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Tuesday 30 June 2020

# Royal Society submission to the National Policy Forum Green Recovery consultation

## Introduction

The Royal Society, the national academy of science for the UK[1], welcomes the opportunity to submit written evidence to the National Policy Forum's Green Recovery consultation.

A successful research and innovation system is vital to our immediate recovery and to realizing a prosperous, resilient and sustainable society. If supported well, UK science offers enormous potential to create new knowledge, innovations and jobs, to contribute to future economic growth and help us face climate change and other long-term challenges.

This submission contains an overview of some relevant Royal Society work in these areas, highlighting some potential opportunities for green R&D investment. Our comments relate mainly to consultation questions 1, 5, 7 and 10, and focus in particular on:

- the need for smarter investment in R&D to help us build back better
- protecting our research capacity through the crisis so we are set up for a strong recovery
- the potential of new technology to produce pathways to net-zero
- potential sources of low carbon energy and the positive economic benefits they could bring.

If the Labour party would like any further information please do be in touch on public.affairs@royalsociety.org .

## The need for additional, well allocated, investment in R&D to power a green recovery

The current crisis has highlighted once again the importance of research and development, with the application of knowledge gained leading to more effective medical treatments and to the creation of the technologies that enabled parts of our economy to continue to work effectively during the COVID-19 crisis.

Research and development must be a priority for government investment, to help us tackle urgent challenges and to equip us our economy and society for a positive future. Labour's 2019 manifesto included, 'a target for 3% of GDP to be spent on research and development (R&D) by 2030' which we welcome as a step towards bringing the UK into line with other high performing R&D nations -see below.

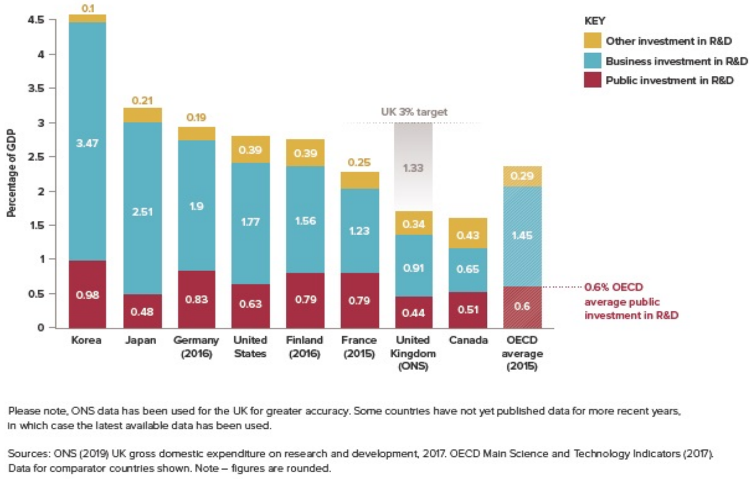



Figure 1: How does UK investment in R&D compare internationally?

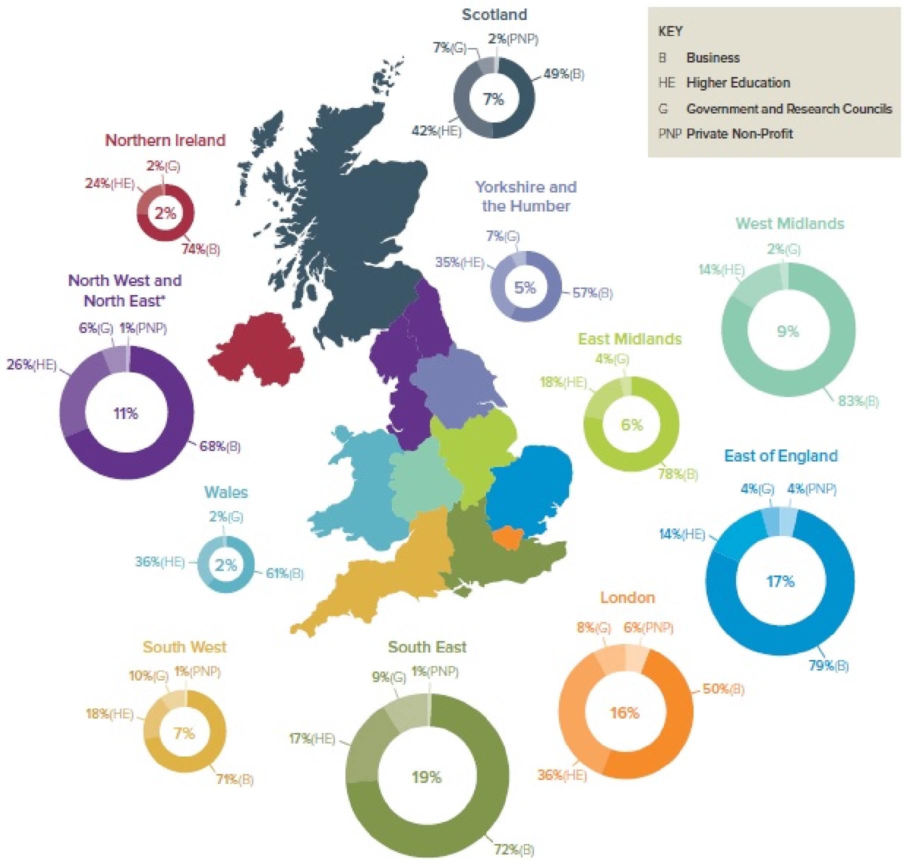
[1] The Royal Society is a self-governing Fellowship of many of the world's most distinguished scientists working across a broad range of disciplines in academia, industry, charities and the public sector. The Society draws on the expertise of the Fellowship to provide independent and authoritative scientific advice to UK, European and international decision makers.

**A strategy is needed to ensure additional investment is allocated in ways which support green economic growth and skilled jobs across the country** and allow the UK to remain a world leader in new and green technologies.

Research and innovation are interrelated and complementary endeavours that take place within a shared ecosystem. Government support for both will be critical to any green recovery programme.

**Currently however, over half of R&D investment is concentrated in three regions of the UK**: the East of England, London and the South East (see Figure 1). This concentration of investment reflects a broader disparity in regional economic performance, prompting a characterisation of the UK as 'two countries'. This disparity hinders national growth and can engender social resentment and disaffection.

Figure 2: Where is investment in UK R&D spent (2017)?




Source: ONS (2019) UK gross domestic expenditure on research and development, 2017. Note – figures are rounded.
*North West and North East regions' data were combined in 2017 due to confidentiality.

**The full economic impact of the coronavirus crisis is not yet clear** but likely to be severe. It appears that it will cut across industries and individuals in ways that are complex and do not neatly align with geography. Nonetheless, the extent to which its economic repercussions are felt most severely by low-income families suggests that **it is more likely to entrench existing regional inequality**.

While pre-COVID 19 employment levels in the UK were high, overall productivity growth in the UK has been flat since the 2008 financial crisis, though this varies massively within and between regions - 'No other large industrialised country faces such productivity inequalities over such a tiny space'.

Care is therefore needed to ensure that essential increases in R&D investment are delivered well. Most R&D funding is distributed on an assessment of research excellence, and existing research strength should absolutely be protected. **However, there is also a clear role for initiatives that support the development of research strength at a local and regional level.**

In addition, given that private R&D investment (about half of which is foreign direct investment) is approximately twice that of the public sector on an annual basis, **we need to aspire to make the UK the R&D investment capital of the world.** This will require new institutional architecture to achieve, including **government taking R&D investment risks** where the market typically fails. Current institutions exist as a consequence of diverse historical policy, and so are highly unlikely to represent an optimal ecosystem. **We would encourage Labour to take a long-term strategic view of optimisation** and drive forward public and private sector support for necessary changes, in order to improve system productivity and cohesion. Any campaign to encourage foreign direct R&D investment will necessarily need to be targeted for best effect. We encourage labour to develop a rationale for deciding priorities for such a targeted campaign.

**Universities have a key role to play in regional development initiatives**. A 2017 Brookings Institution report identifies the following 'success factors' for effective regional R&D strategies: a core competency (i.e. an area of absolute or comparative research strength); access to private and public funding; strong leadership; highly qualified researchers; business capabilities; sophisticated demand; infrastructure provision; supportive regulatory environment; a skilled workforce (commercial and technical expertise to support the research base), amenities and patience on the part of policymakers.

Policy-makers should encourage R&D-led regional growth by considering what could be done at a national and local level to ensure that these success factors exist in as wide a distribution of places as is practicable. In the UK context, the central importance of comparative research strength, a skilled workforce, as well as the generally positive impact of university presence on economic growth, taken together with an already wide geographic spread of higher education institutions suggest **the framework for such regional strategies is there to be built on**.

## Protecting the next generation of UK researchers and innovators through this crisis

A high volume of university research and knowledge exchange has been suspended during the Covid-19 crisis. The sustainability of institutions, and therefore their ability to resume activities, will be reduced by the impacts of a weakened economy and by fewer international students with the desire or ability to come to the UK.

A London Economics report suggests an average loss of income per higher education institution of approximately £20m, with some potentially losing £100m. This could lead to approximately 30,000 job losses in the sector. While the impact will be variable across institutions, all will be affected.

It is imperative to stabilise and protect the research base, in order to avoid irreparable harm to decades of investment in highly skilled people, and to have any chance of properly harnessing the UK's science strength for recovery, subsequent growth and productivity gains, and tackling societal and environmental challenges.

We welcome the Government's announcement of additional funding to support researchers and their institutions, it is positive that ministers have acknowledged the importance of R&D for our response to the crisis and our recovery from it. We look forward to seeing more detail on how and when this funding will be allocated, as it is urgently needed.

Impacts on the UK's STEM skills pipeline will also be impacted by educational deficits experienced by children of all ages. These effects – including on children in education who are still some years away from GCSEs, needs to be analysed and robust mitigation measures put in place to avoid significant constraints on the STEM skills pipeline for years to come.

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## Place the UK at the forefront of global collaboration

From the earliest days of modern science this has been core to the UK's strengths. The Royal Society's contribution to the Covid-19 science effort has been a truly international endeavour. This is just one example of the strength capability and breadth of cutting edge skill that can be rapidly brought to bear on critical problems if deep investments have already been made to build and maintain the science resilience that global networks provide.

It is critical that this global context is fully recognised in shaping and delivering a green recovery. Many opportunities and issues cross international borders and can only be dealt with through concerted global action. In this respect, the year ahead has events in which it is essential the UK substantively engages:

- the upcoming United Nations Convention on Biodiversity 15th Conference of the Parties (COP15) to be held in Kunming, China and the adoption of a post-2020 Global Biodiversity Framework;
- the UN Framework Convention on Climate Change 26th Conference of the Parties (COP26) to be hosted in Glasgow, UK.

Additionally, finance and economics ministries must be central to a sustained Green Recovery. In this respect, it will be important to respond properly to the evidence-base and conclusions of the independent review for the Treasury on the 'Economics of Biodiversity' led by Partha Dasgupta (Fellow of The Royal Society). https://www.gov.uk/government/collections/the-economics-of-biodiversity-the-dasgupta-review

## Linkage between climate change and biodiversity

Climate change and biodiversity loss are inherently linked, affecting the Earth's long-term ability to continue providing services essential to human prosperity.

Ecosystems mitigate climate change by removing the greenhouse gas carbon dioxide from the atmosphere. In recent years roughly a quarter of the carbon dioxide emitted by human activities (due largely to fossil fuel burning and land use change) has been taken up and stored in the plants and soils of terrestrial ecosystems. **In this way, ecosystems act as carbon "sinks".**

**Researchers are exploring ways to manage ecosystems to enhance these carbon sinks beyond the capacity they have exhibited** in the past. Examples of practical interventions relevant to a UK context include forestation and the restoration of wildlife habitats such as wetlands and peatlands.

In October 2018, the Intergovernmental Panel on Climate Change warned that allowing the planet to warm more than 1.5 °C could have long-lasting and in some cases irreversible consequences for ecosystems and that this threshold will be passed by 2030 if current rates of warming continue.

In addition to rising temperatures, researchers are observing changes in precipitation patterns, the occurrence and severity of extreme events, species' behaviours, and the chemistry of the ocean, among other effects. Concurrently, **ecosystems are being modified by a multitude of human-induced stressors,** including resource extraction, habitat degradation and conversion, invasive species, and pollution. **This could affect their ability to continue providing these services in the future.**

More details can be found in the Royal Society's report on 'Greenhouse gas removal' https://royalsociety.org/topics-policy/projects/greenhouse-gas-removal/

(especially Sections 2.1-2.2 & 3.4).

The interlinked nature of climate change and biodiversity was the subject of a joint Royal Society and US National Academy of Sciences report on 'Climate change and ecosystems.' https://royalsociety.org/topics-policy/publications/2019/climate-change-and-ecosystems-report/

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## Using digital technologies to bolster a low carbon revolution and build back better

Achieving the net zero target will require major emissions reductions from all sectors of the economy. **Rapid and unprecedented changes in energy, land use, urban development, transport, infrastructure and industrial systems are needed,** with implications for how individuals live and work.

**Digital technologies could support this transformation, and there are opportunities now to invest in the digital sector in ways that could help achieve the net zero target.**[2]

Digital technologies have already reshaped many daily activities – from online retail to on-demand transport services – with individuals using data-enabled systems to bring physical activities into the digital realm, reducing carbon emissions in the process. **As technologies develop and systems for data use evolve, there will be further opportunities to find new ways of carrying out everyday tasks, with digital technologies bolstering a low-carbon revolution.**

There is a near endless list of areas where **machine learning and conventional computing can be deployed to improve efficiency and lessen the impact a process has on the climate**. Machine learning in **self-driving cars**, for example, is promising a future of more efficient journeys as computers replace humans behind the wheel. Combining digital sensors, wireless networks and computer algorithms can help farmers shift to **precision agriculture**, where the amount of water, fertiliser and energy they need to grow their crops can be improved. **Offices and our homes can be better monitored** to ensure they are only heated and cooled as needed.[3]

Using technology in new ways also brings challenges. **Further action is needed to create an environment of careful stewardship, where the benefits of digital technology are shared across society**. Safe and rapid deployment of digital technologies will require action to:

1. **Create an amenable data environment**: Realising the potential of digital technologies will require access to well-governed data, but large-scale data analysis may be constrained by important legal, reputational, political, business and competition concerns. An amenable data environment would draw from open standards and frameworks or behaviours to ensure data availability across sectors.[4] Certain risks can potentially be mitigated and managed with a set of emerging technologies and approaches often collectively referred to as 'Privacy Enhancing Technologies' (PETs), and there is an opportunity for government to lead by example in demonstrating the utility of these approaches.[5]
2. **Build skills at all levels**: There is a high demand for people with data science skills, with specialists in the field being highly sought after across organisations, from government departments to technology start-ups. Demand for workers with specialist data skills like data scientists and data engineers has more than tripled over five years (+231%). Demand for all types of workers grew by 36% over the same period. Developing foundational skills by ensuring our education system provides all young people with data science knowledge and skills, advancing professional skills by offering nimble and responsive training opportunities, and enabling the movement and sharing of talent by addressing barriers to mobility between sectors will be vital.[6]
3. **Encourage the development of trustworthy technology interfaces**: Digital technologies could become powerful decision-support tools. By integrating data from across different sources or organisations, and identifying points of intervention to increase the carbon-efficiency of a system, these tools could enable more effective human management of complex systems – whether transport, land use, or energy networks. Achieving this requires

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[2] https://royalsociety.org/-/media/policy/projects/digital-technology-and-the-planet/digital-technology-and-the-planet-summary-notes.pdf
[3] https://royalsociety.org/blog/2020/03/how-technology-can-be-harnessed-for-the-good-of-the-planet/
[4] https://royalsociety.org/-/media/policy/projects/machine-learning/publications/machine-learning-report.pdf
[5] https://royalsociety.org/topics-policy/projects/privacy-enhancing-technologies/
[6] https://royalsociety.org/topics-policy/projects/dynamics-of-data-science/

digital systems that work well for people, allowing human users to bring additional contextual understanding or judgment to bear on the operation of the system. For example, human users may need to understand how a digital system has reached a decision, or require information to be provided in ways that are useful in supporting decision-making. This requires careful design of the interfaces between people and technology, with implications for the underlying technical architecture[7] – including the ability of that architecture to track the provenance of data and resources through a system.[8]

4. **Manage carbon emissions from digital technologies**: Digital technologies rely on a complex infrastructure of cables, fibres, computers, data centres, routers, servers, repeaters, satellites, radio masts and energy needed to perform their functions. Operating these systems requires energy, and – if computing systems are to be widely deployed as digital infrastructure for managing activities across sectors – the energy demands and emissions from them will need to be understood and managed. While recent attempts to estimate the carbon footprint of the Internet have prompted dramatic headlines about how much CO2 is associated with each daily digital interaction, a range of such estimates exist, and it can be challenging to calculate the extent to which carbon emissions from digital technologies present a challenge to overall efforts to achieve net zero.[9]

## Low carbon energy – potential avenues for research and infrastructure investment

### Carbon dioxide use[10]

Carbon dioxide emissions are at the heart of the decarbonisation challenge, accounting for 81% of total UK greenhouse gas emissions in 2015. Exploiting the widespread availability of **carbon dioxide could reduce UK dependence on imported hydrocarbons, increase the UK's security of supply in key chemicals and materials and drive growing commercial opportunities** in supply of carbon dioxide based products.

It could provide an alternative source of fuels and chemicals, partially displacing fossil fuels in sectors that are more difficult to decarbonise. For example, **new low carbon fuels could be used as a transition technology in place of traditional fuels in sectors such as aviation, marine and road haulage**.

**Key challenges to invent, scale, commercialise and industrially deploy processes that use carbon dioxid**e remain, including improving the fundamental understanding of catalysis; developing sources of competitively priced low carbon energy; and the need to produce cheap green hydrogen at scale.

**However, using carbon dioxide is now being seriously considered as a commercial proposition to reduce the carbon footprint of process industries such as cement, steel and chemical plants**. A number of companies are already exploring these areas and it is likely that research currently underway will lead to further optimisation and commercialisation of new chemical and biological routes to transforming carbon dioxide in greater volume, **presenting an opportunity for the UK to develop leadership in sustainable manufacturing**.

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[7] https://royalsociety.org/topics-policy/projects/explainable-ai/
[8] https://royalsociety.org/-/media/policy/projects/digital-technology-and-the-planet/digital-technology-and-the-planet-summary-notes.pdf
[9] https://royalsociety.org/blog/2020/05/internet-emissions-whats-the-issue/
[10] https://royalsociety.org/-/media/policy/projects/carbon-dioxide/policy-briefing-potential-and-limitations-of-using-carbon-dioxide.pdf

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**CASE STUDY ONE: North East25**

A review for the Tees Valley Combined Authority explored the potential of carbon dioxide use in the North East25. The Tees Valley industrial cluster contains 58% of the UK's chemical industry, worth approximately £2.5 billion Gross Value Added. Industries include steel, ammonia, hydrogen, ethylene, fine chemical and plastics production. The Tees Valley is also responsible for 5.6% of the industrial emissions in the UK. The review recommended developing a demonstration project for carbon dioxide use in the Tees Valley.

**CASE STUDY TWO: Port Talbot Steelworks**

Port Talbot Steelworks produces carbon dioxide, carbon monoxide and hydrogen, and has land suitable for renewables, including the option of an offshore windfarm and multiple sources of high grade waste heat. All of these emissions make the steelworks a potential site to demonstrate and compare different carbon dioxide use technologies. The waste heat, renewable energy and carbon dioxide streams at Port Talbot steelworks and surrounding area are already being modelled as part of a project led by researchers at Cardiff University.

If the trials are successful they could then be transferrable to other industries such as the cement industry. Since Port Talbot steelworks emits approximately 8Mt of carbon dioxide per year – approximately 15 to 20% of Wales' carbon dioxide emissions – carbon dioxide reuse could make a significant impact on the carbon footprint of Wales.

## Synthetic Biofuels[11]

**Including biofuels in the energy mix reduces cumulative carbon emissions and the cost of meeting 2050 carbon objectives, and biofuel production can benefit local economies (see case study below)**. Policy changes to increase target production have helped to generate market incentives and investor confidence in UK biofuel production. Forecasts for 2032 indicate that sustainably sourced **bioenergy could contribute to between 15 – 25% of the UK's primary energy demand**. Synthetic biofuel production might be best employed either by combining with batteries in a hybrid vehicle, or by **prioritising the use of synthetic biofuels in a difficult transport mode e.g. aviation, offering a lower risk and cost route to low-carbon transport**."

**CASE STUDY THREE: Greenergy International Ltd, Teesside**

Greenergy International Ltd, based in Teesside, is a UK supplier of road fuel and produces 75% of biofuels used in the UK. Their biodiesel is produced from global waste feedstocks such as used cooking oil and food waste. The Teesside biodiesel plant currently receives 4,500 tonnes of used cooking oil per week which is sourced globally from restaurants, fast food outlets and food producers; to produce 284 million litres of biodiesel per year. Their B20 diesel contains a biodiesel-from-waste average content of 20% across the year and requires no engine modifications making it a potentially viable transition technology. In 2016, Transport for London and Low-carbon Vehicle Partnership (LowCVP) commissioned a project to fuel one third of the TfL bus network with B20 biodiesel.

[11] https://royalsociety.org/-/media/policy/projects/synthetic-fuels/synthetic-fuels-briefing.pdf

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## Low-carbon hydrogen[12]

The large-scale production **of low-carbon hydrogen has the potential to play a significant role in tackling climate change and improving air quality**. This has two aspects. Firstly, hydrogen is currently used in many industrial processes, and hydrogen production results in the emission of carbon dioxide. Producing hydrogen using low-carbon methods therefore has the potential to reduce those emissions. Secondly, **using hydrogen as a fuel produces no carbon dioxide, and it can be used flexibly to power transport and decarbonise multiple parts of the energy system including heating buildings**.

**CASE STUDY FOUR: Hydrogen for heat – Leeds H21**

The H21 Leeds City Gate report identified the system requirements (at feasibility level) to convert one city in the UK to 100% hydrogen. The report concluded that it would be possible to reuse the city's existing gas grid and low-carbon hydrogen could be credibly provided, following certain design parameters. It also suggested that the UK gas grid could be converted to 100% hydrogen. Considerable work is required to prove this concept but conversion of UK cities could be achieved incrementally up to 2050 and that appliances could be converted to operate on 100% hydrogen. The H21 project also concluded that a conversion to 100% hydrogen in the UK gas grid could represent a credible and deliverable industrial strategy to meet UK and global climate change obligations, allowing the UK to meet its clean energy targets by 2050. H21 Studies are now under development in Australia and Ireland, and interest is being shown in China, Japan, Hong Kong, New Zealand and across Europe.

The conversion of the natural gas network to hydrogen and the use of hydrogen in fuel cell electric vehicles could play an important role in reducing overall greenhouse gas emissions and air pollutants. However**, there are barriers to the realisation of a hydrogen-based economy including: production at scale, infrastructure investments, bulk storage, distribution and safety considerations**. There is also the issue of how to create a simultaneous demand and supply for hydrogen technologies. To overcome these challenges and realise the potential benefits that hydrogen can bring, **a holistic consideration of the hydrogen supply chain is needed**.

## Green Ammonia[13]

Ammonia production currently accounts for around 1.8% of global carbon dioxide emissions. The production of green ammonia, however, has the **capability to impact the transition towards zero-carbon** through the decarbonisation of its current major use in fertiliser production.

With its relatively high energy density of around 3 kWh/litre and existing global transportation and storage infrastructure, ammonia could form the basis of a new, integrated worldwide renewable energy storage and distribution solution. **These features suggest ammonia could readily be a competitive option for transporting zero carbon energy by road, rail, ship or pipeline.**

Ammonia has been used as a fertiliser for over a century and has been of fundamental importance in providing sufficient food to feed our planet. Decarbonisation options mainly target the production of hydrogen either by **integrating carbon capture and storage** or through the **production of hydrogen via water electrolysis using sustainable electricity.**

Ammonia use does present biodiversity challenges, however. Finding affordable and effective solutions to all these challenges, demonstrating technical feasibility, developing the appropriate regulations and implementing safety procedures will be vital to open up more flexible routes on a global scale towards a low-carbon energy future. Over the coming decades, **ammonia has the potential to make a significant impact through enabling the transition away from our global**

[12] https://royalsociety.org/topics-policy/projects/low-carbon-energy-programme/hydrogen-production/
[13] https://royalsociety.org/-/media/policy/projects/green-ammonia/green-ammonia-policy-briefing.pdf

**dependence on fossil fuels** and contributing, in substantial part, to the reduction of greenhouse gas emissions.

**For more information on any of these subject areas, please contact public.affairs@royalsociety.org**