A Net Zero Climate-Resilient Future: Science, technology and the solutions for change

This Communiqué lays out the need for all countries to anticipate the critical risks associated with climate change, to recognise the transitions that this requires, and to carefully design, plan and accelerate implementation of actions to reach net zero by 2050 or earlier. We urge all countries to deploy the many technological, natural and behavioural solutions that are available to them now and to strengthen and support research and innovation to urgently address the outstanding challenges. All nations of the world must work in partnership: science is a global endeavour and the last year in particular, with the international response to the COVID-19 pandemic, has demonstrated the power of global science.

Terminology in this Communiqué uses science to include engineering and technologies to include nature-based solutions.

The climate crisis and what needs to be done

Climate change is a real and rapidly increasing danger to people and the planet. The world is already experiencing the impacts of a dangerous rise in global temperatures, with significant effects on ecosystems, socio-economic systems, and human welfare. Science tells us we must act now and continue to act into the future to deliver net zero emissions if we are to avoid further dangerous warming. This is the time for all countries to commit to urgent measures of mitigation of, and adaptation to, climate change. The cost of inaction will greatly outweigh the cost of action.

All greenhouse gas emissions must decline rapidly, and carbon emissions in particular must reach net zero by mid-century if we are to limit global warming to well below 2 degrees Celsius, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. This needs immediate deployment of available low-greenhouse gas emission technologies, especially low-carbon technologies. All countries should develop an evidence-based technology roadmap to net zero that is appropriate for them. From this, countries should urgently deploy disruptive low-carbon technologies in infrastructural development and in industrial production, and influence and incentivise institutional decisions as well as personal lifestyle choices to achieve national deployment goals. Early implementation must avoid capital investment that would otherwise lock-in long-term emissions, especially energy infrastructure based on fossil fuels. Care must also be taken to ensure that technologies, such as replacement of fossil fuels by biomass, hydrogen, or ammonia, are properly assessed for their net effect on climate and shown to achieve real near-term net reductions in atmospheric greenhouse gas emissions.

However, deployment of existing technologies will not achieve net zero alone. New technologies and innovations are required to deliver lower emissions solutions, which can scale globally, at lower cost than available today, and in an equitable way with citizens engaging in the process. Research and development of new technologies, and investment in scientific advances, must be accelerated. This is especially important for sectors such as shipping and aviation, steel and cement manufacture, and food production, which face tougher challenges around decarbonisation. The COVID-19 pandemic has demonstrated how innovation can be accelerated in times of great need. The urgency of reaching net zero now requires such rapidity, supported through national technology roadmaps, net zero advisory boards, and mechanisms to engage the resources of science, industry and institutions in order to determine, develop and deploy appropriate and effective solutions.

Well-designed, planned and managed climate adaptation and mitigation solutions offer synergies with the UN's Sustainable Development Goals. These go beyond climate action and include ensuring food and water security, improving health, protecting life on

land as well as below water, reducing poverty and inequality, and importantly, ensuring access to affordable, reliable and sustainable energy for all, for which the cost of carbon is recognised. To achieve these aims, social understanding and transformation is crucial, and social sciences consequently must work hand-in-hand with developments in technology.

Breakthrough science and technologies

- **A resilient energy system for a net zero future**. While different energy solutions are available for particular regions, there are clear commonalities. A low-carbon and resilient electricity system requires deployment of locally appropriate renewable generating technologies, which may include wind, hydro and solar among others. Electricity systems must also meet demand while coping with variability of generation to ensure stability of supply. Further research and development on renewable technologies is required to expand the range of technologies available and should extend to storage, from short-term storage such as batteries to large-scale, long-term options such as pumped hydro. Hydrogen and ammonia have a potential role to play both in storage and as stand-alone energy vectors. Some countries already deploy nuclear power, which they may develop further as part of their low greenhouse gas emissions future. Any continued use of natural gas and energy from biomass must be coupled with carbon capture and storage (CCS) or carbon capture and utilisation (CCU), in places where these approaches are shown to be viable and appropriate. Research on net-carbon removal technologies may be necessary, though high costs and uncertainty over their large-scale viability means such technologies should not be seen as a panacea that reduces the urgency of substantial and rapid emissions reductions now. Demand-side management and a digital (smart) grid, incorporating artificial intelligence and behavioural science will also be needed. On heating and cooling, heat pumps (which are also air conditioners), improved insulation and better energy efficiency, coupled with a reinforced electricity grid and district heating where appropriate, are areas of urgent research and development need. There is much potential for increasing energy efficiency to reach net zero in the building sector and to develop new, regionally appropriate energy-efficient urban planning concepts.
- **Transport**. Research and development on novel fuel types, including green hydrogen and synthetic fuels for sectors which are particularly challenging to decarbonise, such as aviation, marine and heavy goods vehicles, is an urgent need. For passenger and light goods vehicles, advances in battery technology are required. Improving the efficiency of existing technologies, developing incentives for public and non-motorised transport, and reducing demand for high-emission transport will also play an important role alongside decarbonisation.
- **Industry**. Manufacturing of steel, cement and chemicals must transition, supported by CCS and CCU, and this may include energy demand reduction, reduction of emissions from industrial processes, and electrification combined with a low-carbon grid. Promoting circular economy principles including reuse and recovery of resources can also help to reduce demand for energy and virgin materials. Research and development is required to deliver alternative, efficient industrial processes that are low-carbon, clean and economically viable across the diverse sector of greenhouse gas-emitting industries. Working collaboratively across nations can help deliver broad-scale industrial change.
- **Agriculture, forestry and other land uses** are responsible for around 25% of carbon emissions. Research and development on alternatives to current methods of providing nutrition and ensuring food security are essential. Further, the drive for agricultural land has led to the conversion of habitat that is currently responsible for the majority of biodiversity loss, but climate change, if unchecked, will be the dominant threat in the future. Protecting biodiversity while ensuring food security and mitigating climate change requires thoughtful action. Actions include the sustainable intensification of agriculture, improving soil management to ensure carbon uptake, and dietary change. The careful redesign of incentives towards reduced demand on limited land resources and release of areas for rewilding where appropriate are also needed. Nature-based solutions must be found to use land in a way that mitigates climate change while also protecting biodiversity alongside food availability.

- **Adaptation to climate change** requires progress in a number of areas, including investment and advances in climate modelling. Work is needed to narrow the uncertainty in climate sensitivity, to better understand Earth system instabilities, and to provide high-quality local, regional and global projections of both median trends and extremes. Adaptation requires a better understanding of the global carbon cycle, long-term sea level changes from melting ice sheets, climate feedbacks, and tipping points in Earth systems. Increased observations and understanding of our impact on the planet are essential to improve early warning systems to extreme weather and to enhance future predictions.

The role of global science in solving the crisis

The complex challenge of achieving net zero requires a whole systems approach across all sectors of the economy and society, in addition to collaboration across all countries. Localised and sub-national approaches also need to be fostered, as solutions are most effective if they reflect local resources and capabilities. The physical sciences, working in an integrated manner with economics, behavioural and social science, and the humanities, can provide evidence-based roadmaps to support the transformative changes that will be needed to achieve net zero, recognising constraints and trade-offs. This is essential to identify the technologies and actions that are ready for deployment now, which solutions require development, and which need further research.

Science has an essential role to play in both mitigation and adaptation. Adaptation can be improved by better understanding the impacts of climate change, including wildfires, droughts, heatwaves, floods and sea level rise. So too can science lead us to entirely new low-carbon technologies, accelerate the scale-up of existing technologies, provide life-cycle analysis of the efficacy of low-carbon technologies, and eliminate emissions in sectors where reduction is particularly challenging. Investment in research and development is needed now to deliver solutions by 2030 and beyond.

Collaboration between nations will be critical to accelerate vital advances in research and development, and to shorten the timeline to deployment. In particular, collaboration between developing and developed countries is essential to address this global issue, with an equitable sharing of responsibility and cost, alongside engagement and technological transfers between countries. While adaptation and mitigation have local challenges and solutions, there are common global themes that we can and should address together.

Recommendations

The InterAcademy Partnership asks that all Governments:

1. Develop an evidence-based technology roadmap to net zero that is informed and continuously updated by bringing together scientists, economists, social and behavioural scientists, and other experts. The roadmap should recommend the technologies to deploy, develop and research. Overlying frameworks that also enable a diversity of approaches is necessary to mitigate greenhouse gas emissions and limit global warming to well below 2 degrees Celsius, preferably to 1.5 degrees Celsius, relative to pre-industrial levels.
2. Accelerate the pace of change by increasing public and private sector investment in the key research and development challenges on the road to net zero and effective adaptation. This should be done both nationally and internationally via multilateral collaborations.
3. Work together to support developing countries on the road to a climate-resilient, net zero future, ensuring fairness and justice in the transition and co-benefits with other sustainability goals.
4. Work together to advance suitable policy packages to provide both economic and behavioural incentives for carbon-neutral options.

All nations working together can accelerate the pace of decarbonisation to ensure we have a planet fit for future generations.

Signed by the members of the Steering Committee of the InterAcademy Partnership (IAP) in September 2021

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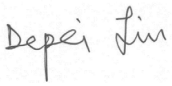

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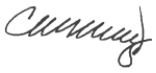

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About the InterAcademy Partnership (IAP)

Under the umbrella of the InterAcademy Partnership (IAP), more than 140 national, regional and global member academies work together to support the vital role of science in seeking evidence-based solutions to the world's most challenging problems. In particular, IAP harnesses the expertise of the world's scientific, medical and engineering leaders to advance sound policies, improve public health, promote excellence in science education, and achieve other critical development goals.

IAP's four regional networks - AASSA, EASAC, IANAS, and NASAC - are responsible for managing and implementing many IAP-funded projects and help make IAP's work relevant around the world. For more information about IAP see www.interacademies.org and follow @IAPartnership on Twitter, on LinkedIn and YouTube.

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