THE ROYAL SOCIETY

CLIMATE CHANGE : SCIENCE AND SOLUTIONS | OVERVIEW

A net zero climate-resilient future:
science, technology and the solutions for change

Over the past year, we have witnessed the power of science in a global emergency as scientists worked to understand the COVID-19 pandemic and created the vaccines to respond. Similarly, science has shown us that life on our planet is in danger from climate change. However, it has also shown us how solutions can be found and how together we can overcome the climate emergency.

The Royal Society, together with the world's leading scientific academies, have issued a statement on the need to accelerate action on climate change. In that, we recommend every government should develop an evidence-based roadmap setting out the technologies that it requires to achieve the goal of reducing greenhouse gas (GHG) emissions to net zero, given its own circumstances. We encourage all countries to deploy technologies and nature-based solutions that are available now and to invest in research and innovation to address the outstanding challenges.

This pack of briefings from the Royal Society supports that statement and sets out to provide more detail, demonstrating how the outstanding challenges of climate change can be met. They represent what we consider to be the priorities for research, development and deployment and offer options which any country might choose to use. Over 120 experts from many disciplines and around 20 countries have contributed to the pack. While each briefing provides a simple overview, we at the Royal Society stand ready to collaborate or provide further support in terms of scientific input.

In summary, these briefings consider how science and technology can help address climate change in 12 specific areas that will be critical in the effort to achieve net zero emissions by 2050 and adapt to the impacts of climate change.

Climate modelling
Creating models that simulate the Earth's climate system has been one of the great scientific achievements of the last half-century. Achieving the step-change in resolution and computing capacity to fully understand global impacts of climate change at kilometre-scale will require international collaboration to harness the power of exascale computing.

Carbon cycle
Much is now understood about the Earth's carbon cycle – how the land and ocean act as sinks to absorb more than half of the carbon dioxide emitted by human activity. However, deeper understanding is needed, – particularly of whether the sinks will continue to sequester carbon dioxide at historical levels as they are themselves affected by climate change.

Digital technology
With access to huge amounts of data, computing science has the potential to create 'digital twins' that simulate and optimise multiple sectors of the economy to reduce carbon emissions significantly by 2030.

Batteries
Lithium-ion batteries (LIBs) have been a scientific success story, now deployed in millions of vehicles worldwide. Advanced LIBs followed by a new generation of battery technologies could deliver faster charging and longer ranges, lower costs and decarbonise the electricity grid and power heavy transport.

Heating and cooling
Heating and cooling account for 40% of energy-related carbon dioxide emissions, yet progress in decarbonisation has been slow as advances in heat pumps, wider hydrogen deployment and novel methods for transporting and converting heat energy are among developments essential to decarbonise this sector.

Hydrogen

As well as heat, hydrogen has a wide range of potential low-carbon roles in transport, power and storage that require demonstration. With the right investment and infrastructure, hydrogen could be scaled up to decarbonise sectors less suited to electrification, such as heat for industry, while ammonia, derived from hydrogen, is a leading option for powering shipping in a net zero economy.

Carbon capture and storage (CCS)

CCS is likely to be important to a net zero world, but current rates of construction are too slow to create the capacity required. Global capture and storage capacity is now around 40MtCO_2/yr, of which only 25% is stored geologically to mitigate climate change. A deployment-led approach is required to accelerate progress in reducing costs and scaling up the technologies.

Climate resilience

Even if warming is limited to 1.5°C, livelihoods and infrastructure will be increasingly affected by climate change and extreme weather, which threaten to displace millions of people. Investing today in climate resilience, particularly through better forecasting, climate-proof infrastructure and nature-based solutions, will be more cost-effective than waiting until impacts are being experienced.

Land use and the global food system

While land use change and farming generates emissions, land-based projects that prevent degradation of forests, grasslands, peatlands and other ecosystems can contribute to net zero and generate benefits for local communities.

The global food system accounts for around one-third of all GHG emissions, a footprint that can be reduced by more sustainable diets, climate-smart farming and innovations in plant science.

Health

There are major co-benefits between action taken on climate change and human health. For example, estimates show that action to phase out fossil fuels to limit warming to 1.5°C would avoid up to 100 million premature deaths from air pollution. Nature-based solutions which tackle mitigation and adaptation also offer physical and mental health co-benefits.

Policy and economics

Policy and economics play a major role in the deployment of the net zero tools provided by science and technology. Analysis informed in association with the British Academy shows how 'Building back better' from COVID-19 can 'kick' or 'shift' economies towards long-term incentives for emissions reduction, that can also support jobs, wellbeing, and the living world.

The evidence from research also shows that countries agree to coordinate their actions when they perceive that a catastrophe is looming. A generation of climate research has starkly demonstrated this is the case. The positive message here is that if governments raise their ambitions, with science as a guide, then we can change course and build a sustainable, resilient, net zero future.

As President of the Royal Society, I thank all the contributors from around the globe that made these briefings possible. They provide a message of hope that together, through raising our level of ambition and working as one we can reach a net zero, climate resilient future and make that achievement the defining success of our age.

Sir Adrian Smith
President of the Royal Society

To view the series of briefings, visit **royalsociety.org/climate-science-solutions**