THE ROYAL SOCIETY

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Royal Society submission to the BEIS Review of net zero call for evidence.

Key Points

- Whilst there are actions and technologies that can and should be implemented now, there remain several issues that need to be solved to achieve net zero by 2050.
- To enable decarbonisation the Government must set the scene, provide policy consistency, act to incentivise and accelerate the pace of change and mitigate market failures.
- A consistent, systematic, whole system-based approach is critical to achieving the Government's ambitions for decarbonisation and economic growth.
- Energy security in the global transition from fossil fuels to renewable energy, will depend both on who develops and controls the technologies (and the related raw materials and supply chains) and where the exploitable natural energy resources (solar, wind, etc.) are located. Securing access to both will be critical to near term energy security.
- An agreed roadmap would enable all to work towards to net zero, giving academics, businesses and consumers the confidence in the direction of travel to a long term prosperous and predictable goal.
- The UK Government must have at its disposal the best and most up to date advice from all relevant areas of expertise. It is proposed that advice should be gathered in a Net Zero Advisory Group.

Introduction

The Royal Society is the national academy of science for the UK. Its Fellows include 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 advice to UK, European and international decision-makers.

The Society's fundamental purpose, reflected in its founding Charters of the 1660s, is to recognise, promote, and support excellence in science and to encourage the development and use of science for the benefit of humanity. Our strategic priorities therefore are to promote excellence in science; to support international collaboration; and to demonstrate the importance of science to everyone.

Achieving net zero

While science and technology alone cannot achieve net zero, we shall not achieve net zero without science and technology. Our views here address the high-level technical challenges, such as advances in batteries for EVs, hydrogen and storage, but perhaps more significantly what changes to the system of advice to Government are necessary to make the best possible decisions delivering faster and cost-effective decarbonisation.

The response to the specific questions of the review are as follows.

2. What challenges and obstacles have you identified to decarbonisation?

There are several scientific and technical challenges that need to be overcome to achieve the net zero target by 2050. Whilst there are undoubtedly many actions that can and should be taken now, several issues need to be solved to better understand the decarbonisation challenge and enable low carbon technologies, such as green hydrogen to be fully implemented. The Royal Society has worked with over 120 scientists to produce a series of policy focussed briefings on the 12 most important challenges in accelerating progress towards 'net zero' greenhouse gas emissions and increased resilience to climate change. The briefings can be found at Climate-change-science-solutions.

Challenges to consider include:

- Batteries: Advances in lithium battery technologies are essential to accelerate decarbonisation of road transport and meet the Government target of EVs only by 2035. Such advances must deliver an increased driving range, faster charging, lower cost and recycling. Innovations, such as solid-state batteries will be needed for road transport but also crucially for the decarbonisation of aviation (drones, short-haul aircraft).
- Decarbonisation of heating and cooling: Many forms of low-carbon heating and cooling are in their infancy compared to fossil-based systems and require significant demonstration and deployment to test their relative cost-effectiveness. Key areas for development include heat pumps (simultaneously provide cooling required for parts of the UK given inevitable future warming), electric heaters and energy efficiency. Our view is that hydrogen is less significant for heating than has been suggested but is vital for other decarbonisation challenges. Industrial heating could be provided by combined heat and power from new advanced modular nuclear reactors.
- Carbon capture and storage (CCS): There are three fundamental and inter-related barriers to CCS: costs; security of storage and regulatory frameworks. The present rates of CCS project construction are much too slow to create the capacity needed to fully contribute to the goal of net zero by 2050. These findings are echoed in a new Royal Society report *Locked in - geological carbon storage* *https://royalsociety.org/topics-policy/projects/low-carbon-energy-programme/geological-carbon-storage/,* which outlines the methodology, technology

and challenges involved in storing carbon dioxide in rock formations deep underground for thousands of years.

- Hydrogen: Green hydrogen will be required if the UK is to meet its commitment to a decarbonised electricity grid by 2035, even with new nuclear build. The commitment to 2035 does not seem to have taken account of the reality at the scale needed. Specifically, cost effective and scalable low-carbon hydrogen technologies will need to be developed further. The timescales required to take the technology from R&D through large-scale demonstration to installation at scale make this particular net zero approach one of great urgency.
- Synthetic fuels: Synthetic efuels offer a medium to long term transition pathway to decarbonisation by reducing fossil fuel use in transport modes such as shipping, aviation, and heavy-duty vehicles. The chemistry to produce the fuels uses processes that could be scaled up to meet demand. Synthetic fuels are currently more expensive than conventional fossil fuels and their production at cost will depend upon the availability of low-cost sustainable electricity to produce low-carbon hydrogen. Further research will be needed to bring this to fruition.
- Digital technology: Digital technology could play an important role in the transition to a low carbon world by enabling emissions reductions across the global economy and limiting the emissions created by computing itself. There is an opportunity to bring together governments, academia, industry and the third sector to create a 'planetary digital twin' or operational 'control loop for the protection of the planet'. Used responsibly, this could simulate, optimise and transform economic activity to minimise emissions and maximise efficiency.
- Large scale electrical energy storage: Great Britain's electricity could largely be provided by wind and solar in 2050 supported by large-scale electrical energy storage, without or with nuclear baseload. A need to store many tens of TWh of energy is revealed by the analysis of many decades of meteorological data (studies of shorter periods seriously underestimate the need). Wind and solar supported by storage could provide Great Britain's electricity at an average cost that compares well with other low carbon options. To realise something approaching a 100% renewable electricity system by the target date of 2035, further feasibility studies and modelling, supported by research and development and the construction of demonstrators, should start now.

4. What more could government do to support businesses, consumers and other actors to decarbonise?

Businesses and consumers need confidence in the direction of travel and for that to be a long term and predictable goal. The UK must determine an evidence-based route to net zero that is fast and cost-effective, providing value for money to the UK taxpayer. While ultimately it is the private sector that will deliver net zero, the targets cannot be met by business-as-usual rates of deployment or development of technologies. Government must set the scene, provide policy

consistency, act to incentivise and accelerate the pace of change and mitigate market failures. By defining and investing in the route to net zero, Government can provide the confidence businesses and investors need, unlocking the significant amount of private capital required to decarbonise.

5. Where and in what areas of policy focus could net zero be achieved in a more economically efficient manner?

While HMG's publication of a net zero strategy and R and D framework are welcome, they are not enough. They summarise all the routes but do not identify their relative merits and do not provide a clear direction of travel to industry. Delivery requires action across all six carbon emitting sectors: electricity, heating and cooling, transport (land, sea and air), land use, agriculture and manufacturing. A whole system approach is needed as cost effective solutions will often straddle several sectors, as well as enabling economic co-benefits in biodiversity and improved health to be realised. For example green hydrogen will play a part in transport, energy storage and manufacturing processes such as steel.

It is unrealistic and economically inefficient to expect individual companies or industrial sectors to solve net zero alone. A consistent, systematic, whole system-based approach is therefore critical to achieving the Government's ambitions for decarbonisation and economic growth. As discussed above, this will require the UK to press ahead with delivering the science to develop new technologies, as well as implementing existing ones.

6. How should we balance our priorities to maintaining energy security with our commitments to delivering net zero by 2050?

Energy security and net zero are not in tension. Decarbonising our electricity system by accelerating the transition to wind and solar as well as nuclear co-generation to produce electricity and heat, will bring energy security. However, we do need to be realistic regarding the need to store tens of TWh of energy for years if we are to operate a decarbonised energy system. For comparison one TWh of energy storage equates to the battery capacity of 25.6 million base level Nissan Leaf cars.

Existing technologies such as batteries and pumped hydro, whilst useful for short term/short duration storage, will not be able to fulfil this need. The development of large-scale hydrogen storage, produced by electrolysis and stored in salt caverns is a credible solution. Similarly the large-scale production of green ammonia, produced using renewable electricity, offers a solution to the international trading of energy from renewable sources. A global network already exists for the bulk storage and transportation of ammonia for use as a fertiliser.

Nuclear will also have a role in our future energy mix. However, a combined heat and power approach is needed, where the heat generated by a nuclear power station is used not only to generate electricity, but to address some of the 'difficult to decarbonise' energy demands such

as domestic heating and industrial process heat. It also enables nuclear plants to be used more flexibly, by switching between electricity generation and cogeneration applications.

Energy security in the global transition from fossil fuels to renewable energy, will depend both on who develops and controls the technologies (and the related raw materials and supply chains) and where the exploitable natural energy resources (solar, wind, etc.) are located. Securing access to both will be critical to near term energy security.

The availability and supply of key raw materials is an obvious risk. This can in part be mitigated by the development of material efficient technologies and processes, but benefits can also be gained by establishing the market conditions that promote the development of industries to recycle of waste and recover critical materials.

29. How can we ensure that we seize the benefits from future innovation and technologies?

Manufacturing and selling low carbon technologies, whether heat pumps for domestic heating, batteries for electric vehicles, electrolysers and fuel cells, or small modular reactors will be important to the future of the UK. The UK knowledge base in green technology clearly has the potential to provide us with a global leadership position in this coming industrial revolution. Government needs to examine how to make market creation policies work more rapidly. The growth of offshore wind has been relatively quick, but many other important transitions, for example CCS have not developed as quickly as is needed.

UK expertise in science and technology is world renowned both in the public and private sector. As in all times of emergency, we must harness our best experts to advise Government. This is all the more important given the rate at which knowledge and understanding is changing in the areas from which solutions to climate change must come. Working together, through an agreed roadmap, academics with businesses and consumers can have the confidence in the direction of travel to a long term and predictable goal.

30. Is there a policy idea that will help us reach net zero you think we should consider as part of the review?

Overwhelmingly yes. The UK Government should have at its disposal the best and most up to date advice from all relevant areas of expertise. It is proposed that advice should be gathered in a **Net Zero Advisory Group**.

Key features of a net zero advisory group

- Given the power to provide independent advice to UK and devolved governments on setting and following a net zero technology road map with a whole systems approach.
- Bring together a range of disciplines in areas of relevance R&D, innovation and deployment expertise

- Beyond political cycle to provide longevity for research to investment and asset use
- Independent of Government

The net zero advisory group could be tasked with providing advice on:

- defining a living and evidence-based technology road map by which the UK could meet its greenhouse gas emission targets rapidly and with value for money.
- Modelling and tensioning one low carbon solution against another from a variety of perspectives to provide advice on which technology choices to make.
- Which scientific and technological solutions are ready to deploy now and what is needed to incentivise their deployment, which solutions require further development and demonstration at scale and which solutions require further research. This is crucial to ensure money is spent on the right problems at the right time.
- an ad-hoc basis to specific questions
- feedback from the progress in deployment, development and research and responsive to changing knowledge domestically and worldwide.

For this to be a success we foresee that it could be:

- Populated by the most eminent scientists, technologists, engineers, lawyers, economists, investors and behavioural scientists across academia and industry.
- A partner body to the Climate Change Committee

For further information, please contact public.affairs@royalsociety.org .