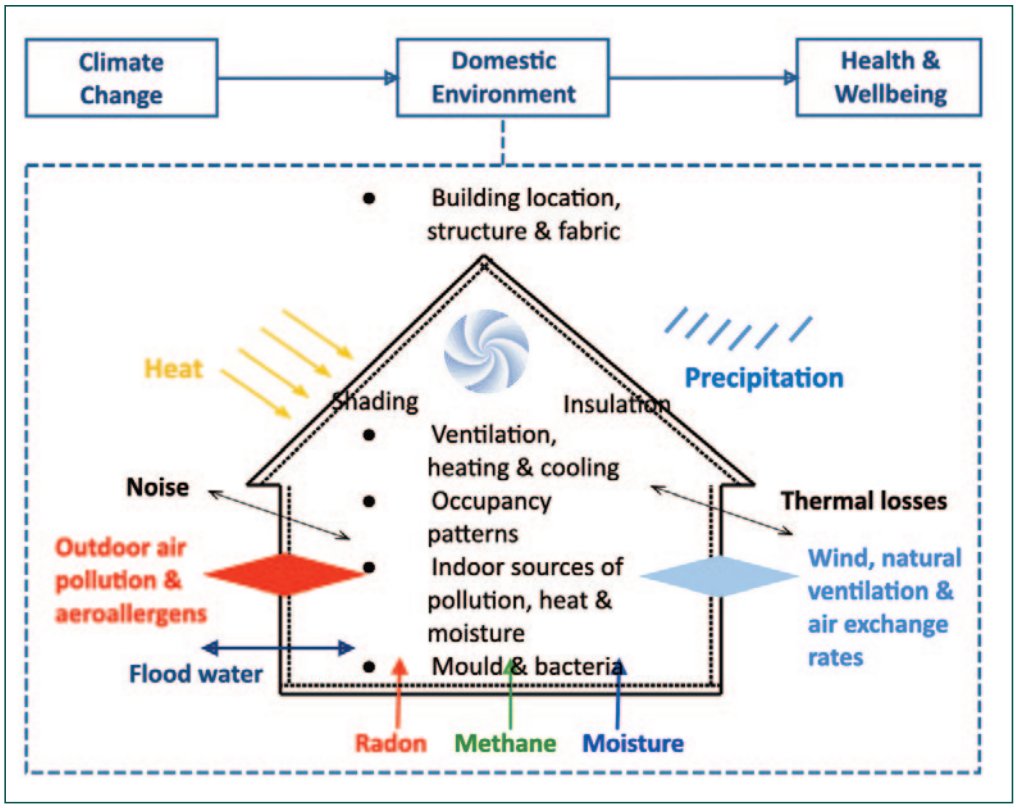
There is growing evidence that climate change has the potential to significantly affect public health, due to mitigation and adaptation policies in the building sector (Vardoulakis et al., 2015). Chapter 5 of the UKHSA's Health Effects of Climate Change report provides the latest evidence on the impact of climate change mitigation and adaptation policies on IEQ and health, which also takes into consideration indoor exposures to air pollution and damp and mould (Dimitroulopoulou et al., 2023b). The net-zero challenge requires significant changes in the performance of both new and retrofitted buildings. Increasing airtightness of dwellings in pursuit of energy efficiency could build up the concentrations of pollutants generated from indoor or ground sources, and biological contamination. This may be due to inadequate ventilation caused by shortcomings of ventilation systems in fabric retrofitted homes. A better understanding is needed in the UK of how IEQ parameters (IAQ, ventilation, indoor temperature and noise) interact and how current and emerging building infrastructure, design, construction, and materials used, may affect these parameters and hence our health and wellbeing.

Inequalities

UKHSA is providing funding and supervision support to PhD projects to develop evidence on the factors that affect personal exposure, especially of vulnerable populations, considering both indoor and outdoor air, and addressing inequalities. Ferguson et al. (2023) concluded in her review that low socio-economic homes experienced higher levels of indoor PM, NO_2, VOCs and ETS, whereas higher radon concentrations were found in homes with a greater material wealth. Inequalities in exposures may arise from poor quality housing, location near congested roads, lack of occupant education regarding the harm of indoor second-hand smoke, and/or higher occupant density resulting in greater re-suspension of particles (Ferguson et al., 2021). Personal exposure modelling estimated $PM_{2.5}$ exposure for around 1.3 million children 4–16 years old in the Greater London area. Children from low-income homes generally have higher personal exposure to $PM_{2.5}$, but the relationship is nonlinear. 57 % of London's school-aged population have a daily exposure that exceeds the previous World Health Organization (WHO) 24-h guideline of 15 μg/m^3. Residential indoor sources of $PM_{2.5}$ are a large contributor to personal exposure for school children in London.

Interventions

UKHSA (formerly Public Health England, PHE) previously worked with NICE (The National Institute for Health and Care Excellence) for the development of guidelines on indoor air quality at home, which are PHE co-badged (NICE, 2020). Both structural and behavioural interventions are proposed, to



The impact of climate change on indoor environmental quality and health (from Vardoulakis et al., 2015).

reduce the sources of indoor air pollution and improve ventilation and are addressed to different groups (local authorities, healthcare professionals, and building industry). For instance, they provide guidance for local authorities on how to reduce damp and condensation and increase ventilation.

UKHSA carried out a systematic literature review to examine the impact of portable air cleaners on indoor air quality (PM2.5) and health, focussing on adults and children in indoor environments (homes, schools and offices) (Cheek et al., 2020). Analysed studies all showed reductions in PM2.5 of between 22.6% and 92.0% with the use of air cleaners. Associations with health impacts were found to include those on blood pressure, respiratory parameters and pregnancy outcomes. Changes in clinical biochemical markers were also identified. However, evidence for such associations were limited and inconsistent. Despite that, there is not enough evidence to confirm health benefits but given that there is strong evidence that exposure to particulate pollutants is harmful to health, using portable air cleaners is likely to have positive health impacts.

Participation in research networks

UKHSA participate in the networks funded by the Government (UKRI) (HEICCAM, TAPAS, FUVN) that address future air quality challenges at the indoor-outdoor interface in residences and in schools. UKHSA is either a co-investigator or partner/advisor.

2. Support our stakeholders - Contribution to policy making

UKHSA has been working together with DLUHC, DfE, Defra, HSE and DHSC/OHID to ensure a joined-up approach on government actions affecting IAQ;

• DHSC / UKHSA / DLUHC (2023) developed a new consolidated guidance for the rented housing sector which sets out the health risks associated with damp and mould and the practical steps housing providers can take to minimise these risks. The guidance is aimed at private and social rented landlords.

• UKHSA contributed to the revision of Building Regulations (Part F: ventilation and Part L: airtightness) led by DLUHC. The PHE IAQ guidelines for selected VOCs (2019) were used as performance criteria for ventilation.

• UKHSA also contributed to the revision of HHSRS (Housing Health and Safety Rating System) organised by DLUHC. UKHSA sat on the Project Board, providing expert advice on hazards and minimum standards.

• UKHSA are working together with HSE (UK REACH work programme, 2022/23) on a Regulatory Management Options Analysis (RMOA) that examines exposure of the general public to formaldehyde from formaldehyde releasers in articles (such as building and construction materials).

• UKHSA worked with DfE for the revision of Guidance BB101 on ventilation, thermal comfort and IAQ in schools (DfE, 2018). Following our PHE recommendation, the WHO (2010) indoor air quality guidelines were incorporated for the first time in the UK into a UK Government guidance.

• UKHSA staff co-authored Defra's Air Quality Expert Group report on indoor air quality (AQEG, 2022).

• UKHSA staff were co-authors in the Chief Medical Officer's annual report 2022 on air pollution, with chapters on air quality and health effects (Exley et al., 2022) and inequalities in relation to air pollution exposure and health (Dimitroulopoulou et al., 2022).

• UKHSA sits on three Cross Government (X-Gov) Groups related to IAQ: i) indoor air quality, chaired by DHSC, ii) gas safety and carbon monoxide awareness, chaired by HSE; iii) Net Zero Co-Benefits, chaired by DESNZ. The members of these X- Gov groups share knowledge and activities in the relevant areas, with an aim to identify any barriers to action and identify ways to move beyond them as well as potential opportunities for cooperation.

• Alongside government departments, UKHSA also works with external stakeholders and organisations (i.e., WHO, NICE, CIBSE – Chartered Institute for Building Services Engineers, and the Royal Colleges RCP/RCPCH) to provide scientific input, using expert knowledge and experience on indoor air quality in relation to public health. For example, UKHSA members of staff are currently working on the revision of CIBSE TM57 design guidance for schools. This is informed from a previous WHO project on assessing combined exposure to multiple chemicals in indoor air in schools (WHO, 2020; 2022), in which UKHSA had participated.

3. Improving awareness of indoor air quality

UKHSA staff have presented and been panellists in various events, including panel discussion on IAQ and health, organised by All Party Parliamentary Groups, Clean Air Networks Conference, UK Indoor Environment Group (UKIEG) Conferences and webinars, UKHSA and Air Quality (AQPH) Conferences and other events organised by our Stakeholders. UKHSA also contributed to the recent POSTbrief on IAQ to inform Parliamentarians of IAQ issues (POST, 2023)

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OBESITY, DIABETES AND GLP 1

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Dr Bryan Hanley ACTA, Netherlands

OBESITY – CAUSE AND EFFECTS

Obesity is defined by the World Health Organisation as the accumulation of fat to a level that is deleterious to health. Body Mass Index (BMI) is the most common measure used to quantify obesity and overweight. It is a simple calculation of weight to height ratio and is defined as the weight in kg divided by the square of the height in metres and so has the units of kg/m^2. Overweight is defined as a BMI greater than 25 while obesity is a BMI greater than 30. It is important to note that the correlation between physiologically dangerous levels of fat accumulation and BMI is not absolute or precise nonetheless, it provides a useful guide.

According to a report from January 2023[1], the proportion of adults in the UK that are overweight or obese stood at one in six of which one in four were classified as obese. The trend is perhaps even more worrying among children. Among this age group, one in ten were found to be obese by age 5, rising to more than one in five by age 11.

This has consequences in the greater prevalence of cardiovascular disease, type 2 diabetes and asthma. The prevalence of type 2 diabetes in obese individuals is over 5 times that of the non-obese. Similar enhancements in disease states are seen in a range of other ailments[2]. In addition to having a greater likelihood of suffering from a range of diseases, stress and infection can exacerbate the severity of illness in the obese.

Even after adjusting for a range of health conditions, the rate of death involving COVID-19 remained 1.64 and 1.62 times greater for men and women with obesity, compared to those who were not obese[2]. This was perhaps most graphically illustrated by the severity of the illness that afflicted the then Prime Minister, Boris Johnson whose BMI was widely reported to be about 36, when he was admitted to hospital and whose recovery was impaired.

The effects may not simply be transient. It has been found that,

post COVID-19 infection, "… obesity (is a) factor associated with more severe physical and mental health impairments 1 year after hospital discharge."[3].

Furthermore, "obesity costs the NHS £6 billion annually and this is expected to rise to over £9.7 billion annually by 2050"[4] with ancillary societal costs amounting to £27 billion annually[5].

DIABETES

Diabetes can take one of two forms. Type 1 diabetes is a consequence of the pancreas not producing sufficient insulin because the insulin producing cells (beta cells) have been destroyed in an autoimmune reaction. The remedy for this is the administration of insulin since, if it is introduced then the body's reaction to it is normal. Without added insulin, people with type 1 diabetes are in a permanent state of hyperglycaemia. Only about 10% of diabetics have type 1 diabetes. The remainder have type 2 diabetes.

Type 2 diabetes occurs when the body is no longer able to use insulin effectively. Although one of the main consequences of type 2 diabetes is the same as type 1 diabetes (hyperglycaemia) the causes are different. Overweight is often cited as a trigger for type 2 diabetes there is also a genetic component. There are a number of genes associated with the risk of developing type 2 diabetes and the heritability of type 2 diabetes has been estimated to be in the range 10-70%[6]. The realisation of the potential to develop full blown type 2 diabetes is linked to weight and to BMI. Obesity is believed to account for 80-85% of the risk of developing type 2 diabetes, while recent research suggests that obese people are up to 80 times more likely to develop type 2 diabetes than those with a BMI of less than 22. The mechanism is thought to involve the production of pro-inflammatory molecules by fat cells which can make the body less sensitive to the insulin it produces by disrupting the function of insulin responsive cells and their ability to respond to insulin[7].

In 2023, Diabetes UK reported the impact of diabetes on the NHS budget costing the NHS in England and Wales an estimated £25,000 per minute[8]. Type 1 diabetes only accounts for 10% of this cost further demonstrating the impact of obesity and type 2 diabetes on public funds.

GLP-1 AGONISTS

GLP-1 is the abbreviation for Glucagon Like Peptide 1. It is a hormone produced in the gut in response to nutrient intake. It increases satiety and potentiates insulin release. It also decreases gastric emptying. One of the problems with therapies associated with GLP-1 directly is that it is a relatively short-lived hormone and is rapidly broken down. Agonists are molecules that produce a physiological effect at a receptor. GLP-1 agonists mimic the action of GLP-1 by binding to the same receptor as GLP-1. In people with diabetes, this has the effect of preventing hyperglycemia. Its effect on satiety (and other physiological effects) means that intake of it can result in significant levels of weight loss. The particular advantage of GLP-1 agonists is that they can be designed such that they have a much longer half life in the body and so will continue to suppress appetite and to stimulate insulin production long after the natural hormone will have been metabolised and excreted.

In addition to its effect on nutrient absorption and as an aid to weight loss, some GLP-1 agonists have been reported to have a beneficial effect on other outcomes of diabetes and obesity including cardiovascular disease[9]. This is thought to be a consequence of the GLP-1 receptor being expressed (at low levels) in the heart and vasculature.

GLP-1 AGONISTS – SIDE EFFECTS

There are a number of side effects noted with GLP-1 agonists including, commonly, constipation; diarrhoea; fatigue; gastrointestinal discomfort; gastrointestinal disorders. It is suggested that, in the case of using one of the most common GLP-1 agonists, Wegovy for weight loss, if after 6 months use, the patient has been unable to lose at least 5% of their body weight then continued treatment should be reviewed.

GLP-1 LONG TERM EFFECTS

In the long term, a rebound effect has been noted with semaglutide (Wegovy). One year after discontinuing use, people regained two thirds of their weight loss and cardiometabolic improvements reverted to baseline[10]. Treatment of obesity requires, therefore, continuous treatment and pharmacological intervention should not be regarded as an option for short term weight loss. The underlying condition will remain. In addition weight loss tends to plateau after 12-18 months and ongoing chronic administration of the drug is required to maintain the loss.

ADMINISTRATION

Most GLP-1 agonists approved by the US Food and Drug Administration (FDA) for type 2 diabetes and weight management are drug-device combinations containing active ingredients sold together with delivery devices. This creates a complex patent landscape and creates barriers to the introduction of new or generic products into the market where developers may not have access to accessible and cost effect drug delivery devices.

Biophys Ltd, a Wales based consultancy, have experience of the use of microarray patches and other technologies for the administration of measured doses of bioactive compounds (https://www.biophys.co.uk/) that could support development of new drugs or drug device combinations.

SUMMARY

While there are relatively few long-term studies on the use of GLP-1 agonists, it has been noted that the use of the drug is not a 'magic bullet' either to cure Type II diabetes or to enable people to lose weight and to maintain that loss. Lifestyle changes are also necessary and, the evidence collected so far suggests that, even with lifestyle changes, continual use of the drug is necessary if weight loss and improvements in cardiovascular health are to be maintained.

Since the reference price from NICE for Wegovy is about £200 per month, this means that a 10-year intervention will cost almost £250k (£200x12x10). There are 12 million people in the UK who are obese, so, if all of them are treated, this will cost almost £30 billion a year. The cost:benefit assessment of the widespread use of GLP-1

agonists should be assessed carefully considering that NICE claims that obesity costs the NHS about £6 billion annually[4,5]. Even in the US where list prices are $12 000 to $16 000 per year and applying maximum negotiated discounts, costs will likely exceed $6500 per patient per year. If all eligible US adults received GLP-1 agonists at discounts, the annual cost would be $600 billion[11].

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DEVELOPING A SUSTAINABLE UK BATTERY INDUSTRY

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A GENERATIONAL ENERGY TRANSITION

We are now at the crossroads of a once-in-a-generation energy transition; from an economy reliant on fossil fuels to one where there is the potential for abundant clean renewable energy. The technology transitions that are enabled by this will have a dramatic impact on society. Internal combustion engine (ICE) vehicles will be replaced by electric vehicles (EVs) and use of renewable solar/wind energy will only increase; reducing reliance on hydrocarbon fuels. However, to enable these technologies, cheaper, longer lasting and more sustainable batteries are needed.

THE END OF THE ICE AGE

UK vehicle production peaked in 2016 with over 1.8 million vehicles produced, but fell to approximately 1.0 million in 2022 (mostly ICE vehicles)[2] due in part to the global pandemic. With the sale of new petrol and diesel vehicles in the UK coming to an end in 2035, the direction of travel is clear; EVs will be the dominant vehicle technology. Forecasts from the Faraday Institution[2] suggests that vehicle production could recover to 1.6 million in 2030, however this is highly reliant on whether a large-scale UK battery industry can be created. Growth to 1.8 million by 2040 is possible, however in the absence of UK gigafactories, the worse-case scenario would mean the production of only 20,000 vehicles in 2040, with significant loss of employment and export potential in the UK automotive sector.

A GLOBAL RACE TO MAKE BATTERIES

The importance of developing a strong battery industry has been recognised globally. Benchmark Mineral Intelligence has tracked >400 battery gigafactories that are in the pipeline to 2030, with two thirds of the ~9,000 GWh/year capacity coming from China (see Figure 1). The Faraday Institution estimates 100 GWh/year worth of battery production is needed in the UK by 2030, with this growing to 200 GWh/year by 2040 as demand grows for in

"The stone age came to an end, not because we had a lack of stones, and the oil age will come to an end not because we have a lack of oil"
Sheikh Ahmed Zaki Yamani, former Saudi oil minister [1]

sectors such as EVs and grid energy storage. Expertise in UK battery production does exist, with notable large-scale examples being AESC Envision's 2 GWh Sunderland plant (with the addition of 12 GWh by 2025) and Agratas's (Tata's Group's global battery business) planned £4bn 40 GWh plant, with battery production planned to start in 2026, bringing potentially 4,000 jobs to the Somerset region[3]. However, based on current announcements, the UK is still far behind in meeting this future battery demand, which will impact competitiveness.

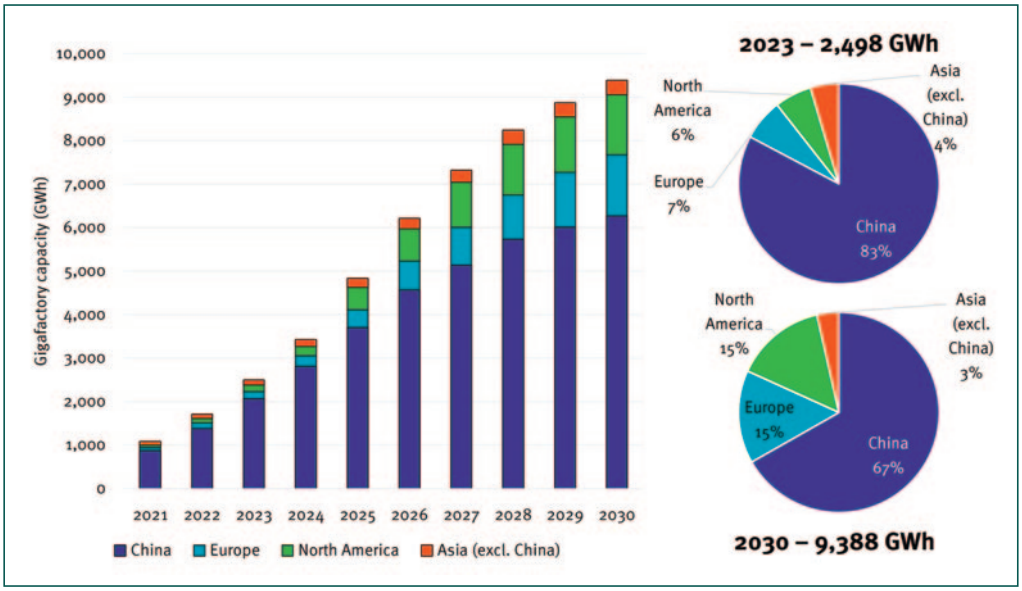

Figure 1 – >400 announced battery gigafactories in the pipeline to 2030, with most of these in Asia. Adapted from Benchmark Mineral Intelligence data

CRITICAL INDUSTRY NEEDS CRITICAL ELEMENTS

In order to meet this demand, the UK will need to source the critical minerals that are used to manufacture batteries, which includes: lithium, nickel and cobalt, amongst others. The supply chains for all of these elements are complex. Taking lithium as an example, the vast majority of raw material supply currently comes from Australia, Chile and Argentina (see Figure 2). However, this needs to be processed into suitable forms for use into batteries, with China being the dominant supplier of the lithium hydroxide and lithium carbonate used in battery production. The global trek that these battery materials make; from Chile to China and then to the UK, opens important questions around sustainability and resilience.

These challenges are compounded by the fact that setting up new mines is extremely capital and time intensive; with highly volatile commodity prices being a key area of uncertainty for the economic viability of future projects. As such, there will likely be mismatches between battery cell production and the supply of critical minerals. In the case of battery grade lithium chemicals, whilst there are potential supply streams that can be ramped up, this is unlikely to keep up with demand in the near term. This potential shortage is estimated to occur towards the end of the decade; limiting cell supply and EV deployment plans.

Developing battery recycling capacity will help but not address all supply demands, with significant lags between old EVs entering the system and the material becoming available for manufacturing. The economic viability of recycling is compounded by current high costs, however, innovations in recycling are certainly possible, though supporting regulations will be needed. The EU Battery Regulation for instance is putting into place rules around recycling efficiency, carbon footprint thresholds and minimum levels

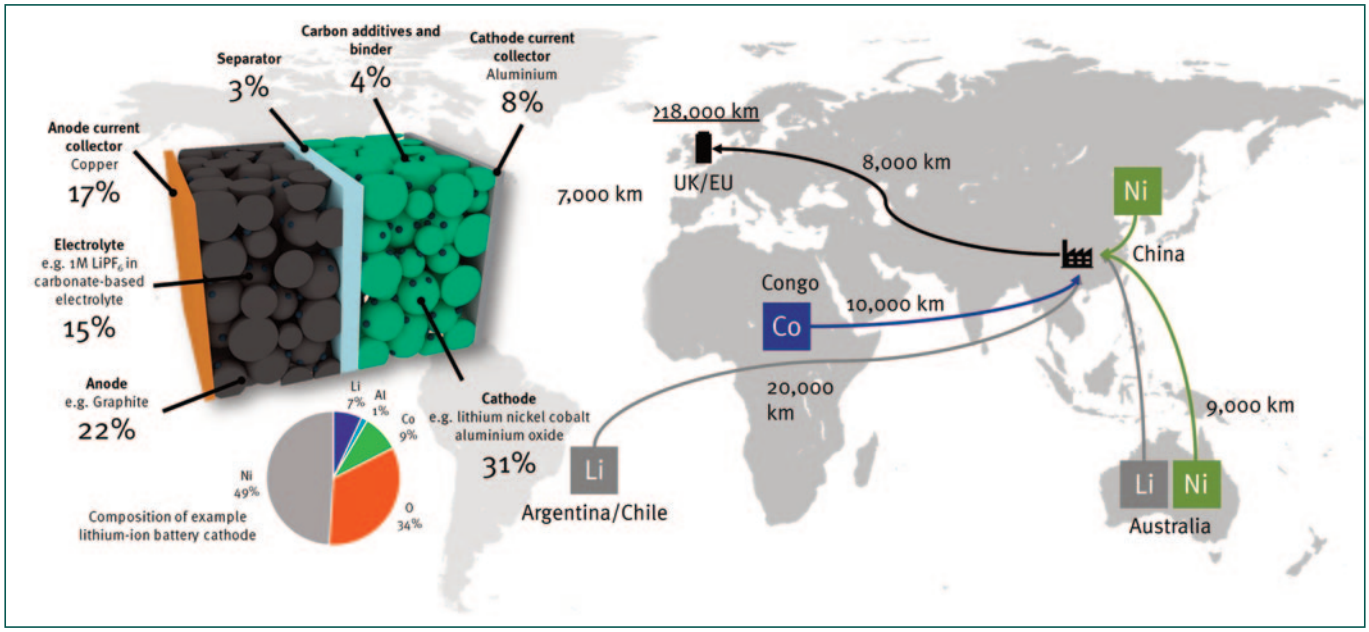

Figure 2 – Critical elements within a lithium-ion battery and typical supply chain route

of recycled battery material to be used in future batteries, supported by a battery passport system to track key metrics. Given that ~80% of UK vehicles produced in 2020 were exported, half of which were to Europe[2], ensuring UK batteries are low-carbon is not just an environmental imperative, but an economic one if alignment to EU markets is sought.

THE WINNERS WILL BE THE INNOVATORS

The UK has and continues to be an intellectual powerhouse with key strengths in battery research. Professor John Goodenough, the 2019 Nobel Prize winner in Chemistry, conducted his seminal work on lithium cobalt oxide at the University of Oxford in the 1980s, the material which would go into the first commercially available lithium-ion battery. Yet, despite the core conceptual advance being developed in the UK, Asia benefited the most, with Sony (after a decade of further research) being the first to commercialise and scale the technology. This is a cautionary tale of missed opportunities.

Ultimately, the field of batteries is rapidly evolving, and the winners of this global race will be the ones who continually innovate. Beyond the traditional lithium-ion battery, a whole family of other technologies are on the cusp of commercial viability. Current sodium-ion batteries, whilst having slightly lower specific energy (~160 Wh/kg sodium-ion vs ~250 Wh/kg lithium-ion), use earth abundant elements and would be highly suitable for smaller EVs and grid connected energy storage. Here, the UK already has significant strengths – Sheffield-based Faradion is a global technology leader and supporter of the Faraday Institution NEXGENNA project on sodium-ion batteries. China has already recognised the potential of sodium-ion technology, with scale-up facilities advancing rapidly.

Solid-state batteries have also garnered significant interest as a potentially safer and more energy dense alternative to traditional lithium-ion technology, with some demonstrating a specific energy as high as 500 Wh/kg. Lithium-sulfur batteries, which remove the need for nickel, another critical mineral, have the potential to have a key role in the electrification of aerospace applications. The UK research community has long since recognised the importance of these technologies. The Faraday Institution has built a leading community of 27 universities, >120 business and ~500 researchers pushing boundaries and forming a strong intellectual foundation, ready to reap the rewards of the investments to date.

However, translation of research takes time, with history suggesting that taking a technology from fundamental discovery to commercialisation can take up to 10 years, and potentially even longer with global scale-up of complex supply chains. Therefore, the battery industry needs to be viewed as a long-term investment, requiring sustained support to realise the significant benefits.

KEY MESSAGES

- Pace of action needs to increase to maximise a once-in-a-generation economic opportunity.
- UK EV production could reach 1.8 million by 2040, but needs a domestic battery manufacturing industry.
- Ensuring these UK batteries are sustainable is both an environmental and economic imperative. Around 80% of vehicles made in 2020 were exported, half of which were to the EU where the Battery Directive is in force, which stipulates sustainability targets.
- Battery supply chains are complex. The main raw lithium suppliers include Chile, Australia and Argentina, but most of the processed battery grade lithium chemicals come from China, with demand outstripping supply potentially towards the end of the decade.
- The winners will be the innovators of new technologies such as sodium-ion batteries, which is on the cusp of commercialisation. Here, the UK is well placed to have a leading position in next generation batteries with an already established strong R&D base and innovation pipeline. It is poised to be an industrial leader in this area but long-term support is needed to create sovereign capability.
- Highly skilled people will be the innovation engine for export opportunities, with a successful EV industry potentially supporting 270,000 UK jobs.

SKILLED WORKERS, THE INNOVATION ENGINE

With the need to innovate, developing a pipeline of skilled workers to power this industry will be essential. In the scenario where 1.8 million UK EVs are produced, this can potentially support ~270,000 jobs by 2040, with 170,000 in vehicle manufacturing, 35,000 in gigafactories and 65,000 in the broader supply chain[2]. These jobs will require skilled people across the industry from production staff to R&D leaders, with training programmes essential to meet the growing requirements.

Creating a sustainable UK battery industry has huge long-term environmental, economic and societal benefits, and needs to be done. This will not be easy, but the prize for those who win this global race will be massive.

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Can we protect staff, patients and visitors better whilst reducing waiting times, saving money and driving towards net zero in the nhs estate?

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Data and modelling for all NHS hospitals in England (by adding specialist hospitals), estimated 834 000 Health Care Acquired Infections (HCAIs) in 2016/2017 costing the NHS £2.7billion, and accounting for 28,500 patient deaths, 7.1million occupied hospital bed days (equivalent to 21% of the annual number of all bed days across all NHS hospitals in England) and 79,700 days of absenteeism among front-line Health Care Professionals (HCPs)(Modelling the annual NHS costs and outcomes attributable to healthcare-associated infections in England, 2020, J. Guest et al)

Later in the pandemic, between June 2020 - March 2021 circa 131,000 patients acquired Covid in hospitals, 1.5% of all admissions (Ben Cooper et al 2023) but also the table below confirms some sample hospital figures on staff sickness from the pandemic and the reduced level of PPE that this could entail.

Hygiene is crucial in all settings providing healthcare services. ill patients are the most vulnerable to disease or infection. Also, there is a large staff cohort and a significant number of visitors which combine to escalate the infection risk significantly and indeed, potentially, to be at risk from others too.

2500 years ago, the Father of Medicine, Hippocrates, developed the "Miasma Theory", stating that diseases were the product of environmental factors such as contaminated water, foul air, and poor hygienic conditions. We estimate that approximately 25% of HCAIs are from airborne infection of respiratory diseases, so the correct ventilation rates in healthcare buildings' is essential so that the air that people breathe within our NHS facilities is clean, wholesome and uncontaminated and that the air that occupants exhale, which could be a potential source of infection risk to others, is removed or inactivated quickly.

However, increasing these air change rates indoors can be costly and also, disruptive if one has to upgrade existing healthcare building mechanical ventilation systems. (We estimate that approximately 50% of NHS facilities are non-compliant with the requisite minimum ventilation standards). Such traditional methods of improving ventilation rates also impact the availability of clinical spaces whilst works are safely undertaken and so, have the potential to add to waiting times, one of the greatest challenges in the NHS.

We also need to bear in mind that Government policy dictates a decarbonisation agenda and therefore, providing higher ventilation rates to protect healthcare facilities better will require more energy than currently utilised even with enthalphy recovery systems, which is counter-policy. However, there are alternatives to satisfy the necessary Net Zero aspirations and comply with the various Guidelines, Standards and Regulations relating to Health Care Building Ventilation and Infection Control and Prevention.

Alternative solutions that have been used during the pandemic are portable air cleaning devices, which are helpful for short-term and temporary situations but the longer-term answer that should be considered for roll-out across the NHS Estate is to install, hard-wired high-level "Upper Room" GUV air cleaning that use a certain wavelength of light to disinfect the air closest to the source of airborne contamination risk (above the human exhaled air plume) Similar GUV technology could be applied to overall building

Table 1: Annual Sickness Absence Rates by NHS England region

		2019-20			2020-21			2021-22		
		Full Time Equivalent Days Lost to Sickness Absence (includes non-working days)	Full Time Equivalent Days Available (includes non-working days)	Sickness Absence Rate	Full Time Equivalent Days Lost to Sickness Absence (includes non-working days)	Full Time Equivalent Days Available (includes non-working days)	Sickness Absence Rate	Full Time Equivalent Days Lost to Sickness Absence (includes non-working days)	Full Time Equivalent Days Available (includes non-working days)	Sickness Absence Rate
	England	**19,568,889**	**436,884,468**	**4.48%**	**21,182,524**	**454,869,841**	**4.66%**	**25,570,899**	**474,999,954**	**5.38%**
Y56	London	2,812,414	72,753,780	3.87%	3,187,140	75,924,854	4.20%	3,710,128	78,532,290	4.72%
Y58	South West	1,858,512	42,159,972	4.41%	1,795,094	43,302,314	4.15%	2,353,899	45,864,901	5.13%
Y59	South East	2,379,085	57,127,680	4.16%	2,626,216	59,651,244	4.40%	3,048,654	62,489,831	4.88%
Y60	Midlands	3,656,790	76,262,071	4.80%	3,901,398	79,710,626	4.89%	4,732,562	83,799,687	5.65%
Y61	East of England	1,706,151	39,925,535	4.27%	1,908,684	41,733,136	4.57%	2,259,575	43,437,805	5.20%
Y62	North West	3,424,429	65,885,885	5.20%	3,807,522	68,906,318	5.53%	4,527,099	71,238,583	6.35%
Y63	North East and Yorkshire	3,393,176	71,298,031	4.76%	3,681,485	73,536,048	5.01%	4,533,539	75,639,823	5.99%
QZZ	Special Health Authorities and other statutory bodies	338,332	11,471,514	2.95%	274,986	12,105,300	2.27%	405,443	13,997,034	2.90%

Figure 1: NHS Sickness Absence Days from the Health and Social Care Information Centre. As you can see from the data an extra 4.4 million "sick days" were taken by NHS staff during 2022 – adding to costs and waiting list times.

ventilation improvement using chemical free photo-disinfection in the HVAC system. This is easily achieved by placing an engineered design array GUV lamps within the ventilation system's ductwork which means that air is decontaminated at source.

When pathogens are exposed to GUV light of the correct intensity and for the correct exposure time their DNA/RNA is reconfigured and damaged such that mitosis cannot occur and inactivate the pathogen, rendering it harmless and unable to multiply. This will result in safer building environments for patients, staff, and visitors. Potentially allowing safely decontaminated air to be recirculated in more areas of the Estate which will help our ability to hit Net Zero and also allow greater utilisation of work space and theoretically reduce waiting times.

A Nobel Prize for Medicine was awarded to Niels Finsen in 1903 for "his contribution to the treatment of diseases, especially lupus vulgaris, with concentrated light radiation, " This light, GUV has been successfully applied against highly infectious airborne diseases

The inactivation solution depends on the medium (air, water, surface), environment, hazard source, presence of people or animals, temperature, humidity, bio-load, exposure time and the target microbe(s) that one seeks to eradicate. GUV lamps operate between 200 and 280nm wavelengths of the electromagnetic spectrum by passing an electrical discharge through a low-pressure gas (including mercury vapour) enclosed in a soft glass or quartz tube. Researchers over the past 80 years have found that the optimum wavelength for lamps to operate at is 254 nm, at which they are Germicidal, the most efficient to destroy microbiological matter. GUV emitters of 222nm, known as FAR UV, are currently being assessed for future potential by several UK and international universities and are less harmful to human skin and eyes.

HEPA filters are another alternative to GUV, they were created originally for the Manhattan Project to stop radioactive material escaping the labs. They are very effective at stopping microbes too, however, they are also very energy-intensive because the filter pores are so small to push air through, and the pressure drop reduces the airflow significantly unless more energy is applied to get the air flow rate to the requisite level for adequate ventilation.

OPTIONS

Portable Air Cleaning Units

Portable UVC or HEPA devices should only be considered as a temporary solution and where used, they must be positioned to avoid interference. They operate as a recirculating air system that passes air from the room space through the device decontamination chamber which has a GUV light which disinfects or a HEPA filter and then, discharges that cleaned air into the room, so they need clear space in front of their intake and their discharge grills to be effective. Unfortunately, most types exceed NHS standards on noise.

Infection Source Control – GUV Upper Room Devices

GUV Upper Room devices have been in use for several decades to combat respiratory diseases such as tuberculosis and importantly, they were deployed in the previous COVID pandemic (SARS in 2003) in Hong Kong Hospitals successfully. These devices were positioned between patient beds and about 2.7m off the floor to intercept/disinfect the exhaled air from the patients below.

Upper room devices are also, a low-cost and easy-install intervention for areas with inadequate ventilation (We estimate over 50 % of Health Care Spaces are insufficiently ventilated) because they provide an equivalent decontamination rate to make up for the shortfall that should exist to comply with conventional ventilation requirements, often exceeding 10 air changes per hour.

The Hong Kong hospitals were fully equipped with these GUV tools to deal with airborne pathogens, and they managed incredibly well under the COVID-19 (SARS-2) pandemic.

Primary Building Ventilation

Correctly engineering GUV lamps installed into HVAC ductwork, whether that be retrofit into existing or newly built hospitals' ventilation systems, would make sites safer from respiratory-driven nosocomial infection sources, would make the NHS Estate pandemic-resilient but also reduce the enormous burden that respiratory illnesses bring to hospitals, especially each winter. This safe intervention can only serve to free up beds and so also, to reduce waiting times.

Adding GUV light to building ventilation systems is a long-term investment with little maintenance and some of the products on the market can be linked to the building management system for optimising energy and ventilation rates. GUV is now specified in the latest version of The Building Regulations and so, the use of GUV should now be retrospectively applied to the NHS Estate to bring all healthcare facilities up to the correct compliance levels and standards of healthier building.

There have been very few studies undertaken on the impact of GUV and its positive impact on internal air quality. The next stage for the NHS Estate is to run some large trials to confirm the savings that they bring in both electrical costs, reduction in staff sickness absence, and the reduction in nosocomial infection leading to prolonged stays for patients and bed spaces freed. Some work undertaken on creating infection-resilient environments puts the potential savings at around £23 billion per year per the Royal Society of Engineering report on Infection Resilient Environments social cost benefit analysis. ■

DELIVERING HEALTHY AND SUSTAINABLE INDOOR ENVIRONMENTS

Chris Rush
Project Director and Air Quality Consultant at Hoare Lea.
Chair of the Institute of Air Quality Management.

YOU ARE WHAT YOU BREATH

There has never been a more important time to engage with how we bring about a healthy and sustainable indoor environment. A healthy space comprises a number of aspects – acoustics, air quality, lighting and other environmental parameters like temperature and relative humidity.

In developed countries like the UK, we spend around 90% of our time indoors, whether at home, at work, or commuting between the two. Further, we spend around two thirds of our time in our homes. This means that most of our exposure to health impacting elements of that environment, such as air pollution, happens in the home, even if the pollutants were generated outdoors. When we consider that air is one of our largest daily consumables – its quality has a significant impact on our health and wellbeing.

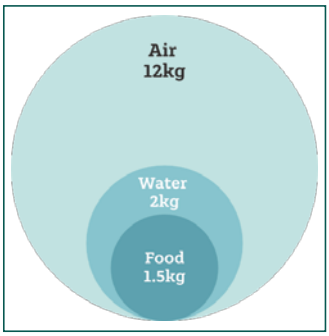


Figure 1: Average daily consumption of an individual

The effects of climate change continue to impact our everyday activities – with extreme weather events – such as high temperatures being experienced across the UK driving people to take refuge in their buildings. Drawing the curtains and sealing themselves into these indoor environments is a thing that is happening now – shifting more of people's time to indoor spaces at times of year which historically saw a proportion spent outdoors.

The recent Covid-19 pandemic demonstrated the importance that buildings play in keeping us healthy – and indeed how good ventilation in buildings can help reduce the transmission of the virus (and other airborne diseases). Aspects, like good ventilation also improve IAQ, where the main sources of air pollution are indoors.

Of particular concern within the net zero context, is that buildings will continue to become more airtight through energy efficiency measures to the detriment of IAQ.

The air we breathe contains many different and often invisible pollutants that as individuals we can't sense.

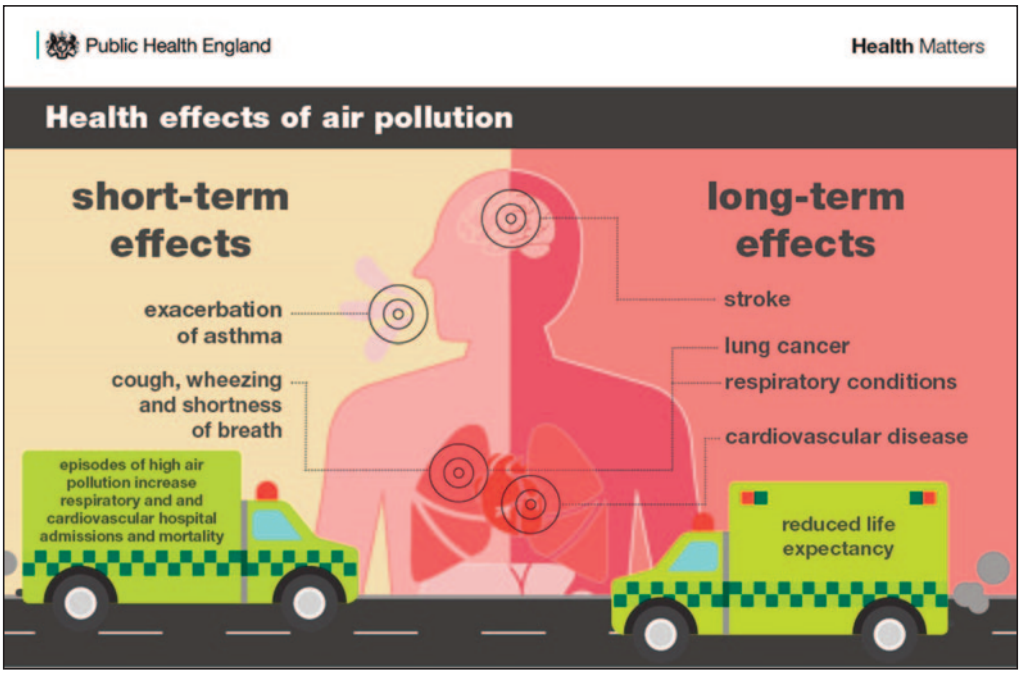


Figure 2: Health effects of air pollution: source PHE

These pollutants can bring about a range of short and long term health impacts as seen in figures 2 and 3.

Liken every breath to a sip from a glass of water. If that water you got from the tap in your home or workplace was dirty – it wouldn't be consumed and action would be taken immediately to remedy the situation given the importance of water not just for good health but our survival. Every breath that we take contains numerous pollutants and is equivalent to drinking a dirty glass of water.

Figure 4: You are what you eat, drink and breath: source google 2024.

A study undertaken by the Royal College of Physicians (RCP) highlighted that each year in the UK approximately 40,000 deaths are attributable to exposure to outdoor air pollution, which equates to an annual financial cost in excess of £20 billion to the UK economy . As part of this the area of the internal environment within buildings and the relationship between indoor air quality (IAQ) and the health of occupants was highlighted as needed further investigation.

Knowing the robust science with regards the impact poor air quality and environments have on our health and wellbeing, how can we improve our buildings and the spaces we live, rest, work, learn, play and enjoy our time in. Could we harness our buildings and indoor spaces to not only be safe places that are not causing us harm – but could even offer improvements to our health and wellbeing and in turn even a marginal

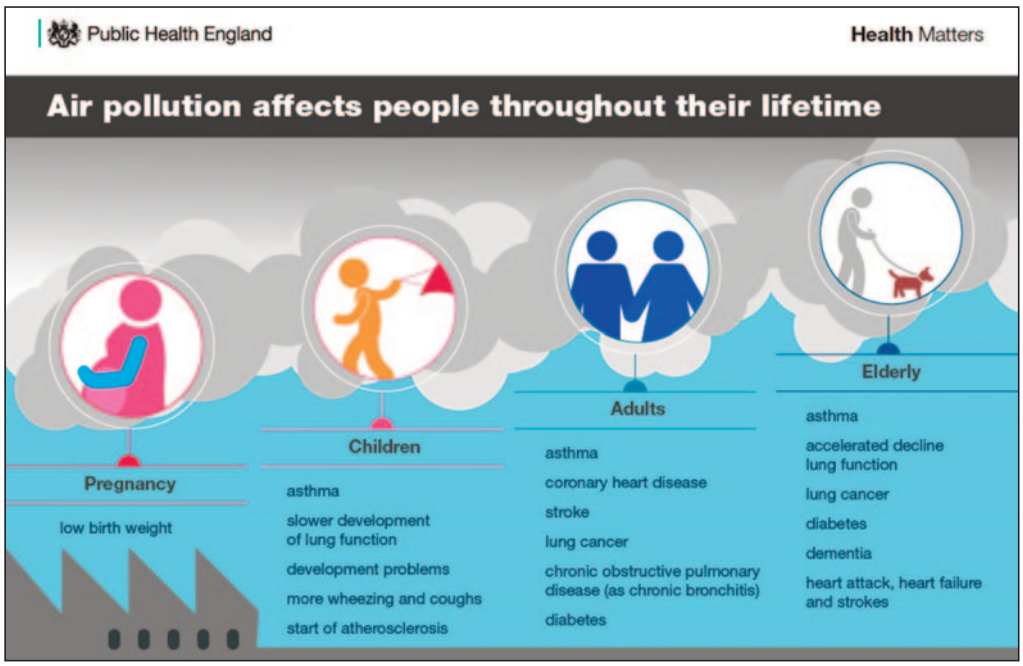


Figure 3: Air pollution affects people throughout their liftime: source PHE

improvement could deliver significant financial benefits to the UK economy when considering the values mentioned earlier.

MIND THE GAP

The existing limited legislation in place that influences the health of individuals within our buildings – if present at all – is in part disconnected with the latest internationally recognised limits and levels setout based on research. An example of this is the UKs air quality objectives, or limits. When these are compared with both the 2005 and the most recent 2021 World Health Organisation (WHO) Air Quality Guidelines as illustrated in the below figure 5, it's possible to observe the disparity between the science the legislative that is informing the majority of design and operations of our indoor spaces.

SHIFTING APPROACH

When looking at how to bring forward a healthy and sustainable indoor space, outside of legislation, that would be required to facilitate this shift. How various stakeholders engage with the topic of health and the indoor environment is one area of opportunity.

IDENTIFICATION AND UNDERSTANDING

Architects, building services engineers, building managers and specialist consultants, such as air quality, are some of the

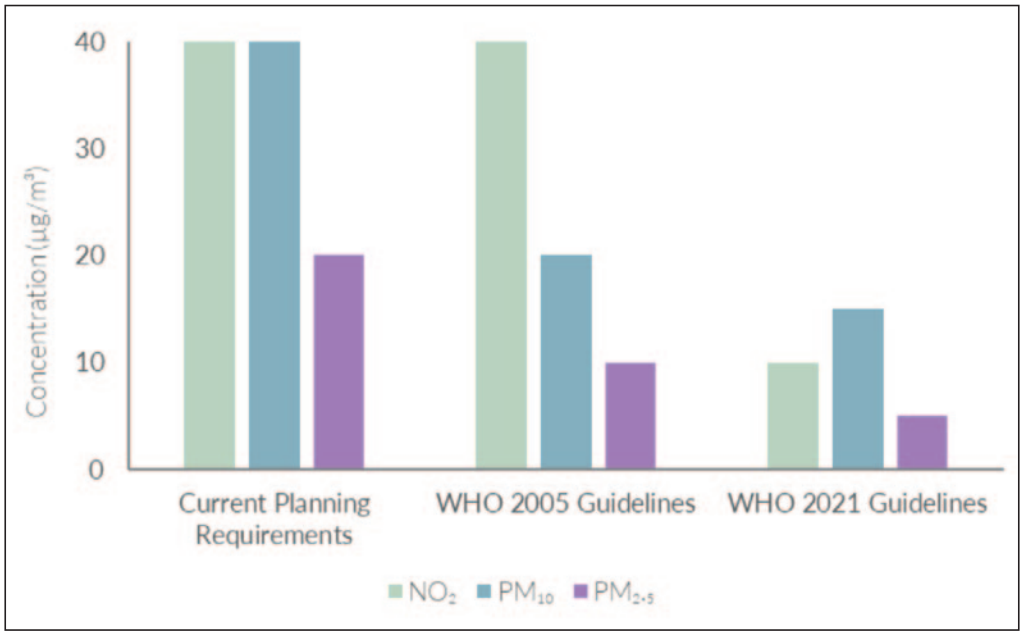


Figure 5: Illustrative comparison of UK air quality objectives (limits) compared with WHO guideline values for NO_2, PM_{10} and $PM_{2.5}$

people who have a role to play in how the quality of our indoor spaces is taken into account in the design and subsequent operation of a building.

Having a firm grasp of the issue at hand and the science is the first step in moving towards a building with the desired indoor environmental quality (IEQ). This means that identifying and understanding both the outdoor and indoor environment in terms of the sources of pollution as well as the pollutants' chemistry / physics and behaviour in the environments is necessary in order to inform other professionals in the group, such as the architect and the building services engineer. This allows for effective design and subsequent operation.

ADAPTATION AND MITIGATION

Effectively adapting the building design and applying mitigation as appropriate to address and account for the prevailing and projected quality of the air sits largely with the mechanical engineers and architect, and they will have been and should continue to be guided by the specialist in the area e.g. air quality expert.

As with the identification and understanding stage, to realise the full potential that IEQ can offer, adaptation and mitigation should not be progressed in isolation – and the role of the specialist expert is to support the mechanical engineer and architect in the interpretation of the impacts of design decision on IEQ.

IMPORTANCE OF COLLABORATION

The complexity of the indoor environment, with different disciplines interacting, collaborating and influencing IEQ outcomes, means that specialist experts are integral. Having a solid scientific basis on which to build is critical and means that this expertise acts as an identifiable point of reference for a project team to help navigate the growing complexities and opportunities in this evolving topic in the later design stages. This allows for a truly robust design and operation.

NEXT STEPS

There appears a level of consensus that legislative drivers are needed to support a healthy indoor space. In parallel to this a focus should be given to both behavioural and system change – the perception and role of a building services professional and specialist – such as an air quality consultant, as part of the design, commissioning, handover and operation of our buildings needs to shift in approach to take account of the demand from consumers and growing science base.

Early consistent and ongoing considering through these stage is needed in an informed way back by robust science. How the quality of this important part of an individuals environment is communicated to them and how they are able to interact with it, needs to be improved to allow for maximum benefits to be realised.

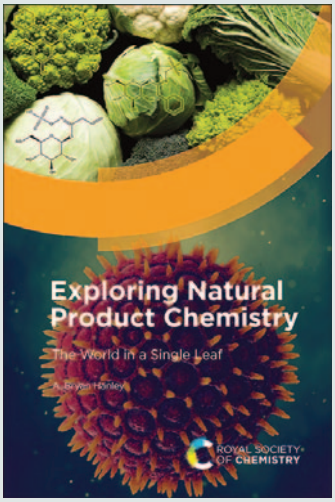
While there may be a cost associated with better consideration of indoor spaces and the health outcomes they provide – this should be seen as an investment. Given the significant financial costs to the UK economy – impacts to NHS, lost work days, associated with poor quality environments – alongside elements like investment attraction and retention – providing better improved indoor spaces is of huge importance given the increasing pressures and demands that our buildings are being put under.

To support in the uptake and investment associated with improved IAQ given the complexities in this area, a performance metric with a health strategy set for a building.

Strategic engagement with the topic of health and wellbeing at an early stage throughout a buildings life in a holistic way that provides cohesion and consistency between the various factors at play – acoustics, air quality, lighting, sustainability etc is needed to drive the delivery of a health and sustainable indoor space. ■

EXPLORING NATURAL PRODUCT CHEMISTRY: THE WORLD IN A SINGLE LEAF

By A. Bryan Hanley
Status: Coming soon



About this book

Global warming and, even more recently, the COVID pandemic have brought into public focus our dependence on science and the lens with which it considers the world. Science is providing opportunities for new ways of thinking and has always opened new avenues for creative thought and advances.

This book examines and summarises the developments and changes in approaches to organic and natural product chemistry as seen through the published works of the author and seeks to place them in a philosophical and societal context. Demonstrating and explaining how scientists and, more particularly, chemists arrive at a world view, it will show how this is predicated not just by scientific advances but also by societal influences. The author uses personal experience to detail progress through science. Techniques used in such investigations are alluded to but not described in detail since the interested reader can access the full published papers if required.

Interesting both to the general, scientifically literate reader and to the specialist wanting information on natural product chemistry, the book does not create a rulebook for carrying out natural product chemistry but rather examines the processes that lie beneath the development of natural product chemistry and how this enables chemists to examine and interpret the world. Students of chemistry (whatever their age or stage of career) may also be interested in reading how peer reviewed and published material relates to the wider society view.

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This information was provided by permission of the Royal Society of Chemistry.

STEM FOR BRITAIN 2024

On Monday 4th March, 120 early career researchers from universities and research institutions from across the United Kingdom came to Westminster to take part in STEM for BRITAIN.

This annual poster competition and exhibition is organised by the Parliamentary and Scientific Committee and designed to encourage interaction with MPs and Parliament.

During the course of the day these scientists, engineers, technologists and mathematicians had the opportunity to show their posters and explain their research to over 40 Parliamentarians from both Houses.

The competition comprised of five specialist sections: Biological and Biomedical Sciences; Chemistry, Engineering, Mathematics, and Physics. Judging for each category was undertaken by panels of distinguished scientists:

Gold, Silver and Bronze winners in each category received certificates and cash prizes, with medals going to the Gold winners.

The Physiological Society Prize was awarded for the sixth year running, and the Nutrition Society Prize for the fifth. The Dyson Sustainability Award consisted of three prizes.

CONGRATULATIONS TO THE WINNERS!

BIOLOGICAL AND BIOMEDICAL SCIENCES

L-R **Natalie Jenkins**, University of Glasgow, Bronze; **Karina de Almeida**, University of Nottingham, Silver; **Kyle Greenwood**, Imperial College London, Gold; **Helena Fisk**, University of Southampton, The Nutrition Society Prize, and **Grace Meeker**, University of Oxford, The Physiological Society Prize

Credit: John Deehan Photography

CHEMISTRY

L-R **Zhen Whang**, University of Cambridge, Silver; **Maciej Walerowski**, University of Southampton, Gold, and **Rachel Kilbride**, University of Sheffield, Bronze

ENGINEERING

L-R **Ross Millar**, University of Glasgow, Silver; **Anna Weatherburn**, Durham University, Gold; and Y**asmine Baghdadi**, Imperial College London, Bronze

MATHEMATICS

L-R **Katherine Benjamin**, University of Oxford, Silver; **Daniel Gardham**, University of Surrey, Gold; and **Francisco de Melo Virissimo**, University of Cambridge, Bronze

PHYSICS

L-R **Sama Al-Shammari**, Cardiff University, Bronze; **Christina Ruiz Villena**, National Centre for Earth Observation/University of Leicester, Gold; and **David Bajek**, University of Dundee, Silver

THE DYSON SUSTAINABILITY AWARD

L-R **Zamaan Mukadam**, Imperial College London 3rd Prize; **Sawsan El Zahir**, University of Oxford, 1st Prize; and **Daniel Commandeur**, University of Cambridge, 2nd Prize

Credit: John Deehan Photography

HEALTHY SAFE AND SUSTAINABLE INDOOR ENVIRONMENTS – MANAGING TRADE-OFFS FOR INDOOR AIR QUALITY AND NET ZERO GOALS

Dr Alexandra Smyth, Head of Policy - Infrastructures and Resilience, Royal Academy of Engineering.

Matthew Rooney, Head of Policy, Institution of Mechanical Engineers.

As media attention over recent years has highlighted, air pollution has negative effects on health throughout the course of people's lives. Research shows this often exacerbates existing inequalities, with households in more deprived areas experienced higher levels of indoor air pollution.

Indoor air quality depends on the ingress of outdoor pollutants into the indoor environment; and air pollutants that are emitted indoors. Levels of indoor air pollution depend on factors such as:

- the quality of the building and provision of fresh air;
- where the building is located - near busy or congested roads, or industrial sites;
- indoor activities such as cooking, and heating;
- cleaning and personal care products that can emit pollutants.

Concentrations of these indoor pollutants can be increased by higher occupancy levels, and lack of adequate ventilation. But we know from the work undertaken by the National Engineering Policy Centre, a partnership of 42 professional engineering organisations that cover the breadth and depth of our profession, led by the Royal Academy of Engineering, during the COVID-19 pandemic that ventilation is not well managed in the UK. As it became clear that the COVID-19 virus spreads through aerosols and droplets in the air as well as close contact, the design and operation of buildings and transport infrastructure and the potential to ventilate them well, became public health and policy priorities. But we discovered the UK's infrastructure lacks infection resilience, that is, it was not well equipped to minimise transmission of COVID-19.

While managers of many buildings mobilised quickly to provide hand sanitiser, encourage the use of face coverings, and implement social distancing measures, it was not always easy to provide clean air for people to breathe. With windows painted shut, air-filtration systems not serviced to operate at full capacity and the need to maintain a comfortable temperature, there were few adequate systems in place to respond to changing ventilation needs. A series of evidentiary hearings with building owners and managers found that ventilation systems were often not preforming at the specifications it was designed to. This was considered to be a symptom of a general lack of priority given to buildings management, resulting in a reduced capacity and capability to respond rapidly to the public health crisis and compounded by limited research and regulatory capability to respond to the new demands.

This not only posed a risk to anyone using those spaces during the height of the pandemic but will continue to be a health risk even as the pandemic has waned. Poor indoor air quality can hinder concentration and cause poor sleep, for example. Alongside poor indoor air quality, a lack of adequate ventilation exposes people to harmful contaminants, exacerbating conditions such as asthma, or enabling the transmission of common colds and seasonal influenza. A social cost benefit analysis commissioned to support this work estimated that in the event of another severe influenza-type pandemic during the next 60 years, the societal cost to the UK could equate to £23 billion a year considering costs not only for healthcare but reduction in GDP, depression etc.[1] Even without the extreme circumstances of a pandemic, the report estimates that seasonal diseases cost the country as much as £8 billion a year in disruption and sick days.

The National Engineering Policy Centre report, "Time for a major upgrade", highlights eight actions to improve the health and sustainability of our indoor environments through regulations and standards that

apply throughout the life of a new or existing buildings, setting a clear baseline for what best practice in infection resilience looks like, and encouraging a commissioning process that ensures all buildings operate as they were designed to.[2]

While we expect our buildings to have water that is safe to drink, we may not consciously have that same expectation for clean air. The quality of indoor air is not monitored or reported like energy performance or food hygiene, and many buildings have no formal management in place to monitor this. COVID-19 has been a wake-up call about the importance of good ventilation and now remains an opportune moment to take steps to improve indoor air quality more broadly. It is vital that we raise awareness of good practice, making buildings that manage clean air well stand out. This will encourage action from others, allow individuals to assess their own risk, and help to ensure we can all play a role in maintaining healthy environments, from our homes to our workplaces.

This is not the first time that a major disease outbreak has required our built environment to evolve and adapt: cholera epidemics in the early 19th century drove the development of effective sewage systems; tuberculosis led to changes in building design to allow for more sunlight and air; and major outbreaks of legionella and *E. coli* in the UK resulted in regulatory reform on water treatment and food standards.

The UK is already working to transform the built environment and transport sector to meet the Net Zero targets enshrined in UK law. Measures that seek to improve energy efficiency – such as increased insulation and double glazing and reduced infiltration – may reduce the ingress of outdoor pollutants from nearby industry and traffic. However, these measures can allow accumulation of pollutants from indoor sources if there is not also adequate ventilation for indoor pollutants to leave the building and introduce fresh air. But with intelligent engineering design, or mechanical ventilation with heat recovery systems that reduce heat loss, we can achieve both. Even simple actions such as proper installation and maintenance of ventilation systems, and managing ventilation needs throughout the day, can help reduce energy demands. There is an opportunity to be seized by aligning UK decarbonisation strategies with improving the health of our indoor environments.

This needs to be supported by regulation. To create a culture shift, the prominence of health and wellbeing should be embedded across parts of the Building Regulations. Indoor environmental quality encompasses not only air quality, but also levels of light and noise pollution and thermal control, all of which have a direct impact on health, as well as implications for energy demand. To maintain standards of safe and healthy building performance over a building's lifetime, in-use regulations need to be established with local authorities. This needs to be accompanied by the capacity, skills, and capability for enforcement, as well as clear mechanisms to measure and publicly communicate compliance.

Much research has been done during the pandemic on air flows and ventilation to control the spread of the airborne COVID-19 virus. We must take the opportunity to integrate that learning with what we know about reducing emissions and fire safety to deliver buildings that are safe, healthy and sustainable – throughout their entire lifespan as well as on the drawing board.

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HEAT AS A THREAT TO HEALTH – STRENGTHENING OUR RESPONSE AND BUILDING RESILIENCE

Emily Loud and Carl Petrokofsky, Extreme Events and Health Protection team, Centre for Climate and Health Security, UKHSA

A warm summer day is often a cause for cheer among the British public. However, we know that hot weather can be harmful and, due to climate change, it's becoming an increasingly significant threat to health in the UK. Although many people may be familiar with heat-related illnesses such as heat exhaustion and heat stroke, higher temperatures also exacerbate existing chronic illnesses and increase likelihood of heart attacks, strokes and respiratory problems[1]. Initial analysis shows that there were 2,295 deaths due to heat last summer,[2] following a peak of almost 3,000 deaths in 2022[3]. In future, these impacts are only projected to grow, with the UK looking at more than 20,000 deaths due to heat each year by the 2070s[4] (figure 1) under a worst-case scenario (with limited decarbonisation or adaptation). Though substantial, these numbers don't capture the long shadow cast by the impact of

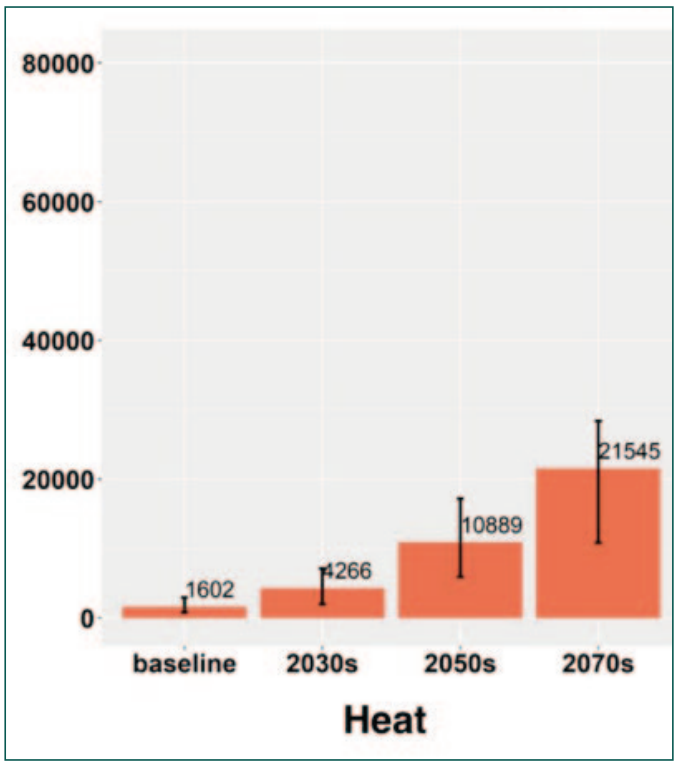

Figure 1: projected heat-related mortality in the UK by decade. From UKHSA's Health Effects of Climate Change 2023, Chapter 2: Temperature effects on mortality in a changing climate

heat on health service demand and delivery. It's been estimated that there are as many as 102 admissions for every death due to heat[5].

The scientific evidence that heat is a current and growing health problem is clear. What, then, are the solutions? Fortunately, harms from high temperatures are not inevitable. They can be prevented by individual, organisational and societal level adaptations, many of which also have other benefits for public health. In response to the growing challenge of heat, in a context where many other types of weather are growing more extreme due to climate change, our organisation the UK Health Security Agency (UKHSA) launched the Adverse Weather and Health Plan in spring 2023[6]. This programme of work includes the plan itself, the supporting evidence that informs it, guidance for the public and professionals, and the Weather-Health Alerting System[7]. This approach represents a step forward internationally, by addressing several types of extreme weather together. Another innovation was the introduction of impact-based alerting for the Weather-Health Alerting System. This means alert levels reflect not only the risk to health posed by a temperature threshold being breached, but also the possible impact of temperature given other risks that may be present across the health and care system[8]. For example, the impact of hot weather could have more of an effect on people's health when it coincides with large outdoor sporting or music events, or when health services are dealing with an increased number of COVID-19 patients.

Even with these advances, we recognise that we all need to do more to protect health as the planet warms. So we were glad to be part of the discussion in November 2023, when the Parliamentary and Scientific Committee hosted an event reflecting on the record-breaking summer heat of 2022. There, The Physiological Society[9] (and others[10]) shared research on the UK's hottest summer so far, and called for a national heat resilience strategy. This would supplement work started by the Adverse Weather and Health Plan, which recognises that heat preparedness needs to be a year-round activity, and organisations across health and care sector need to understand and engage with relevant guidelines ahead of time. This includes working with the public (for example through WeatherReady[11] and Beat the Heat[12] materials), who need to be able to understand the risks heat poses to their health and how to minimise them.

All of this requires mobilisation and reorganisation of resources. However, many of the measures for building heat resilience in the UK are impressively good value for money. Total economic costs of heat-related mortality in the 2020s is projected to add up to approximately £6.4 billion pounds per year[13]. The wider costs due to non-fatal harms and lost productivity due to heat will be far larger. Against this costly backdrop, there are a series of solutions that can generate up to £10 of net economic benefits for every £1 invested. This includes heat alerts and hot weather planning, weather and climate services including early warning, and capacity building. These form part of our current package of work at UKHSA, which includes a suite of targeted guidance[14] and training materials[15] for health and care professionals in addition to an alerting system.

But even with this promising picture, there are still research gaps that must be filled. One clear example is improving our understanding of how health

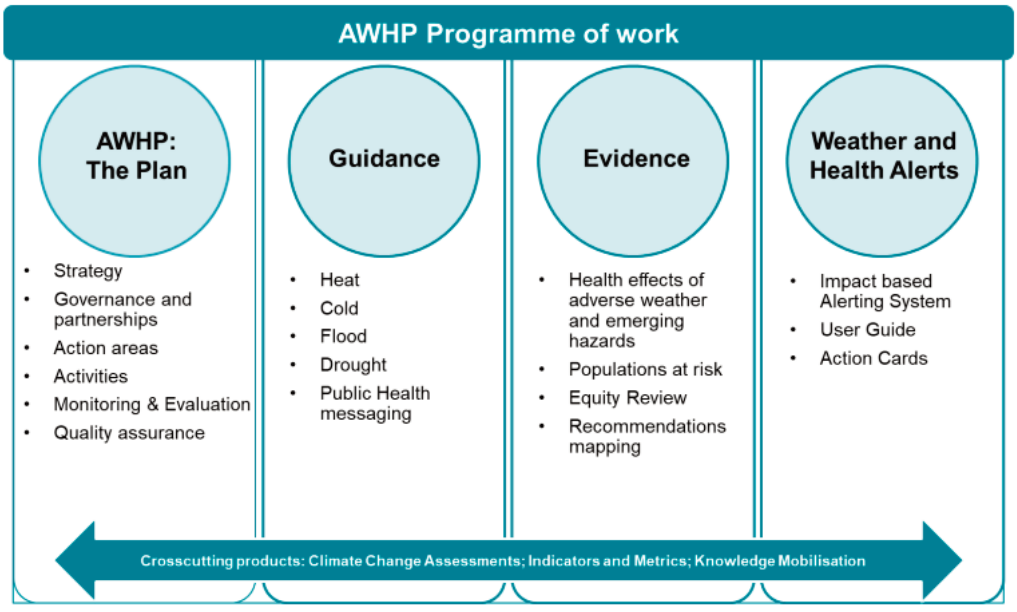

Figure 2: the Adverse Weather and Health Plan programme of work at UKHSA

inequalities in heat-related harm can be reduced[16]. Hot weather does not affect everyone equally, with older individuals, those with existing health conditions, and people who are unable to adapt their behaviours or environments most at risk of illness. In this context, more work is required to understand how best to protect some of the most at-risk and marginalised groups in the heat, including homeless individuals[17].

Figure 3: public facing advice about what to do in hot weather from UKHSA

However, as a crisis professional will tell you, resilience to any threat goes beyond response, and depends on preparing for success with longer term actions. The Adverse Weather and Health Plan can prevent harm to health through supporting behaviour change when temperatures climb. However, the extent to which someone is physically able to change their behaviour to protect themselves from heat can be reduced if they have limited funds, low quality accommodation, or insecure living arrangements, among many other barriers.

This is where building the infrastructure that enables everyone to keep cool is crucial. Evidence points to adaptations like high quality windows, external shading (like shutters) and natural ventilation, as well as increasing green space in cities as being important for bringing down temperatures for all without using more electricity[18]. While interventions like air conditioning may be helpful to protect the health of the most at-risk individuals (such as in hospitals and care homes), passive cooling options can be highly effective in most situations and don't worsen global warming while tackling its effects. These options and more were laid out by the Environmental Audit Committee in January 2024, which recommended the government enable greater access to them[19].

In England we have therefore started the essential work of strengthening our response and resilience to hot weather but, as the Adverse Weather and Health Plan highlights, reducing excess illness and death related to heat is not something that can be tackled without a long-term strategic approach. At UKHSA, we look forward to continuing our work to strengthen England's response to hot weather, while collaborating with researchers, wider government and four nations colleagues to ensure that together we are laying the foundations of heat resilience in our infrastructure, as well as creating strong systems to protect all those at risk.

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A HUMAN-CENTRED APPROACH TO CLIMATE CHANGE: FROM PHYSIOLOGY TO POLICY TO ACTION

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Do you remember the time when an article on climate change had to start with a wealth of statistics on the climate? Those days are gone, such an opening salvo is no longer required. As we sit in the UK and write in the world's warmest February on record, with Spring a month early, it must be obvious to all that across the globe we are witnessing changes in our climate. These changes are resulting in diverse risks and challenges, ranging from the direct threats of extreme weather, to challenges to food and water supplies, mental and physical health. There are knock-on consequences for health care systems, social unrest, migration, mortality and the existence of humanity, and these issues are set to get worse.

Physiology is the science of life. It describes the mechanisms of living things, from cell function to the integrated behaviour of the whole body. It includes examination of the influence of the external environment on human physiology and pathophysiology. As such, it should be a central weapon in the response to climate change. For example, those designing green indoor and outdoor living spaces must know what constitutes thermal comfort for a human. Therefore, an understanding of thermal physiology should contribute to the design specification.

What do we know about this? Humans evolved via intellectual and technological advancement, rather than alterations in body composition (more blubber or fur). The oldest building made by hominids (in Tanzania) was a windbreak constructed by *Australopithecus* ~3.25. million years ago. More than 1 million years ago, *Homo erectus* was building huts from stones, branches and furs. Clothing might have been used by humans 120,000 years ago. Throughout history, humans have used these behavioural adaptations to create a microclimate next to the skin, and consequent body temperatures, that matched the same, comfortable, thermal state seen when naked and at rest in their East African origin (skin temperature 33°C, deep body temperature 37°C). Thus, anyone who reports feeling thermally comfortable is likely to have body temperatures that are very close to these (Tipton et al, 2007).

While an intellect-driven, technological form of evolution has its advantages and has been "successful", underpinning an explosion in the numbers of humans on the planet, it has two major drawbacks. Firstly, we become very dependent on technology for comfort, function and survival. This is particularly evident when it fails or is overwhelmed and we see tens of thousands of excess deaths

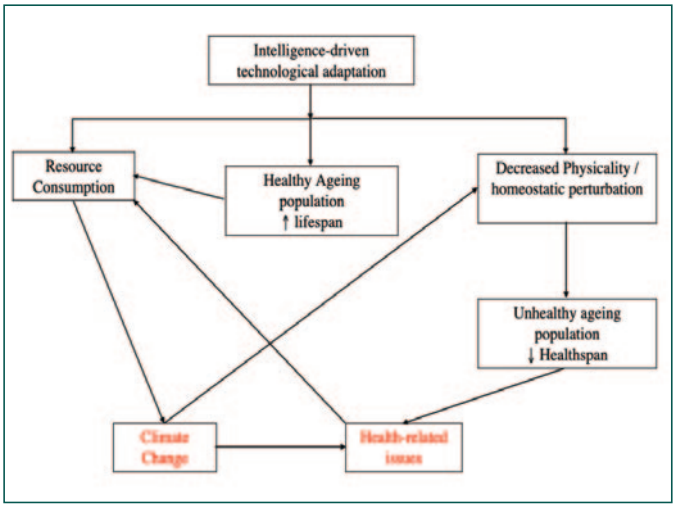

Figure 1. The link between intelligence-driven technological adaptation, climate change and health-related issues (from Tipton & Montgomery, 2022)

occurring during cold snaps and summer heat waves. Secondly, a technological approach can consume finite resources and, when the energy required comes from fossil fuels, the problem of climate change is compounded as we use more energy to cool, heat, pump and blow, and thereby enter a vicious and descending spiral.

Other reasons for understanding human physiology to help adapt to, and mitigate, climate change include the insight it gives into critical areas such as: vulnerable populations; nutrition; adaptation to heat; and cooling strategies to avoid heat illness.

Vulnerable populations

The populations vulnerable to climate change in the form of warming include:

- The very young
- Older people (>75 years)
- The pregnant
- The homeless
- Those living in poverty
- Those with comorbidities
- Those on some prescription drugs
- Those working in hot environments
- Those working in Personal Protective Equipment
- Those new to an environment

The reasons for the vulnerability of these groups differ. They range from the simple overwhelming of a compromised thermoregulatory system, to changes in the cardiovascular, biochemical and neurophysiological state of the body with warming and an individual's inability to respond to these changes. In all cases, understanding the physiological mechanisms underpinning these vulnerabilities enables targeted and optimised interventions to improve outcomes.

Nutrition

Physiologists are researching how dietary protein choices can help mitigate climate change. Plant-based protein rich foods are considered more sustainable for the environment than animal-based protein, but the ability of these different sources must also be considered in terms of the maintenance of muscle structure and function.

Heat adaptation

Humans can acclimatise to heat in as few as 5-10 days, this results in a range of physiological adjustments including lower body temperatures, improved cardiovascular function and improved functionality and thermal comfort in the heat. Thermophysiologists know a lot about this process and the associated improvements in resilience and functionality. We know less about the value of acclimatisation for different populations, including vulnerable populations. Heat acclimatisation alone would not have enabled humans to move too far away for their equatorial origins; wider migration required technology-based behavioural adaptation. It is critical that these technologies are effective but sustainable (e.g. natural cooling rather than air-conditioning); this is an area that requires more consideration (Figure 2).

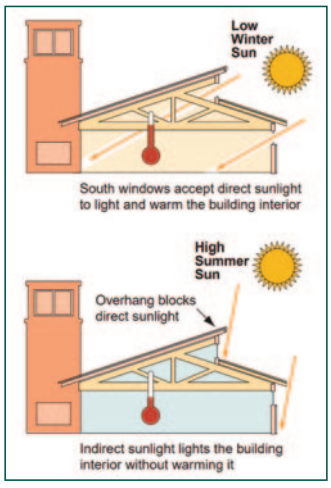

Figure 2. Zion Canyon visitor centre – built in 1960 with consideration of the thermal environment. A chimney to create airflow (can be closed) and strategically placed windows to use/avoid radiant heat.

Effective and sustainable cooling strategies

By far the best way to cool a hot human is to understand how the body attempts to lose heat naturally, and then augment these processes. So it is, that hand immersion in cold water or fanning, that allow the body to deliver heat to the skin and then help remove it, are more effective than ice vests, air and liquid conditioned garments that try and overwhelm the thermophysiological responses of the body.

Gaps in our current understanding

Despite the above, there remain important gaps in our understanding around topics like: the response of different populations to chronic heat exposure; how different co-morbidities and prescription medicines interact in the presence of heat; the relationship between increased heat stress and mental health and neurological conditions; the relationship between heat and immune function; the response of cells to heat at the molecular and biochemical level; individual variation in the responses to heat and differing susceptibility to heat illness; the best cooling strategies for those with differing disabilities. We need to know more in these areas.

Coordinated rapid action across research and policy

We have provided just a few examples of how an understanding of physiology can optimise the response to the causes and consequences of climate change. Understanding the physiological basis of differing vulnerability across the population can guide the design of built environments and the effectiveness of public health interventions, as well as prioritise research and preventative interventions. But, whilst physiology is a critical component of the responses to climate change, it is not enough. The path to comprehensive solutions also requires collaborative, integrated action by politicians, policy makers, civil servants, epidemiologists, engineers, architects, climate change scientists, behavioural psychologists, healthcare professionals, botanists and others - to provide fundamental, comprehensive understanding of what humans can tolerate, what needs to be achieved and how it might be achieved. The silos in which expertise mostly exist, as a result of the way we learn more and more about less and less, must be deconstructed, and the response to this existential challenge must be collaborative and prioritised.

A Heat Resilience Strategy for the UK

There is an urgent need for a heat resilience strategy, founded on an understanding of how the human body works and fails, that coordinates expertise, governments, businesses and communities across the UK to improve resilience to climatic extremes. This needs to be facilitated and enabled by informed policy; too often the translation of scientific findings into policy is interrupted or overlooked; this could be a firm requirement of funding bodies. In calling for a human-centred multi-stakeholder heat resilience strategy, The Physiological Society has recommended:

i. The establishment of a Heat Adaptation Research Exchange Taskforce, chaired by the Cabinet Office working closely with other government departments and devolved administrations. This Taskforce should tackle

research gaps and increase the speed of research translation into policy and action.

ii. The formation of a Human-Centred Climate Adaptation Design and Planning Institute to accelerate the adaptation of the built environment to higher temperatures, with governments across the UK mandating thermally efficient design principles and promoting the use of green infrastructure.

iii. A requirement that all employers develop a physiologically informed and sustainable plan for workers during extreme heat events to protect health, safety, wellbeing and productivity, including introducing statutory guidance on maximum temperatures for different levels of activity and types of Personal Protective Equipment worn.

iv. Bringing together public health professionals from across the UK and devolved governments, local authorities, and charities to deliver a public health campaign and expanded early warning systems focused on supporting vulnerable groups to improve their long-term resilience to heat and preparedness for heatwaves.

It is only through the seamless integration and collaboration between disparate groups that we can optimise our response to a climate threat that is not waiting for us.

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ARTIFICIAL INTELLIGENCE: What's the hype and how is it impacting society?

Dr Devyani Gajjar
Physical Sciences and Digital Adviser
POST Parliamentary Office of Science and Technology

Everyone has been talking about AI. So, what's causing the hype? November 2022 saw the first public release of the popular chatbot ChatGPT and AI was thrust into a global limelight.

For many people, ChatGPT, and other chatbots released since then such as Bard and Claude, seemed to be producing outputs that were increasingly indistinguishable from human outputs. For example, AI seemed to be able to perform tasks, such as writing essays, at a similar level to humans, and this had implications for different areas of society, such as AI impacting peoples' jobs or AI being used by students in exams.

The Parliamentary Office of Science and Technology (POST), Parliament's in-house research team, has recently produced several impartial research briefings on various aspects of AI to inform scrutiny. Our research explains new advances in AI, drivers of these advances, and synthesises evidence around how it could impact society.

NEW ADVANCES IN AI

In the past few years, AI systems have gained two main advances compared to previous forms of AI [1].

Firstly, the ability of some AI technologies, known as generative AI, to generate realistic content such as text, images, media and audio, has improved drastically.

Secondly, recent advances mean some AI systems can be increasingly adapted to a wide range of tasks. This is in contrast to many AI technologies previously being designed to perform a specific task only. AI systems that can perform a wide range of tasks are known as Foundation Models. Large Language Models, such as ChatGPT, are a specific type of Foundation Model that can carry out a wide range of language related tasks. For example, ChatGPT can write essays, answer questions, spellcheck, and synthesise different sources.

DRIVERS OF ADVANCES IN AI

There have been four main drivers of recent advances in AI.

1) Firstly, increased data availability has meant AI models can be trained on larger and larger datasets. Large language models are often trained on billions or even trillions of bits of data. For example, the large language model underpinning ChatGPT 3.5 (the version released to the public in November 2022) was trained using 300 billion words obtained from internet text. [2]

2) Secondly, the amount of computing power used to develop and run large AI models has increased exponentially in the past half-decade. For example, a report by the Centre for Security and Emerging

Technology noted that a Foundation Model released in 2020 used 600,000 times more computing power than a noteworthy model in 2012[3].

3) Thirdly, there have been investments in computing infrastructure.

4) Fourthly, new AI algorithms developed in the past few years have greatly improved generative AI.

Only a few large private sector technology companies have developed the biggest Large Language Models due to the scale of computing power and data required. A 2023 report by the Government Office for Science predicted that, in the near future, the development of cutting-edge large language models is highly likely to be carried out by a select few companies with the required funding for computing power, skills and data[4]. These include OpenAI, Google, Anthropic and Meta. Due to high costs, concerns exist around the inaccessibility of developing Frontier models for small companies, open-source communities and academia, and the concentration of market power by a few private sector organisations.[1]

CONCERNS AND ISSUES

Alongside issues around unequal access to AI systems, AI could create other ethical challenges including discrimination and inequalities from biases in AI systems, decisions being based on incorrect information generated by AI, the spread of false information, and increased mistrust in online information. The use of AI technologies could also impact the economy with evidence suggesting potential effects could be mixed.

Discrimination and inequalities

It has been well-established that AI systems can contain biases which can manifest themselves in different ways, such as an AI developer training the system on data that leads to inappropriate AI decisions. Biased AI systems have already had real-world discriminatory impacts. For example, a 2019 study found that an algorithm used to allocate healthcare in US hospitals was less likely to refer Black people who were equally as sick as White people to healthcare programmes.[5]

Decisions being based on incorrect information generated by AI

Large Language Models, such as ChatGPT, generate text by predicting the most likely words and phrases that go together based on patterns they have seen in training data. However, they are unable to identify if the phrases they generate make sense or are accurate.[1] This can sometimes lead to inaccurate results, also known as 'hallucination' effects, where Large Language Models generate plausible sounding but inaccurate text. Hallucinations can cause problems where the results of an AI are used to take decisions without proper consideration of the risk that the results are inaccurate.

The spread of false information

AI systems can also generate realistic images and videos which can enable the creation of 'deepfakes': pictures and video that are deliberately altered to spread false information either for causing harm or political, personal or financial gain.[5] Whilst deepfakes have been around for years, they had previously required skills and time to produce. Advances in generative AI means that anyone with basic IT skills is more easily able to produce fake content. Particularly with elections around the corner, there are questions about what the impact of AI generated false information could be on elections, on public trust in online content and institutions, and on divisions in society. An example of a recent deepfake that went viral was an audio clip of the London Mayor making inflammatory remarks about Armistice Day.[6]

Impacts on the economy

Evidence is mixed on the implications of AI for the economy. An OECD report says AI is changing the nature of work and could improve productivity and some emerging academic research says AI could be linked to a loss of quality and earnings in some white-collar jobs.[5] There are concerns around AI disproportionately affecting some groups, such as AI more likely affecting clerical work which is mostly carried out by women.[5]

POTENTIALS

Alongside the risks, AI also has immense potential to benefit society. AI tools could be used to strengthen democracy by engaging the public and helping voters to understand manifestos and which candidates and political parties might best align with their priorities.

In healthcare, AI is being used to help diagnose diseases, find new drugs, and develop personalised treatments, which could lead to better health outcomes. In education, AI tools could provide different ways of learning and help educators with lesson planning, marking and other tasks.[7]

AI could be applied across various sectors, increase worker productivity and assist with decision making. A 2023 McKinsey report estimated that generative AI has the potential to add between $2.6 trillion to $4.4 trillion annually to the global economy.[8]

While there are risks and opportunities posed by AI, their societal impact will depend on how AI is used, regulations, geopolitics, access, ownership, safety measures and public attitudes.

For more information on AI, you can read our recent POST reports on the policy implications of AI, an AI explainer and the use of AI in education delivery and assessment. Subscribe to get the latest from POST delivered to your inbox, including new research.

Our AI reports were produced through POST's fellowship schemes. Over 3 months, our POST fellows learn how to write with balance and impartiality, get to experience new and exciting areas of research, and build relationships with key Parliamentary stakeholders. Find out more.

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HOW CAN THE UK BETTER ADAPT TO HEAT IN THE WORKPLACE

Professor Elizabeth Robinson, Director of Grantham Research Institute, London School of Economics and Political Science

Dr Candice Howarth, Head of Local Climate Action, Grantham Research Institute, London School of Economics and Political Science

Dr Shouro Dasgupta, Environmental Economist at Euro-Mediterranean Center on Climate Change and Visiting Senior Fellow at Grantham Research Institute, London School of Economics and Political Science

The 2022 UK heatwaves, when temperatures of over 40°C where recorded, brought to the fore that the UK is not sufficiently well adapted or prepared to deal with current, let alone future, climate change. There is plenty that could be done to protect the UK's workforce from increasing heat linked to the changing climate.

In common with all countries across the globe, the UK is warming due to anthropogenic climate change. 2022 was the UK's warmest year on record (Met Office, 2024), and in the summer of 2022, the UK recorded temperatures of over 40°C, that would have been statistically "extremely unlikely" without human-induced climate change (World Weather Attribution, 2022; Fankhauser et al., 2023). This type of extreme heat, that has been described as an 'invisible risk' (Brimicombe et al., 2021), is a new challenge for the UK, and evidence suggests that the country was not ready for these temperatures, and that even with some warning, many people could not sufficiently adapt or prepare for the extreme heat (Howarth et al., 2023). This type of heatwave event is likely to be more frequent and more extreme until at least 2050, even if global net zero targets are achieved. Although summer 2022 saw five heatwave periods over the months June to August, only one day experienced temperatures over 40°C (19th July): considering how the UK's ability to prepare for and adapt to this event was weak, this puts into perspective the need for the nation to seriously consider how it can prepare for scenarios where multiple, consecutive, and possibly more extreme, temperatures will be experienced.

Many of the impacts of the 2022 heatwaves have been well documented. There were over 3000 excess deaths, and though most of these were among those aged over 65 (UHKSA, 2022), other groups were also vulnerable, including children under 1 year old, people with underlying health conditions, and people directly exposed to the heat due to their line of work (Physiological Society, 2023).

Whilst the evidence suggests that some sectors such as energy and water providers are relatively well prepared and resilient to tackle heatwaves (Howarth et al., 2023), there are likely to have been consequences that are harder to evaluate. The health impacts of heat extremes are still not fully understood, and there has not been a comprehensive analysis of the short- or long-term impacts on how workers' health was affected by the 2022 heatwaves, particularly those employed in the high exposure sectors of agriculture, construction, forestry, quarrying and mining. Any health impacts, in addition to being troubling in their own right, almost certainly will have implications for economic growth and equity.

Even in the absence of heatwaves, analysis by Dasgupta and Robinson (Dasgupta et al., 2021; van Daalen et al., 2022; Dasgupta and Robinson, 2023) suggests that the gradual warming that the UK has already experienced over, and above pre-industrial levels is resulting in labour supply and GDP growth already being measurably lower than they would have been. For example, compared to 1965-1994, labour supply (the amount of labour offered for hire per unit time) is estimated to have been 0.39 percent lower between 1995 and 2000 than it would have been without warming, and 1.86 percent lower between 2016 and 2019. This is equivalent to 6.6 and 29.4 fewer hours of labour supplied per worker per year, respectively. This lower level of working hours translates into lower individual income and lower economic growth. Current economic damages are estimated to amount to around 1% of GDP but are projected to be higher than 7% under a near catastrophic scenario of SSP3-RCP7.0. These data also almost certainly reflect a negative impact on worker health, due to heat stress and increased occupational injuries. However, whilst the southern parts of the UK are most negatively affected, northern areas, including the whole of Scotland, currently appearing to benefit from warming.

ADAPTATION CHALLENGES

There is evidence of autonomous adaptation already occurring, whereby individual workers, where feasible, choose to, and are able to, for example, adjust their work patterns, change their clothing, or ventilate

or cool their homes and workplaces, absent of employer or government actions. Employer-driven adaptation may include the introduction of air conditioning, or changes to work schedules. Though the design of adaptation strategies such as shifting working time needs to consider potential trade-offs on the health of workers and fatigue-related accidents if, for example, sleep patterns are interrupted. More generally, there is much more that the UK could do to protect the UK's workforce from increasing heat linked to the changing climate.

A sensible starting point would be for the government to introduce protections for workers through a statutory maximum working temperature. Currently the UK does have guidelines. For example, the Management of Health and Safety at Work Regulations, states that "[t]emperature in the workplace is one of the risks you should assess, whether the work is being done indoors or outdoors" (HSE, n.d.). And there are currently suggested minimum temperatures. But there is no maximum temperature for workplaces. Increasingly European countries are introducing worker protections from extreme heat by setting maximum workplace temperatures, but these vary considerably across member states (Carbonaro, 2023). The first European Climate Risk Assessment (EUCRA) has identified heat stress impacts on the labour force as a key climate risk facing Europe, and the European Commission is considering additional worker protection action on climate risks in response (EEA, 2024; EC, 2024).

More information is needed. For example, it is only relatively recently that increased incidences of kidney disease have been linked to increasing heat and dehydration experienced by farm workers (Johnson et al., 2019). More broadly, the short- and longer-term health impacts of heat stress on workers are not sufficiently understood by workers themselves, employers, or the government, and what information one group has may not be known to the others. This asymmetry of knowledge can result in misaligned incentives that lead to worse outcomes for workers and employers alike (Dasgupta and Robinson, 2023). Adequately designed early warning systems can protect workers, and the population more broadly, especially those most vulnerable to heat, from at least some of the worst impacts of heat stress.

We are particularly concerned over the impact of heat extremes on workers in the gig economy, which has been defined as a way of working that is based on people with temporary jobs or doing distinct pieces of work that are paid for separately (CIPD, 2017). Estimates of the number of people who can be considered part of the gig economy vary widely, from the Trades Union Congress (TUC) estimate of around 4.4 million people (14.7%) in 2021, to the Chartered Institute of Personnel and Development (CIPD) estimate of just under half a million (around 1.4% of total employment) in 2022 and 2023. Workers in the gig economy are over-represented by ethnic minorities and people with disabilities, with important implications therefore for inequality (CIPD, 2023). There are no easy solutions for this growing group of workers in the UK who are increasingly likely to be facing the choice during periods of high heat over whether to protect their health, by working less, or protect their income but put their health at risk. Quite possibly people may end up compromising both health and income.

More broadly, adaptation decisions rely on information on the size and incidence of the costs and benefits of adaptation, the feasibility of adapting, the availability of funds, and often political will. There are also important questions to be asked with regards to whether the anticipated risks suggest a policy of acting now to adapt and build resilience, waiting for more information, or accepting an "adaptation gap" and dealing with the consequences ex post.

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HOUSE OF COMMONS SELECT COMMITTEES

BUSINESS AND TRADE COMMITTEE

The Committee scrutinises the policy, spending and administration of the Department for Business and Trade, and its public bodies.

Membership:

Rt Hon Liam Byrne MP, Labour (Chair)
Douglas Chapman MP, Scottish National Party
Jonathan Gullis MP, Conservative
Antony Higginbottom MP, Conservative
Jane Hunt MP, Conservative
Ian Lavery MP, Labour
Anthony Mangnall MP, Conservative
Julie Marson MP, Conservative
Andy McDonald MP, Labour
Charlotte Nichols MP, Labour
Mark Pawsey MP, Conservative

Current Inquiries:

- Batteries for electric vehicle manufacturing. Opened 17th January 2023.
  Report published 21st November 2023. Government response published 14h February 2024.
- Export-led growth. Opened 26th May 2023.
- The performance of investment zones and freeports in England. Opened 9th June 2023.
- Industrial Policy. Opened 9th December 2023. Deadline 29th January 2024.

For further details: Tel: 020 7219 5777
Email: commonsbtc@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
Rt Hon Chris Grayling MP, Conservative
Ian Levy MP, Conservative
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Jerome Mayhew MP, Conservative
Anna McMorrin MP, Labour
John McNally MP, Scottish National Party
Dr Matthew Offord MP, Conservative
Cat Smith MP, Labour
Claudia Webbe MP, Independent

Current Inquiries

- Mapping the path to net zero: Opened 25th June 2021.
- Net zero aviation and shipping: Opened 20th July 2021. Report published 21st December 2023.
- The financial sector and the UK's net zero transition. Opened 30th May 2022.
  Report published 29th November 2023. Government response published 23rd February 2024.
- Sustainable timber and deforestation. Opened 25th July 2022. Report published 4th January 2024.
- Environmental Change and Food Security
  Opened 10th November 2022. Report published 8th December 2023. Government response published 21st March 2024.
- Enabling sustainable electrification of the UK economy. Opened 4th May 2023.
- Outdoor and indoor air quality targets. Opened 10th May 2023.
- Heat resilience and sustainable cooling. Opened 3rd July 2023. Report published 31st January 2024.
- The role of natural capital in the green economy. Opened 31st July 2023.
- Small modular reactors in the transition from fossil fuels. Opened 19th October 2023.
- Climate change and security. Opened 18th March 2024. Accepting written evidence until 29th April 2024.

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SCIENCE, INNOVATION AND TECHNOLOGY COMMITTEE

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The Science, Technology and Innovation Committee is appointed by the House of Commons to examine the expenditure, administration and policy of the Department of Science, Innovation and Technology, and associated public bodies.

It also exists to ensure that Government policies and decision-making are based on solid scientific evidence and advice.

Membership:

Rt. Hon Greg Clark MP, Conservative, Chair

Dawn Butler MP, Labour

Chris Clarkson MP, Conservative

Tracey Crouch MP, Conservative

Dr James Davies MP, Conservative

Katherine Fletcher MP, Conservative

Rebecca Long-Bailey MP, Labour

Stephen Metcalfe MP, Conservative

Carol Monaghan MP, Scottish National Party

Graham Stringer MP, Labour

Christian Wakeford MP, Labour

Current Inquiries

- The right to privacy: digital data – Opened 16th December 2021.
- My science inquiry. Opened 12th July 2022. Report published 8th November 2022.
- Delivering Nuclear Power. Opened 19th July 2022. Published 31st July 2023.
  Government response published 25th October 2023.
- Governance of artificial intelligence (AI). Opened 20th October 2022. Report published 31st August 2023. Government response published 16th November 2023.
- The antimicrobial potential of bacteriophages. Opened 9th November. Report published 3rd January 2024. Government response published 1st March 2024.
- Emerging diseases and learnings from covid-19. Opened 15th December 2022.
- Commercialising quantum technologies. Opened 16th March 2023.
- Insect decline and UK food security. Opened 20th March 2023. Report published 7th March 2024.
- UK Astronomy. Opened 10th September 2023.
- Cyber resilience of the UK's critical national infrastructure. Opened 15th September 2023.

HEALTH AND SOCIAL CARE COMMITTEE

The Committee scrutinises government and in particular the work of the Department of Health and Social Care.

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

Amy Callaghan 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

- Assisted dying/assisted suicide. Opened 5th December 2022. Report published 29th February 2024.
- NHS Dentistry. Opened 7th December 2022. Report published 14th July 2023.
- Government response published 13th December 2023.
- Prevention in health and social care. Opened 18th January 2023. Report published 19th January 2024.
- Future cancer. Opened 21st March 2023.
- Pharmacy. Opened 8th June 2023.
- Men's health. Opened 20th July 2023.
- NHS leadership, performance and patient safety. Opened 23rd January 2024.

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

ENERGY SECURITY AND NET ZERO COMMITTEE

The Energy Security and Net Zero Committee scrutinizes the policy spending and administration of the Department of Energy Security and Net Zero and its public bodies, including Ofgem and the Committee on Climate Change.

Membership:

Angus Brendan McNeil, Independent, Chair

Rt Hon Vicky Ford MP, Conservative

Barry Gardiner MP, Labour

Mark Garnier MP, Conservative

Sir Mark Hendrick MP, Labour

Mark Pawsey MP, Conservative

Dr Dan Poulter MP, Conservative

Lloyd Russell-Moyle MP, Conservative

Alexander Stafford MP, Conservative

Derek Thomas MP, Conservative

Mick Whitley MP, Labour

Current Inquiries:

- The work of the Department for Energy Security and Net Zero. Opened 14th June 2023.
- Keeping the power on: our future energy technology mix. Opened 7th July 2023.
- Heating our homes. Opened 7th July 2023.
- A flexible Grid for the future. Opened 7th July 2023.
- Securing the domestic supply chain. Opened 17th November 2023.
- Energy bills for domestic consumers. Opened 24th November 2023.
- Economics of the energy sector. Opened 5th March 2024. Accepting written evidence until 19th April 2024.
- Net zero and trade. Opened 7th March 2024. Accepting written evidence until 19th April 2024.

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HOUSE OF LORDS SELECT COMMITTEES

SCIENCE AND TECHNOLOGY COMMITTEE

The Science and Technology Committee has a broad remit "to consider science and technology".

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 Lord Berkeley OBE, Labour

The Lord Borwick, Conservative

The Rt Hon. the Lord Drayson, Labour

The Lord Lucas, Conservative

The Baroness Neuberger DBE, Crossbench

The Rt Hon. the Baroness Neville-Jones DCMG, Conservative

The Rt Hon. the Baroness Northover, Liberal Democrat

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The Viscount Stansgate, Labour

The Lord Strasburger, Liberal Democrat

The Lord Wei, Conservative

The Baroness Willis of Summertown CBE, Crossbench

The Baroness Young of Old Scone, Labour

Current Inquiries

- The effects of artificial light and noise on human health. Opened 30th January 2023. Report published 19th July 2023. Government response published 1st December 2023.
- Long-duration energy storage. Opened 26th July 2023. Report published 13th March 2024.

For further details: Tel: 020 7219 5750

Email: hlscience@parliament.uk ■

Kate Baillie, Chief Executive Officer of the Biochemical Society and Managing Director of Portland Press, has announced her plans to retire at the end of this year, December 2024.

In more than 12 years at the helm, Kate has overseen a period of immense change and progress. She has implemented a complete restructuring of the organisation in order to capitalise on the synergies across the breadth of our scientific content in journals, events, training and public engagement activities. She has also been instrumental in introducing a systematic strategic planning process and the evolution of a responsive business model that is well-placed to meet the challenges ahead. Under Kate's leadership, the organisation has led the way in working practice innovation, including the move from an office base at Charles Darwin House to a fully remote working model and trial of the Four Day Week, and she has been central to the Society embedding equity, diversity and inclusion across all our activities.

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY (POST)

SPRING 2024

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.

RECENTLY PUBLISHED WORK

POST research is published on our website. POST research produced since December 2023 includes:

- Demand side response: A tool for lowering household energy bills
- Human stem cell-based embryo models
- Enabling green choices for net zero
- Use of artificial intelligence in education delivery and assessment
- Freshwater habitat restoration
- Carbon offsetting
- The future of fertiliser use
- Policy implications of artificial intelligence
- Green skills in employment and education

Ongoing and future projects approved by the POST Board

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

- Consumer debt and mental health
- Biodiversity net gain
- Reform of the Mental Health Act – impacts on people with learning difficulties and on people with autism
- Psychedelic drugs to treat mental health conditions
- Social and psychological implications of fraud
- Increasing the resilience of landscapes and habitats to wildfires
- Water Fluoridation and Dental Health
- Public Health Impacts of Heat
- Enhanced weathering: spreading rock dust to remove greenhouse gases
- Plastic waste reduction
- Ultra Processed Foods
- Diet and Cancer
- The Hydrogen Backbone
- General election polling - rapid response
- 6G – Next Generation mobile communication technologies
- Cybersecurity of the metaverse

POST will announce a new round of research projects in April 2024. Stakeholders are encouraged to contact POST if they would like to engage with this research.

Please subscribe on our website to receive alerts about these projects and our other work.

THE POST BOARD

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

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Oliver Bennett MBE **Head of POST**

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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 Science and Environment Section (SES) is one of eight teams in the Research Service in the House of Commons Library.

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. Members and their staff can request briefing by visiting the Member's Library in the Palace or by emailing HCLibrary@parliament.uk. SES has recently provided confidential briefings to MPs on a wide range of issues including energy, planning law, health, environment, water quality, telecommunications and animal welfare.

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.

In recent months, SES has published and updated briefings on issues including:

General debate on farming

Published Friday, 23 February, 2024 CDP 2024/0042

A debate pack prepared ahead of a general debate on farming on 26 February.

On 20 February 2024, the Prime Minister Rishi Sunak gave a speech at the annual conference of the National Farmers' Union. Agricultural policy is a devolved matter. This briefing provides statistics on farms in England and focuses on some of the Prime Minister's key announcements.

Debate on an e-petition to reform the Groceries Supply Code of Practice to better protect farmers

Published Wednesday, 17 January, 2024 CDP 2024/0007

A debate pack prepared ahead of a Westminster Hall debate on 22 January on the Groceries Supply Code of Practice.

E-petition 643216 calls for the government to amend the Groceries Supply Code of Practice (GSCOP, or the Code) to require retailers, "without exception", to: "Buy what they agreed to buy, Pay what they agreed to pay [and] Pay on time".

The Groceries Supply Code or Practice (GSCOP, or the Code) was introduced in 2009 following a market investigation by the Competition Commission (CC, now the Competition and Markets Authority, the CMA).

This pack includes information on the Code and the Adjudicator, the views of farmers and grocery retailers and how farmers' relationships with supermarkets could change, as well as recent Parliamentary material, news and press releases.

Pet Abduction Bill 2023-24

Published Wednesday, 17 January, 2024 CBP 9929

This briefing was prepared ahead of the Second Reading of the Bill on 19 January 2024.

The Pet Abduction Bill is a private member's bill with support from the government, which has published Explanatory Notes and a Delegated Powers Memorandum alongside the bill.

There is currently no legislation aimed at addressing pet theft specifically. Animals fall under the definition of property in legislation, and as such pet theft is dealt with under the Theft Act 1968. Campaigners have called for stronger legislation that reflects the emotional value of pets to their owners and the distress associated with their theft.

Debate on legal protections for hedgerows

Published Monday, 22 January, 2024 CCP 2024/0012

A debate pack prepared ahead of a Westminster Hall debate on 24 January on legal protections for hedgerows.

The government is changing the way in which it supports farmers now that the UK is no longer a member of the EU and has left the EU's Common Agricultural Policy (CAP). Cross compliance rules ceased to apply to farm payments from 1 January 2024, including standards to protect hedgerows. Defra is incorporating hedgerow management into its new approach to farm support, called environmental land management (ELM).

Under the Sustainable Farming Initiative (SFI) tier of ELM, farmers can now choose to be paid to undertake certain activities focused on improving hedgerows and hedgerow trees.

Under existing Countryside Stewardship schemes farmers could be paid for sustainable hedgerow management. These schemes are being developed to include payments for new actions, such as

leaving hedgerows uncut for longer, under the new Countryside Stewardship Plus tier of ELM.

Animal Welfare (Livestock Exports) Bill 2023-24

Published Monday, 22 January, 2024 CBP9912

The Animal Welfare (Livestock Exports) Bill 2023-24 would make it an offence to export livestock from or through Great Britain for slaughter outside the British Islands. The Bill had its second reading on 18 December 2023. Committee stage and third reading were held on 15 January 2024 when the Bill passed unamended.

The Lords will now consider the Bill and a date for second reading is awaited.

The government has said that the UK's departure from the EU gives it the freedom to implement such a ban. The 2019 Conservative Party Manifesto included a commitment to control live animal exports.

Dogs (Protection of Livestock) (Amendment) Bill 2023-24

Published Thursday, 01 February, 2024 CBP 9949

The Dogs (Protection of Livestock) (Amendment) Bill is a Private Members' Presentation Bill, with government support. Explanatory Notes have been provided by the Department of Environment, Food and Rural Affairs (Defra) alongside the Bill.

Livestock worrying by dogs is currently covered by the Dogs (Protection of Livestock) Act 1953 (as amended). The Act makes it an offence to be in charge of a dog that worries livestock on any agricultural land.

Rather than replace the existing legislation, as was proposed in the Animal Welfare (Kept Animals) Bill, this Bill would amend the existing legislation. According to the Explanatory Notes, the proposals will increase the powers available to police for "gaining evidence and subsequently improve police enforcement". The Bill would also extend the places covered to include roads and paths. It would expand the scope of livestock covered to include camelids, such as llamas and alpacas. The legislation would extend to England and Wales only.

Debate on e-petitions relating to animal testing and non-animal research methods

Published Thursday, 15 February, 2024 CDP 2024/0028

E-petitions calling on the government to end the use of animals for toxicity tests and prioritise non-animal methods (NAMs) (633591) and ban the use of dogs for testing and research purposes (645885) wer debated on 19 February 2024.

Energy Bill [HL] 2022-23 Progress of the Bill

Published Monday, 26 February, 2024 CBP 9853

The Energy Act 2023 received Royal Assent on 26 October 2023. This paper summarises the Bill's committee stage and final stages through Parliament.

The ban on XL Bully dogs

Published Monday, 04 March, 2024 CBP 9897

A government ban on American XL Bully dogs in England and Wales came into force on 31 December 2023.

The ban was in response to increased reports of injuries and deaths caused by dogs, which have been linked in some cases to XL Bully dogs.

The Scottish Government announced on 18 January 2024 that it would be introducing similar 'safeguarding measures' for XL Bully dogs.

Hunting Trophies (Import Prohibition) Bill 2023-24

Published Thursday, 21 March, 2024 CBP 9991

The Hunting Trophies (Import Prohibition) Bill 2023-24 is a Private Member's Ballot Bill. Second Reading in the Commons will take place on 22 March 2024

The bill would "make provision prohibiting the import of hunting trophies into Great Britain".

Flood risk management and funding

Published Monday, 12 February, 2024 CBP 7514

This briefing paper provides an overview of flood and coastal risk management in the UK, including which bodies manage risk, current policy on flood risk management, and how flood funding works.

Debate on the environmental impact of neonicotinoids and other pesticides

Published Sunday, 03 March, 2024 CDP 2024/0047

A debate pack prepared ahead of a Westminster Hall debate on 5 March on the environmental impact of neonicotinoids and other pesticides.

Pesticides are highly regulated in the UK. The agricultural sector has argued that pesticides such as neonicotinoids can provide "the tools to effectively control crop pests in a way that is responsible, not just in terms of minimizing environmental impacts, but also in terms of being able to produce food and plants in a way that is safe, reliable and affordable for everyone".

Animal Welfare (Import of Dogs, Cats and Ferrets) Bill [2023-24]

Published Wednesday, 13 March, 2024 CBP 9981

The Animal Welfare (Import of Dogs, Cats and Ferrets) Bill makes provision to restrict the commercial importation and non-commercial movement of dogs, cats and ferrets into the United Kingdom on grounds of animal welfare. The Private Member's Bill had its second reading on 15 March 2024.

General Debate: New dementia treatments

Published Tuesday, 09 January, 2024 CDP 2023/0235

A debate pack published ahead of a general debate on new dementia treatments in Westminster Hall on 11 January 2024.

Currently, there is no cure for dementia. There are medicines and treatments that can help manage, or temporarily reduce, some of the symptoms. These, however, do not treat the cause of the underlying disease. This means that they do not stop, or slow, its progression.

Drugs that slow, or stop, the progression of dementia (sometimes referred to as 'disease-modifying' treatments) have not, at the time of writing, been approved for use in the UK. There are, however, some new disease-modifying treatments in development. Notably, two drugs, lecanemab and donanemab, are scheduled to be appraised by the National Institute for Health and Care Excellence (NICE) in 2024.

The regulation of e-cigarettes

Published Wednesday, 10 January, 2024 CBP 8114

This briefing paper provides an overview of the regulation of e-cigarettes in the UK.

The new European Union Tobacco Products Directive (TPD) entered into force on 19 May 2014, revising the 2001 Directive of the same name. It introduced new regulatory controls on electronic cigarettes (e-cigarettes, sometimes referred to as 'vapes'), as well as setting out requirements on tobacco products. The UK Tobacco and Related Products Regulations 2016 implemented the TPD in full. This Commons Library Briefing Paper outlines the product requirements for e-cigarettes and identifies where national regulations have gone beyond what is in the TPD.

Vaping and health

Published Friday, 12 January, 2024 CBP 9933

E-cigarettes are recognised as being less harmful than tobacco cigarettes, but little is known about their long-term health risks. This briefing provides an overview of the evidence.

Support for cancer in England

Published Wednesday, 07 February, 2024 CBP 9766

Briefing on Government and NHS policy on cancer in England and cancer research.

Cancer is the cause of just over a quarter of all deaths in England in a typical year. The most common cancers are breast, lung, prostate and bowel cancer.

In 2021, 134,802 people died from cancer in England. The number of deaths has increased by 6% since 2001. But after accounting for the fact that England's population is both growing and ageing, the rate of cancer deaths has fallen by 23% among men and 16% among women.

Debate on premature deaths from heart and circulatory disease

Published Friday, 16 February, 2024 CDP 2024/0037

February is World Heart Month. This pack was prepared ahead of a debate on 'Premature deaths from heart and circulatory diseases' on 22 February 2024 in the Commons Chamber.

Help with energy efficiency, heating and renewable energy in homes

Published Wednesday, 10 January, 2024 CBP 9585

This briefing outlines available financial support for installing energy efficiency, heating and renewable energy in homes.

What was agreed at COP28?

Published Wednesday, 17 January, 2024 CBP 9909

The United Nations Climate Change Conference (COP29) was held from 30 November to 1 December 2023 in Dubai, United Arab Emirates. This briefing covers new developments from the conference and their reception.

Who is responsible for managing flood risk? (England)

Published Wednesday, 24 January, 2024

This constituency casework page sets out the responsibilities of property owners, the Environment Agency and local authorities for managing flood risk.

Financial support following a flood (England)

Published Monday, 26 February, 2024

This constituency casework page sets out what financial support may be available following a flood in England, and how to access this.

Debate on the performance of South West Water

Published Thursday, 29 February, 2024 CDP 2024/0048

A debate pack prepared ahead of a Westminster Hall debate on 5 March on the performance of South West Water.

Carbon Border Adjustment Mechanism

Published Tuesday, 05 March, 2024 CBP 9935

This briefing outlines the purpose of a Carbon Border Adjustment Mechanism (CBAM), the impact of the EU CBAM, the UK Government plans for a UK CBAM, and international trade considerations. It also sets out commentary on a need for global cooperation, and further reading.

Debate on the 10th Conference of Parties to the WHO Framework Convention on Tobacco Control

Published Wednesday, 17 January, 2024 CDP 2024/0008

A debate pack prepared ahead of a Westminster Hall debate on 18 January on the 10th Conference of Parties to the WHO Framework Convention on Tobacco Control. The subject for the debate was chosen by the Backbench Business Committee.

This debate pack contains information on the 10th Conference of Parties to the WHO Framework Convention on Tobacco Control, which took place from 5th to the 10th February in Panama. The pack includes an overview of the matters to be discussed at the Conference, and background on tobacco policy and regulation in the UK.

Debate on the Civil Nuclear Roadmap

Published Friday, 16 February, 2024 CDP 2024/0036

A debate pack prepared ahead of a debate in the Commons Chamber on 22 February 2024 on the Civil Nuclear Roadmap. The subject for the debate was chosen by the Backbench Business Committee.

In January 2024, the government published its Civil Nuclear: Roadmap to 2050 which sets out "the pathway to a UK resurgence in civil nuclear, covering both the long-term strategy and the near-term enabling policies we are pursuing."

This briefing provides background and statistics on nuclear energy in the UK; a summary of the government's Civil Nuclear Roadmap; and stakeholder commentary and Parliamentary material on the Roadmap.

Debate on digital exclusion

Published Monday, 26 February, 2024 CDP 2024/0041

A debate pack prepared ahead of a Westminster Hall debate on 28 February on digital exclusion.

Digital exclusion refers to a person being unable to use the internet in ways that are needed to engage full in modern society. The House of Lords Communications and Digital Committee, in its June 2023 report on digital exclusion, heard evidence about digital exclusion affects people.

There is currently no government strategy specifically aimed at promoting digital inclusion. The government says that it "does not consider digital inclusion as a stand alone issue, but rather something that is considered in all policy areas where applicable". Different aspects of digital inclusion are covered by different departments, and each department is responsible for promoting digital inclusion within its own policy areas.

Air quality: policies, proposals and concerns
Published Monday, 19 February, 2024 CBP 9600

A briefing on evolving air quality policies and legislation across the UK, targets, statistics and health and inequality concerns.

Poor air quality is considered by the government to be "the largest environmental risk to public health in the UK". As well as human health, air pollution also has implications for the natural environment and for the economy. Due to the transboundary nature of air pollution, action to manage and improve air quality in the UK has been driven by both international agreements and EU legislation, as well as national and devolved legislation.

This briefing gives an overview of the current outdoor air quality legal framework, the changing governance and enforcement mechanisms following the UK's EU exit, forthcoming legislative changes and ongoing issues and concerns.

Plastic waste
Published Wednesday, 20 March, 2024 CBP 8515

A briefing on plastic waste in the UK including legislation, statistics, government policies and proposals for change.

The withdrawal of landlines and switch to digital calls
Published Friday, 12 January, 2024 CBP 9471

This briefing addresses frequently asked questions about the switch of traditional landline phones to digital, Voice over Internet Protocol (VOIP) services.

Over the next few years, landline telephone services in the UK will switch to a fully digital network. This means phone calls will be carried over the internet.

Access to Telecommunications Networks Bill 2023-24
Published Tuesday, 23 January, 2024 CBP 9940

The Access to Telecommunications Networks Bill is a Private Members' Bill. It had its first reading on 11 December 2023. Second reading took place on 26 January 2024.

The Bill would require mobile network operators (MNOs) to share their network infrastructure with each other where doing so would ensure "consistent network coverage". It would also "incentivise" MNOs to allow customers to roam onto another MNO's network in areas where their 'home' network does not provide coverage. This is known as 'rural roaming'.

These measures are intended to tackle partial not-spots (areas that receive coverage from at least one MNO but not all four).

Broadband companies and telegraph poles
Published Monday, 05 February, 2024

A constituency casework article aimed at helping to find out about the rules broadband companies need to follow when they install telegraph poles.

This page explains the rules around telegraph poles deployed as part of broadband networks. It covers whether broadband companies (also called 'operators') need to consult with planning authorities and residents, and whether they should install cables underground or utilise existing infrastructure instead.

Switching off 2G and 3G in the UK
Published Wednesday, 07 February, 2024 CBP 9959

The mobile industry plans to switch off the 3G mobile network by 2025. 2G will be retired by 2033 at the latest. This page provides information about the switch-off, including how users may be affected and the obligations mobile companies have toward their customers.

Rural mobile coverage in the UK: Not-spots and partial not-spots
Published Friday, 01 March, 2024 SN7069

This briefing paper looks at mobile coverage in the UK with a focus on rural 4G mobile coverage. It covers government targets and policies to tackle partial not-spots and total not-spots, such as the Shared Rural Network.

5G in the UK
Published Friday, 08 March, 2024 CBP 7883

This briefing provides information on 5G and its expected uses; the

rollout of 5G in the UK; and policy challenges associated with 5G, including planning rules, health, and security.

RAAC in the UK: Concerns and government response

Published Wednesday, 10 January, 2024 CBP 9917

This briefing discusses the use of reinforced autoclaved aerated concrete, including in schools and hospitals, and the government's response.

Reinforced aerated autoclaved concrete (RAAC) is a type of lightweight concrete which, unlike traditional concrete, does not contain gravel and pieces of crushed stone. It was used in the UK between the 1950s and 1990s, mostly to construct public buildings, such as schools and hospitals.

RAAC came to public and media attention in 2023, when the Department for Education (DfE) advised schools to close buildings with RAAC until safety work took place, just before the start of term.

Planning for onshore wind

Published Tuesday, 16 January, 2024 SN4370

The government updated planning rules for onshore wind in England in September 2023. These rules differ from those for other energy projects.

All onshore wind turbines, except for small-scale domestic turbines, require planning permission from the local planning authority (LPA) in England. In September 2023, the government updated national planning policy to provide that LPAs should approve planning applications for an onshore wind farm if:

It is an area identified as suitable in the local development plan (local plan or a neighbourhood plan) or a supplementary planning document.

The planning impacts identified by the affected local community have been appropriately addressed and the proposal has community support.

Unfinished housing developments

Published Wednesday, 24 January, 2024 CBP 9689

This briefing examines the problems caused by unfinished housing developments and roads, and the powers available to local authorities to prevent and deal with them.

The need to build new homes is a common topic of political interest. However, local news reports have highlighted concerns that developers may not finish housing developments or the infrastructure necessary to support them, such as roads.

The issue of unfinished housing developments was raised in a parliamentary debate in October 2022. A December 2022 debate focused on the related issue of unadopted roads and the lack of facilities for new housing estates.

This briefing covers England and the devolved administrations.

Spray foam insulation and mortgages

Published Monday, 05 February, 2024

A constituency casework article aimed at helping to find out why some homeowners have had difficulties remortgaging or selling homes that have spray foam insulation and what they can do about it.

Planning for solar farms

Published Monday, 12 February, 2024 CBP 7434

This briefing covers planning policy for solar farms in England and the devolved administrations and commentary on the use of agricultural land for solar farms.

When is planning permission not needed? Permitted development in England

Published Wednesday, 14 February, 2024

A constituency casework article aimed at helping to find out about permitted development rights and why some building works do not need planning permission from the local planning authority.

Planning in England: Permitted development and change of use

Published Wednesday, 06 March, 2024 SN 0485

This briefing discusses the use of permitted development rights to convert other buildings (such as offices) to homes.

The government has expanded permitted development rights which allow buildings in other uses (such as offices) to be converted to homes without planning permission from the local planning authority. The use of permitted development rights to deliver housing has subject to significant debate.

Planning is a devolved matter, and this briefing focuses on England.

Calculating housing need in the planning system (England)

Published Tuesday, 12 March, 2024 CBP 9268

This briefing explains how the government expects local authorities to assess and meet housing need. It also sets out recent changes made in December 2023.

Planning is a devolved matter, and this briefing focuses on England.

The government has set a national housing target of delivering 300,000 new homes in England per year by the mid-2020s. However, the government does not set binding local housing targets for local planning authorities (LPAs). Instead, LPAs are required to calculate and meet housing need in their local area. The government sets out which steps LPAs must follow in the National Planning Policy Framework (NPPF).

Coronavirus: Long covid

Published Thursday, 29 February, 2024 CBP 9912

Information about long covid, including guidance and services for long covid patients, statistics and the impact of long covid on healthcare, employment and education.

Some people who are infected by SARS-CoV-2, the virus that causes Covid-19, experience symptoms after the acute stage of the illness has passed. Long covid is a term used to describe ongoing symptoms of Covid-19, or new symptoms that develop after a Covid-19 infection. People with long covid can experience a wide range of symptoms affecting different parts of the body. Research exploring the causes of the condition and potential treatment options is ongoing. ■

SCIENCE DIRECTORY

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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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For over 70 years, AWE has supported the UK Government's nuclear defence strategy and Continuous At Sea Deterrence. On behalf of the Ministry of Defence, AWE manufactures, maintains and develops the UK's nuclear warheads, and applies its unique expertise to support nuclear threat reduction and to protect national security. The company provides guidance to UK military and police counter-terrorism teams, as well as emergency response in the event of nuclear or radiological incidents.

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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 is the leading UK charity representing scientists and clinicians who study the immune system in humans and animals. As a membership organisation, we act as a focal hub for the immunology community, supporting and empowering immunologists working in academic, industry and clinical settings to drive forward scientific discovery and application. We aim to harness the knowledge generated by our membership to ensure society is aware of and can gain from the health benefits that immunology research can deliver.

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

- to work closely with scientists and engineers
- to experience science as a creative, questioning, team exploration
- to add real-life meaning and motivation, from primary to post-16
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- Post-16; our **unique UK-Japan Young Scientist Workshop Programme** hosted in universities in England and Japan since 2001
- Primary; our local **Meet-a-Medic Programme** since 2005

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 an independent charity, established to be a UK flagship for discovery research in biomedicine.

The Crick's mission is discovery without boundaries. We don't limit the direction our research takes. We want to understand more about how living things work to help improve treatment, diagnosis and prevention of human disease, and generate economic opportunities for the UK.

In our institute more than 2,000 staff and students use their wide-ranging knowledge and expertise to work across disciplines and explore biology at all levels, from molecules through cells to entire organisms.

SCIENCE DIRECTORY

Daphne Jackson Trust

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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.

EngineeringUK

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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.

fera

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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.

GAMBICA

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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.

The Geological Society

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The Geological Society of London is the UK's national society for geoscience, providing support to 12,000 Fellows (members) worldwide.

The Fellowship encompasses those working in industry, academia and government, with a wide range of expertise on policy-relevant science, and the Society is a leading communicator of this science to government bodies and other non-technical audiences.

The Society aims to be an inclusive and thriving Earth science community advancing knowledge, addressing global challenges, and inspiring future generations.

IBMS Institute of Biomedical Science

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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.

Institute of Food Science + Technology ifst

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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.

IKE®

Institute of Innovation & Knowledge Exchange

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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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Physicists, engineers and technologists play vital roles in delivering our healthcare. The Institute of Physics and Engineering in Medicine (IPEM) is the professional organisation that represents this diverse workforce. We are a charity with more than 4,600 members drawn from healthcare, academia and industry.

Our Mission is 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 make it happen. We work to support them through professional development, community and leadership services and initiatives. 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

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The Institution of Chemical Engineers (IChemE) is the UK based and internationally recognised qualifying body and learned society for chemical, biochemical and process engineers.

We advance chemical engineering's contribution for the benefit of society, facilitate the development of chemical engineering professionals across a wide range of sectors including energy, water, food and health, and provide connections to a powerful network of 30,000 members in more than 100 countries.

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 leading global life science tools company, providing genomics and quality assurance solutions into high growth application areas within human healthcare and applied market segments. Our core purpose is Science for a Safer World.

Our 180 years of scientific heritage, combined with a focus on innovation and value-enhancing acquisitions, has enabled us to build a highly valued product portfolio, and to closely collaborate with our customers, partners and the global scientific community.

As the UK Government Chemist www.gov.uk/government/organisations/government-chemist, LGC acts as the referee analyst and advises Government and the wider analytical community on analytical measurement matters for policy, standards and regulation.

LGC is also the UK's National Measurement Laboratory for chemical and bio-measurement, finding solutions to fundamental and emerging measurement challenges, driving innovation, productivity and economic growth.

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

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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.

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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.

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The Microbiology Society is a membership charity for scientists interested in microbes, their effects and their practical uses. It has a worldwide membership based in universities, industry, hospitals, research institutes, schools, and other organisations.

Our members have a unique depth and breadth of knowledge about the discipline. The Society's role is to help unlock and harness the potential of that knowledge.

Our principal goal is to strengthen our culture of being a community-driven Society by amplifying our members' voices, wherever they are in the world, and empowering them to embed the benefits of microbiology within wider society.

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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.

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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.

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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.

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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.

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The Nutrition Society, formed in 1941, is a diverse community with the independence and courage to challenge, question and progress the field of nutrition. Through a progressive approach that champions collaboration and breaking down research silos, we welcome members from around the world, regardless of their level of expertise. They must however have a genuine interest in pushing forward the field of nutrition for the benefit of people, animals while balancing the health of our planet too.

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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.

Society for Underwater Technology

Society for Underwater Technology
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Chief Executive
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www.sut.org
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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.

Society of Chemical Industry

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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

SCIENCE DIRECTORY

Society of Cosmetic Scientists

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E-mail: secretariat@scs.org.uk
Website: www.scs.org.uk

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.

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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E-mail: Andrew.muir@midven.co.uk
Website: https://ukinnovationscience seedfund.co.uk/

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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Deputy Director, Enterprise
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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

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Registered in England Charity No: 207996

The Universities Federation for Animal Welfare (UFAW) is an international independent scientific and educational animal welfare charity and membership society.

UFAW's vision is a world where the welfare of all animals affected by humans is maximised through a scientific understanding of their needs and how to meet them. We promote an evidence-based approach to animal welfare by funding scientific research, helping develop the next generation of animal welfare scientists and sharing animal welfare science knowledge with both experts and the wider public.

The Welding Institute

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Website: www.twi-global.com

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
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FORTHCOMING DISCUSSION AND OTHER MEETINGS

Monday 15th April 2024
Annual General Meeting
The Westminster Medal Award
Discussion Meeting on Creating a World-Leading Science and Innovation Industry?
In partnership with the Society of Chemical Industry
5.00pm to 6.50pm, Palace of Westminster
Chairman's Reception 7.00pm to 7.35pm

Monday 1st July
Discussion Meeting on Re-Use, Renew and Replace
In partnership with the Institute of Corrosion
5.15pm to 6.45pm, Palace of Westminster
Chairman's Reception 7.00pm to 7.35pm

Monday 2nd July 2024
Annual Luncheon
Cholmondeley Room, House of Lords
12.15pm to 2.30pm

Monday 10th September
Discussion Meeting on AI (Title to be confirmed)
In partnership with the Institution of Chemical Engineers
5.15pm to 6.45pm, Palace of Westminster
Chairman's Reception 7.00pm to 7.35pm

ROYAL SOCIETY OF BIOLOGY

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

ROYAL SOCIETY OF CHEMISTRY

Tuesday 21st May 2024
Science and the Senedd
The Senedd and Pierhead, Cardiff Bay
12.45pm to 7.30pm
For further details please contact
events@rsc.org

ROYAL SOCIETY

Details of all events can be found on the events calendar at events@royalsociety.org
For scientific meetings queries:
scientificmeetings@royalsociety.org

The Parliamentary and Scientific Committee is an All-Party Parliamentary Group funded by Membership – for details go to https://www.scienceinparliament.org.uk/publications/annual-reports/

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STEM FOR BRITAIN 2024

Stephen Metcalfe MP, Chairman, Parliamentary & Scientific Committee APPG

Viscount Stansgate, President, Parliamentary & Scientific Committee APPG

CHEMISTRY, MATHEMATICS, AND PHYSICS PRIZE WINNERS

BIOSCIENCES AND ENGINEERING PRIZE WINNERS

Credit: John Deehan Photography

CMI
UK Research and Innovation
SCI where science meets business
AWE
dyson
IOP Institute of Physics
The Council for the Mathematical Sciences
The Nutrition Society
The Physiological Society
IBMS Institute of Biomedical Science
Support · Progress · Promote
ROYAL SOCIETY OF CHEMISTRY
BIOCHEMICAL SOCIETY
Royal Society of Biology
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WMG THE UNIVERSITY OF WARWICK